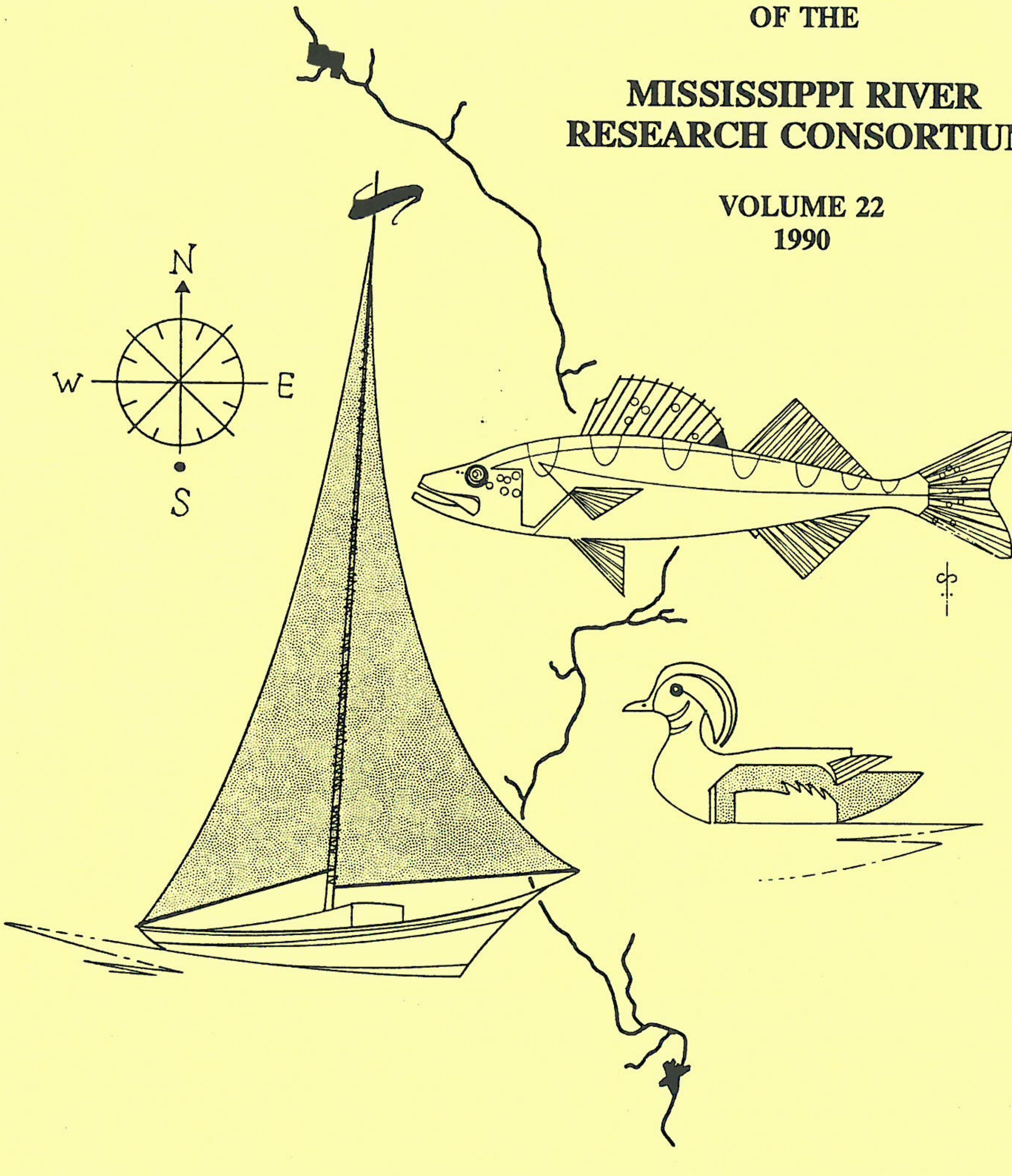
PROCEEDINGS
OF THE

MISSISSIPPI RIVER
RESEARCH CONSORTIUM

VOLUME 22
1990



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MISSISSIPPI RIVER RESEARCH CONSORTIUM, INC.

22ND ANNUAL MEETING
19-20 April 1990

Island Inn and Convention Center
La Crosse, Wisconsin

CONTENTS

PROGRAM SCHEDULE
MISSISSIPPI RIVER RESEARCH CONSORTIUM, INC.

22ND ANNUAL MEETING
LA CROSSE, WI ISLAND INN

THURSDAY, APRIL 19, 1990

REGISTRATION

07:30-08:15 a.m.

INTRODUCTION

08:20-08:30 a.m.	Welcome and Announcements: John Sullivan
SESSION I	Keynote Addresses: Long-Term Trends in Climate and Hydrology in the Upper Mississippi River System. Moderator: Doug Blodgett
08:30-09:15 a.m.	A climatic assessment of the 1988-90 drought in the upper midwest. Stanley A. Changnon.
09:15-10:00 a.m.	Long-term trends in climate and hydrology in the Upper Mississippi River System: where has all the water gone? William H. Koellner.
10:00-10:20 a.m.	BREAK
SESSION II	Moderator: Ron Rada
10:20-10:40 a.m.	The Metropolitan Wastewater Treatment Plant and the Mississippi River: 50 years of improving water quality. D. Kent Johnson and Paul W. Aasen.
10:40-11:00 a.m.	A habitat window: Pool 26 LTRM water quality. R. V. Anderson, F. A. Cronin, J. J. Rundell, and M. A. Morris.
11:00-11:20 a.m.	Mississippi River water quality during the summers of 1986 and 1988: an evaluation of high flow versus low flow conditions. John F. Sullivan.
11:20-11:40 a.m.	Contaminants in sediments, plants, and macroinvertebrates from Mississippi River Pool 19 during a drought (1977) and a high-flow year (1978). K. Douglas Blodgett and Richard E. Sparks.
11:40-12:00 p.m.	Instream flow requirements of upper Mississippi River smallmouth bass. William A. Swenson and Daniel J. Orr.
12:00-01:00 p.m.	LUNCH AT THE ISLAND INN

SESSION III	Moderator: Marian Havlik
01:00-01:20 p.m.	Modelling the recent decline in fingernail clam populations of the upper Mississippi River. Jim Eckblad.
01:20-01:40 p.m.	Sediment toxicity in the upper Illinois River: a search for the toxic substance(s). Frank S. Dillon, Philippe Ross, Richard E. Sparks, and LouAnn Burnett.
01:40-02:00 p.m.	Histological and ultrastructural methods for determining effects of sublethal cadmium exposures on juvenile *Lampsilis* from the upper Mississippi River: preliminary studies. Becky A. Lasee, Brent C. Knights, and Leslie Holland-Bartels.
02:00-02:20 p.m.	Physiological responses of the pocketbook mussel (*Lampsilis ventricosa*) to cadmium. T.J. Naimo, L.E. Holland-Bartels, and G.J. Atchison.
02:20-02:40 p.m.	What's in the soup: electrophoretic analysis of the host-parasite relationship between the flathead catfish and the mapleleaf mussel. M. A. Romano, D. Barry Markillie, and R. V. Anderson.
02:40-03:00 p.m.	BREAK
SESSION IV	Moderator: M. A. Romano
03:00-03:20 p.m.	A survey for naiad mollusks (Unionidae) at Minnesota River Mile 10.8, Interstate Highway 35 west, between Burnsville and Bloomington, Minnesota. Marian E. Havlik.
03:20-03:40 p.m.	Length/age/sex of fresh-dead *Lampsilis higginsi* (Lea, 1857) (Unionidae) from the Prairie du Chien, WI area, Mississippi River, April-November, 1987. Marian E. Havlik.
03:40-04:00 p.m.	The distribution, abundance, and species diversity of naiad mollusks from the lower Chippewa River, Wisconsin. Terry A. Balding.
04:00-04:20 p.m.	Good rocks and bad rocks: life on a wing dam. R. V. Anderson, D. M. Day, J. W. Grubaugh, D. A. Deters, and J. L. Owens.
04:20-04:40 p.m.	Mallard nesting on the upper Mississippi River. John F. Wetzel and Robert B. Dahlgren.
04:40	DISMISS UNTIL 6:30 CRUISE ON NEW ISLAND GIRL

06:30-08:30 p.m.	<u>SOCIAL & DINNER CRUISE ON THE NEW ISLAND GIRL</u>
<u>FRIDAY, APRIL 20</u>	
08:20-09:00 a.m.	<u>BUSINESS MEETING</u>. Moderator: Doug Blodgett
<u>SESSION V</u>	Moderator: Nani Bhowmik
09:00-09:20 a.m.	In the light of day: production in channel border habitats of the upper Mississippi River. <u>R. V. Anderson</u>, R. E. Sparks, J. W. Grubaugh, and K. D. Blodgett
09:20-09:40 a.m.	Continuous water quality monitoring in Upper Mississippi River System backwaters. <u>Jennifer L. Owens</u>, William G. Crumpton, and Kyle H. Holland.
09:40-10:00 a.m.	Studies on the physical effects of commercial navigation traffic in the upper Mississippi River: results of 1989 sampling. <u>Andrew C. Miller</u>, Barry S. Payne, and Dan Ragland.
10:00-10:20 a.m.	How should we answer the question "does commercial navigation impact fish communities of the UMRS by increasing ichthyoplankton mortality?" <u>Kenneth S. Lubinski</u> and D. Wilcox.
10:20-10:40 a.m.	<u>BREAK</u>
<u>SESSION VI</u>	Moderator: Mark Sandheinrich
10:40-11:00 a.m.	Strategies for evaluating sedimentation and commercial navigation impacts on the upper mississippi river system. <u>Kenneth S. Lubinski</u>.
11:00-11:20 a.m.	Correlations between suspended sediment concentration and turbidity at Mile 50.1 on the Illinois River. <u>J. Rodger Adams</u> and Edward Delisio.
11:20-11:40 a.m.	Changes in velocities within the channel border areas due to the movement of barge traffic. <u>B. S. Mazumder</u> and T. W. Soong.
11:40-12:00 p.m.	Waves generated by recreational traffic on the Upper Mississippi River System. <u>Nani G. Bhowmik</u>, Ta Wei Soong, Walter Reichelt, and William C. Bogner.

ABSTRACTS OF INVITED PAPERS

KEYNOTE SESSION: LONG-TERM TRENDS IN CLIMATE AND HYDROLOGY IN THE UPPER MISSISSIPPI RIVER SYSTEM.

KEYNOTE ADDRESS NO. 1:

A CLIMATIC ASSESSMENT OF THE 1988-90 DROUGHT IN THE UPPER MIDWEST. **Stanley A. Changnon, Illinois State Water Survey, and Changnon Climatologist, Mahomet, IL 61853.**

The severity of the drought that appeared in the upper midwest in 1988 and that has lingered on into early 1990 has raised numerous questions. Was it the worst the area has ever experienced? Was it the start of greenhouse-related climate change scientists have been forecasting? Will it continue for one, two, or more years? Can droughts like this be predicted weeks, months, and years in advance?

This paper presents answers to these questions, and explores many other issues relating to drought in the upper midwest. Importantly, the area has become, over time, ever more susceptible to drought-induced water shortages. The drought of 1988 alone was not the worst "climatic drought" the area has experienced in the last 100 years. We entered the drought after an unusual period of prolonged wetness lasting about 20 years. Experience of the past indicates severe, multiyear droughts in the region often persist 4 to 5 years. Scientists largely do not believe that the drought is a precursor of the expected major change in climate, but some uncertainty remains. Climate change is expected to bring some major changes to the region; what these may be will be explored.

KEYNOTE ADDRESS NO. 2:

LONG-TERM TRENDS IN CLIMATE AND HYDROLOGY IN THE UPPER MISSISSIPPI RIVER SYSTEM, WHERE HAS ALL THE WATER GONE?

William H. Koellner, Army Corps of Engineers, Rock Island District, Rock Island, IL 61204-2004.

The Mississippi River navigation system is entirely dependent on its ability to transport commodities efficiently. The system's capabilities are in part directly related to climate. Extreme meteorological events in the region generate stresses on the system that often reduce its efficiency. The United States is very dependent on the movement of different kinds of commodities, both for internal national use and for export. The Mississippi River system links the Gulf of Mexico to the Great Lakes, as well as to other waterways.

The major portion of all tonnage originating or terminating in the system is comprised of five commodity groups: grain, agricultural chemicals, coal, cement or stone, and petroleum products. If any of the sub-systems that these commodities move through are affected by adverse climatic conditions, the efficiency of the whole system may be reduced drastically and even render inoperative for some period of time. Constraints on the system usually become activated under conditions of either too much or too little water. Climate variability affects navigational commerce--the supplier, the shipper, and the purchaser.

The Mississippi River is 2,340 miles long and has a watershed area of 1,245,000 square miles. Forty percent of the area of the United States and 13 percent of the area of Canada drain into this river system which provides an outlet for various commodities. The Inland Waterway systems transport 25% of all waterborne commerce and the Rock Island District portion of the Inland Waterway system handles 20% of those commodities which is about 100 million tons as shown in **Figure 1.**

The purpose of canalization is to provide a dependable 9-foot navigation channel for the safe movement of barges and towboats with widths suitable for long-haul common carrier service.

The Mississippi River lock and dam system from St. Louis, Missouri, to St. Paul, Minnesota, on the Mississippi River, and from the mouth to Chicago, Illinois, on the Illinois Waterway was designed to maintain a minimum 9-foot channel in each pool. This would be accomplished by the closure of moveable gates on each dam. Each gate could be placed at a zero setting and, theoretically, no water would be released in that gate bay. Gates can be closed, releasing only the water flowing into the pool from the upstream dam and local tributaries, while the authorized pool level is maintained.

Conflicts over river usage have occurred at least since the 1930s because of diverse, sometimes competing, uses by a variety of interest groups. Adding to this problem is the fact that societal and environmental uses of the river have changes over time.

On the Mississippi River where the pools are more braided, the backwater areas are not continuously replenished with moving high water under low flow conditions. When this occurs during a warm period, the algal population increases and fish kills occur. During the low flow period in the summer of 1987, two large fish kills were reported (at Cordova, Illinois, and Keithsburg, Illinois).

