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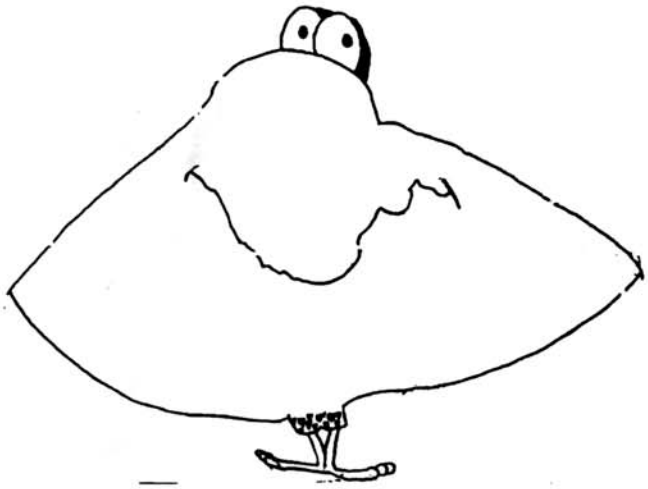
Triannual Unionid Report

Report No. 11

March 1997

A forum for the informal exchange of information
on the status of
North American unionid research, management, and conservation



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NOTE: The intent of this report is to expedite the exchange of information in an informal format. Report submissions were solicited from individuals and agencies involved in unionid conservation. The submissions were not edited. They were copied as received and assembled into the report.

COVER: THE MUSSEL OF THE COVER WAS DRAWN BY AN ELEMENTARY SCHOOL STUDENT AS PART OF A CONTEST TO DESIGN THE CHARACTER "RUSSELL THE MUSSEL' HELD BY THE TENNESSEE AQUARIUM, CHATTANOOGA, TENNESSEE.

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*Welcome to the **UNIO Listserver** home page. This page is currently under construction. Please stop back soon.*

Description:

UNIO is an unmoderated Internet listserver focusing on the biology, ecology and evolution of freshwater unionid mussels. The primary objectives of the list are (1) to foster communication and collaboration among scientists, researchers, and students engaged in mussel-related activities and (2) to facilitate the informal discussion of regional and federal research priorities. Postings related to mussel conservation issues, including the artificial propagation and captive rearing of threatened and endangered species, are especially welcomed. Subscribers are also encouraged to use the list for posting information on mussel-related meetings, symposia, workshops, and funding opportunities. The list is sponsored by the *University of Maryland Baltimore County* (UMBC) and administered and managed by Rick Tankersley (*tankersl@umbc.edu*). There are no limitations on who may subscribe to the list and the subscription is FREE.

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Questions, Concerns, Problems?

If you have any questions regarding the list or encounter any problems while attempting to post messages, please contact Rick Tankersley at the snail mail or email address listed below.

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Home Page

(2)

Spectaclecase (*Cumberlandia monodonta*) conglutinates unique, host(s) elusive

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The host requirements of *Cumberlandia monodonta*, a federally listed species (Category 2), have not been studied (Watters 1994). Knowledge of host requirements is essential to determine the viability of imperiled mussel populations either in degraded habitats, where they now occur, or in habitats being considered for receiving relocated mussels. As part of a larger study to determine the natural hosts of *C. monodonta*, we conducted laboratory studies to identify suitable hosts.

Five fish species and larval tiger salamanders were tested in 1996 for host suitability using procedures similar to Hove and Neves (1994). Due to the small size of the glochidia, the glochidial attachment period is defined as the number of days glochidia were observed in tank siphonate. Glochidial metamorphosis was not observed for any of the species tested (Table 1).

Table 1. Species exposed to *Cumberlandia monodonta* glochidia.

Species	Scientific name	Number inoculated	Number survivors	Glochidia attachment period (days)
mimic shiner	*Notropis volucellus*	4	0	*
longnose dace	*Rhinichthys cataractae*	9	7	20-22
northern redbelly dace	*Phoxinus eos*	8	3	20-22
banded killifish	*Fundulus diaphanus*	8	0	*
Iowa darter	*Etheostoma exile*	2	2	24-27
tiger salamander	*Ambystoma tigrinum*	7	7	23-26

* - Incomplete study, fish died before completion of experiment.

Cumberlandia monodonta conglutinates collected from three gravid females in the field were flat and white (Figure 1). Unbroken conglutinates were 3 - 6 mm wide and 5 - 13 mm long. Lateral branches were common on many conglutinates, occurring on one or both sides. Branches were 1 to 4 mm long and extended outward from the conglutinate at a 45 degree angle. Some conglutinates had a forked tail.

Figure 1. Outline of branched *Cumberlandia monodonta* conglutinates (actual size).

erature Cited

Hove, M. C., and R. J. Neves. 1994. Life history of the endangered James spinymussel *Pleurobema collina* (Conrad, 1837) (Mollusca: Unionidae). American Malacological Bulletin 11(1): 29 - 40.

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Mantle-waving behavior and suitable fish hosts of the ellipse

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The ellipse, *Venustaconcha ellipsiformis*, is a small to medium-sized stream dwelling unionid uncommon in the Midwest (Oesch 1984). It is extirpated from Ohio, threatened in Iowa, Wisconsin, and Minnesota, and a species of special concern in Illinois and Indiana (Cummings and Mayer 1992).

We exposed eleven fish species to *V. ellipsiformis* glochidia collected from females of the North Fork Zumbro River in Goodhue County, Minnesota. Slimy sculpins and Johnny darters, facilitated metamorphosis of glochidia (Table 1). Several fishes did not serve as suitable hosts (Table 2). Juvenile mussels were collected from six walleye just nine days after exposure to *V. ellipsiformis* glochidia in the first trial. However, juvenile *V. ellipsiformis* developed for 35 d and 57 d on slimy sculpins and Johnny darters respectvely. Subsequent studies on walleyes did not produce any juvenile mussels. We believe the juveniles collected from the walleye were probably from a natural infestation. Additional host suitability studies will be conducted on walleye and other fishes.

Table 1. Suitable fish hosts for *V. ellipsiformis* glochidia.

Species	Number tested	Juvenile collection period (d)
Johnny darter	6	57-95
slimy sculpin	6	35-59

Average water temperature was 19 ± 2 °C

Table 2. Unsuitable fish hosts for *V. ellipsiformis* glochidia.

Species	Number tested	Encystment period (d)
longnose dace	3	17-20
black bullhead	6	19-23
white sucker	6	19-23
bluegill	6	29-31
walleye I	6	unclear*
walleye II	4	7-10
walleye III	4	21-24
walleye IV	5	27-29
golden shiner	6	19-23
yellow perch	6	22-25
logperch	4	45-48
northern pike	4	31-33

*Results were confounded with juvenile mussels from a natural infestation.

In the laboratory, gravid *V. ellipsiformis* exhibited an interesting mantle display. Ventral to the incurrent siphon are a pair of 10 x 2 mm mantle flaps. The mantle flaps have four to six papillae 3-6 mm long that lie perpendicular to the long axis of the mantle flap. The top side of the mantle flap is the same color as the surrounding mantle, dark mottled brown. One mantle flap lies on either side of the marsupia. Occassionally, inflated marsupia are presented just beyond the perimeter of the valves and just interior to the mantle flaps. During the display period a female mussel displays the cream-colored underside of the mantle flaps. The underside of the mantle also has a small "eyespot" at the posterior end. The mantle is briefly closed and redisplayed whenever the shadow of a small fish or hand passes over the gravid female. Conglutinates are cream-colored, leaf-shaped, and approximately 1 x 5 x 10 mm in size.

Funding for this study was provided by the Minnesota Department of Natural Resources, Natural Heritage & Nongame Research Program, and the University of Minnesota, Undergraduate Research Opportunities Program.

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Cummings, K.S. and C.A. Mayer. 1992. Field guide to freshwater mussels of the Midwest. Illinois Natural History Survey. Manual 5. Champaign, IL. 194 pp.

Oesch, R. D. 1984. Missouri Naiades: A guide to the mussels of Missouri. Missouri Department of Conservation. Jefferson City, MO. 270 pp.

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Ictalurids serve as suitable hosts for the purple wartyback

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Cyclonaias tuberculata
glochidium

In July 1996 the purple wartyback (*Cyclonaias tuberculata*) was added to Minnesota's list of threatened species. Identification of fish hosts for *C. tuberculata* is of interest to Minnesota and Wisconsin natural resource managers charged with conservation of this species.

