COPE

Triannual Unionid Report

Report No. 6

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

Compiled by

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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.

NOTE: If you are receiving duplicate mailings, have a change of address, no longer wish to receive this report, or know someone who would like to be added to our mailing list, please contact Sherrie Jager at the above address or phone 704/665-1195, Ext. 221

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Montana Cooperative Fishery Research Unit
Department of Biology

16 NOV 94

Richard G. Biggins
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Dear Dick:

When I was at the Oklahoma Unit, we received a donation of back issues of the *Veliger*. Since my departure, no one there is using them, and they would like to free up their library space. Accordingly, the Oklahoma Unit would be willing to donate them to a good home. The only catch is that the recipient would have to pay postage. Also, they would have to take the whole lot (see below). If you can think of anybody who might be interested, please have them contact Judy Gray at 405-744-6342. If not, perhaps you could include a notice in the next Triannual Unionid Report. Volumes, numbers, and years available are listed below.

Thanks very much. I appreciate receiving the TUR and might even get back into mussels one of these days. Take care.

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" Using Physiology Measurements to Establish Water Quality Criteria Freshwater Mussels"

Alan Heath, Department of Biology, VA Tech, Principle Investigator
Li-Yen Chen, Graduate Research Assistant

ABSTRACT

The primary objective of this study is to determine dissolved oxygen levels below which normal physiological function begins to fail in adult freshwater mussels. For this purpose oxygen consumption and heart rate of some species has been measured under declining dissolved oxygen levels. Oxygen consumption is measured by placing single mussels in respirometer chambers equipped with oxygen probe in the lid, a screen above the floor, and a magnetic stirring bar on the floor. Heart rate is detected by using electronic means. For this purpose a small hole is drilled in each valve in the vicinity of the heart. Small insulated wires (with the ends bared) are inserted through the holes and sealed in with glue. Photoperiod, water temperature, feeding condition and water quality is controlled. The experiments have been done on several species from different habitats such as *Pyganodon grandis* from profundal areas of the Claytor lake, *Villosa constricta* from the riffle areas of the Nottoway River, *Villosa iris* from the riffle areas of North Fork Holston river, *Elliptio complanata* (from the pool areas), *Elliptio fisheriana* (from the bank margins) and *Elliptio lanceolata* (from the shallow sand areas) of the Rappahannock River. The results show that some species are more like regulators. They can maintain oxygen consumption at a certain level over a wide range of dissolved oxygen; some species are more like comformers. Their oxygen consumption slowed when the dissolved oxygen was decreased. The species living in the lake, pool areas and bank margin of the river have better ability to regulate oxygen consumption than those found in the riffles (i.e. *Villosa iris* and *Villosa constrica*). The *Villosa iris* is especially sensitive to hypoxia and handling stress. High mortality was found in two weeks for the specimens that underwent the declining dissolved oxygen experiments and surgery of heart beat rate detection. *Pyganodon grandis* is tolerant to the surgery stress; most of samples can survive more than a month after surgery. The heart beat rate of *Pyganodon grandis* increases slightly as the dissolved oxygen declined but decreases abruptly when dissolved oxygen is below 1 mg/l at 24.5 °C. For the effects of temperature, *Pyganodon grandis* has a lower oxygen consumption and a better ability to regulate oxygen consumption at 16.5 °C than 24.5 °C. The tolerance of *Villosa iris* to hypoxia is evidently improved at 16.5 °C when compared to 24.5 °C. The oxygen consumption of *Villosa constricta* under declining dissolved oxygen shows that the brooding females have higher oxygen consumption and lower ability to regulate oxygen consumption than the male. The observations of diurnal behavior have been conducted for *Pyganodon grandis, Elliptio complanata, Elliptio fisheriana* and *Villosa iris*. The lake-living species *Pyganodon grandis* has a higher activity of open rate of the valves, oxygen consumption and heart beat rate at night. None of the species living in the river have a diurnal rhythm in opening and closing of the valves or oxygen consumption.

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ARE UNIONID TRANSLOCATIONS A VIABLE MITIGATION TECHNIQUE? THE WOLF RIVER, WISCONSIN, EXPERIENCE: PART 3, AUGUST 1994.