Recreational boaters, who normally are not aware of river controlling works, collide with the submerged wing dams during low flow periods, which causes damage to their craft and occasionally injures boaters. With continued siltation of the backwaters, what is presently and excellent sport and commercial fishery would be destroyed as a result of low water levels.

Additional channel closures can be expected during low flows, which will slow the movement of commodities. This will force normal river users to use other modes of transportation.

The water quality problem generated during low flow periods could potentially be more serious. Presently, both communities and industries treat effluent before it enters the river system. However, the level of treatment is commensurate with the mixing level of the river, and if river flows are low for extended periods, the proportion of pollutants entering the system would increase.

Changing hydrological and meteorological conditions, towboat traffic, and variable channel dimensions, among other factors, result in the hydraulically unsteady-state conditions which exists throughout much of the navigation system. However, the primary factor affecting the ability to maintain the 9-foot navigation system is the rainfall-runoff relationship of the Mississippi River Basin. Climatic conditions over the several thousand square miles of drainage area determine the system's eventual water yield.

A long streamflow record, the basis for analyses of the Mississippi River and Illinois Waterway systems, constitutes a tenuous set of information, in that it represents both deterministic and stochastic data. The variability in runoff does not follow any easily forecasted trend.

The climate of the Upper Mississippi River Basin has been a major factor in the region's agricultural, commercial, and industrial development. During recent years, climate extremes in the Upper Mississippi Basin caused millions of dollars in lost production, in addition to other related economic costs and losses. The increasing frequency, intensity, or duration of extreme meteorological events experience in recent years in the United States has increased climatic stress and resultant hydrologic stress.

The greatest climate stress to date occurred during 1959-1986. This period ranks as the wettest 28-year period in the climatic history of the Mississippi River Basin. The extreme wetness of this period is also apparent in the recorded streamflow, which was well above normal as noted on the hydrologic record at St. Louis, Missouri **(Figure 2, United States Geological Survey Water Resources Data for the period 1879-1986).**

The most recent drier period, which began in late 1986, has regionally continued. This has had an effect on the streamflows in the Upper Mississippi River Basin tributaries, as well as in the Mississippi River. Navigation was impacted in 1988 and 1989 primarily on the Mississippi River below St. Louis, as several restrictions were imposed on size of tows and amount of tonnage loaded on individual barges during the summer, fall and winter of 1989. Several examples of the low flow conditions will be shown at the conference as will other impacts that were noted during the last three years.

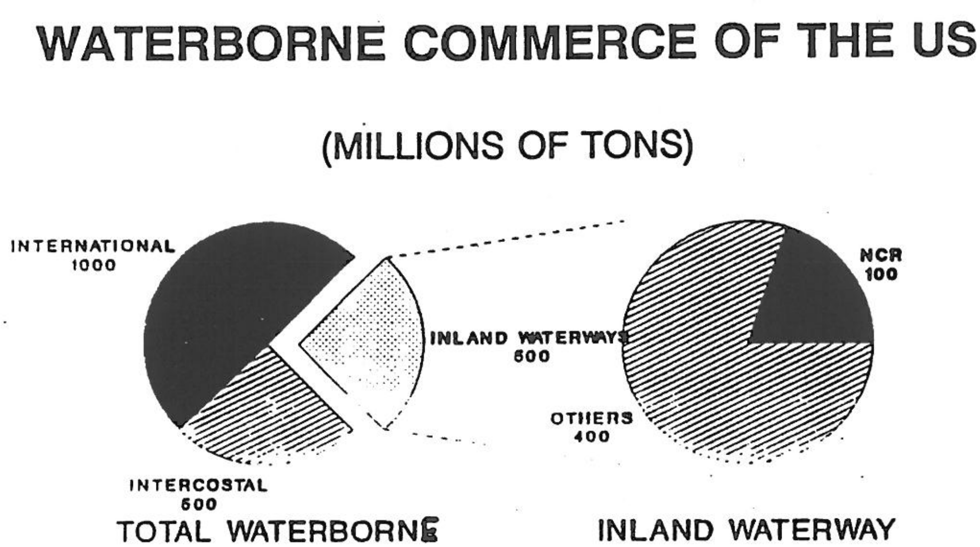


Figure 1

Koellner 1990.

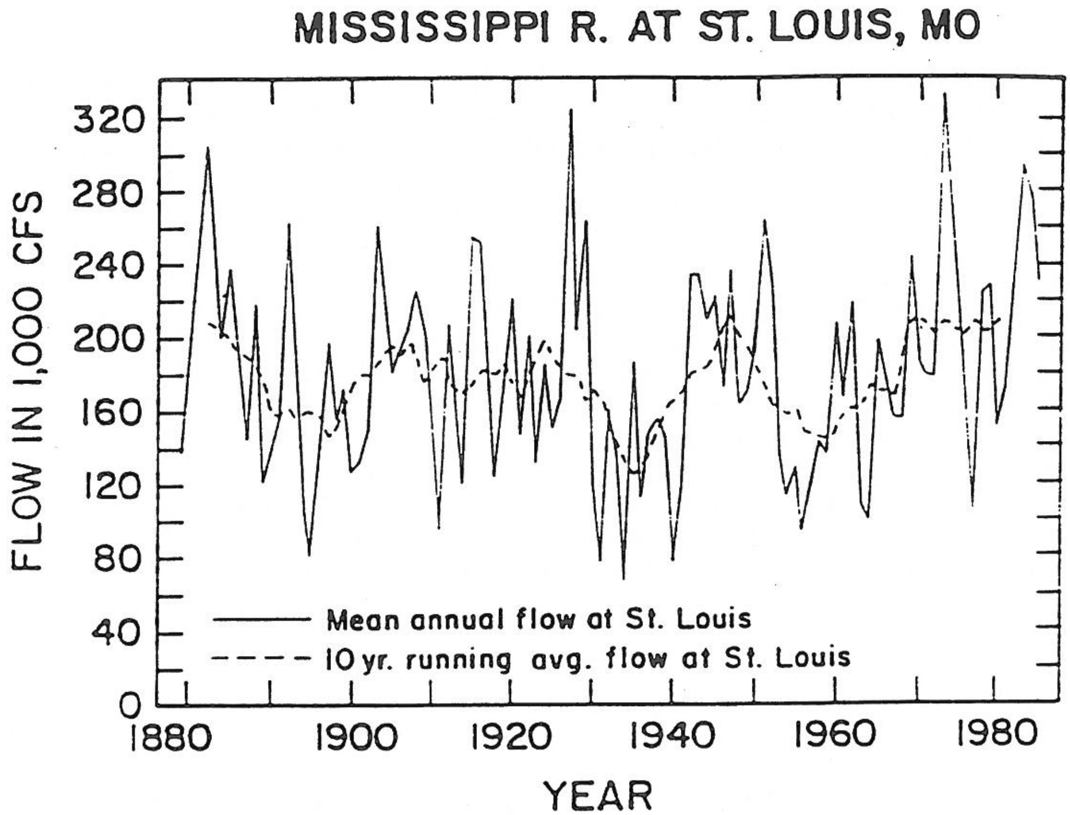


Figure 2

ABSTRACTS OF CONTRIBUTED PAPERS: IN ORDER OF PRESENTATION

THE METROPOLITAN WASTEWATER TREATMENT PLANT AND THE MISSISSIPPI RIVER: 50 YEARS OF IMPROVING WATER QUALITY. D. Kent Johnson and Paul W. Aasen, Water Quality Monitoring Division, Metropolitan Waste Control Commission, St. Paul, MN 55101.

The Metropolitan Waste Control Commission and its predecessors have operated the Metropolitan Wastewater Treatment Plant (Metro WWTP) on the Mississippi River at St. Paul, MN, for the past 50 years. Since the Metro WWTP began operating in 1938, extensive plant expansions have been completed to accommodate increasing flows (Fig. 1), and to provide substantial improvements in effluent quality (Fig. 2). Analysis of water quality data collected over the past 60 years shows a general improvement of water quality as the waste treatment process has been upgraded. In 1926, dissolved oxygen concentrations ranged from <1 mg/L to 2 mg/L in the river reach from St. Paul to Lock and Dam 3 (August mean values). In 1987, dissolved oxygen values in the same area were 7 mg/L or greater (Fig. 3). Drought conditions during 1988 and 1989 produced dramatically reduced flows in the Mississippi River, but dissolved oxy-gen concentrations continued to meet or exceed the 5 mg/L water quality standard (Fig. 4). Biological sampling in 1926 and 1959 showed an absence of clean-water macroinvertebrates. Biological sampling in 1985 showed an abundance of clean-water macroinvert-ebrates. The most dramatic evidence of this resurgence is the reappear-ance of the Hexagenia mayfly in the Twin Cities section of the Mississippi River, after a 50-year absence. The water quality improvements in the Mississippi River correlate directly with improved treatment plant processes, particularly the current advanced secondary treatment facility, and with improved waste control throughout the Minneapolis/St. Paul area.

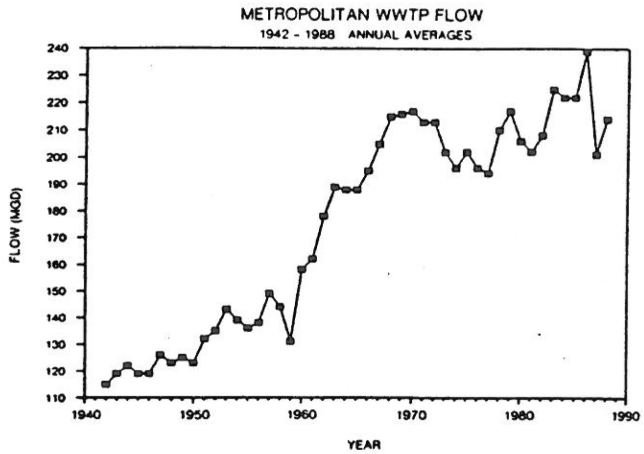


Figure 1

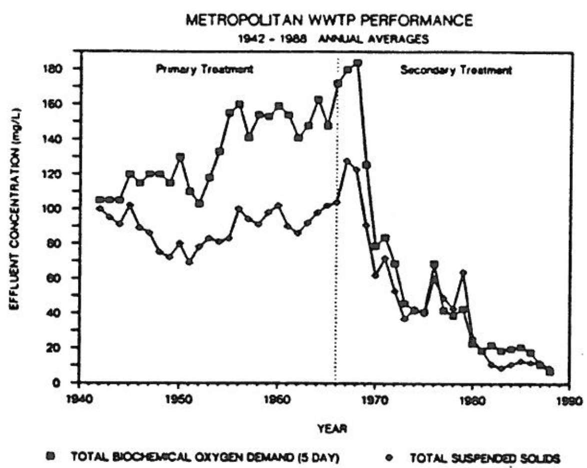


Figure 2

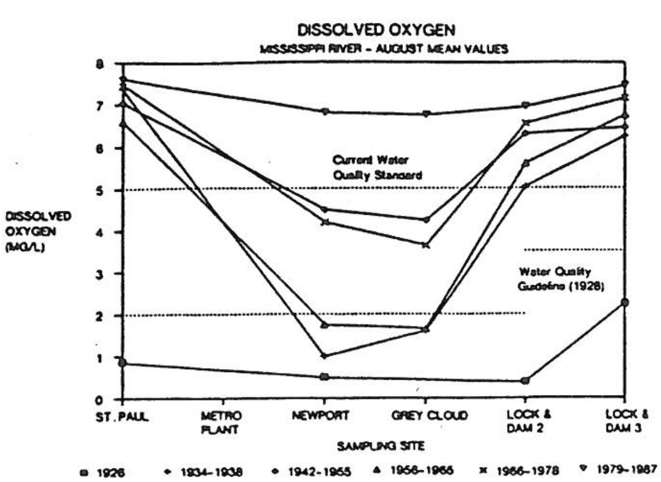


Figure 3

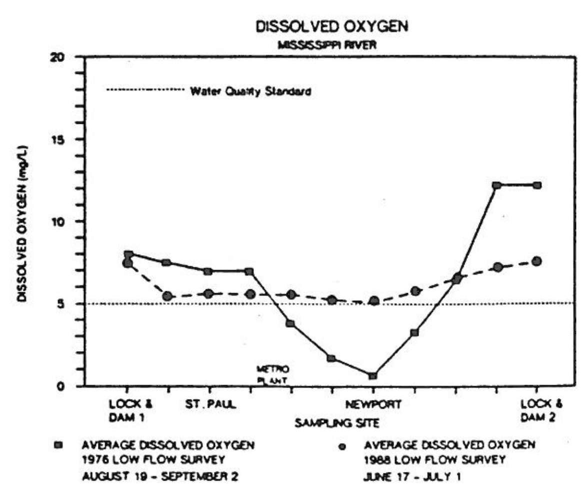


Figure 4

A HABITAT WINDOW - POOL 26 LTRM WATER QUALITY. R. V. Anderson, F. A. Cronin, J. J. Rundell, and M. A. Morris, Department of Biological Sciences, Western Illinois University, Macomb, IL 61455.

Dissolved oxygen, temperature, turbidity, transparency, and specific conductivity have been measure since May 1988 at 17 sites in Pool 26 as part of the EMP-LTRM program. These sites represent major habitat types and include structured and unstructured channel border and vegetated and unvegetated backwater habitats as well as sites in the lower Illinois River. Similar habitat types were sampled in the upper and lower reaches of Pool 26. The river system was in a severe drought during the sampling period and temperature and turbidity were significantly lower and transparency higher than samples from similar habitats in the pool collected during the early 1980's. Seasonal fluctuation in dissolved oxygen was greatest in backwater habitats and smallest in structured channel border habitat. Signifi-cant differences in all parameters were observed between sites in the Mississippi River compared to the Illinois River. With the exception of isolated backwater habitats there were generally greater differences between the river systems than between sites within a river system.

MISSISSIPPI RIVER WATER QUALITY DURING THE SUMMERS OF 1986 AND 1988: AN EVALUATION OF HIGH FLOW VERSUS LOW FLOW CONDITIONS. John F. Sullivan, Wisconsin Department of Natural Resources, La Crosse, WI 54601.