During 1996 glochidia were obtained from gravid *C. tuberculata* collected from the St. Croix River, Minnesota and exposed to three species of Ictalurids. All three species, channel catfish, black bullhead, and flathead catfish, were found to be suitable hosts (Table 1). These results confirm my earlier findings on the suitability of channel catfish to serve as hosts for *C. tuberculata* . This is the first time that flathead catfish and black bullheads have been identified as suitable hosts for this mussel. It is interesting that on three earlier occasions (n=3 individuals) glochidial metamorphosis was not observed on black bullheads (unpublished data).

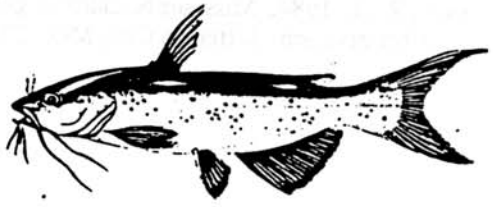
Table 1. Fish species that facilitated metamorphosis of glochidia.

Species		Number of hosts inoculated	Number of survivors	Juvenile recovery period (days)	Number of juveniles recovered
Ictalurus punctatus	(channel catfish)	3	1	17-29	119
Ameiurus melas	(black bullhead)	6	6	12-22	5
Pylodictus olivaris	(flathead catfish)	3	3	19-27	3

A disproportionately larger number of juvenile mussels were collected from the channel catfish than from black bullheads and flathead catfish. This may be due the channel catfish serving as a superior host. However, the body length of the surviving channel catfish was four times greater than any of the other individuals tested. To determine if juvenile *C. tuberculata* production is significantly greater for channel catfish, a more rigorously controlled study is needed.

In the future I plan to conduct host suitability studies on *Lasmigona compressa*, *Ligumia recta*, and *Anodontoides ferussacianus*.

Flathead catfish were obtained from James Hardin, Calhoun City, Mississippi. Partial funding was provided by the Minnesota Department of Natural Resources, Natural Heritage and Nongame Research Program.



Channel catfish

Suitable fish hosts and mantle display behavior of *Tritogonia verrucosa*

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Tritogonia verrusoca is a widespread but relatively uncommon freshwater mussel in the midwest (Cummings and Mayer 1992). This species is endangered in Iowa, threatened in Wisconsin (Cummings and Mayer 1992), and threatened in Minnesota. *T. verrucosa* are often found in gravel or rocky substrates (Thiel 1981). In the Upper Mississippi River these already uncommon habitats are becoming extremely rare due to dredge disposal activities and elevated sedimentation rates.

We exposed 9 species of fish to *T. verrucosa* glochidia collected from the St. Croix River, Interstate State Park, Minnesota. Yellow bullheads facilitated glochidia metamorphosis and dramatic juvenile growth before excystment (Table 1). Flathead catfish have also been reported as suitable hosts for *T. verrucosa* (Howell 1996).

Table 1. Suitable fish hosts for *Tritogonia verrucosa* glochidia.

Species	Number tested	Juvenile collection period (d)
yellow bullhead	3	15-22

Average water temperature was 19 ± 2 °C

Table 2. Unsuitable fish hosts for *Tritogonia verrucosa* glochidia.

Species	Number tested	Encystment period (d)
black bullhead	6	10-13
killifish	8	*
longnose dace	8	17-24
Iowa darter	5	17-24
spotfin shiner	7	15-17
creek chub	6	22-24
rock bass	6	14-16
tadpole madtoms	6	19-21

Average water temperature was 19 ± 2 °C
* Fish died before end of study.

Tritogonia verrucosa presents an unusual mantel during the glochidial release period. The portion of the mantle dorsal to the excurrent siphon is inflated, and crenulated with blue-gray edges and a tan-colored interior. (It really looks like the decorative cream on an eclair.) Although we don't think eclairs are natural food items of Ictalurids, perhaps the mantle is specialized to release a chemical attractant to prospective fish hosts. Additional host suitability studies will be conducted on Ictalurids and other fish families.

Funding was provided by the Minnesota Department of Natural Resources, Natural Heritage and Nongame Research Program, and the University of Minnesota, Undergraduate Research Opportunities Program.

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Cummings, K.S. and C.A. Mayer. 1992. Field guide to freshwater mussels of the Midwest. Illinois Natural History Survey. Manual 5. Champaign, IL. 194 pp.

Howells, R. G. 1996. Pistolgrip and Gulf Mapleleaf hosts. Info-Mussel Newsletter. 4(3): 3.

Thiel, P. 1981. A survey of unionid mussels in the Upper Mississippi River (pools 3-11). Technical Bulletin Number 124. Wisconsin Department of Natural Resources. Madison, WI. 21 pp.

News About *Potamilus amphichaenus* (Frierson, 1898)

by
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According to Neck and Howells (1994) the "Texas heelsplitter has been, and remains, a rather rare species. Only about 150 specimens appear to have been documented since the species was described in 1898. Among these, only about 50 have been found within the last 15 years and among those, only two were alive when found." They also reported that in their surveys, no specimens were found in the Trinity River system.

In the summer of 1996, the present authors visited several sites in the middle reaches of the Trinity River in the vicinity of Houston and Leon Counties, Texas to check on the status of mussel beds that had experienced severe population crashes. In 1981, healthy, very dense mussel beds were sampled in this region. In 1985, large numbers of dead mussels were noted in the region so an effort was made in 1986 to resample one of the earlier sites. During several man-hours of sampling, only a single live mussel (*Lampsilis teres)* was found and it was too weak to close its shell. In 1996, several of these devastated mussel beds were re-examined to determine if there had been any recovery. Surprisingly, good populations of all the species found previously were found during the 1996 survey. In one area during about two man-hours of sampling, a total of 8 living adults and 49 living juvenile *Potamilus amphichaenus* were found. Good populations of this species were also found at every other site sampled.

Neck, R. W. and R. G. Howells. 1994. Status survey of Texas heelsplitter, *Potamilus amphichaenus* (Frierson, 1898). Special Report, Texas Parks and Wildlife Department, Austin, TX, 47pp.

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1996 Mississippi River Research Consortium abstracts

The following abstracts were selected from presentations made at the 28th annual meeting of the Mississippi River Research Consortium. The next meeting will take place at LaCrosse, WI on April 24-25, 1997. All are invited to attend! For more information please contact: Mark Hove at University of Minnesota, Department of Fisheries & Wildlife, 1980 Folwell Avenue, St. Paul, MN 55108, or by phone (612) 624-3019, FAX (612) 625-5299, or email mh@fw.umn.edu.

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

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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
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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.

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

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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.

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 Branchamong 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: *Cumberlandia monodonta*, *Cyclonaias tuberculata*, *Plethobasis cyphysus*, *Quadrula metanerva*, *Simsonaias ambigua*, *Tritogonia 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.

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

J.D. Jack[1], J.H. Thorp[2], and A.F. Casper[2]
[1]Dept. of Biology, Western Kentucky University, Bowling Green, KY 42101; [2]Large River Program, Dept. of Biology, University of Louisville, Louisville, KY 40292

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

Andrew F. Casper, R. Brent Summers, Tim Sellers, James H. Thorp, & James Alexander
Large River Program, Dept. of Biology, University of Louisville, Louisville, KY 40292

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.

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.

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-Êm 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 x 1014 and 2.4 x 1014 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 Êm in 1994 and 109.0 Êm in 1995. For both years, approximately 80% of veligers were between 95 and 135 Êm (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 Êm, growth rates of 6-13 Êm/day, a settling size of 180-250 Êm, 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.

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.

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

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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.

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

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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

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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 popilation 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.

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Mussel News from Missouri

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In September 1996, the Missouri Department of Conservation hired Sue Bruenderman to fill a newly-created malacologist position. First on the large slate of jobs to be done is a statewide survey to determine the current status and distribution of Missouri's mussel fauna. The survey will be conducted using a basin-by-basin approach, and the Meramec River basin in eastern MO has been selected as the first to be examined (to begin in spring 1997). Another task to be completed in the spring is a search for the federally endangered Curtis' pearly mussel, *Epioblasma florentina curtisi*. The last known remaining population occurs in the upper Little Black River (of the Current River) in southeastern Missouri. Biologists from the United States Fish and Wildlife Service (USFWS) and Southwest Missouri State University (SMSU) will help MDC biologists search for this endangered species. If gravid individuals are found, glochidia will be collected and used by Dr. Chris Barnhart for use in laboratory experiments to hopefully identify fish hosts of this species. Dr. Barnhart has been actively conducting fish host and *in vitro* culture work for the past several years. Increased cooperation between SMSU, MDC and the USFWS over the past year has led to some positive changes that we hope will result in a relatively stable funding base for mussel conservation work in Missouri for years to come.