As reported, May 1994 Triannual Unionid Rept., in August 1992, 8120 marked unionids (14 taxa) were translocated from the County A bridge, Wolf River, N of Shawano, WI. At the 461 m^2 translocation site, pre-project mean densities from 10 - 1.0 m^2 were 20.7/m^2. Post-project, densities were increased by 85%. Unionids were out of water 15 minutes to identify and mark, then stored in mesh bags below the river surface, before translocation the same day.

The numbers for the 1993 follow-up differ slightly from those reported previously because I have excluded data from a special, high density quadrat. The 1993 study (funded by Malacological Consultants) recovered 373 living mussels from 6 - 1.0 m^2 quadrats (mean density 62.17/m^2). We found a one year post-translocation survival rate of 98.36% among 120 living plus 2 dead marked mussels (marked mussel density of 20.3/m^2 confirmed we nearly doubled original density). 32.2% of the (tripled) densities were from the marked unionids; 33.3% of the mussels were from the pre-project (ambient) density. The remaining 34.5% of the tripled densities were from an unknown source. Perhaps pre-project densities were the result of diver efficiency or other sampling artifact, and/or else densities increased after 1993 high water. Two marked, threatened unionids were recovered, with no mortalities found among 33 relocated, threatened unionids. One new species was added to the site list. (The seventh quadrat sampled yielded 74% of 100 specially marked unionids placed in a 1.0 m^2 area; pre-project density in this quadrat was represented by 31 unmarked unionids found in 1993; no dead specimens were in the special quadrat).

The Conchologists of America and Malacological Consultants sponsored the August 1994 relocation followup. 31 random 0.25m^2 quadrats yielded 478 living unionids (mean density 61.9/m^2), including 152 living marked mussels (plus 2 dead). Another marked dead mussel was found during a random search. All marks on the anterior valves were clearly legible after 2 years, even on the 3 dead specimens. Survival among marked unionids was 98.9% (mean density 19.9/m^2; 31.8% of total living). 326 unmarked living mussels were found; 2 unmarked Alasmidonta viridis (Rafinesque, 1820) and 1 Simpsonaias ambigua (Say, 1825) were uniquely marked. Since 1992 Elliptio dilatata (Raf., 1820) has increased from 71.4% to 73.3% (1993) to 78.9% (1994). Few fresh-dead mussels were among 152 empty shells; most were sub-fossil or fragments. Site density was slightly lower than in 1993, but 9 juveniles were found.

Ten of the 100 specimens from the 1992 special quadrat were recovered a second time, even though these specimens were returned to the river from the surface in 1993 because divers ran out of air; none of those specially marked unionids have been found dead. These data show our methods resulted in a successful relocation, 2 years post-project, even at doubled to tripled densities, although the relative abundance of the dominant species increased slightly.

Zebra Mussel Monitoring - Ohio River Mile 395 - 397
1994 Summary

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Refuge staff completed baseline mussel inventories and zebra mussel monitoring in waters surrounding the Manchester Islands this past fall. Using water scopes, brailling, SCUBA transects and SCUBA quadrat excavations, staff collected 245 native specimens representing 17 different species around the two islands, in addition to 199 zebra mussels. One-hundred-and-five of the natives, or 43%, were infested with zebra mussels (minimum 1, maximum 13, mean 2.0 zebras per native). The zebra mussels ranged in size from 9 mm to 27 mm, and 70% were in the 20-25 mm size class.

Visual observations revealed that the river substrate is very sandy for the most part, with scattered clusters of gravel and cobble. The zebra mussels have settled on available hard substrate, including river snails. Refuge staff will conduct follow-up monitoring in 1995.

The species found, in order of relative abundance, were:

Dreissena polymorpha
Quadrula quadrula
Amblema plicata
Quadrula nodulata
Quadrula pustulosa
Obliquaria reflexa
Potamilus alatus
Quadrula metanevra
Fusconaia flava
Leptodea fragilis
Pleurobema cordatum
Lampsilis teres
Fusconaia ebena
Elliptio crassidens
Lampsilis cardium
Megalonaias nervosa
Tritogonia verrucosa
Truncilla truncata

Cyprogenia stegaria Collected in the Ohio River Rivermile 181.2, Neal Island, Wood County, WV

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While conducting SCUBA quadrat substrate excavations at the head of Neal Island, refuge staff collected one live individual of *Cyprogenia stegaria* in one of the quadrats. The individual was 57 mm long, weighed 80 grams, and was approximately 8 to 10 years old. Water temperature was 68 degrees Fahrenheit, depth was 13-14 feet, and substrate consisted of four inches of soft sand over gravel and cobble. Numerous photographs were taken of the specimen, then it was hand-placed by divers back in the substrate. This represents the first record of the fanshell on refuge property.