An evaluation of Minnesota's and Wisconsin's water chemistry data of the Mississippi River for the months of June through August, 1986 and 1988, was conducted. The river reach extended from above Minneapolis (RM 859) to Genoa, Wisconsin (RM 648). Data were available from STORET, U.S. EPA's computer data base, from monthly monitoring conducted by the Minnesota Pollution Control Agency and the Wisconsin Department of Natural Resources.

During the summer of 1986, average Mississippi River flow at Winona, Minnesota was 91% greater than the annual daily average. In general, typical water quality characteristics included: high levels of total suspended solids, total-N, and nitrate + nitrite-N. These conditions reflected non-point source input from tributary streams and the impact was most apparent below the Minnesota River inflow. Water temperature, pH, ammonia and un-ionized ammonia-N were low in comparison to low flow conditions of 1988.

In the summer of 1988, average river flow at Winona was 68% below the annual daily average. As a result of the low flow conditions, the hydraulic retention time of the river Pools increased which promoted the development of phytoplankton, especially Aphanizomenon flos-aquae, during the month of July. Levels of total-P, ortho-P, ammonia-N, un-ionized ammonia-N, total Kjeldahl-N, pH, solar radiation, and temperature, were high during this period. Un-ionized ammonia-N exceeded Minne-sota's and Wisconsin's 0.04 mg/l standard in Pools 2 and 8 (Fig 1). Dissolved oxygen levels were depressed to the 5.0 mg/l water quality standard in Pool 2. As expected, the most serious water quality problems were evident below major point source discharges, or in areas with high algae concentrations.

(See Fig. 1, Page 11).

Sullivan 1990.

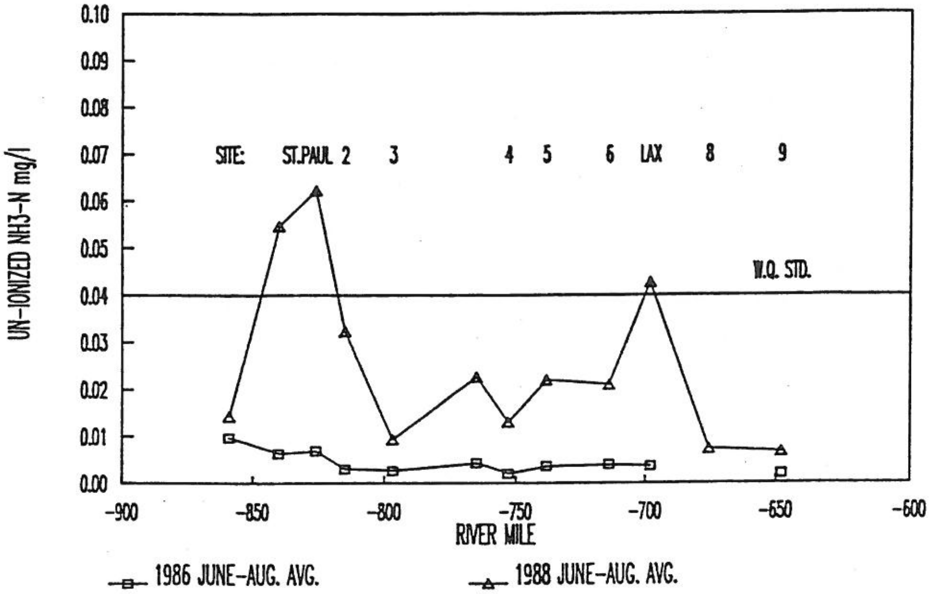


Figure 1. Un-ionized ammonia nitrogen levels in the Upper Mississippi River during the summer months (June-August) of 1986 and 1988. Lock and Dam sites are indicated with a number. W.Q. STD. = Minnesota's and Wisconsin's water quality standard of 0.04 mg/l.

CONTAMINANTS IN SEDIMENTS, PLANTS, AND MACROINVERTEBRATES FROM MISSISSIPPI RIVER POOL 19 DURING A DROUGHT (1977) AND A HIGH-FLOW YEAR (1978). K. Douglas Blodgett and Richard E. Sparks, Illinois Natural History Survey, Forbes Biological Station, River Research Laboratory, P.O. Box 599, Havana, IL 62644.

Samples of sediment and selected aquatic plants and macroinvertebrates were collected from Mississippi River Pool 19 during the falls of 1977 and 1978 and analyzed for 19 metals and 11 pesticides. Fall 1977 was near the end of a 1.5-year drought that affected the upper midwest and severely reduced flow in the Upper Mississippi River. A wet year followed in 1978 resulting in a protracted spring flood and relatively high flows through the fall. Chemical analyses were conducted by the Illinois Natural History Survey's laboratory in Champaign, IL, and were cross-checked by two independent laboratories. Aquatic plants analyzed included wild celery (Vallisneria americana), water star grass (Heteranthera dubia), and coontail (Ceratophyllum demersum). Macroinvertebrates were snails (Helisoma trivolvis, Campeloma crassula, and Viviparus georgianus) and fingernail clams (Musculium transversum). Although mean values were sometimes significantly different among the labs, standard deviations as percentages of means were similar indicating the repeatability of the analyses within each lab were similar.

Fig. 1 summarizes data collected at a representative site near river mile 365 just above lock and dam 19 at Keokuk, IA. Trends from that site were generally characteristic of the other sites. In sediment, concentrations of 8 heavy metals increased while 8 others decreased from 1977 to 1978. For the organics in sediments, dieldrin increased whereas heptachlor epoxide decreased, and the other target pesticides were below detection limits. With the exceptions of nickel and selenium in wild celery, heavy metal concentrations increased in plants from 1977 to 1978. For water star grass, dieldrin and heptachlor epoxide increased while DDT, DDE, and PCBs decreased. In wild celery, dieldrin, heptachlor epoxide, and PCB concentrations decreased. Concentrations of heavy metals were generally lower in macroinvertebrates during the high-flow year (1978). Notable exceptions where metal concentrations increased significantly were rubidium in snails, cadmium in fingernail clams, and antimony and tin in both groups. Dieldrin and PCB concentrations decreased significantly in both groups, while DDE increased.

(Blodgett and Sparks 1990, Cont.)

In general, concentrations of heavy metals in the plants increased from 1977 to 1978, while concentrations in macroinvertebrates decreased. As a group, the pesticides did not show detectable trends. Concentrations of PCBs decreased drastically from 1977 to 1978 except in sediments where they were below detection levels both years. During the drought, water transparency increased and the areal extent of plant beds in the pool tripled from 1975 to 1978. During the same period, fingernail clam densities and growth rates declined drastically, possibly due to stresses associated with increased contaminant concentrations resulting from reduced dilution in the water column. Lower body burdens of contaminants during the high flows of 1978 may have resulted from increased dilution of toxicants.

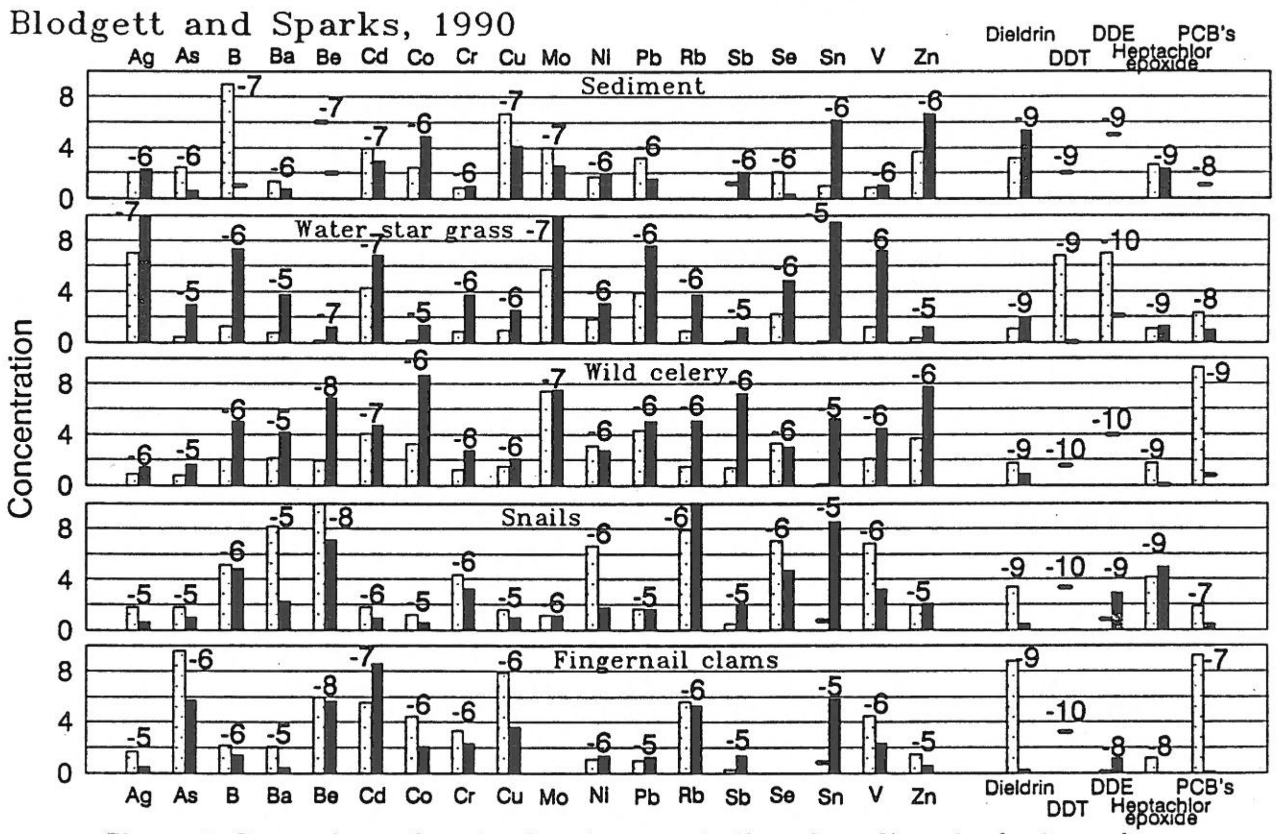


Figure 1. Comparison of contaminant concentrations in sediment, plants, and macroinvertebrates during a drought (1977, ▭) and a high-flow year (1978, ■) near river mile 365, Pool 19, Mississippi River. Numbers at the tops of bar indicate powers of 10 (i.e. $-6 = 10^{-6}$ = parts per million = mg/kg). Horizontal bars indicate detection limits (maximum undetected values) for comparison.

INSTREAM FLOW REQUIREMENTS OF UPPER MISSISSIPPI RIVER SMALLMOUTH BASS. William A. Swenson, Division of Sciences and Mathematics, UW - Extension, University of Wisconsin-Superior, Superior, WI 54880 and Daniel J. Orr, Environmental and Regulatory Activities Department, Northern States Power Company, Minneapolis, MN.

We describe the importance of smallmouth bass (Micropterus dolomieui) to the growing sport fishery on the upper Mississippi and the relationships between smallmouth abundance and instream flow. Information collected through the Northern States Power Company monitoring program near its plants at Monticello and Becker, Minnesota showed the recreational fishery is growing and 60% of the fishing pressure is directed at smallmouth bass. During the period from 1973 through 1988, the strongest year-classes formed during years of low spring and summer discharges (1976, 1977, 1980, 1987 and 1988).

Detailed field observation and laboratory flume studies were conducted to promote understanding of the mechanisms through which discharge influences year-class abundance (Fig. 1). Field observation showed nesting occurs in areas with near substrate velocities below 15 mm/sec. Nest observations and laboratory flume studies indicated newly risen sac-fry are displaced at higher velocities. In experiments with fingerlings, (22-82 mm SL) conducted in flumes with Mississippi River water, we found the ratio of foraging (energy reward) to respiration (energy cost) peaked between 80-130 mm/s, the range most frequented by fingerlings in the river. Lengths back-calculated from scale samples confirmed that first year growth was faster during years of low discharge. Preliminary analysis using the PHABSIM model indicated habitat availability for spawning, fry survival and first summer growth increased during years of low spring and summer discharge.

A predictive model is being developed to assess past and future management alternatives on the basis of their influence on the smallmouth bass population and the recreational fishery which it supports.

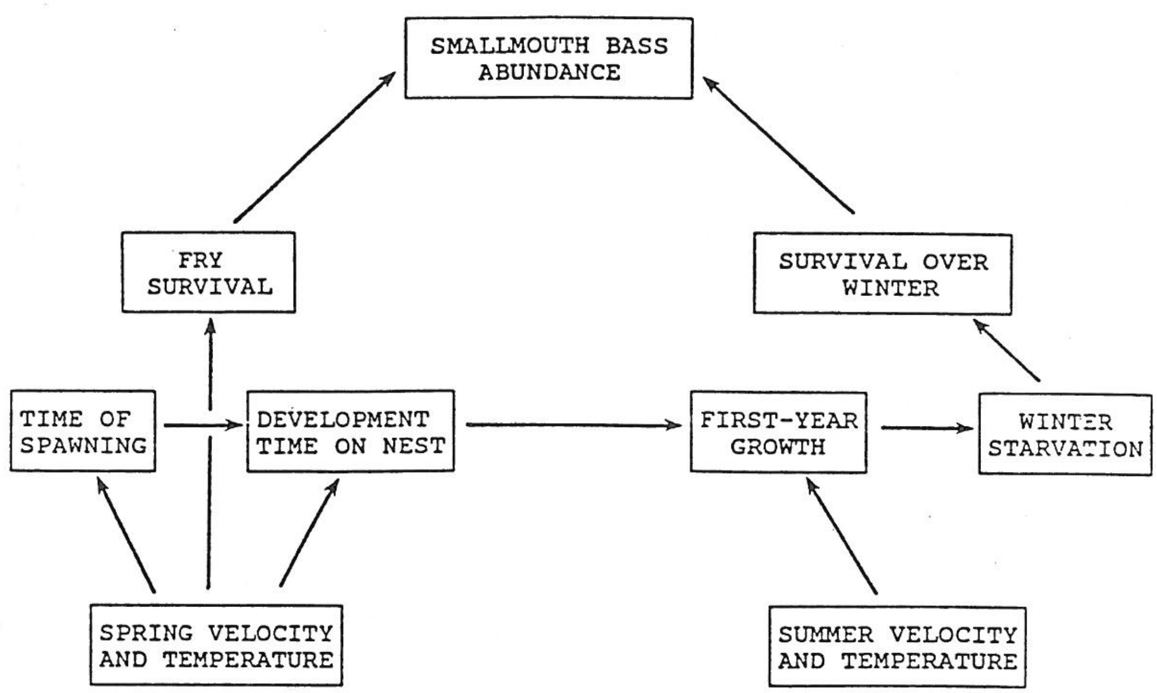


Fig. 1. Mechanisms through which spring and summer stream velocities and temperatures control year-class success and abundance of smallmouth bass. Reprinted from J. Minnesota Academy of Science, Vol: 55, No. 1, p. 148.