Greg Cope Joins Toxicology Department at North Carolina State University

Greg Cope has joined the Department of Toxicology at North Carolina State University in Raleigh, North Carolina as the Department's Environmental and Extension Toxicologist. Greg will continue to conduct research related to the effects of anthropogenic stresses on aquatic organisms, with emphasis on fish and invertebrates, and the fate, bioavailability, and transport of contaminants in aquatic ecosystems. In addition, he will direct the Department's extension activities including county agent training and support, preparing extension-related literature, and conducting short courses and meetings. He will also be responsible for the College of Agricultural and Life Sciences's Agromedicine Program operated in conjunction with the Medical School at East Carolina University and other health-related organizations.

Greg has a Ph.D. with a Double Major in Toxicology and Fisheries Biology from Iowa State University, an M.S. in biology with emphasis in Aquatic Sciences from the University of Wisconsin-La Crosse, and a B.S. in Environmental Science from Lenoir-Rhyne College. He has worked as an ecotoxicologist at the U.S. Geological Survey's, Upper Mississippi Science Center in La Crosse, Wisconsin for the past six years conducting research on the effects of waterborne and sediment-associated contaminants on fish and invertebrates, assessing various toxicant and nontoxicant methods for controlling zebra mussels, and developing methods for preserving the biodiversity of native unionid mussels. His new address is Department of Toxicology, North Carolina State University, Box 7633, Raleigh, NC 27695-7633 (phone 919-515-5296; fax 919-515-7169; greg_cope@ncsu.edu).

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The upper Tennessee River NAWQA study unit will be concentrating our sampling efforts this spring and summer in the French Broad River system (North Carolina) including the Nolichucky (Tennessee). Sampling will be conducted with TVA's French Broad River Action Team (RAT) and will include fish, benthic macroinvertebrates (mollusks), algae, and water quality. Streams selected for sampling are as follows:

<u>French Broad River</u>
French Broad River (6 sites TN/NC)
Little River, NC
Davidson River, NC
Mud Creek, NC
Mills River, NC
Cane Creek, NC
Hominy Creek, NC
Swannanoa River, NC
Newfound Creek, NC
Reems Creek, NC
Sandymush Creek, NC
Ivy River, NC
Spring Creek, NC
Big Laurel Creek, NC

<u>Nolichucky River</u>
Nolichucky River (3 sites TN)
Bent Creek,TN
Lick Creek (2 sites TN)
Big Limestone Creek (3 sites TN)
Little Limestone Creek, TN
Little Chucky Creek, TN
Sinking Creek, TN
Richland Creek, TN
Camp Creek, TN

In Virginia, we will continue our sampling in the Guest River, Copper Creek, and Middle Fork Holston River.

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DIFFERENCES NOTED IN A DREISSENA POLYMORPHA POPULATION DURING A UNIONID MOLLUSK TRANSLOCATION FROM A MISSISSIPPI RIVER SIDE CHANNEL, MILE 725.8, WINONA, MINNESOTA/BUFFALO COUNTY, WISCONSIN.

A pre-project survey at the T.H. 43 bridge, Mississippi River, Winona, MN/Wisconsin yielded a mean density of 11 unionids/m^2 (14 species) at nine piers that were to be enlarged. Dreissena polymorpha (Pallas 1771) were less numerous than at La Crosse, Wisconsin, 30 miles downstream (Triannual Unionid Report No. 10), because this side channel did not have direct commercial navigation impacts. A mussel translocation from 3-17 September 1996 yielded 6117 unionids (23 species) at a mean density of 2.0/m^2. No federally listed unionids were found but 2% represented seven Minnesota and Wisconsin endangered, threatened and special status species. Most of 80 Obovaria olivaria (Rafinesque 1820) were juveniles. Ellipsaria lineolata (Rafinesque 1820) (1), Pleurobema sintoxia (Raf. 1820) (4), Ligumia recta (Lamarck 1819) (12), and Utterbackia imbecillis (Say 1829) (11), were also represented by juveniles. Other special status species were Arcidens confragosus (Say 1829) (2), and Megalonaias nervosa (Rafinesque 1820) (2). At Pier 1 a mat of D. polymorpha, 25-75 mm thick, carpeted the riprap, debris and mud substrata complicating recovery of 1371 unionids. Divers had difficulty determining if there were rocks or living unionids under the Dreissena. Although all special status species were at this site in depths up to 6 m, over 300 D. polymorpha were attached to most unionids Most unionids from Pier 1 were adults, but there were some juveniles. Overall the current was less than at La Crosse, WI. Many dead unionids were found, but few were fresh-dead. All visible D. polymorpha were removed by hand and both unionid valves were marked. The first Alasmidonta marginata Say 1818 (a threatened, small stream species) reported from the Minnesota portion of the Mississippi River since 1930 was found at the nearby translocation site which had a resident density of 4.0/m2 (2 other special status species were found on the first dive). Special status mussels were hand planted 15 m offshore in a longitudinal transect.

At Piers 2-9 about 50% of the unionids were under 3 years of age and less than 35 mm long. Recovery of juveniles was the result of careful searching in sand substrata. There were fewer exotics, but up to 60 D. polymorpha, from 1-5 mm in length representing the August-September 1996 cohort, covered most of many small unionids. These findings have profound implications for juvenile unionids. Depths at Piers 2-9 ranged from 5 cm, but averaged 3-5 m, with a substrata of sand, mud, and dead trees. This site was a prime example of a patchy unionid distribution. Preliminary survey results from 45-0.25 m^2 quadrats had indicated a population of 32,000 mussels, but fewer were recovered even though 3100 m^2 were searched twice. A few young Corbicula fluminea (Muller 1774) were also found, but they were not considered problematic at the site.

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Biodiversity of Freshwater Mussels in the Lower Great Lakes Drainage Basin

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Over the last 50 years, the freshwater mussel fauna of North America has been decimated. As a result, in the United States, mussels have been protected under endangered species legislation for many years. The U.S. Fish & Wildlife Service has drafted a national strategy for the conservation of native mussels, and recovery plans are in place for most endangered species. The plight of mussels in Canada has recently been recognized with the formation of the Mollusc Working Group (MWG) of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 1995. Since molluscs (which include mussels) are one of the most threatened groups, the MWG was formed to develop a national list of Canadian species at risk and to prepare status reports on these species. Two of the authors are members of the MWG, hence the impetus behind the project.

The study focused on the lower Great Lakes drainage basin because this area historically supported the most diverse mussel fauna in Canada (41 of the 53 Canadian species occur here and 22 are found only here). Recently, however, zebra mussels have virtually eliminated native mussels from the lakes themselves, leaving the rivers and streams as the last refuge for many species. The purpose of the project was to develop a computerized, GIS-linked database on the historical diversity of freshwater mussels in the study area in order to: develop biodiversity objectives for the various waterways, compare historical and recent data to determine if diversity is declining, identify the species most at risk and species-rich areas that should be protected, and identify data gaps. The database consists of data obtained from natural history museums within the basin, the primary literature, government reports, and university theses. Over 4000 records for 41 species of mussels collected from over 1500 sites between 1860 and 1996 have been entered to date. Each record represents the occurrence of a given species at a given site on a given date. The geographic distributions of the 41 species are a consequence of their post-glacial re-invasion routes; 36 species are southwestern in origin and only 5 are northeastern. Some species are widespread, but most have local distributions and this is significant because species with restricted ranges are very vulnerable.