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The following abstract is the first report on a review of the fossil North American unionoideans. Anyone having fossil Pre-Pleistocene specimens is urged to contact me - I can use all of the records I can get.

Watters, G. Thomas. 1994. Pre-Pleistocene North American Unionoideans. *Abstract of paper given at American Malacological Union Annual Meeting, July 1994.*

The Pre-Pleistocene unionoideans of North America represent a diverse assemblage of several major lineages, most of which became extinct, or were severely depleted, during the Mesozoic-Cenozoic extinction event. Paleozoic "unionoideans" seem to belong to other, unrelated groups. Triassic forms include margaritiferans, and hyriids that occurred as far north into North America as New England. These groups originated in and were shared with Europe, Africa, and South America during the existence of Pangaea at that time. The unionid vetulonaians appear in the Triassic, and reached their greatest diversity in the late Cretaceous. A great diversity of unionoideans arose in the Cretaceous, located mainly in western North America. These included the proparreysians, elliptioids, and anodontines. These may be ancestral to some Recent groups. These Mesozoic genera convergently evolved shell shapes very similar to Recent forms, presumably in response to similar ecological needs: anchoring, anti-scouring, etc. They were isolated during much of this period in the western part of the continent by the intracontinental seaway. Most became extinct. Most margaritiferans and anodontines retreated to the northwest, where they crossed the Bering landbridge to Asia. Ancestors of many Recent forms were species that survived the extinction event and moved eastwards when the seaway closed. Lampsiline-like forms first appear in the Eocene, and Miocene of Texas and Louisiana. Thus, the center of unionoidean diversity now has shifted from the west in the Mesozoic to the east in the Cenozoic.

New publications:

Watters, G. Thomas. Unionidae of the Big Darby Creek system in central Ohio, U.S.A. *Malacological Review* 27: 99-107.

Results are presented for two surveys (1986 and 1990) of the Unionidae of Big Darby Creek of the Scioto River drainage in Ohio. A total of 5,846 living or freshdead specimens comprising 37 species were found during the two surveys. An additional four species are known only from weathered specimens. The system has the highest unionid diversity of any North American drainage of equal size. The system supported two federal category 1 species (*Epioblasma rangiana* [Lea, 1839] and *Pleurobema clava* [Lamarck, 1819]), three federal category 2 species

(*Epioblasma triquetra* [Rafinesque, 1820], *Simpsonaias ambigua* [Say, 1925], and *Villosa fabalis* [Lea, 1831]), and seven Ohio endangered species. Plots of diversity versus river mile revealed impacted areas of the system, and demonstrated that such data were reproducible and potentially useful in monitoring water quality.

The following paper was published in the bulletin of the Conchologists of America as a popular introduction to unionids. The second part is due soon, and this may become a series on an occasional basis.

Watters, G. Thomas. 1994. North American Freshwater Mussels. Part I. The Quick and the Dead. *American Conchologist* 22(1): 4-7.

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Martin Kohl, 117 Sylvia Dr. #12, Knoxville, TN 37912

The Asian *Anodonta woodiana* (Lea, 1834) in the Dominican Republic

The southeast Asian unionid *Anodonta woodiana* (Lea, 1834) is reported here for the first time from the Dominican Republic, Hispaniola. Specimens, including soft-parts, sent by Mr. Glenn Duffy are identical to examples from Asia and Sulawesi. He informs us that the mussel is now common in two places: Rio Yuna in the El Cibao region, and the lake Presa de Rincón near Bonao. We believe that they were introduced as glochidia on exotic fish(es) imported from Asia or Indonesia. This species already has been introduced from Taiwan into Indonesia, Java, Sumatra, Sulawesi, Nusa Tenggara Islands, and Moluccas (Djajasasmita, 1982; Dharma, 1992). Initial invasions to these islands were the result of the introduction of parasitized Nile tilapia and silver carp as food fishes. The mussel is now using native species as hosts. Based upon previous invasions, *Anodonta woodiana* is a prolific breeder and may become abundant (Dudgeon & Morton, 1983). This is the first record of this species for the New World. Several of the hosts for this unionid have been introduced into the southeastern United States, and it is possible that it may become established there as well. We are endeavoring to determine the hosts that were introduced to the Dominican Republic, and a more detailed account will appear in the future.