MODELLING THE RECENT DECLINE IN FINGERNAIL CLAM POPULATIONS OF THE UPPER MISSISSIPPI RIVER. Jim Eckblad, Department of Biology, Luther College, Decorah, IA 52101.

Sampling from a variety of backwater lakes has shown a dramatic recent decline in the fingernail clam populations of the Upper Mississippi River. In the 1970's they often comprised over 30 percent of the numbers and 50 percent of the benthic macroinvertebrate biomass of backwater lakes. Their populations currently make up less than 3 percent of benthic communities. The STELLA modelling software has been used to develop models which help describe possible factors contributing to the decline in fingernail clam populations (see Figs. 1 and 2). Models will be presented showing possible causal relationships and the general features of this modelling software will be described.

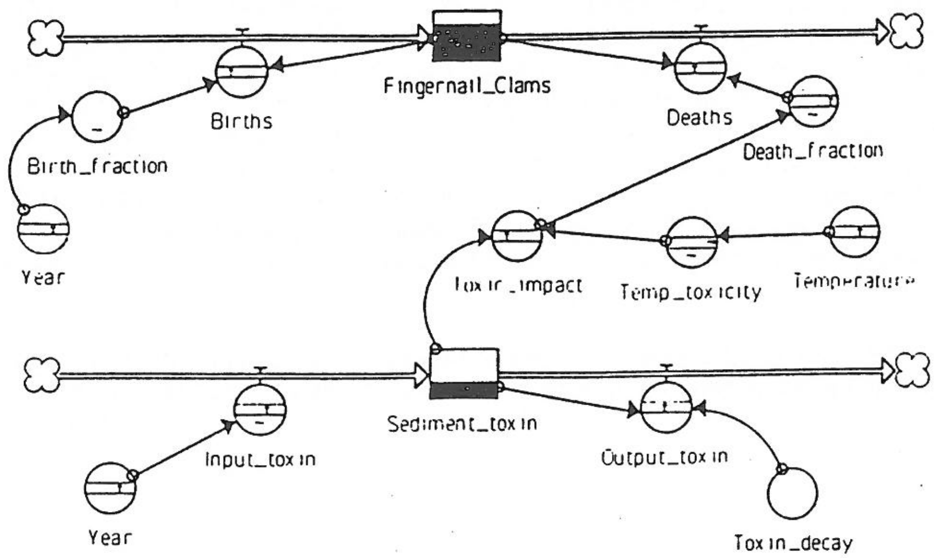


Fig. 1. A simple model of how unknown sediment toxins and temperature might interact to influence death rates in fingernail clam populations.

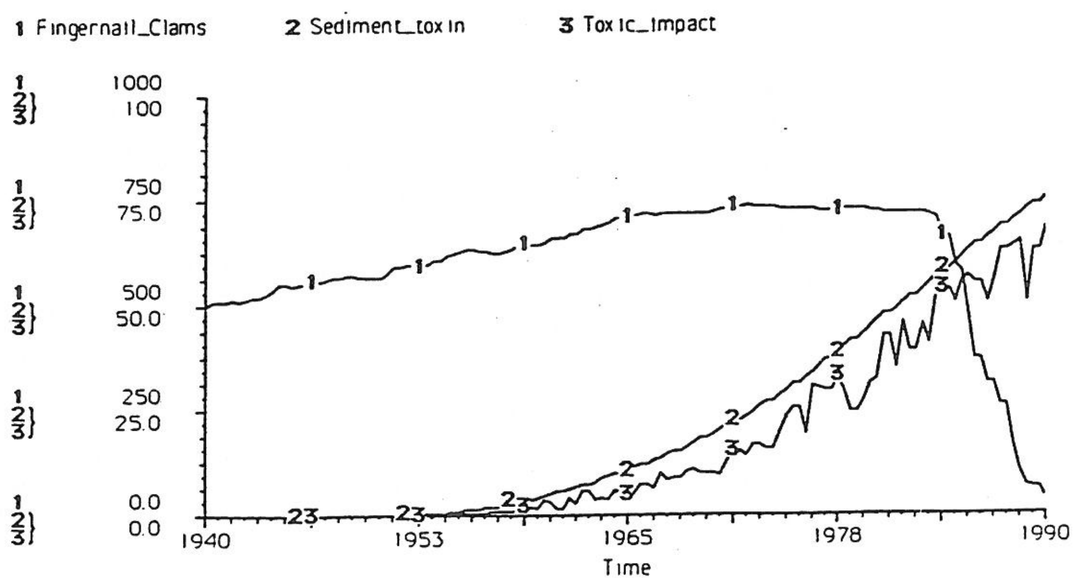


Fig. 2. A simulation of the model in Fig. 1 over the time period 1940 to 1990 for numbers of fingernail clams, amount of sediment toxin, and toxic impact due to the interaction with temperature.

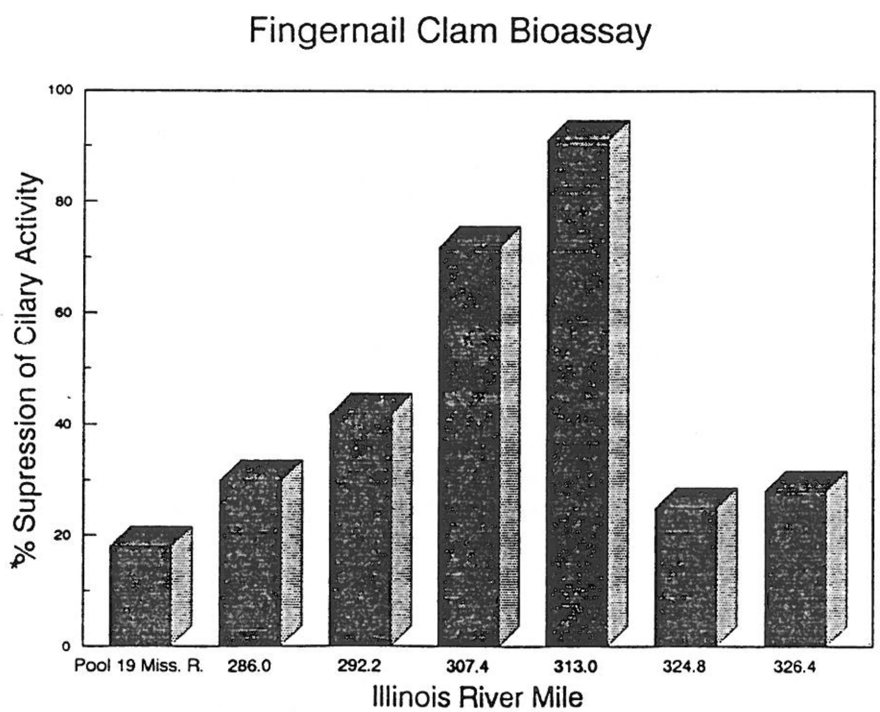
SEDIMENT TOXICITY IN THE UPPER ILLINOIS RIVER: A SEARCH FOR THE TOXIC SUBSTANCE(S).
Frank S. Dillon, Philippe Ross, Richard E. Sparks, and LouAnn Burnett, Illinois Natural History Survey, Forbes Biological Station, River Research Laboratory, Havana, IL 62644.

The presence of sediment-associated toxicity in the Upper Illinois River has been documented by several investigators. This toxicity has been linked to declines in benthic invertebrates and subsequent drastic declines in fish and waterfowl populations on the Illinois River. To date a clear relationship between specific toxic compounds and observed toxicity has not been established. Due to the complex mixtures of contaminants that are present in most toxic sediments it has been difficult to link compounds with toxicity.

Recently, methodologies have been developed to identify specific toxic compounds in complex mixtures. Toxicity Identification Evaluation (TIE) techniques are toxicity-based fractionation schemes, designed to characterize and identify compounds exhibiting acute toxicity to aquatic organisms. These techniques were applied to Illinois River sediments in an effort to identify the substance or substances responsible for the disappearance of benthic invertebrates. In addition, a suite of microbiological assays and a functional assay using the fingernail clam (Musculium transversum) were used to determine relative levels of toxicity of sediments, in an effort to locate the primary source(s) of the toxic substance(s).

Preliminary findings have identified two patterns. Sediment toxicity increases upstream and peaks about river mile 313.O (Chicago Sanitary and Ship Canal at Summit) (Fig. 1) and T.I.E. analysis indicates that a pH dependent toxin(s) is(are) present.

Figure 1. Relative toxicity* of sediments, determined by the fingernail clam assay, from sites in the upper Illinois River.



* Suppression of ciliary activity indicates toxicity

HISTOLOGICAL AND ULTRASTRUCTURAL METHODS FOR DETERMINING EFFECTS OF SUBLETHAL CADMIUM EXPOSURES ON JUVENILE LAMPSILIS FROM THE UPPER MISSISSIPPI RIVER: PRELIMINARY STUDIES. Becky A. Lasee and Brent C. Knights, Department of Animal Ecology, Iowa State University, Ames, IA 50011 and Leslie Holland-Bartels, National Fisheries Research Center, P.O. Box 818, La Crosse, WI 54601.

Reduction in numbers and species diversity of bivalves in the UMR suggests habitat deterioration is having a serious impact on mussel populations. Freshwater mussels may be especially sensitive because of their longevity, complex life cycles, benthic orientation and filter-feeding behavior. The histopathogenic effects of pollution on larval, juvenile and adult freshwater mussels are not well known nor have they been adequately studied. The susceptibility of an individual bivalve may depend on its age, and it is possible that larvae and juveniles are more vulnerable than adults. Light and electron microscopic examinations of 0-to 56-d old laboratory-reared juveniles were performed to establish baseline information on early development and growth. These data are to be used in future studies to discern possible sublethal cadmium impacts on development of young. Average length at dropoff is 0.21 mm. Growth and survival of juveniles in cultures is highly variable; however, a maximum growth rate of 0.02 mm/d was obtained by day 35 and a maximum length of 1.14 mm occurred by day 56. Organ system development during this time was extensive. Cadmium toxicity testing protocols have been developed and a 48 h range-finding test (1 to 1000 ppb) was performed on 0-d L. ventricosa. Approximate LC_{50} values were 311 ppb and 258 ppb at 24 and 48 h, respectively. At 48 h, condition of juveniles was assessed using the following categories: (1) alive-active, moving; (2) stressed-no movement, ciliary action evident; and (3) dead-no movement or empty valves. Using stressed and dead juveniles as a criterion, an EC_{50} of 40 ppb was found. Currently, cadmium toxicity tests are being conducted on 0-d, 7-d and 14-d L. ventricosa using cadmium concentrations of 10-500 ppb. Surviving juveniles from these tests will be processed for light and electron microscopic examination and will serve as a comparison to samples described above.

PHYSIOLOGICAL RESPONSES OF THE POCKETBOOK MUSSEL (LAMPSILIS VENTRICOSA) TO CADMIUM. T. J. Naimo and L. E. Holland-Bartels, National Fisheries Research Center, LaCrosse, WI 54602 and G. J. Atchison, Department of Animal Ecology, Iowa State University, Ames, IA 50011.

The Upper Mississippi River (UMR) contains one the most numerous and diverse assemblages of freshwater mussels in the United States. Recent studies indicate that both the density and diversity of these organisms are declining. One proposed explanation concerns the subtle, pervasive impacts from low level contamination in the UMR. A study was conducted to evaluate the physiological responses of adult Lamsilis ventricosa to sublethal cadmium exposure. Physiological processes studied included respiration rate, food clearance rate, ammonia excretion rate and food absorption efficiency. Mussels were exposed to Cd (0, 30, 125 and 300 ug/l) for 28 days in a proportional diluter. Analyses indicate that respiration rate was the most sensitive and least variable indicator of Cd exposure, while food absorption efficiency was the most variable response. Respiration rates in mussels exposed to 30 ug Cd/l were significantly ($p < 0.05$) depressed compared to respiration rates in mussels with no Cd exposure. Although food clearance rates and ammonia excretion rates showed no statistical differences among Cd treatments, ammonia excretion rates in mussels exposed to 300 ug Cd/l fell from 22 to 5 ug/hr/g dry tissue weight by day 28. By day 28, food clearance rates also fell to one third of their original values in mussels exposed to 300 ug Cd/l. Assimilation efficiencies decreased over the test duration in all treatments. Freshwater mussels can be sensitive indicators of sublethal contaminant exposure. However, due to large variability in some physiological rates, care must be taken in selecting appropriate physiological indicators of contaminant effects.

WHAT'S IN THE SOUP: ELECTROPHORETIC ANALYSIS OF THE HOST-PARASITE RELATIONSHIP BETWEEN THE FLATHEAD CATFISH AND THE MAPLELEAF MUSSEL.

M. A. Romano, D. Barry Markillie, and R. V. Anderson, Department of Biological Sciences, Western Illinois University, Macomb, IL 61455.

The only reported fish host for the glochidial stage of the mapleleaf mussel, Q. quadrula, is the flathead catfish, Pylodictis olivaris; therefore patterns of gene flow within these two species should be correlated. To test this hypothesis, sample sites of similar mussel density and diversity were chosen from pools 15, 16, 18, 19 and 26 of the Mississippi River, and one site from the Illinois River. Electrophoretic analysis indicated gene flow among the mapleleaf populations tended to be higher within pools and lower between pools separated by lock and dam systems. The genetic variability observed among flathead catfish was low compared to other organisms within the system. We speculate that a past history of toxic stress due to the unique nature of Lock and Dam 19 may have been responsible. A comparison of the patterns of relationship may indicate the extent of effect of the flathead catfish on the genetic structure and ecology of mapleleaf populations. Pylodictis olivaris appears to have a direct effect on the genetic structure of Q. quadrula based on enzyme electrophoretic data between the two species. Analyses of systematic relationships among populations of both species showed a close parallelism of population structure between the two species, thus, the data suggest that the flathead catfish is the only host fish for the mapleleaf glochidia.