Using the database, we attempted to derive biodiversity objectives for 10 waterbodies in the study area. The simplest objective is species richness which is the total number of species that a system has historically supported. The species richness objectives are as follows: Lake St. Clair & the Detroit River (33), Sydenham River (33), Thames River (32), Lake Erie (35), Grand River (34), Niagara/Welland Rivers (27), Lake Ontario (18), Moira River (16), Trent-Severn River (14), and Rideau River (13). Lake St. Clair and Lake Erie drainages historically supported a much more diverse mussel fauna than the Lake Ontario drainage (the last four waterbodies listed). All species have been found in the Lake Erie & Lake St. Clair drainage, but only 23 have been found in the Lake Ontario drainage. The database was also used to determine if species composition had changed over time. Data for the entire study area were divided into six time periods and examined for trends; the results showed that significant changes were beginning to take place around 1960. Major changes included a reverse in the order of dominance of the two most common species, with *Lampsilis siliquoidea*

accounting for the greatest proportion of the records prior to 1960 and *Pyganodon grandis* accounting for the most records after 1960. *L. siliquoidea* was found at 30% of the sites in both time periods. However, P. *grandis* was found at 16% of the sites before and 45% after 1960, so it appears to have become more common. Two other species of Anodontinae, *Strophitus undulatus* and *Lasmigona complanata* also became much more common after 1960. It has recently been shown that all three of these species move into areas that have become deforested, suggesting that they may be general indicators of degraded conditions. As a number of less common species appeared to have become more rare since 1960, the data for each waterbody were examined for evidence of species losses. We found that losses had occurred in waterbodies of the Lake St. Clair and Lake Erie drainages and in Lake Ontario itself, but there were no losses in the three river systems draining into Lake Ontario.

The Grand River is a large, well-studied tributary to Lake Erie with 900 unionid records available for the period 1885 to 1996. During this period, the structure of the mussel community changed from a community with a large number of well-represented species prior to 1960, to a community becoming increasingly dominated by fewer and fewer species and eventually resulting in a species loss of at least 30%. Eight species accounted for 50% of the records prior to 1960 vs. only six species in the period 1961-1983 and five species in the recent time period. Also, the community has become dominated by Anodontinae, i.e. *P. grandis, S. undulatus*, and *A. ferussacianus* ranked 7th , 18th, and 21st in dominance prior to 1960, 1st, 2nd, and 10th in the period 1961-1983 and 2nd, 7th and 1st in the period 1984 to 1996.

To identify the species that should be recommended to COSEWIC for national status designation, the following factors were taken into account: recognized conservation status in Ontario, Canada, and North America, evidence of decline in the study area, restricted range, host specificity, and vulnerability to current threats, especially zebra mussels. It should be noted that Ontario's Natural Heritage Information Center has ranked the species in our study area, but have used only a subset of the data we now have available. Based on these considerations, the following species were deemed to be most at risk (threatened, endangered, or extirpated) and are proposed for consideration by COSEWIC: *Cyclonaias tuberculata, Ligumia nasuta, Obovaria subrotunda, Pleurobema coccineum, Truncilla donaciformis, Utterbackia imbecillis,* and *Villosa fabalis.* Several other species already presumed extirpated from Canada include: *Epioblasma obliquata obliquata, Epioblasma triquetra, Epioblasma torulosa rangiana, Obliquaria reflexa, Obovaria olivaria, Simpsonaias ambigua,* and *Toxolasma parvus.*

The mussel database provides the most complete picture possible of the historical distributions of mussels in the lower Great Lakes drainage basin and will be used as a resource to support the activities of the Mollusc Working Group of COSEWIC. This year we plan to focus our efforts on additional surveys at high diversity sites where priority species were found in the past. This information will be used to refine the conservation status rankings of species and to identify waterways in need of protection or rehabilitation.

The authors would like to thank Environment Canada's Ecological Monitoring Coordinating Office and Great Lakes 2000 Program for their financial support. We would also like to thank the curators of the following museums for their willing contributions to our project: Canadian Museum of Nature, Ohio State University Museum of Zoology, Royal Ontario Museum, University of Michigan Museum of Zoology, Buffalo Museum of Science, and the Rochester Museum and Science Center. A special thanks also goes out to the several biologists of the Ontario Ministry of Natural Resources who contributed to our project.

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Interim report on a resurvey of the unionids of the upper Susquehanna basin in New York

Between 1955 and 1965, Arthur Clarke, Willard Harman, and Carol Stein surveyed the unionid communities at about 70 sites in the Susquehanna basin in New York. We are resurveying these sites and trying to correlate patterns of faunal change with water quality and land use. Because of unusually rainy weather, we were able to resurvey only 47 sites in 1996; the remaining sites will be examined in 1997.

Unionids are extremely patchy at most sites; it was not uncommon for us to spend over half an hour before finding our first living unionid. Nonetheless, faunas appear to have been very stable since 1955-65, with few changes in species lists at any site (see table below). Exceptions to this general statement are *Alasmidonta varicosa*, which seems to be declining in the upper Susquehanna basin, and possibly *Lasmigona subviridis*, which may show a decline in distribution.

Species	**Number of sites (1955-65)**	**Number of sites (1996)[a]**	**Number of living specimens (1996)**
Elliptio complanata	29	25	807
Lasmigona compressa	3	0	0
Lasmigona subviridis	6	3	7
Anodontoides ferussacianus	2	1	1
Pyganodon cataracta	16	11	41
Alasmidonta undulata	16	15	55
Alasmidonta marginata	14	12	101
Alasmidonta varicosa	12	3	19
Strophitus undulatus	22	22	238
Lampsilis radiata	11	13	105
Lampsilis cariosa	14	20	108

[a]includes living or freshly dead shells only

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THE NATIONAL NONINDIGENOUS AQUATIC SPECIES GEOGRAPHIC INFORMATION SYSTEM

Nonindigenous aquatic species have been and continue to be a major source of socio-economic benefits and costs to many sectors of American society and a significant threat to the maintenance of biological diversity. Despite this significance, nonindigenous species issues in general have been vastly under-recognized. Primarily in response to the introduction of zebra mussels into the Great Lakes, Congress enacted the Nonindigenous Aquatic Species Prevention and Control Act of 1990 (Act). The major focus of the Act was to set up a framework to reduce the risk of unintentional introductions and to monitor and control nonindigenous aquatic nuisance species. A core element of this framework was to create an Information Service to provide timely, reliable data about the presence and distribution of nonindigenous aquatic species.

In 1993, The National Nonindigenous Aquatic Species Geographic Information System was established at the USGS, Biological Resources Division research facility in Gainesville, Florida. This public access information system includes maps, fact sheets, data sets, general and scientific reports, and other related information regarding aquatic introductions reported since 1850. The current on-line data base contains over 35,000 geographically referenced accounts of over 680 species of fish, mammals, amphibians, reptiles, tunicates, bryozoans, sponges, coelenterates, annelids, mollusks, crustaceans, algae, ferns, monocot and dicot plants, diseases, and parasites. This service is routinely used by Department of Interior Bureaus, NOAA, Department of Agriculture, state agencies, universities, and numerous U.S. and Canadian private industries to monitor the distribution of these organisms and to enable regional and national assessments of important species for management and control. It has also been recognized as the model system for developing a joint US/Canada/Mexico system under the auspices of the North American Free Trade Agreement (NAFTA).

General accessibility is provided through a world-wide-web site (http://www.nfrcg.gov/nas) which was a pioneer in data serving on the internet. The information content and format has earned the site a `4-star' rating by the Magellan Internet Guide and was recognized by Discovery Communications, Inc., parent company of Discovery Channel and The Learning Channel who featured the site *twice* during the past 2 years. To date the site has been accessed by nearly 70,000 *unique users* from around the globe. Site content has been used within a variety of other information products including a CD-ROM demonstrating advanced capabilities of the Internet, school and university teaching aids (Canadian and U.S), and the new USGS Digital Atlas.

Additional services are provided by research staff who serve as a central contacts for national aquatic nuisance species information. Informal networks of regional and state contacts are maintained to encourage information exchange and bring new understanding to nonindigenous aquatic species issues. Radio and television interviews, extension service satellite teleconferences, scientific presentations and demonstrations, press releases, popular articles, reference books, map products, fact sheets, and scientific publications are all products prepared by the staff to provide broad-spectrum outreach and public service for this recognized information need.

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On- Site Cleaning of Zebra Mussels from Unionids on Lewis Creek Delta Lake Champlain

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The Lake Champlain Basin supports the most diverse freshwater mussel fauna in New England (14 species). Eight species are at or near their northeastern range limits in the drainage, of these, none are common in Vermont.
In 1993 the exotic zebra mussel (Dreissena polymorpha) was discovered in Lake Champlain. The zebra mussel poses a very serious threat to the native unionid populations of Lake Champlain. By the summer of 1995 Dreissenid infestations were already causing significant native unionid mortality in southern Lake Champlain.