Dharma, B. 1992. *Siput dan Kerang Indonesia* **2**. Verlag Christa Hemmen, Wiesbaden. 135 pp.

Djajasasmita, M. 1982. The occurrence of *Anodonta woodiana* Lea, 1837 in Indonesia (Pelecypod: Unionidae). *Veliger* **25**: 175.

Dudgeon, D. & B. Morton. 1983. The population dynamics and sexual strategy of *Anodonta woodiana* (Bivalvia: Unionacea) in Plover Cove Reservoir, Hong Kong. *Journal of Zoology, London* **201**: 161-183.

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REPORT ON ELK RIVER MUSKRAT MIDDEN MUSSEL FINDS

MEMORANDUM TO: Lyle Bennett, WVDEP-Water

FROM: Doug Wood, WVDEP-Water

DATE: June 30, 1994

On June 16, 1994 I found a muskrat midden on Elk River below the mouth of Little Sandy Creek. As I began digging into the midden I found that under layers of sediment there were many shells. The further down I dug the more chalky and brittle the shells were. These two charasteristics indicate age. The more pronounced they are, the greater the age of the shells. In the deeper layers Pleurobema clava(clubshell) was abundant. This species now appears to be extirpated or nearly so from the lowermost reach of Elk River. As far as I know, currently only sites upstream of Big Sandy Creek support reproducing populations of P. clava.

In my nonstructured, exploratory "dig" (more like "scoop") into the midden, I found very few Fusconaia subrotunda(longsolid) in the upper handfulls, but many more just below the surface. Associated with this species under the upper layers were P. clava and Corbicula sp.(Asiatic clam). Although shell mixing during alternating periods of deposition and scouring is possible, I think that P. clava may have been present at the site when Corbicula sp. first found its way into the river. Further down, where Corbicula sp. shells were not present, P. clava was more abundant, along with F. subrotunda, P. cordatum(Ohio pigtoe), Elliptio crassidens(elephantear) and Epioblasma torulosa rangiana(northern rifffleshell), which is now extirpated from most of the river. In the deeper "scoops" I picked up some valves of → Quadrula cylindrica cylindrica(rabbitsfoot). These shells were identified by John Schmidt and Bill Tolin, biologists with the U.S. Fish & Wildlife Service. This may be the first time that Q. cylindrica shells have been found in Elk River. The layer this species came from is probably representative of a period of history before extensive agriculture in Elk River Valley, although this is conjecture on my part.

It would be useful to us in understanding the historical, chronological decline in the mussel diversity of lower Elk River to excavate this midden through a methodical procedure. Janet Clayton, WVDNR biologist and the state's mussel data compiler, agrees that this information would be useful. Art Bogan, an independent malacological research consultant associated with Carnegie Museum of Natural History agrees and has offered to help identify the shells obtained from the dig. Art recommends that we should also keep the snail shells from the dig also.

As you know, nonpoint source pollution such as sediment from Interstate road cuts along Big Sandy Creek, chlorides from oil wells on Little Sandy Creek and acid from mine refuse piles on Buffalo Creek have had significant negative impacts on the river. Several water quality studies by various agencies have shown at least localized degradation of Elk River in recent history. A study of the midden below Little Sandy Creek will perhaps give us insight into the degrading processes that have been at work since before recent history. Through the use of mussels as long-term biological monitoring tools we may be able to answer questions such as "Is Elk River water quality improving now?" Archaeological data combined with recent historical information and current mussel data will be useful in helping us understand Elk River and assisting us in restoring it to a former, more biologically diverse state. Shall I move forward with the proposed excavation of the submerged muskrat midden?

cc: Janet Clayton, WVDNR

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REPORT ON A VISIT TO DUNKARD CREEK