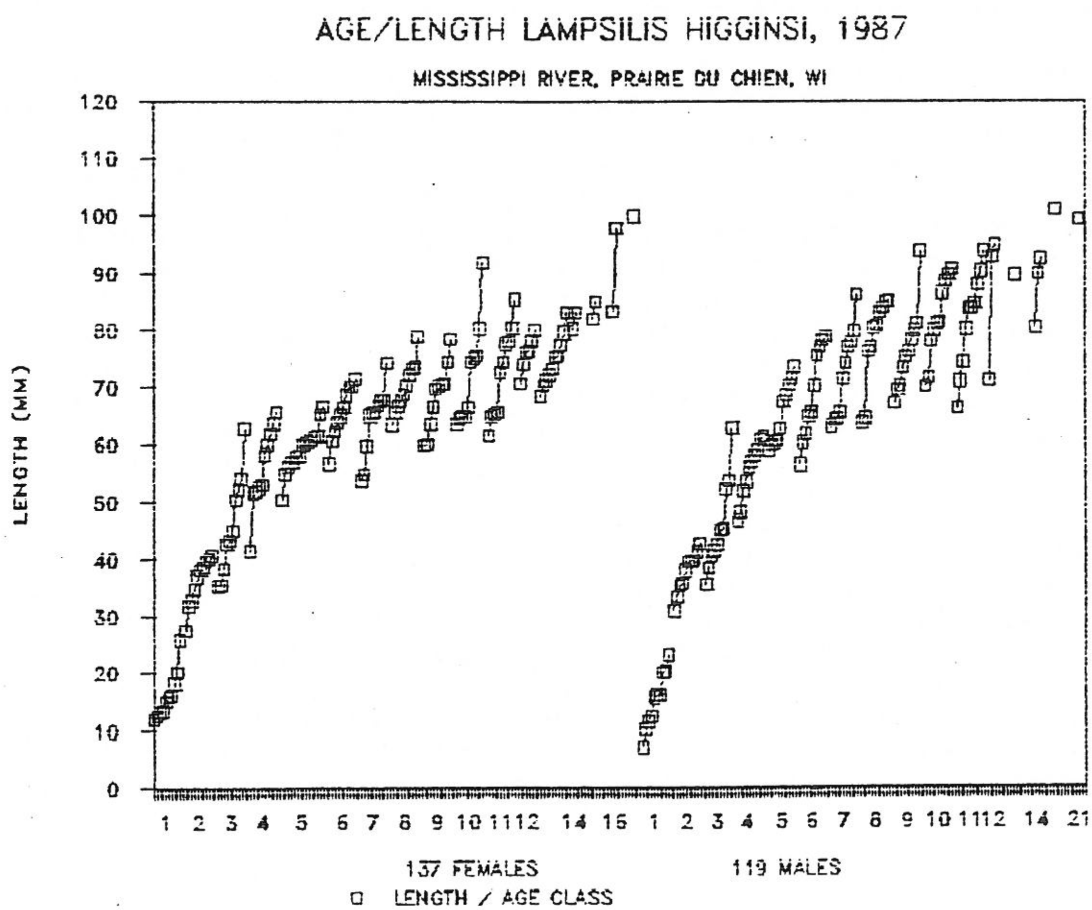
A SURVEY FOR NAIAD MOLLUSKS (UNIONIDAE) AT MINNESOTA RIVER MILE 10.8, INTERSTATE HIGHWAY 35 WEST, BETWEEN BURNSVILLE AND BLOOMINGTON, MINNESOTA.

Marian E. Havlik, Malacological Consultants, 1603 Mississippi Street, La Crosse, WI 54601.

A survey for naiad mollusks was conducted on 22 dive transects, from 600 feet upstream to 1100 feet downstream of Minnesota River Mile 10.8, Interstate Highway 35 West bridge, Burnsville-Bloomington, MN, October 1989. The study was part of an environmental assessment done for the Minnesota Department of Transportation for a possible additional bridge. The emphasis was on endangered Lampsilis higginsi (Lea, 1857), and species of special concern. Two surveys in the general vicinity (Havlik 1977, 32 empty species; Fuller 1978) did not yield any living naiades in the lower 15 miles of the Minnesota River. During the 1989 survey, two SCUBA divers collected 968 discrete living and dead naiad mollusks representing 30 species, from predominantly mud substrata. Nine species were represented by 25 living or fresh dead specimens (2% of the total) on dive transects 75 feet long X 6 feet wide, and from random collections in the river and along the shorelines. Live/fresh-dead specimens were aged and measured for length. Since the living/fresh-dead specimens were all clearly less than 10 years of age, they could not have been in the river at the time of 1977 and 1978 surveys. One male valve of L. higginsi probably had been empty for 20 years or more. The specimen was thin, but clearly that species based on my experience with over 2500 L. higginsi. No living rare or endangered species were found, but two single unmatched, worn valves of the proposed endangered Quadrula fragosa (Conrad, 1835), Winged Maple Leaf, were recorded for the first time from the Minnesota River. Worn-dead specimens of Fusconaia ebena (Lea, 1831), Ebony Shell (25), and Elliptio c. crassidens (Lamarck, 1819) (1), Elephant Ear, appeared to have been empty for a long time. The latter two species are of special concern in Minnesota. A total of 38 naiad species have now been reported from the Minnesota River. Since living naiades were found in this survey, water quality may be improving in the lower Minnesota River. Chemicals used on bridges in winter may contribute to the paucity of living mussels in rivers due to bridge drainage system design. Future bridges should be designed to alleviate this situation. An assessment of the present day naiad fauna, and mitigation/enhancement possibilities will be discussed.

LENGTH/AGE/SEX OF FRESH-DEAD LAMPSILIS HIGGINSI (LEA, 1857) (UNIONIDAE) FROM THE PRAIRIE DU CHIEN, WI AREA, MISSISSIPPI RIVER, APRIL-NOVEMBER, 1987. Marian E. Havlik, Malacological Consultants, 1603 Mississippi Street, La Crosse, WI 54601.

Due to 1987 low water levels, 316 paired and 203 single valves of empty Lampsilis higginsi were salvaged from the Mississippi River, Prairie du Chien, WI, the largest number ever collected from one area in one year. In lieu of large samples of living L. higginsi, these specimens afforded the opportunity to begin age/length studies. After cleaning, and numbering, 137 fresh-dead specimens (judged likely to have died that year) were sexed, measured X 3, and aged X 3 by counting the annual rest rings on both valves. Other data included nacre color, general condition, and other comments. Most were whole specimens, but a few single valves were included to increase the sample size for each age/sex class. Data were also recorded from eight living L. higginsi before they were returned to the river. Results were entered into a database, and graphed according to age/length, and number/date of birth. Specimens ranged from two to 21, with most between four and 13 years. Over 63% (92) were females, 32% (46) males, and 5% (7) juveniles under four years of age. Sexual dimorphism is apparent at 4 years. Regression analyses were conducted with Symphony and SAS software. Preliminary analysis for age/length, with both sexes grouped together, yielded an R of 0.66. Sorting by sex, and including data on seven immature juveniles with both the female and male groups, increased the R^2 to 0.67 for females and 0.75 for males. Back-measuring was done on randomly selected specimens to bring the sample size to 10 for each age group of both sexes, ages one through 11 years. The R^2 was 0.70 for all 256 data sets combined (including from back measured specimens). Separate, analyses on 137 females and 119 males increased the R^2 to 0.72 for females, and decreased the R^2 to 0.74 for males. Only three specimens were older than 17 years. My past experience with L. higginsi suggests that it has a life span of about 25 years in the Prairie du Chien area to over 30 years in the lower Rock River. Little is known of the demography of living L. higginsi populations in the Prairie du Chien area. A similar analysis, using only living specimens, would likely yield different results since previous sex ratio data were reversed, based on living and empty specimens we collected from 1972 through 1986. This may suggest that females were stressed during 1987 low water levels. Data on L. higginsi collected in 1988 is also being analyzed, separately as well as combined with the 1987 data.



THE DISTRIBUTION, ABUNDANCE, AND SPECIES DIVERSITY OF NAIAD MOLLUSKS FROM THE LOWER CHIPPEWA RIVER, WISCONSIN. Terry A. Balding, Biology Department, University of Wisconsin-Eau Claire, Eau Claire, WI 54702.

The Chippewa River, from Eau Claire to its mouth with the Mississippi River, was divided into 37 sampling stations, each about 1.5 miles in length. During the summers of 1986-1989, naiad mollusks from each station were collected, mainly by wading. Altogether 4,832 dead shells were identified, and 2,161 live shells were identified, measured, and returned to the water. Twenty six different species were found, 24 having living representatives. The lower half of the river had significantly fewer species and individuals. Four Chippewa River species are recognized as endangered in Wisconsin.

GOOD ROCKS AND BAD ROCKS: LIFE ON A WING DAM. R. V. Anderson, D. M. Day, J. W. Grubaugh, D. A. Deters, and J. L. Owens, Department of Biological Sciences, Western Illinois University, Macomb, IL 61455 and Illinois Department of Conservation, Streams Program, Aledo, IL 61231.

During the summer of 1988 three new wing dams were constructed in Pool 21 above Quincy at river mile 331. Benthic macroinvertebrates and fish utilizing this new habitat were compared with those using old wing dams in the same area of the river. Macroinvertebrates were collected directly from the rock on the dams and from artificial substrates placed on the top of the dams and allowed to colonize for a 6 weeks. Fish were sampled by electrofishing at 1 new and 1 old wing dam 4 times during the day. To determine what food items fish were utilizing digestive track contents were also examined. Benthic invertebrate diversity was significantly higher on the new wing dams but density was greatest on the old wing dams. Invertebrate communities were dominated by chironomids on the old wing dams while the new wing dams had abundant mayfly and caddisfly populations. Twenty-four species of fish were taken from the wing dam habitat with a greater diversity and abundance of fish associated with the new wing dams. However, almost 3 times more fish biomass was collected from old wing dams. More piscivorous and insectivorous fish were found associated with the new wing dam while the old wing dam had high densities and biomass of bottom feeders.

MALLARD NESTING ON THE UPPER MISSISSIPPI RIVER. John F. Wetzel, Wisconsin Department of Natural Resources, 3550 Mormon Coulee Road and Robert B. Dahlgren, U.S. Fish and Wildlife Service, La Crosse, WI 54601-2484.

The Upper Mississippi River (UMR) primarily has been known for its important role in providing habitat for spring and fall waterfowl migrations. Studies of islands free of raccoon (Procyon lotor) and fox (Vulpes sp.) used by nesting mallards (Anas platyrhynchos) on the Upper Mississippi River National Wildlife and Fish Refuge have shown that the UMR can also function importantly for duck production.

Ron Nicklaus, former Wisconsin DNR employee, surveyed 4 islands in lower Pool 8 during 1981-1987. He found up to 51 nests per island and 59 nests/acre (145.8/ha) with average nest success of 69%. This is in contrast to typical upland Midwest nest densities of 0.1 to 1.0/acre (0.04-0.4/ha) and nest success rates of 10-35%; population stability requires nest success rates of 15-20%.

In 1988-89, we expanded Nicklaus' study to include many more islands in Pools 4, 5, 5A, 7, 8, 9, 12, 13, and 18. The smallest islands generally had the highest nest densities. Of 8 islands free of raccoon and fox (FRF) checked in both 1988 and 1989: 3 were <0.25 acres in size averaging 67 nests/acre/year, 4 were 0.25-0.49 acres in size averaging 40 nests/acre/year, and 1 was >1.0 acre in size averaging 33 nests/acre/year. Some degree of nesting occurred in all pools studied. Nest densities ranged as high as 200 nests/acre (494 nests/ha) on FRF islands and these densities rival any reported in the literature. Nest success was as high as 100% on some FRF islands, averaging 70%. The complexes of islands separated by running sloughs in the upper end of most pools are heavily infested with fox and raccoon. In these complexes, few nests were found and nest success rates were 0-21%. One 0.68-acre island (0.28 ha) in Pool 13 that had 65 nests in 1988 had no nests in 1989 because a fox had denned on the island in the winter of 1988-89. Where raccoon and fox were present, abandonment increased and hatching

(Wetzel and Dahlgren 1990, Cont.)

success was greatly reduced. Predator control techniques should boost duck production considerably. Predation by birds occurs, but species causing it have not been defined.

Mallards are ubiquitous nesters and showed no preference for grassy islands over brush or timbered islands. Mallards commonly sought nesting sites with canopy coverage of 50-75% or more in tangles of brush, in roots of fallen trees, under fallen trees, within tangles of vines, at the base of trees, and in various types of cavities.

The goals of our current studies are to: 1) document the extent and fate of mallards nesting within the UMR system, 2) determine the characteristics of islands that attract high nest densities, and 3) develop recommendations for both habitat and predator management to increase waterfowl production. Under Environmental Management Programs, plans call for construction of about 50 islands to reduce sediments entering backwaters and control wind fetch. Thus we feel it is important to understand the ecology of duck nesting and how nesting is impacted by island size, vegetation on the island, and other factors.

IN THE LIGHT OF DAY: PRODUCTION IN CHANNEL BORDER HABITATS OF THE UPPER MISSISSIPPI RIVER. R. V. Anderson, R. E. Sparks, J. W. Grubaugh, and K. D. Blodgett, Dept. of Biological Sciences, Western Illinois University, Macomb, IL 61455 and River Research Laboratory, Illinois Natural History Survey, Box 599, Havana, IL 62644.