The greatest immediate threat is to those species that are found only in the Lake Champlain drainage, there are seven species - Potamilus alatus, Leptodea fragilis, Ligumia recta, Lampsilis ovata, Lasmigona costata, Anodontoides ferussianus and Pyganodon grandis.

Lewis Creek delta supports a diverse and dense mussel population, that has recently become heavily colonized by zebra mussels. In the summer of 1995 native unionids had 1 - 6 zebra mussels attached to their shells, by the summer of 1996 attachment had increased to 40 - 100 zebra mussels per native unionid.

In an effort to conserve a small but diverse population of native unionids in the Lewis Creek delta a 60 meter by 30 meter area was designated for physically removing zebra mussels from the native unionids. Scuba divers working inside the designated area removed native unionids from the substrate, rubbed off the zebra mussels; crushing as many as possible in the process and replaced the native unionids into the substrate.

Rare native unionids encountered by scuba divers inside the designated area and outside the area by snorkelers (Leptodea fragilis, Potamilus alatus, Lampsilis ovata, and Pyganodon grandis) were collected, cleaned of zebra mussels and placed into a 5 meter by 10 meter area near the mouth of Lewis Creek for potential relocation next year. Between 100 and 150 rare native unionids were collected, cleaned and placed into the 5 by 10 meter area.

The effort to clean all native unionids inside the 30m by 60m area was impressive, but the size was a little more than the half dozen SCUBA divers could manage in one days effort.
The following week, survey work was conducted inside and outside the maintained area to document zebra mussel attachment on the native unionids.

Results indicate that there had been some re-attachment of zebra mussels that had been removed from native unionids inside the maintained, presumably some clumps of zebra mussels that had been rubbed off the natives but not crushed had reattached to the native unionids inside the maintained area.

Work will be conducted in the summer of 1997 to document the survival of native unionids inside and outside of the maintained area; and zebra mussel attachment to native unionids.
Future efforts to conserve native unionids most likely will focus on collecting and relocating as many rare native unionids from sites threatened by heavy Dressenid infestations.

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Freshwater Mussels in Missouri's Bootheel: Rediscovery of the Fat Pocketbook Mussel in Missouri.

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The lowlands of southeastern Missouri were once a vast, wooded flood plain, watered by the Mississippi, St. Francis, and Castor rivers. Since the turn of the century, enormous drainage and deforestation projects have converted the region to agriculture. Although the destruction of natural landscapes in the Bootheel is nearly complete, a surprisingly diverse aquatic fauna exists in the hundreds of miles of man-made waterways, including numbers of freshwater mussels (Unionidae).

We surveyed unionid mussels in the waterways of Dunklin and Pemiscott Counties in summer of 1996. Objectives were to determine diversity and abundance of unionids, and, in particular, to investigate the possible presence of the federally endangered fat pocketbook mussel, *Potamilus capax*. A total of 114 man-hours was spent in searching at 71 sites. A total of 1,708 individual live mussels of 28 species was examined. The ten most abundant species, in order of abundance, were *Amblema plicata, Potamilus purpuratus, Quadrula nodulata, Pyganondon grandis, Quadrula pustulosa, Quadrula quadrula, Leptodea fragilis, Lampsilis cardium, Lampsilis teres,* and *Obliquaria reflexa.*

Twenty-four living individuals of *Potamilus capax* were found along a 3-mile stretch of the Belle Fountain Ditch in southern Dunklin County. Significantly, 3 of these individuals were less than 3 years of age, indicating that the population is reproducing. Mussels are relatively long-lived and juveniles are often rare. Relatively large numbers of juveniles of other species were noted as well. Despite the effects of intense agriculture and periodic dredging impacting these waterways, it appears that they provide good habitat for a number of mussel species.

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Reproduction and Fish Hosts of the Fat Pocketbook Mussel, *Potamilus capax.*

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Recent mussel surveys in southeast Missouri permitted investigation of the reproduction of the federally endangered fat pocketbook mussel. A total of 22 adult individuals were examined in the Belle Fountain waterway in Dunklin County, MO. Two of six individuals were gravid with mature glochidia on June 6-20. No further observations were made until August 13-22, at which time none of 16 individuals examined was gravid. Evidently, glochidia were released in July or August.

Twenty-eight species of fish were tested as possible hosts of the parasitic glochidia larvae. Glochidia successfully transformed to juveniles only on freshwater drum (*Aplodinotus grunniens*). Glochidia remained encysted for several days on white crappie (*Pomoxis annularis*) but died within the cysts without transformation. Other fish species tested generally shed attached glochidia within 24 hours. Preliminary attempts to culture the glochidia *in vitro* were unsuccessful.

Metamorphosis from glochidium to juvenile was completed in 15-26 days at 21 C, with the peak of excystment at 20 days post-infection. Unlike most mussel species, the glochidia of *Potamilus* grow substantially during encystment. Shell length (anterior-posterior) of *P. capax* increased from 95 micrometers in glochidia to 334 micrometers in recently excysted juveniles (means of 5 individuals).

This study supports previous evidence that drum may be the primary natural host of *Potamilus capax* (Cummings & Mayer 1993). At least twelve other mussel species are also known to utilize drum as a host, including all members of the genus *Potamilus* that have been investigated (Watters 1994).

Literature Cited:

- Cummings, K.S. and C. Mayer 1993. Distribution and host species of the federally endangered freshwater mussel, *Potamilus capax* (Greene 1832), in the lower Wabash River, Illinois and Indiana. Illinois Natural History Survey Center for Biodiversity Technical Report 1993(1):1-29.
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Sterile Eggs in Unionid Mussels and Their Roles in Conglutinate Function.

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Unfertilized or infertile eggs have been reported in a number of unionid species (Howard 1914). These undeveloped eggs have sometimes been interpreted as a failure of fertilization due to low population density and shortage of sperm (Downing et al. 1993). However, little attention has been given to the fact that, in many unionids, a large fraction of eggs normally do not develop, regardless of the availability of sperm. These sterile eggs occur in species that release cohesive masses (conglutinates) of sterile eggs and glochidia larvae. Conglutinates attract host fish, which then become infected with the parasitic glochidia larvae while attempting to ingest the conglutinates.

Sterile eggs appear to enhance conglutinate function in several ways. For example, in *Fusconaia, Pleurobema,* and *Cyprogenia*, sterile eggs provide color and opacity to conglutinates and thereby render them more visible to hosts. Mature eggs bearing glochidia are transparent. In *Cyprogenia aberti*, sterile eggs comprise up to 85% of the conglutinate total and serve a structural role by providing a tough and elastic support upon which the developed glochidia are arrayed in a superficial layer. This support increases handling time by the host fish and ensures that the glochidia are easily shed when the conglutinate is bitten. Although evidence is scant, it appears that sterile eggs may also make conglutinates more attractive to the host through taste and scent.

Improved rates of host fish infection by conglutinates bearing sterile eggs presumably offset the consequent reduction in the number of larvae that are produced. The mechanisms that are responsible for the production and orderly placement of sterile eggs within the conglutinates are unknown. (Abstract submitted for 1997 annual meeting, North American Benthological Society.)

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- Howard, A.D. 1914. Experiments in propagation of freshwater mussels of the *Quadrula* group. Bureau of Fisheries Document 801:1-51.

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Current Research Projects

Relationship between stream discharge and mussel recruitment. Dina J. Crawford, James B. Layzer, and Lesa M. Madison.

Reintroduction of freshwater mussels into the Tennessee River and its major tributaries (start: July 1997). Natalie Constantino and James B. Layzer.

The relation between mussel density and survival during quarantine. Robert D. Quinn and James B. Layzer.

Feasibility of reestablishing populations of eight federally listed mussel species and two federally listed fish species into Shoal Creek, Alabama and Tennessee. Lesa M. Madison and James B. Layzer.

Maintenance and production of Ohio River mussels. Jason R. Khym and James B. Layzer.

Zebra mussel impacts on unionids. Lesa M. Madison and James B. Layzer.