MEMORANDUM TO: Lyle Bennett, DEP-Water
FROM: Doug Wood, DEP-Water

JUNE 30, 1994

On June 19 and 20 I checked nine sites in the Dunkard Creek watershed for the presence of mussels. Those sites are listed in Table 1. My search was not undertaken as part of a scientific investigation. I was interested in checking the mussel diversity in order to help assess the impacts of nonpoint source pollution upon the stream. I participated in an interstate mussel survey with the WVDNR Wildlife Resources Office and the PA Department of Environmental Resources in 1993. Art Bogan, a malacological researcher often associated with the Carnegie Museum of Natural History was along as an expert consultant. I was able to assist on only one day of the two day survey in 1993 and so one of my reasons for returning to Dunkard Creek was to familiarize myself with parts of the stream I was unable to visit last year.

Seven of the nine sites I visited are on the Dunkard Creek mainstem. Two of the sites are on tributaries, West Virginia Fork and Pennsylvania Fork. I collected dead shells at eight of the sites. The one site at which I did not collect shells(Site 2) is on PA Fork. Quite by accident I collected dead shells from a mainstem site in PA(Site 3). What I mean is that I thought I was collecting in WV (the border is somewhat nebulous) when I was actually collecting in PA. I have contacted PA authorities regarding this mistake, since I did not have a PA collection permit, and all is forgiven.

At all mainstem sites I found shells of Epioblasma triquetra(snuffbox) which is a candidate for listing on the federal endangered species list. At two sites(Sites 3 and 6) I found living specimens of E. triquetra. At five locations freshly dead specimens were found. There was evidence that the high water of late winter and spring storms carried many individuals, both living and dead, high above the normal water level and stranded them. The evidence for these being relatively recent events was the great lot of shells left high and dry which contained mummified soft parts. These shells were of many species including E. triquetra. At five sites I found over 30 relic shells of E. triquetra. One particularly productive site(Site 6) is located beside and below the Division of Highways garage and gravel piles at the junction of WV Rt. 7 and Monongalia County Rt. 7/12. At this place searching for

approximately 45 minutes I found two living males, one freshly dead animal and over 40 relic shells and valves. The 2 living animals were located in spots where they must have been carried to recently. One was in a small puddle separated from the rest of the stream at average flow levels. The other was in an area with hardened substrate unsuited for burial by mollusks. This individual along with a Lampsilis siliquoidea(fatmucket) specimen was crawling about on the rock substrate, apparently trying to find a suitable burial place. Good grief, now I am trying to think like a mussel!

At six mainstem sites I found shells of Simpsonaias ambigua(salamander mussel), another candidate for listing on the endangered species list. The PA location(Site 3) appeared to be very suitable for this species since I found 10 freshly dead individuals that a muskrat or a raccoon had eaten and 1 living specimen. Apparently this is the first record of S. ambigua found in Dunkard Creek in PA. The PA site was also productive for E. triquetra. I found 3 living females and 2 living males, 8 freshly dead animals in a muskrat midden, and 10 shells and 6 valves which I would classify as relic. This is also the first record of living E. triquetra in the PA portion of Dunkard Creek. I wonder if these animals know where the Mason-Dixon line lies?

After having John Schmidt and Bill Tolin, U.S. Fish & Wildlife Service biologists in the Service's Elkins office, confirm and correct my identifications, I left the collection of shells at the Elkins WVDNR office for Janet Clayton who is keeping track of mussel populations in WV. At least one valve of the S. ambigua shells collected in PA will be given to the Carnegie Museum, one will also be given to the Ohio State University collection. The remainder of the PA shells will be given to the PA Natural Heritage Program. Bill Tolin kept 1 specimen of the PA Simpsonaias ambigua shells for his office collection.

Much of Dunkard Creek is negatively impacted by sediment from tributary streams which have agricultural and construction activites on them. Just about 0.2 mile below the Division of Highways garage spoken of earlier Days Run contributes a tremendous volume of sediment to Dunkard Creek. The evidence for this is a huge silt/sand bar at the mouth of the tributary. Nonetheless the diverse mussel population of Dunkard Creek has survived thus far despite such impacts. The PA site had the cleanest substrate of all the sites I visited. It is located immediately downstream of a small impoundment on the mainstem which acts as a sediment catch basin. A probable negative impact of the impoundment is its role in blocking fish passage which therefore impedes transport of mussel glochidia upstream of the dam. However, this negative impact is probably outweighed by the positive impact which the catch basin currently has on the mussel population immediately below.