Gross production in channel border habitats of Pool 19 and Pool 26, upper Mississippi River, were determined using oxygen production/consumption in light and dark BOD bottles incubated in situ. In Pool 19, 6 to 8 determinations over 24 to 48 hour sample periods were used seasonally. During the summer, sites were located in both vegetated and unvegetated channel border habitat. During the winter sampling sites were located in open water and under the ice. In Pool 26 only a fall sampling was done; however, sites were located on the Mississippi River above its confluence with the Illinois River, below the confluence, and just above the confluence on the Illinois River. At each sampling site BOD bottles were positioned at the surface, midpoint, and bottom of the water column. Production typically followed two general patterns (Fig. 1). During the summer and fall oxygen production increased sharply during the day and oxygen consumption without much production caused a sharp decline at night. During the winter and spring oxygen production and consumption was relatively stable throughout the diel sampling period. Both vegetation and ice decreased net production. In the former case due to higher rates of decomposition in the vegetated habitat and in the latter case due to inadequate light penetration. The Illinois River had higher rates of production and consumption than the Mississippi River and thus diel pattern fluctuated greatly. Production in Pool 26 was stable and had higher oxygen levels sustained throughout the 24 hour period. Substantial gross production occurs in these habitats but it is not adequate to support consumption by decomposers and secondary consumers.

(See Fig. 1, Page 21)

Anderson, Sparks, Grubaugh, and Blodgett 1990,

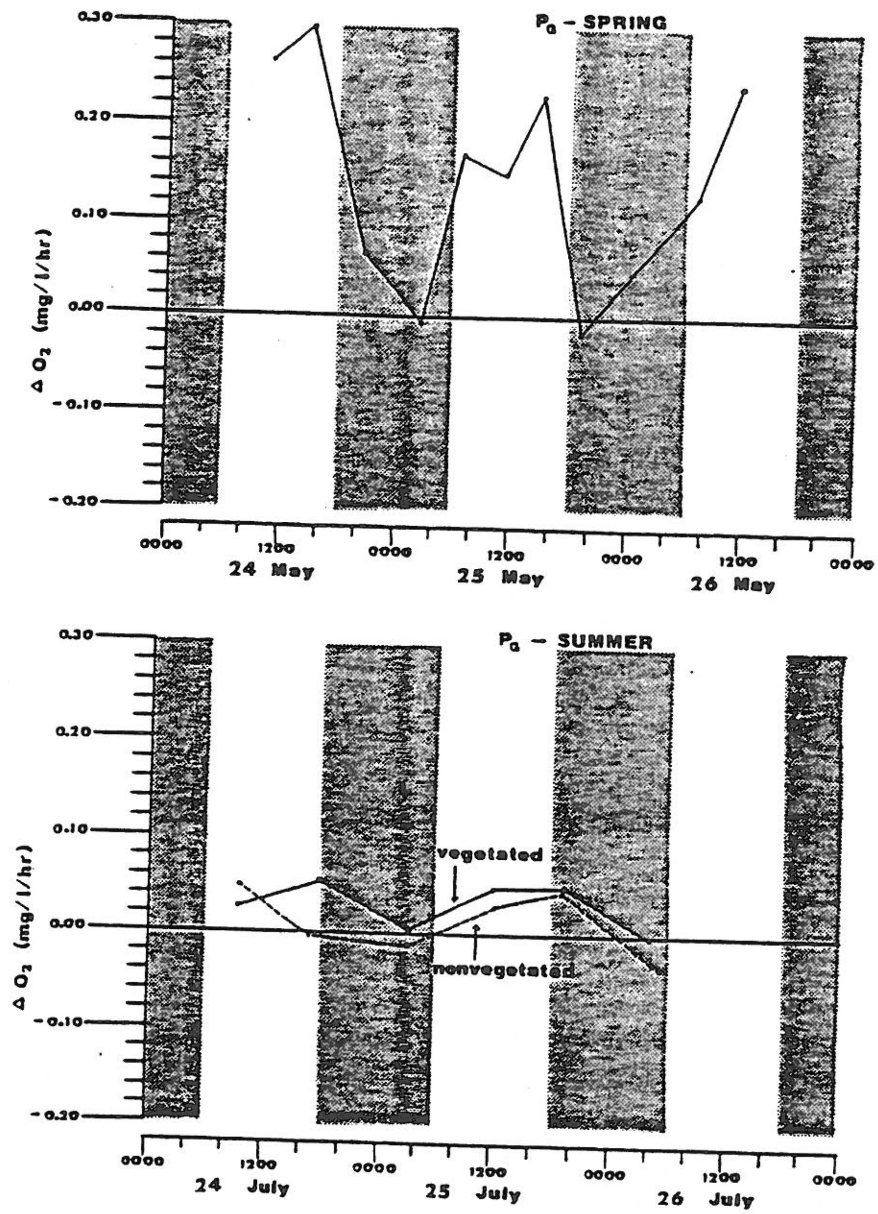


Figure 1. Example of spring and summer gross production as measured by oxygen in BOD bottles at a channel border site in Pool 19, Mississippi River.

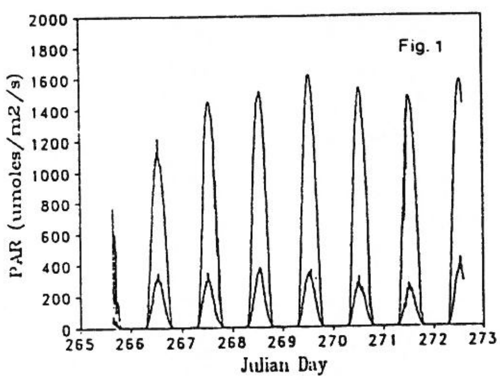
CONTINUOUS WATER QUALITY MONITORING IN UPPER MISSISSIPPI RIVER SYSTEM BACKWATERS.
Jennifer L. Owens and William G. Crumpton, Department of Botany, and Kyle H. Holland, Department of Electrical Engineering, Iowa State University, Ames, IA 50011.

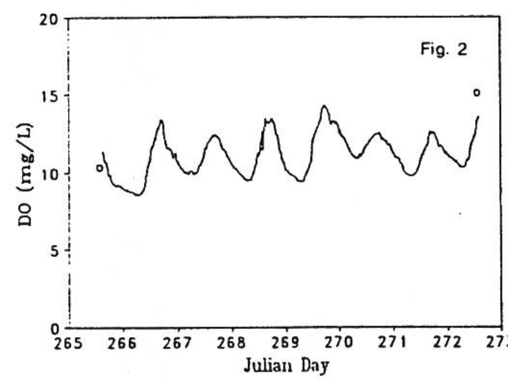
A microprocessor based, submersible water quality monitoring system incorporating sensors for light, temperature, pH, and dissolved oxygen has been developed by a research team at Iowa State University. This continuous monitoring unit was used in a pilot study performed for the U.S. Fish and Wildlife Service in conjunction with the Long Term Resource Monitoring Program for the Upper Mississippi River System.

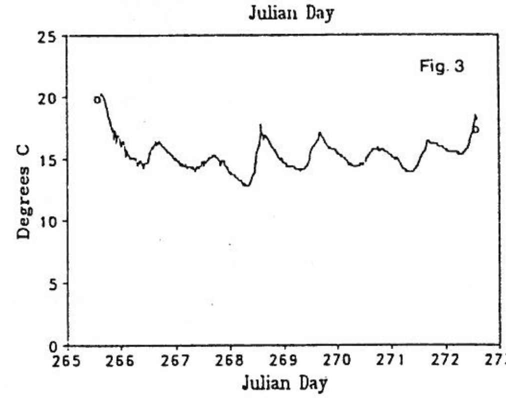
Between September 8, 1989 and October 27, 1989 these monitoring units were used to monitor photosynthetically active radiation at three depths, and dissolved oxygen and temperature at one depth at the LTRMP water and sediment monitoring site at River Mile 686. The monitoring units were retrieved at weekly intervals and data were downloaded-to a microcomputer. Data from each week were displayed graphically in relation to time, and compared to LTRMP data taken at the same location.

Results indicate that this unit is capable of continuously monitoring water quality under field conditions. Representative data for light (Fig. 1), dissolved oxygen (Fig. 2), and temperature (Fig. 3) demonstrate the precision and sensitivity of the monitoring system.

Owens, Crumpton, and Holland 1990.







Photosynthetically active radiation (Figure 1) at surface (upper line) and 0.5 meter depth (lower line), dissolved oxygen (Figure 2), and temperature (Figure 3) for days indicated as determined using the continuous monitoring unit.

STUDIES ON THE PHYSICAL EFFECTS OF COMMERCIAL NAVIGATION TRAFFIC IN THE UPPER MISSISSIPPI RIVER: RESULTS OF 1989 SAMPLING. Andrew C. Miller and Barry S. Payne, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS 39180-6199, and Dan Ragland, U.S. Army Engineer District, St. Louis, MO 63101-1986.

Studies on freshwater mussels (Mollusca: Unionidae) at productive beds in the upper Mississippi River were initiated by the U.S. Army Engineer District, St. Louis in 1988 as part of an investigation of physical effects of commercial navigation traffic. Studies conducted in 1989 included qualitative and quantitative (0.25 sq m total substrate) mussel collections and measurements of water velocity and suspended solid concentrations immediately following vessel passage. With respect to biotic parameters such as relative species abundance, total density, species diversity and species richness, differences between 1988 and 1989 were minimal. In addition to biological studies, preliminary water velocity data following vessel passage at two mussel beds were obtained with a pair of Model 527 Marsh McBirney meters. Data indicated that a commercial vessel causes a change of 1-2 ft per second for approximately 5-10 seconds immediately above the substrate-water interface near the center of the mussel bed. The effects of these physical changes on biotic conditions at mussel beds will be evaluated by annual biological and physical monitoring.

HOW SHOULD WE ANSWER THE QUESTION "DOES COMMERCIAL NAVIGATION IMPACT FISH COMMUNITIES OF THE UMRS BY INCREASING ICHTHYOPLANKTON MORTALITY?" Kenneth S. Lubinski, U.S. Fish and Wildlife Service, Environmental Management Technical Center, 575 Lester Drive, Onalaska, WI 54650 and D. Wilcox, U.S. Corps of Engineers, 1421 U.S. Post Office and Custom House, St. Paul, MN 55101.

"Single commercial traffic events increase ichthyoplankton mortality in main channel and channel border habitats" is a hypothesis being tested under the Problem Analysis element of the Long Term Resource Monitoring Program. In January, 1990, we hosted a workshop to obtain an independent, expert review of the research strategy we've developed to test the hypothesis, and to review scientific approaches that could be used to determine if navigation-related mortality results in reductions in future year classes. Most of the workshop dialog focused on the selection of available models, their limitations and assumptions, and how different models could be used in an evolutionary thought-process to pose questions. A draft physical impact model was presented that identified the mechanisms and physical variables that link traffic events to potential ichthyoplankton impacts. Impact mechanisms included propeller jet flow, return flow, and waves. Workshop participants agreed that the first step in model development was to construct and analyze worst-case models built on simple assumptions. Suggested assumptions for a propeller jet entrainment model included: a simple relationship between the ratio of river reach volume to the volume of water entrained by a tow; homogenous distribution of ichthyoplankton in a channel cross-section; 100 percent mortality of all ichthyoplankton entrained; and complete re-mixing of the water column after each event. The assumptions are similar to those used in the Fish and Wildlife Service's Coordination Act report for Lock and Dam 26. We are now conducting sensitivity analyses on a draft of this model. Based on typical minimum channel widths and depths (Fig. 1), estimates of the percent of reach volume entrained by one tow ranged between 0.5 and 2.5 for approximately 75 percent of the reaches in Mississippi River Pools 11-26, and between 1 and 5 percent for approximately 90 percent of the reaches in Mississippi River Pools 1-10 and the Illinois River pools (Fig. 2).

(See Figs. 1 and 2, Page 24)

Lubinski and Wilcox, 1990.

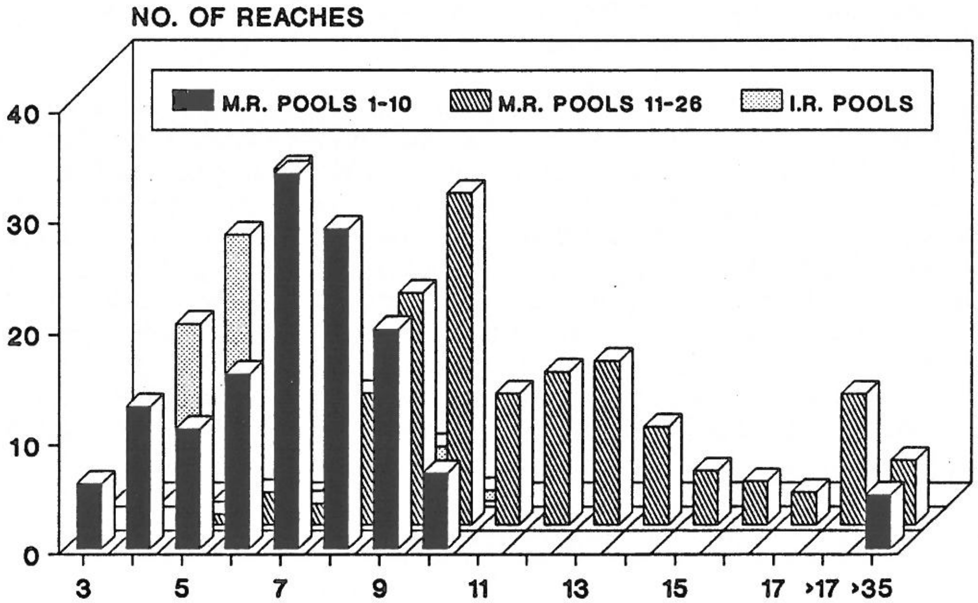


Figure 1. Frequency Distribution of Minimum Channel Widths of the Upper Mississippi River System (Simons et al. 1981).