Survival and Growth of Hatchery-reared Juvenile *Lampsilis cardium*

Olivia J. Westbrook and James B. Layzer

In April 1996, 64 fish of three known host species were infested with glochidia of *L. cardium*; 5 fish were held in laboratory aquaria and the remaining fish were released into a raceway at the Minor E. Clark Fish Hatchery. Juvenile mussels produced in the laboratory were transferred to petri dishes filled with substrate and suspended in a wire cage in the raceway. Survival was assessed at 60, 90 and 120 days by removing one or two petri dishes and examining the contents under a dissecting microscope (10X). Survival declined from 17% at 60 days to 3.5% at 120 days; however, mean length increased from 1.88 mm to 18.2 mm during this same period. Results of quantitative sampling in October indicated a juvenile density of 12.1/m^2 in the raceway. Mean length of juveniles in the raceway was 21.5 mm.

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Long-Term Holding of Mussels in Captivity

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In 1994 we began to establish captive populations of unionids. As of December 1997, we are holding 7,017 mussels of 36 species at several locations in Tennessee and Kentucky. Some of these species are being held primarily for propagation studies.

Table 1. Numbers and Species of Mussels in Captivity

Species	Number	Species	Number
Actinonaias ligamentina	175	*Megalonaias nervosa*	115
Amblema plicata	554	*Obliquaria reflexa*	223
Arcidens confragosus	5	*Obovaia olivaria*	8
Cyclonaias tuberculata	251	*Plethobasus cooperianus*	5
Ellipsaria lineolata	126	*Pleurobema coccineum*	45
Elliptio crassidens	5	*Pleurobema cordatum*	336
Elliptio dilalata	385	*Pleurobema pyramidatum*	10
Epioblasma capsaeformis	20	*Potamilus alatus*	23
Fusconaia barnesiana	6	*Ptychobranchus fasciolaris*	130
Fusconaia ebena	3,725	*Quadrula cylindrica*	1
Fusconaia flava	143	*Quadrula metanevra*	60
Lampsilis cardium	11	*Quadrula nodulata*	146
Lampsilis fasciola	6	*Quadrula pustulosa*	272
Lampsilis siliquoidea	13	*Quadrula quadrula*	25
Lasmigona costata	39	*Tritogonia verrucosa*	86
Leptodea fragilis	8	*Truncilla truncata*	5
Lexingtonia dolabelloides	42	*Villosa taeniata*	4
Ligumia recta	6	*Villosa vanuxemensis*	3

(25)

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Arthur E. Bogan, former Director of Freshwater Molluscan Research, Sewell, NJ has accepted the position of Curator of Aquatic Invertebrates at the North Carolina State Museum of Natural Sciences in Raleigh. He arrived 1 January, 1997, and will continue working on the systematics and zoogeography of freshwater bivalves, participating in workshops on freshwater mollusks, developing a morphological phylogeny of unionoid bivalves, and will begin to enhance the NCSM freshwater molluscan collections. The NCSM is in the process of building a new museum, with new exhibits due to open in 1999. The museum is also constructing a new collections and research facility. Since his arrival, he together with the Wayne Starnes, Curator of Fishes, completed the movement of the Institute of Marine Sciences Mollusk collection from Morehead City, NC to Raleigh. Hugh Porter built this collection, which contains about 12,000 lots of marine and brackish water mollusks with a healthy representation of freshwater mollusks.

AN ABSTRACT OF A THESIS

THE RELATIONS BETWEEN COMPLEX HYDRAULICS AND MUSSEL DENSITY

Bart S. Hardison

Master of Science in Biology

The hydraulic conditions that are most relevant in determining mussel distribution are those that characterize flows near the substrate, because adult and juvenile mussels live in the substrate and excysting juveniles must settle onto the stream bottom. A stratified random sampling design was used to examine the relations between selected hydraulic variables and the density of mussels in the Green, Licking, and Rough Rivers of Kentucky. Strata were positioned to ensure that samples were collected over a wide range of hydraulic conditions at each site. Eight 0.25 m^2 quadrat samples were collected from each 25 m^2 stratum. Before collecting each sample, mean water column velocity, depth, and substrate roughness were measured in each quadrat. 'Fliesswasserstammtisch' hemispheres were used to estimate shear stress. Substrate roughness was positively correlated with mussel density for the Rough River. Depth was positively correlated with mussel density in the Green River, negatively correlated in the Rough River, and was not significantly correlated in the Licking River. Mean water column velocity, Froude number, shear velocity, and Hemisphere density were negatively correlated with mussel density for all rivers. Although mean water velocity was significantly correlated with mussel density, the relations between complex hydraulic variables (especially shear velocity and hemisphere density) and mussel density had higher correlation coefficients. Therefore, shear velocity and hemisphere density may be more useful for predicting the distributions of freshwater mussels.

AN ABSTRACT OF A THESIS

AGE, GROWTH, AND STABILITY OF A MUSSEL ASSEMBLAGE IN HORSE LICK CREEK, KENTUCKY

Bradley S. Houslet

Master of Science in Biology

During the past 15 years, several studies have documented mussel distributions in Horse Lick Creek and how strip mining of coal in the lower watershed reduced the distributions of many species. Recent data indicated that mussel length in the lower portion of the creek were significantly less than those upstream of mine run-off. Forty-three *Villosa taeniata* were collected at one site in the upper portion and 46 at one site in the lower portion to determine if the difference in mussel size was related to differences in growth or was indicative of colonization following possible post-mining improvements in water quality. Ages determined from thin-sections ranged from 11 to 27 years at the lower site, and from 6 to 44 years at the upper site. Length was highly correlated with age at the upper site but there was no significant correlation between these variables at the lower site. Results of analysis of covariance indicated that increases in width, height, and mass of shells per incremental increase in length were similar between sites. Tissue dry mass was 67% greater at the upper site. Apparently, mussels at the lower site were still being affected by the residual effects of strip-mining of coal. At the lower site, the lack of young (<11 yrs) and old (>27 yrs) mussels, their poor condition and lower density likely reflects the residual effects of past strip-mining.

Community stability of the upper site musselbed in Horse Lick Creek, Kentucky, was assessed by comparing total mussel density, length frequency distributions, and relative abundance data with data collected in 1990 and 1991. Total mussel density increased from 4.88 mussels/ m^2 in 1991 to 9.04 mussels/ m^2 in 1995. However, juvenile density decreased from one juvenile in 4.3 m^2 to one juvenile in 10 m^2. Relative abundance remained unchanged or increased for 8 of 14 species, including an endangered mussel *Pegias fabula*. Although relative abundance decreased for three species, these were species considered rare (< 1% of the assemblage) and are thus more likely influenced by differences in normal sampling variance than actual causal effects of natural or anthropogenic perturbations. Average length decreased for 11 species, while minimum and maximum lengths of five species increased. The mussel community sampled in 1995 was 95.9% similar to the community sampled in 1990. Analyses of length frequency distributions and aging suggest that mussel populations do not necessarily need high annual reproductive success to maintain a stable population. The long-lived nature of *Villosa taeniata* and irregular length frequency distributions suggest that this particular musselbed is demonstrating regular stability.

AN ABSTRACT OF A THESIS

REPRODUCTIVE ECOLOGY OF TWO SPECIES OF FRESHWATER MUSSELS IN TENNESSEE

Jackie R. Heinricher

Master of Science in Biology

The reproductive biology and age at sexual maturity were determined for *Fusconaia ebena* (Lea 1831) in Kentucky Lake, Tennessee, for a period of one year beginning October 1993. *Fucsconaia ebena* is a short-term brooder (tachyticic) and is dioecious. Spawning began in April and continued into mid-August. Gonadal acitivity increased in the spring with increased water temperatures; the least amount of gonadal activity occurring during the winter months. Sex ratio of the sample population was 1:1. Only one of the 326 individuals examined histologically, was found to be a hermaphrodite. This hermaphrodite was considered to be functionally male with a majority of the gonadal tissue involved in spermatogenesis. Gonadal tissue color was dimorphic during the spawning season: testes were fleshtone, while ovaries ranged from pink to dark purple. Thin-sectioning shells of *F. ebena* was a successful technique for accurately obtaining the ages of individuals of various sizes. Ninety-six percent agreement was reached in a double-blind reading of 53 thin-sections. Sagital sectioning of the hinge ligament was also a successful and efficient method for determining the age of *F. ebena*. Shell growth was determined to be annular for *F. ebena* with one new growth line occurring in April. *Fusconaia ebena* becomes sexually differentiated by age four. By age five *F. ebena* becomes sexually mature and begins active gametogenesis. Ages of the sample population ranged from two to eleven years. Retention of coded wire tags injected into the hinge ligament was 100% over a two year period. These tags are potentially an effective tool for enforcement and research purposes.