As we discussed on June 23, the Division of Highways needs

to make some changes at the garage beside Dunkard Creek. The gravel piles have been placed so that they extend into the stream. The piles should be moved away from the stream bank so that it has a chance to revegetate. This should be done in a manner which does not disturb the stream substrate. Even those gravels which are currently in the stream bed, under the surface of the water should not be removed since I did find one E. triquetra individual in that vicinity looking for a decent home. Also the precipitation runoff from the gravel piles and the garage area should be prevented from going directly into the stream without treatment as it currently does. At the very least, a sediment catch basin should be dug to prevent the greater portion of runoff solids from entering Dunkard Creek. You indicated that you would contact the Division about this problem, but if you need my assistance, please feel free to ask. There are other pollutant sources on Dunkard Creek which pose threats to the continuing existence of the diverse mussel fauna as well as to other aquatic organisms. Perhaps we could begin looking more closely at the watershed to find ways to minimize the nonpoint sources of pollution in a way which operates more speedily than our current programs. The state of PA may be willing to work with us on such an effort.

I will send this memo to Dick Biggins in NC for the Mussel Triennial Newsletter so that he can glean it for pertinent information regarding the new finds in PA. Art Bogan suggested that I provide Dick with this information. If you agree, I will follow through with that suggestion.

cc: Janet Clayton, WVDNR
Craig Stihler, WVDNR
John Schmidt, USFWS-WV
Bill Tolin, USFWS-WV
Andy Shiels, PAFBC
Tom Proch, PADER
Carole Copeyon, USFWS-PA
Art Bogan, NJ (The Garden State?)

Steven Ahlstedt, Tennessee Valley Authority, Clean Water Initiative, Aquatic Biology Lab, Norris, TN 37828. Phone: (615) 632-1781

QUANTITATIVE REASSESSMENT OF THE FRESHWATER MUSSEL FAUNA IN THE CLINCH AND POWELL RIVERS, TENNESSEE AND VIRGINIA

Quantitative reassessment of the mussel fauna in the Clinch and Powell rivers was recently completed in September, 1994. This was a joint cooperative project between biologists with TVA's Clinch/Powell River Assessment Team (RAT) and biologists with the U. S. Fish and Wildlife Service, Virginia Cooperative Fisheries Unit, Virginia Nature Conservancy, State of Virginia and Tennessee. Both rivers had been sampled at mussel beds identified during TVA's 1979 CMCP float-survey. Sites identified in 1979 were re-sampled in 1983, 1988 and 1994. In the Powell River, 16 sites were sampled for a total of 468 (0.25 meter square) quadrat samples. For the Clinch River, 14 sites were sampled for a total of 428 quadrat samples.

Preliminary observations of mussels in the Powell report further declines in species numbers with a slight increase in total number of mussels found. The increase in total numbers of mussels reported since the 1988 mussel survey is a result of limited reproduction which was noted at a few sites for Actinonaias pectorosa, Lampsilis fasciola, Medionidus conradicus and Ptychobranchus fasciolaris. Other mussel species found during the survey continue to decline in total numbers. Federally listed species found in quadrat samples were Dromus dromas, Fusconaia cor, Quadrula intermedia, and Quadrula sparsa.

The Clinch River mussel fauna appears to be on the rebound on the Tennessee side of the river and at a few sites in Virginia. Good reproduction was noted for 14 species especially in the area from Kyles Ford downstream to Swan Island. A few sites in Virginia had limited reproduction and consisted mainly of Actinonaias pectorosa, Medionidus conradicus, Ptychobranchus fasciolaris, and Villosa iris. Numerous dead shells were observed at the Pendelton Island mussel preserve. Overall, species numbers and total abundance were down at a number of sites, while some sites appeared to be doing well or improving. It is the opinion of the author that the Clinch River has suffered a mussel kill which occurred gradually over time and that it may have started during the severe five-year drought which ended in 1989. Coal fines present in the river substrate appears to have increased significantly since previous surveys. Federally listed species found in quadrat samples were Conradilla caelata, Cyprogenia stegaria, Dromus dromas, Fusconaia cor, Fusconaia cuneolus, and Hemistena lata. Of important note, nine live specimens of Epioblasma walkeri were found qualitatively in Virginia. Specimens were aged at between 4-10 years. A more detailed report of the Clinch/Powell mussel survey is in progress.