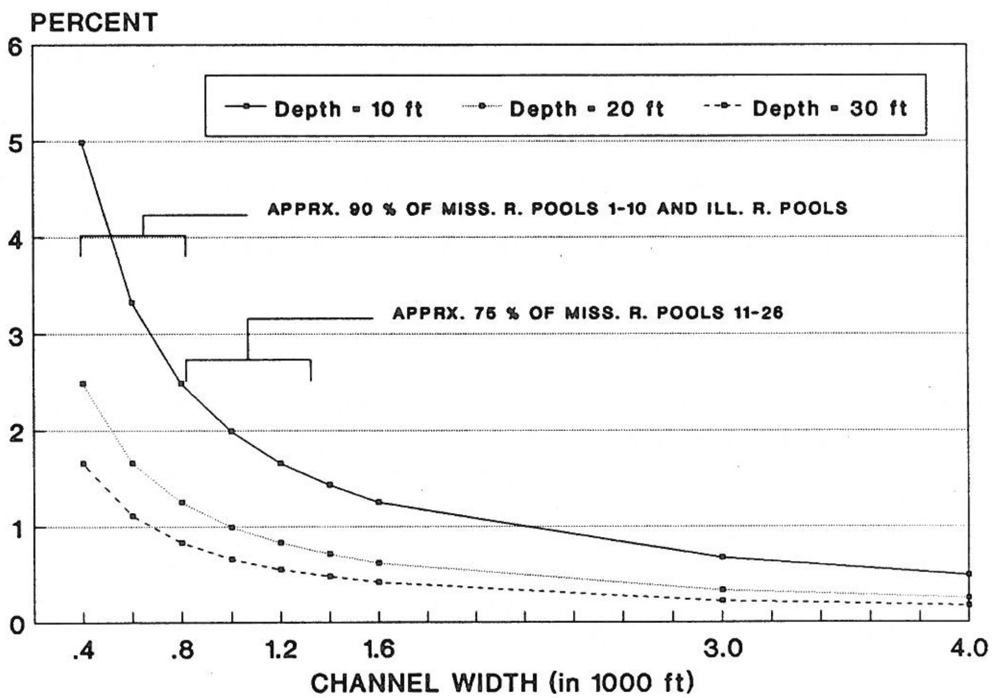


Figure 2. Percentages of Reach Volume Entrained by One Tow.

STRATEGIES FOR EVALUATING SEDIMENTATION AND COMMERCIAL NAVIGATION IMPACTS ON THE UPPER MISSISSIPPI RIVER SYSTEM. Kenneth S. Lubinski, U.S. Fish and Wildlife Service, Environmental Management Technical Center, 575 Lester Drive, Onalaska, WI 54650.

Future increases in commercial traffic on the Upper Mississippi River System (UMRS) may magnify already existing ecological problems related to sedimentation. One function of the Long Term Resource Monitoring Program is to provide information necessary to quantify and minimize impacts. Long-term (10-year) research strategies to test impact hypotheses are under development. Strategies include formulation of impacts models, definition of critical biological thresholds, documentation of cause and effect relationships, description of spatial and temporal impact patterns within the UMRS, and evaluation of possible solutions. An example of an impact hypothesis is "Commercial Traffic Events Increase the Movement of Sediment into Side Channels and Backwaters." Cause and effect relationships that are being documented to test this hypothesis include those between tow and physical variables, and physical and biological variables. In 1988, we began funding field research to quantify physical impact relationships. The description of spatial impact patterns emphasizes large-scale differences among river reaches and small-scale differences associated with channel geomorphometry. A Geographic Information System is being used to generate maps at both spatial scales. The process of developing strategies has allowed us to focus on timely generation of research products and provided a concise work plan that can be used by river regulation agencies to track our progress.

CORRELATIONS BETWEEN SUSPENDED SEDIMENT CONCENTRATION AND TURBIDITY AT MILE 50.1 ON THE ILLINOIS RIVER. J. Rodger Adams and Edward Delisio, Illinois State Water Survey, Champaign, IL 61820-7495.

Continuous sampling of suspended sediment concentration is one aspect of the Illinois State Water Survey's project to measure the physical impacts of navigation. Because of the need to take discrete volumetric samples for laboratory determination of sediment concentration, the maximum sample collection rate is one sample per minute even when using pumped samplers with intakes at fixed points in the river. In an effort to obtain truly continuous measurements, another set of intakes and pumps are used to obtain continuous turbidity data. A two-hour continuous ambient suspended sediment concentration and turbidity illustrates the variability of conditions over time and shows the use of a turbidity-concentration relation to estimate sediment concentrations from turbidity data. Sediment concentration and turbidity measurements at the same location in the river for typical tow passage events are also presented.

The measurements reported here were obtained in May and June 1989 at river mile 50.1 (80.6 km) on the Illinois River just upstream of McEvers Island. The river flow rates were 212 m^3/s in May and 594m^3/s in June.

For the continuous measurements of ambient conditions, suspended sediment concentration samples were collected 0.91 m above the river bed, and turbidity was measured at 0.45 m and 0.91 m above the river bed. The intakes were located 25 m from shore where the water was 2 m deep. During the two hour period, the measured suspended sediment concentration 0.91 m above the bed decreased from about 215 mg/l to 180 mg/l (Fig. 1). A parallel decrease in turbidity was observed at both 0.45 and 0.91 m above the bed. Exponential curves were fit to these data sets. A regression equation was developed between the turbidity and sediment concentration at the 0.91 m level which had an R^2 of 0.52. This equation was used to generate the sediment concentrations at the 0.45 m level. The concentrations and turbidities are shown in figure 1 for the two hour period.

Both suspended sediment concentration and turbidity were also measured during 11 of a total of 13 tow passage events during the May 1989 field data collection trip. Typical plots and summary tables will be presented. Generally the turbidity values show less increase and range of variation than the sediment concentrations.

(See Fig. 1, Page 26)

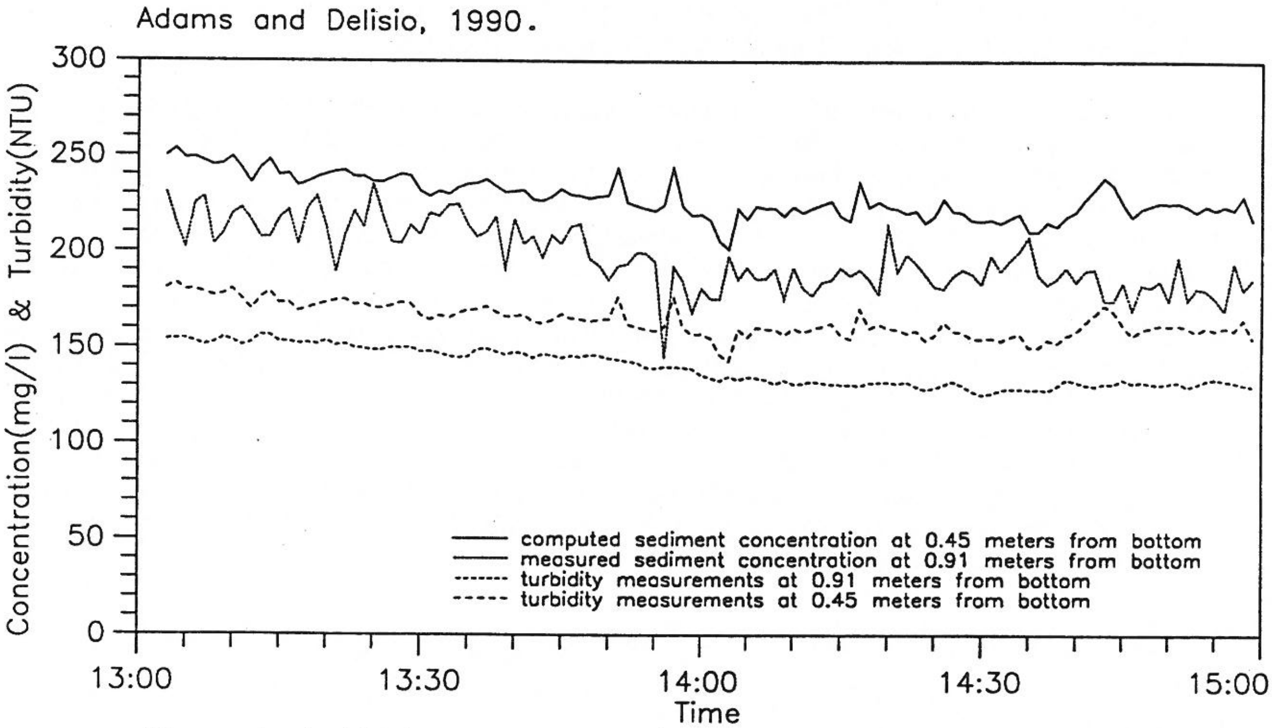


Figure 1. Ambient suspended sediment concentrations and turbidities. Afternoon of June 14, 1989 on the Illinois River at mile 50.1.

CHANGES IN VELOCITIES WITHIN THE CHANNEL BORDER AREAS DUE TO THE MOVEMENT OF BARGE TRAFFIC. B. S. Mazumder and T. W. Soong, Illinois State Water Survey, 2204 Griffith Drive, Champaign, IL 61820-7495.

The Illinois State Water Survey is conducting research on impacts of commercial navigation on velocity structures within the channel border area on the Upper Mississippi River System (UMRS). A temporary increase in water velocity both in longitudinal and lateral directions does occur during the passage of barge traffic in a river. An increase in velocity and turbulence produced by a barge-tow may increase the resuspension of sediment and turbidity. There is a rapid return flow superimposed to the ambient flow in the opposite direction of the movement of the barge traffic in the zone between the barge and bank. The return velocity distribution depends on the towspeed, barge-dimension, and the river geometry.

In the first year of this research, velocity data were collected from the Illinois River using six current meters. The flow velocities were measured at four different distances from the barge to the shore in one side of the river. Preliminary analysis of velocity data due to the movement of the barge in the upstream direction shows that the return flow beside the barge is superimposed on the ambient flow resulting in an increase in velocity near the middle section between the barge and the bank. When the barge moves in the downstream direction, the supperimposed velocity decreases near the middle section between the barge and bark. The velocity near the boundaries of the barge and the bank is different from that of the middle point. It is believed that the changes of velocity near the barge is due to the combined effects of bow push and jet behind the barge and that near the boundary of the bank is because of the drawdown effect. The changes of velocity distribution with lateral distance and time due to the movement of the barges in one side of the river are being analyzed. Fig. 1 shows a typical plot of velocity changes with time near the shore during the movement of the barge traffic.

(See Fig. 1, Page 27)

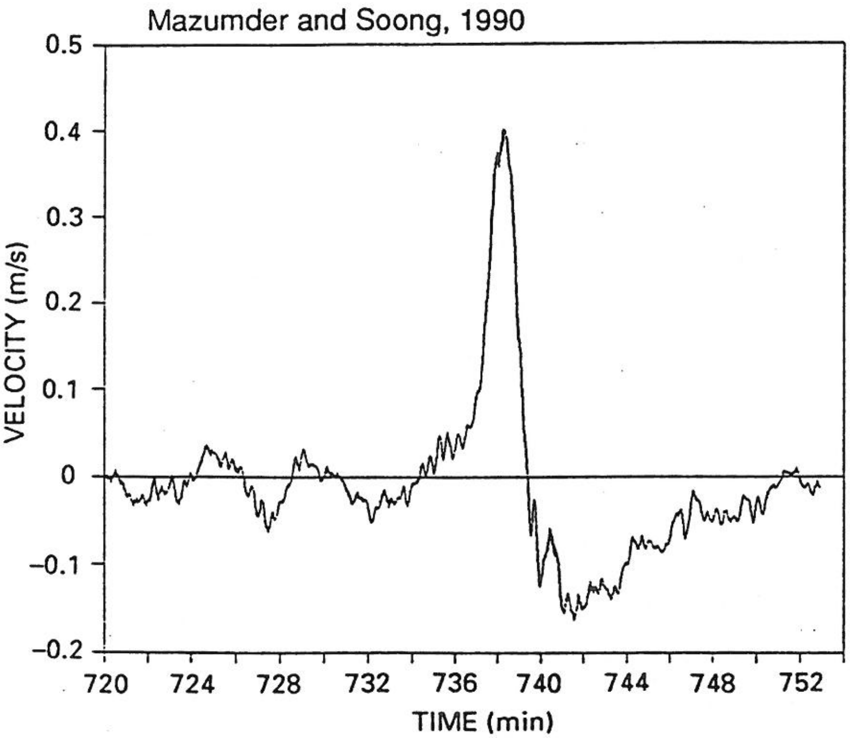


Figure 1. Velocity Changes near the Shore Due to the Movement of an Upstream Bound Barge

WAVES GENERATED BY RECREATIONAL TRAFFIC ON THE UPPER MISSISSIPPI RIVER SYSTEM. Nani G. Bhowmik, Ta Wei Soong, Walter Reichelt, and William C. Bogner, Illinois State Water Survey, 2204 Griffith Drive, Champaign, IL 61820.

Vessels of all sizes from canoes to 15 barge tows share the Upper Mississippi River System (UMRS), and every vessel interacts with the river by its displacement, propulsion, and maneuvering. Barge tows cause moderate wave action, but result in drawdown and return flow velocities and cause large waves and high turbulence from their propulsion system. Small power boats tend to be fast and generate substantial wave trains, but have small propellor jets. Larger cabin cruisers and towboats without barge convoys, generate the largest wave trains on the river and have propulsion wakes in proportion to their power. Up until now very few research studies were conducted on the specific area of waves generated by recreational traffic within the inland waterways of the nation. Recently a fairly comprehensive investigation has been conducted to determine the character and nature of waves generated by recreational boats on the Illinois and Mississippi Rivers. In this project, recreational boats of various sizes, shapes, and propulsion were used to conduct a series of controlled experiments where the amplitudes, duration, and other wave related parameters were recorded by a pair of electronic wave gages. Speeds and distances of the recreational boats were varied to determine the variability of the waves generated by this type of river traffic. Subsequently, a series of wave data due to the uncontrolled movement of recreational boats were collected from a reach of the Mississippi River where extremely heavy recreational traffic existed during a two-week period which included a national holiday weekend. Fig. 1 shows the frequency distribution of the maximum wave heights for these naturally occurring waves due to the movement of recreational traffic. Analyses of these data have shown that mathematical regression type relationships can be developed to predict the wave heights generated by recreational traffic on a typical waterway. These relationships once verified can be used for similar waterways of the country.

(See Fig. 1, Page 28)

Bhowmik, Soong, Reichelt and Bogner, 1990.