Reproduction of *Megalonaias nervosa* (Rafinesque 1820) has not been documented for over 20 years in much of the Cumberland River, where water temperature and flow regimes have been greatly altered by hypolimnetic discharges from impoundments. Studies in other streams have implicated altered temperature or discharge patterns as causative factors inhibiting reproduction. *Megalonaias nervosa* were collected from the Cumberland River, translocated to the Tennessee River, and held in an embayment of Kentucky Lake. After the first and second year, samples of *M. nervosa* were taken from the Cumberland River, an existing population in Kentucky Lake, and the translocated group. Histological examination indicated that translocated mussels had a high incidence of hermaphroditism, and like mussels originating in Kentucky Lake, had undergone an otherwise normal reproductive development. Individuals functioning successfully as females from the translocated group had mature glochidia in their marsupia. Females from the Kentucky Lake

sample also had mature glochidia present. In contrast, there was no indication of reproductive activity in gonads or marsupia of individuals collected from the Cumberland River. These results suggest that the more natural temperature regime in Kentucky Lake reinstated reproduction in translocated mussels. This study suggests that the altered temperature regime may be disrupting the gametogenic cycle of all mussels including at least six federally-listed endangered species occurring in the Cumberland River. These relic populations will likely disappear unless they are translocated or the thermal regime returned to normal.

AN ABSTRACT OF A THESIS

FEASIBILITY OF REINTRODUCING FRESHWATER MUSSELS INTO SHOAL CREEK, ALABAMA AND TENNESSEE

Annette Morgan

Master of Science in Biology

In 1991, a study was initiated to evaluate Shoal Creek as a possible location for reestablishing freshwater mussels. About 20 years earlier, nearly all mussels were extirpated from the creek by pollution. Shoal Creek may now provide a unique opportunity for reintroducing several rare mussels because of substantial improvements in water quality. Between 1992 and 1996, 29 species of mussels were introduced: 5,957 adults of 26 species, 7,472 juveniles of two species, and an estimated 15,000 juveniles of one species by infesting 174 host fish with glochidia and releasing them into the creek. During two qualitative searches, many of the located adult mussels had been transported downstream as much as 1.3 km during high flows. No glochidial infestations were detected on 2,365 fish, collected in 1995 and 1996, at the introduction sites.

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Wally Holznagel, Kevin Roe, and I have a number of ongoing studies examining the conservation genetics and systematics of freshwater molluscs. Available reprints are listed below:

Lydeard, C., and R. L. Mayden. 1995. A diverse and endangered aquatic ecosystem of the Southeast United States. Conservation Biology 9:800-805.

Lydeard. C. 1996. U.S. Biodiversity Status Report. Conservation Biology 10:1480-1482.

Lydeard, C., M. Mulvey, and G. M. Davis. 1996. Molecular systematics and evolution of reproductive traits of North American freshwater unionacean mussels (Mollusca: Bivalvia) as inferred from 16S rRNA gene sequences. Phil. Trans. R. Soc. Lond. B 351:1593-1603.

Lydeard, C. W. E. Holznagel, J. Garner, P. Hartfield, and J. Malcolm Pierson. 1997. A molecular phylogeny of Mobile River drainage basin pleurocerid snails (Caenogastropoda: Cerithioidea). Molecular Phyl. Evol. 7:117-128.

TAXONOMIC STATUS OF WESTERN LILLIPUT (*Toxolasma mearnsi*)

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Freshwater mussels of the genus Toxolasma, represent a unique, but taxonomically perplexing group. Intraspecific variability and interspecific similarity make classification difficult. At present, three species are recognized in Texas: lilliput, *T. parvus* (Barnes 1823); Texas lilliput, *T. texasensis* (Lea 1857); and western lilliput, *T. mearnsi* (Simpson 1900). In the past, both *texasensis* and *mearnsi* have been given as subspecies of *T. parvus* (Strecker 1931). Currently the American Fisheries Society (Turgeon et al. 1988) lists all three as valid species. However, similarity between *T. texasensis* and *T. mearnsi* has led some to question the validity of the latter and Howells et al. (1996) did not distinguish between them. During statewide surveys of freshwater mussel populations by Texas Parks and Wildlife Department's Heart of the Hills Research Station 1992-1995, tissue samples from all three lilliputs were obtained for subsequent electrophoretic examination. Horizontal starch gel electrophoresis following the methods, buffers, and enzyme designations of Morizot and Schmidt (1990) was used. Specimens of *T. parvus* from Falcon Reservoir on the Rio Grande, *T. mearnsi* from the Nueces-Frio System, and *T. texasensis* from the Colorado, Brazos, Angelina, and Buffalo Bayou Systems were examined (Table 1). Results indicated *T. parvus* from the Rio Grande possessed several unique or rarely-shared alleles which designate it as different from *T. mearnsi* and *T. texasensis*. However, none of the enzyme-system loci examined produced alleles unique to *T. mearnsi*; it and *T. texasensis* were distinguishable electrophoretically. Unfortunately the *T. parvus* specimens examined were from the extreme southwestern limit of its range; other populations further to the northeast or from the Mississippi River valley need to be examined. Further, a freezer malfunction resulted in the loss of the original tissue samples and a drought in 1996 confunded ability to obtain additional *T. parvus* specimens. Although the numbers of specimens and enzyme systems examined has been limited, these preliminary data suggest *T. parvus* and *T. texasensis* are clearly distinct, but *T. mearnsi* has yet to display genetic differences to distinguish it from *T. texasensis*. If the genetic patterns seen here are maintained at other loci and among other populations, it would be difficult to justify maintaining *T. mearnsi* as a distinct species.

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Strecker, J. 1931. The distribution of the naiades or pearly fresh-water mussels of Texas. Baylor University Museum Bulletin 2, Waco.

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Table 1. Results of horizontal starch gel electrophoresis used to examine specimens of *Toxolasma* at Heart of the Hills Research Station 1994-1995. Allele frequencies represent percentage of migration distance based upon the most common allele for *T. texasensis*.

			Allele Frequency by Enzyme System								
Species	Water Body (Drainage Basin)	N	TPI (-)	GPI (TEB)	GPI (TC)	MDH	ME	IDH	HK	PGM	SOD
parvus	Falcon Reservoir (Rio Grande)	4	90	95	95	90	-	-	-	-	-
mearnsi	San Miguel Creek (Frio River)	4	100	100	100	100	100	100	100	100	100
mearnsi	L. Corpus Christi (Nueces River)	4	100	100	100	100 95 90	100 95	100	100	100	100
texasensis	Giddings Lake (Colorado River)	6	100	100	100	100 95 90	100 95 90	100	100	100	100
texasensis	L. Nacogdoches (Angelina River)	1	100	100	100	100	100	100	100	100	100
texasensis	Flat Bank Creek (Brazos River)	1	100	100	100	100	100	100	100	100	100
texasensis	Buffalo Bayou	1	100	100	100	100	100	100	100	100	100

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Success Story on Bridge Replacement in Virginia

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The Virginia Department of Transportation (VDOT) proposed replacement of the Route 40 bridge over the Nottoway River, Nottoway/Lunenburg counties, Virginia in 1993. Because the Nottoway River is home to the federally endangered dwarf wedgemussel (Alasmidonta heterodon), a mussel survey was requested by the U.S. Fish and Wildlife Service (FWS) in September 1993, from 200 m upstream to 800 m downstream of the existing bridge. This piedmont river is characterized by slow flow, 15-20 m width, and sand substratum at the bridge site. Five dwarf wedgemussels were collected during the survey in 1993; hence, FWS issued a Biological Opinion in July 1994, placing several requirements on VDOT to ensure protection of the endangered dwarf wedgemussel. Two of the requirements included: 1) the removal of all dwarf wedgemussels and other mussel species each year from the construction area (40 m upstream to 40 m downstream), and 2) a resurvey of the 1000 m each year during and after construction to record possible changes in the unionid assemblage resulting from the project. In September, 1994 and 1995, mussel surveys were conducted during bridge replacement, and again in September 1996 following completion of the project. Thus, 4 years of survey data were collected to compare pre- and post-construction impacts as well as impacts to unionids during the bridge replacement.

Results of these surveys documented the presence of 8 unionid species, and compared number of live mussels collected per hour, or catch-per-unit-effort (CPUE), and species richness among years. Overall, the abundance of mussels and species composition did not change appreciably among sampled river reaches (upstream, downstream) and years. CPUE among years was nearly identical (Table 1). The apparent increase in mussel abundance in 1996 was attributed to a more experienced survey crew in the downstream reach (lower 800 m). Presence of the endangered dwarf wedgemussel in various reaches during 1994-1996 indicated that its occurrence at the site had not changed during the project period. The comparability of CPUE among years, continuous presence of dwarf wedgemussels, and limited habitat disturbance in the survey reach indicated that environmental safeguards were effectively maintained on this project. Thus, this study demonstrated that a bridge replacement project can be compatible with unionid conservation, at least in piedmont rivers. I attribute the success of this project to planning and cooperation between VDOT and FWS, adequate environmental safeguards (erosion and silt control structures, etc.), scrutiny by the VDOT project inspector, and adherence to contract requirements by the construction firm. Kudos to VDOT and the construction firm for maintaining the biological integrity of this reach of the Nottoway River.

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Table 1. Summary of total number of mussels and sampling effort at the Route 40 bridge crossing, 1993 - 1996.

Year	Number of Mussels	Effort (man-hr)	CPUE
1993	724	29.0	25
1994	1273	54.5	23
1995	973	37.7	26
1996	1122	27.9	40

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Commercial Musseling: In August 1996, the Tennessee Wildlife Resources Commission (TWRC) voted to remove three species (*Cyclonaias tuberculata, Quadrula pustulosa and Quadrula nodulata*) from the TWRA list of commercially harvestable mussels. This action was taken after two years of documented incidental harvest of the federally endangered orange-foot pimpleback mussel *(Plethobasus cooperianus)*. Between 1994 and 1995, seven *P. cooperianus* (five fresh dead, two live) were taken from musselers working the Kentucky Reservoir reach of the Tennessee River in Perry and Hardin counties, TN; or from shell containers at Borden's Shell Co., Crump, Hardin Co.,TN. Although this action posed no significant economic burden on the mussel harvesters or buyers, considerable opposition was encountered from some shell companies who feared further restrictions might follow. However, faced with the choice of closing all commercial mussel harvest within the historical range of *P. cooperianus* or possibly having the three similar species listed as endangered based on their similarity of appearance, the TWRC removed them from the list of commercially harvestable species.

In 1995, Tennessee mussel buyers reported purchasing 3,881 tons of shell form State waters worth an estimated $14.7 million (wholesale). Then, after more than ten years of increasing demand and prices, Tennessee's commercial shell industry experienced a declining market in 1996. Wholesale shell prices began falling in March 1996 and continued to drop through the fourth quarter, some shell prices dropped as much as 76%. In October, some companies stopped buying shells and by mid-January 1997, none were purchasing from local harvesters. Shell company representatives blame diseased oyster beds in Japan, Chinese competition and altered jewelry consumer purchases for the current depressed market for U.S. mussel shells. They also expect total U.S. mussel shell exports to be 60 to 70 % lower in 1997 than 1996, when approximately 4,500 tons were shipped. The current market condition is expected to extend through 1997 and possibly 1998. Regardless of the cause for the decline, Tennessee's commercial mussel stocks could benefit from reduced harvest pressure. Recent survey data on Kentucky Reservoir indicate that 98% of some commercial mussel populations are under legal size limits (Hubbs and Jones 1995).

Hubbs, D. and A. Jones. 1995. 1995 Statewide commercial mussel report. Tennessee Wildlife Resources Agency, Fish Management, Nashville, Tennessee. Report Number 96-15. 49p.

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1. New publication

Watters, G.T. & S.H. O'Dee. 1996. Shedding of untransformed glochidia by fishes parasitized by *Lampsilis fasciola* Rafinesque, 1820 (Mollusca: Bivalvia: Unionidae): evidence of acquired immunity in the field? *Journal of Freshwater Ecology* 11: 383-389.

ABSTRACT - Fifteen fish species were exposed to glochidia from the freshwater mussel *Lampsilis fasciola.* Mussels and fishes were collected in the Big Darby Creek system in Ohio. All fishes began shedding untransformed glochidia within 24 hrs of exposure and continued for approximately eight days. On Day 19, after two weeks of inactivity, rosefin shiner began to shed numerous untransformed glochidia again. This release lasted 24 days. Rainbow darter began shedding untransformed glochidia on Day 25 and continued to do so for 14 days. No transformation occurred on either fish species. We believe this reaction was due to an acquired immunity and may represent the first report of this phenomenon in wild-caught fishes.

2. Surrogate hosts: transformation on exotic and non-piscine hosts

As part of a search for surrogate hosts, funded by the Ohio Chapter of The Nature Conservancy, the following hosts were identified for *Lampsilis cardium* and *Utterbackia imbecillis.*

Lampsilis cardium

Painted sword	Panchax killifish	Guppy
Lavender gourami	Flame gourami	Siamese fighting fish
Larval tiger salamander		

Utterbackia imbecillis

Zebra Malawi cichlid	Marbled cichlid	Peacock cichlid
Angelfish	Giant danio	Goldfish
Blue danio	Golden barb	Brilliant rasbora
Red-eye tetra	Von Rio tetra	Silver tip tetra
Glowlight tetra	Silver dollar	Panchax killifish
Painted sword	Guppy	Lavender gourami
Pearl gourami	Flame gourami	Siamese fighting fish
Australian rainbow fish	Black loach	Pangasius catfish
Chinese algae-eater	Glass knifefish	Northern leopard frog (tadpole)
Bullfrog (tadpole)	African clawed frog (adult)	Larval tiger salamander

3. Prolong™ and glochidial transformation

Prolong ™ (Argent Chemicals) is a commonly administered product for reducing stress and removing parasites from fishes. We found that at the recommended dosage, the medication did not affect encysted glochidia, or delay or decrease transformation. Largemouth bass and *Lampsilis cardium* were the test subjects.

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AN UPDATE ON THE STATUS OF THE ROCK POCKETBOOK, *Arcidens confragosus* (SAY, 1829), IN THE MARAIS DES CYGNES AND OSAGE RIVER DRAINAGES IN KANSAS

Published accounts of the occurrence of *Arcidens confragosus* in Kansas are as sparse as the species itself. Reference is often made to the 1962 Kansas Unionid book by Murray and Leonard which indicates its presence in the state. In the 35 years since this book was written, shells are still found, demonstrating to us that the Rock Pocketbook is apparently holding its own, even though water quality in Kansas has deteriorated.

In the early 1980's, Charles H. Cope collected several shells while sampling Pottawatomie Creek in Anderson County. Employees of the Kansas Department of Health and Environment have also acquired specimens in the same creek. Brian K. Obermeyer found one large fresh dead shell in the Marais des Cygnes River west of Osawatomie, Miami County, in August, 1994. He also surveyed an area of Big Sugar Creek in Linn County and a portion of the Little Osage River in Bourbon County without locating additional specimens. The author collected three shells of different size classes in the Marais des Cygnes River within the city limits of Ottawa, Franklin County, in March, 1996. This site is above the city's wastewater treatment plant and is the westernmost locality the species has been found (in Kansas) to date. Two of the shells were fresh dead; the smallest measured 5.6 cm. It appeared to have succumbed to predation. Drought conditions had been occurring for a period of approximately eight months, and the extremely low water levels were causing other mussel species in the riffles to become stranded.

The latest Marais des Cygnes site, and areas adjacent to it, were revisited in the Fall of 1996. Further specimens of *Arcidens* were not seen, although Dr. Robert Angelo (KDHE) encountered a living specimen of *Actinonaias ligamentina*, which was believed extirpated in the state. Future plans are to again investigate this length of river between a low-head dam and the wastewater treatment plant.

Due to its rarity and its being restricted to a single drainage in the state, *Arcidens confragosus* is listed as "threatened" by the Kansas Department of Wildlife and Parks; this species is considered "currently stable" in some states. Species diversity in the Marais des Cygnes River was once greater than at present, although the short stretch of river intersecting the city of Ottawa provides a good variety of mussels even now.