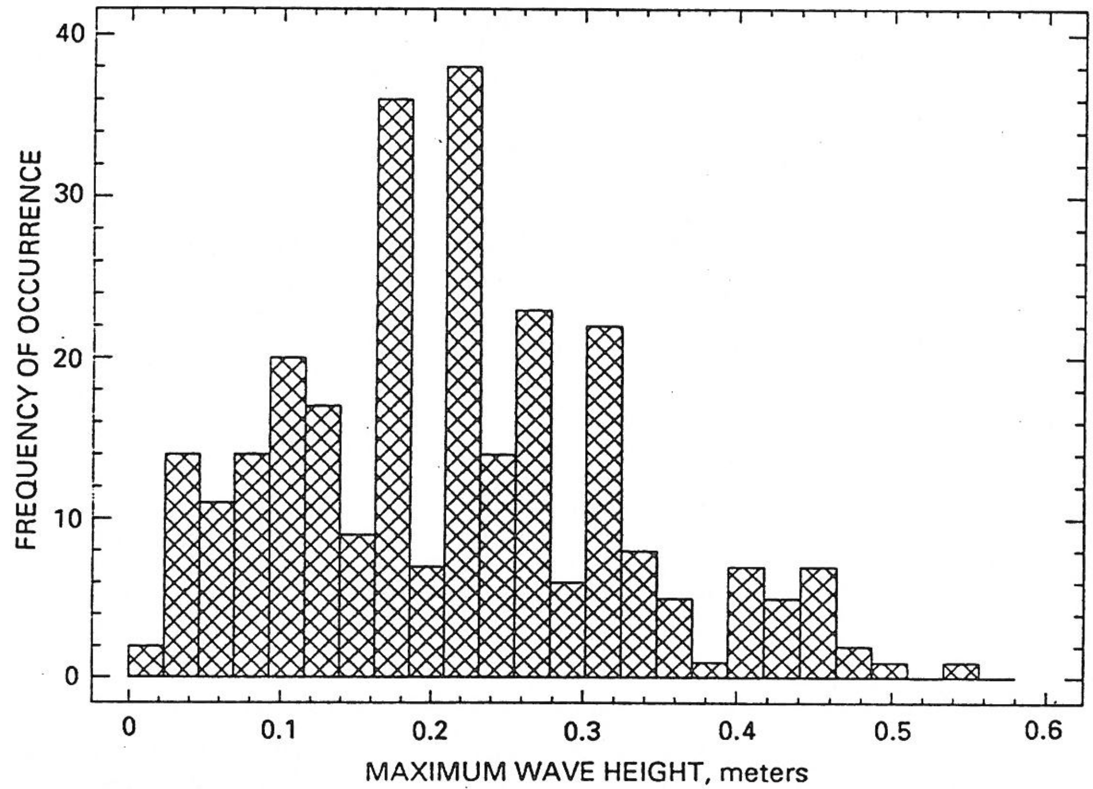


Figure 1. Frequency Distribution of Maximum Wave Heights (Per 5-Minute Interval) Generated by Recreational Boats at Redwing, Minnesota

ACKNOWLEDGMENTS

The following persons and institutions have contributed substantially to the planning, execution, support, and ultimately, the success of the 22nd annual meeting. The 1989-90 Board of Directors gratefully acknowledges their involvement.

Local Meeting Arrangements

John Sullivan, Wisconsin Department of Natural Resources, La Crosse, WI

Program and Keynote Speaker Recruiting

Douglas Blodgett, Illinois Natural History Survey, Havana, IL

Meeting Announcement, Proceedings, and Mailing

John Ramsey and the Iowa Cooperative Fish and Wildlife Research Unit, U.S. Fish and Wildlife Service and Iowa State University, Ames, IA

Registration Table

Stephanie Edwards, Illinois Natural History Survey, Havana, IL

Mary Mackrill, Environmental Management Technical Center, Onalaska, WI

Paula Heiderscheit, Wisconsin Department of Natural Resources, La Crosse, WI

Technical Session Moderators

Ron Rada, River Studies Center, University of Wisconsin, La Crosse, WI

Marian E. Havlik, Malacological Consultants, La Crosse, WI

M. A. Romano, Department of Biological Sciences, Western Illinois University, Macomb, IL

Nani Bhowmik, Illinois State Water Survey, Champaign, IL

Mark Sandheinrich, River Studies Center, University of Wisconsin, La Crosse, WI

Assistance With Visual Aids

Jeff Mensinger, Paul Raibley, and Steven Stenzel, INHS

Cover Art

Craig Phillips, Silver Spring, MD

MINUTES OF THE BUSINESS MEETING, 21ST ANNUAL MEETING OF THE MISSISSIPPI RIVER RESEARCH CONSORTIUM, INC., APRIL 28, 1989

Bill LeGrande presided for the Board of Directors. Business meeting called to order 8:12 a.m.

A raffle was announced for the morning break. Keynote speaker Mark T. Brown was granted 5 minutes of Business Meeting time for remarks on biological-cultural-economic interactions of energy.

Financial Report: submitted by Jerry Rasmussen [the accounting reported here is balanced as of July 25, 1989].

Assets	
Balance on hand April 14, 1988	$2,267.24
Income from registration and book sales	3,444.15
Total Assets	$5,711.39
Expenses	
Wisconsin corporation fee	$10.00
Office supplies	16.37
Holiday Inn charges for 1989 annual meeting	1,110.78
Dinner Cruise (Riverboats America, Inc.)	1,256.25
Prints for raffle (Northwinds Art Gallery)	200.00
Entertainment at annual meeting (Jim City)	115.00
UMRCC (Research Summaries for annual meeting)	100.00
Total Liabilities	$2,808.40
Balance on Hand July 25, 1989	$2,902.99

Keynote Speaker Costs: Jerry Rasmussen reported that all travel costs for the three keynote speakers had been contributed by the Cousteau Society. Marian Havlik suggested that the MRRC write a letter of appreciation. Jerry Rasmussen agreed to write the Cousteau Society thanking them for their generous support. He also will write to thank the keynote speakers.

OLD BUSINESS

New Journal Work Group: Leslie Holland-Bartels reported on an Upper Mississippi River Conservation Committee survey by Gail Carmody regarding changing the UMRCC annual meeting proceedings to a regional Mississippi River journal. Fewer than half the UMRCC members favored the proposed change, although more than half expressed interest in there being a refereed journal on the upper Mississippi River.

MRRC work group members had mixed feelings about starting a regional journal. John Ramsey pointed out a proliferation in aquatics journals and their competition for good articles. Leslie Holland-Bartels cautioned that an overly ambitious start on a new MRRC regional journal might not be sustainable, and one might die after publication of one issue. On this subject, Gail Carmody distributed her design for a study on the logistics of producing journals. No one has made time to carry it out, however. Leslie reiterated that FWS and other researchers must try to publish mostly in national and international journals.

All concurred in a compromise proposed in discussion by Marian Havlik and Nani Bhowmik. The 1990 MRRC annual meeting program and abstracts will have a proceedings volume number printed on the cover, and will contain extended abstracts and figures. Nani Bhowmik will provide examples of the extended abstracts commonly published in engineering conference proceedings.

Funding an expanded proceedings was discussed. No one knew what to expect, so it was moved and seconded to allow 1990 dues to be raised from $5 to a maximum of $10 to cover publication costs, if needed. The motion carried. Actual costs will be reported by John Ramsey at the 1990 meeting.

Minutes of 1988 Annual Meeting: Approved as submitted.

NEW BUSINESS

Environmental Management Plan: The MRRC Board of Directors will forward a letter supporting the EMP to the local U.S. Congressman.

Meeting Organization: Joe Wlozinski urged there be an hour set aside to discuss poster displays. Marian Havlik suggested a combined poster session and get-together on Wednesday evening before the meeting, rather than late on Friday. Gail Carmody stressed the importance of allowing time for discussion in paper sessions. Jim Eckblad suggested that speakers be cut off after 15 minutes to allow 5 minutes for questions and comments. The consensus was that MRRC participants greatly value having time to discuss each presentation.

Dues Ceiling: (See Old Business for note of approval to raise dues to a maximum of $10 if needed to cover publication costs.)

Election of Directors: The outgoing Board of Directors nominated Doug Blodgett (INHS), John Ramsey (Iowa Coop. Unit), and John Sullivan (Wisconsin DNR) as candidates for the 1990-91 Board of Directors. The membership voted unanimously to accept the slate of nominees.

Acknowledgments: Bill LeGrande thanked the other Board members and all those who helped make the 1989 MRRC annual meeting such a resounding success.

The Business Meeting was dismissed at 9:00 a.m. (These Minutes were prepared and submitted by John Ramsey.)

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

Meeting		Place	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 Coll.-St. Cloud	Dr. Joseph Hopwood
5th	1972	Loras College, Dubuque	Dr. Joseph Kapler
6th	1973	Quincy College, Quincy	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. R. V. Anderson Dr. D. McConville Dr. J. G. Wiener
16th	1984	Radisson Hotel, La Crosse	Dr. K. S. Lubinski Ms. R. A. Schnick Dr. M. M. Smart
17th	1985	Radisson Hotel, La Crosse	Mr. R. C. Hubley Dr. J. G. Nickum Ms. P. A. Thiel
			Board of Directors
18th	1986	Radisson Hotel, La Crosse	Dr. J. W. Eckblad Dr. C. E. Korschgen Dr. J. H. Peck
19th	1987	Univ. of Wisconsin-La Crosse	Mr. Hannibal Bolton Dr. L. E. Holland Mr. M. R. Winfrey
20th	1988	Univ. of Wisconsin-La Crosse	Mr. John Pitlo Dr. Verdel Dawson Dr. Nani Bhowmik
21st	1989	Holiday Inn, La Crosse	Dr. Larry Jahn Mr. Jerry Rasmussen Dr. Bill LeGrande

CONSTITUTION OF MISSISSIPPI RIVER RESEARCH CONSORTIUM, INC.

ARTICLE I. NAME AND OBJECT

1. This organization shall be named Mississippi River Research Consortium, Inc.
2. The objectives 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 by-laws.
2. The by-laws of this organization shall designate the officers and standing committees, the provisions for the election of the 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 by-laws of the MRRC may be amended by an affirmative vote of two-thirds of the eligible voting members present at the annual meeting.

BY-LAWS OF THE MISSISSIPPI RIVER RESEARCH CONSORTIUM, INC.

ARTICLE I: NAME, PURPOSE AND DUTIES

1.01 There is hereby established a Board under the name of the Mississippi River Reasearch Consortium Inc., having the 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 included 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.

(c) To coordinate and make decisions regarding priorities of services.

1.02 The purpose of this 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.

(c) To provide an annual meeting where research results can be presented, common problems can be discussed, information can be disseminated, and 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 within or without 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 may not be, identical with the principal office in the State 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 register office.

ARTICLE 3. BOARD OF DIRECTORS

3.01 General Powers 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 jointly organize, hold and preside over the annual meeting. The Board shall be responsible for the development of a program of technical papers to be presented at the annual meeting. The number of Directors of the corporation shall be not less than three (3) elected members.

3.02 Election and Term of Directors

Each director shall hold office for a term of one (1) year. The term of the office begins and ends with each annual meeting. At lest one director shall be representative of an academic institution and at least one director shall be a representative of either a state of federal agency. A director may be removed from the office by an affirmative vote of a majority of the Board of Directors, taken at a meeting by the Board of Directors for the purpose. A director may resign at any time by filing a written resignation at the registered office.

3.03 Regular Meetings

The Board of Directors shall meet on the times and dates to be established by them but at least once per year.

3.04 Special Meetings

Special meetings of the Board of Directors may be called by or at the request of any office. 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.

3.05 Notice; Waiver

Notice of such meeting of the Board of Directors shall be given by written notice delivered personally or mailed or given by telegram to each Director at his/her home address or at such other address as such director shall have designated in writing with the secretary of the Board of Directors, in each case not less than ten (10) days 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 of notice of such meeting.

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 Removal

Any member of the Board who is absent from three (3) consecutive regular 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.

3.08 Conduct of Meetings

The president and in his/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.

3.09 Vacancy

Any vacancy occurring in the Board of Directors shall be filled as soon as possible by the majority action of the Board.

ARTICLE 4: MEMBERSHIP AND DUES

4.01 Membership and Eligibility

Membership to include anyone interested in the research and study of the Upper 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: OFFICERS

5.01 Creation of Officers

The officers of the Board shall consist of a president, vice-president, secretary-treasurer and such additional assistant officers as the Board may elect.

5.02 Executive Director of the Corporation

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

5.03 Election of Term Office

The officers of the corporation shall be elected by the Board of Directors at the first annual meeting following the annual meeting to serve as one (1) year term. Each officer shall hold office until his successor shall have been duly elected or until his death, resignation or removal.

5.04 Removal

Any officer or agent may be removed by the Board of Directors whenever in its judgement the best interests of the corporation shall be served thereby, but such removal shall be made without prejudice to the contract rights of person so removed. Election or appointment shall not of itself create contract rights.

5.05 Vacancies

A vacancy in any principal office because of death, resignation, removal, disqualification or otherwise, shall be filled by the Board of Directors for the unexpired portion of the term.

5.06 President

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,

(c) 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.

5.07 Vice-President

The vice-president, at the request of the president, shall perform the duties and exercise the functions of the president, and when so acting shall have the power of the president and shall perform such other duties as delegated by the president.

5.08 Secretary-Treasurer

The Secretary-Treasurer shall:

(a) Keep the minutes of the meeting of the Board,

(b) See to it that all notices are fully given in accordance with the provisions of the By-laws,

(c) 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,

(e) Keep all financial records of the Board,

(f) Be responsible for record keeping and assessment of dues as established by the Board of Directors,

(g) Supervise the preparation of the annual budget,

(h) Perform all duties incident to the office of the treasurer of the Board and such other duties as from time to time may be assigned by the president of the Board.

5.09 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 all the power to perform all of the duties of the office to which he is so appointed to act, except as such powers may be otherwise defined or restricted by the Board of Directors.

ARTICLE 6: COMMITTEES

6.01 Nominating Committee

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

6.02 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 7: MEETING OF MEMBERSHIP

7.01 Annual Meeting

The annual meeting of the organization shall be held in La Crosse, Wisconsin, with local arrangements being handled by the membership located in La Crosse, Wisconsin. The time of the meeting shall be established by the Board of Directors within the month approved by the two-thirds (2/3rds) vote of the previous annual meeting. At the meeting reports of officers and committees shall be delivered. The Board of Directors shall 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.

7.02 Special Meetings

Special meetings may be called by the president of 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.

7.03 Quorum

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

ARTICLE 8: AMENDMENTS

8.01 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 affirmation vote of two-thirds (2/3rds) of the members present at a meeting at which a quorum is in attendance.