NEW POSITION:

After 20 years of service with TVA, I have accepted a position as Study Unit Biologist with the U. S. Geological Survey (NAWQA), 1013 North Broadway, Knoxville, Tennessee 37917. I am still working at my old TVA office at least for a year (615) 632-1781 as well as in Knoxville (615) 632-4716. If anyone has any questions, please call. Thanks - Steve

Update on Zebra Mussels and Native Unionids in the Illinois River

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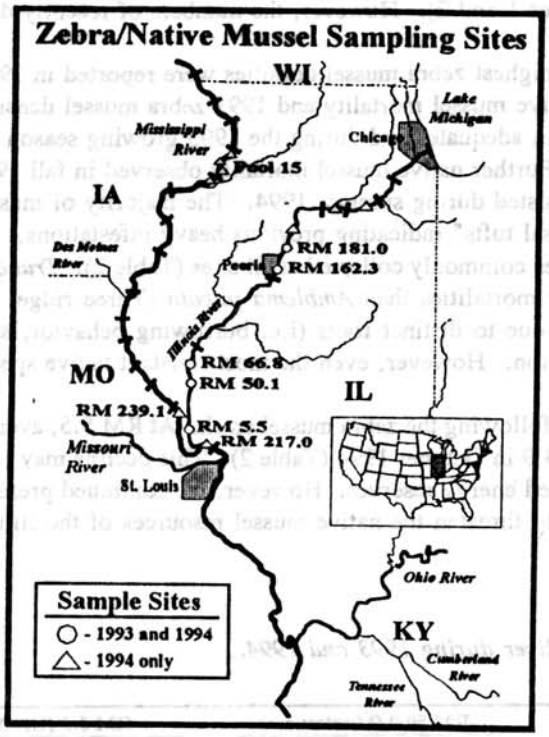
Released 3 January 1995



Decline of zebra mussels in the lower Illinois River

Zebra mussel populations in the lower Illinois River exploded in 1993, achieving maximum densities of nearly 100,000 • m^{-2}; since then, populations have experienced high mortality, resulting in greater than 99% reduction at some sites. This crash is being attributed to poor environmental conditions resulting from overpopulation and fluctuations in water quality.

During summer 1993, divers collected quantitative samples at five sites along the lower 181 miles of the Illinois River (see map). Zebra mussel densities increased in the downriver direction (Table 1), ranging from less than 1 • m^{-2} at river mile (RM) 181 to 61,126 • m^{-2} at RM 5.5. Downriver populations consisted almost entirely (>99%) of a single cohort which settled in the spring or early summer of 1993, while upriver populations consisted of both >1-yr-old (39%) and newly settled (61%) cohorts. These dense populations of zebra mussels covered nearly all available hard surfaces (i.e. rocks, native mussels, glass bottles, tin cans, organic debris, etc.) and carpeted expansive areas of soft mud. However by fall 1993, significant mortality had occurred, as evidenced by numerous empty shells in our samples. Mortality was most severe at lower river sites which had the densest zebra mussel populations in 1993. This downward trend in average densities has continued through the 1994 sampling season, resulting in a greater than 99% reduction at both RM 5.5 and RM 66.8. The most dramatic declines occurred between sampling in fall 1993 and June 1994. Length frequency histograms indicate at least three recruitment events in 1993; no significant recruitment occurred at any of our Illinois River sites during 1994. Both mortality and poor recruitment may be attributed to stressful environmental conditions which were first observed in late summer 1993 and became more severe in summer 1994.

During the summer months of 1993 and 1994, alarmingly low dissolved oxygen (D.O.) concentrations (1.7-3.0 mg/l) occurred in the main channel of the lower Illinois River at sites where we had found the densest populations of zebra mussels in 1993. Extended periods of low D.O. created stressful conditions which may have caused mortality among zebra mussels, native unionid mussels, and several species of fish including gar, catfish, buffalo, and carp, which were floating dead in large numbers during July 1994. Initial calculations indicate that under low water conditions, these dense Illinois River populations (61,000 • m^{-2}) could consume 2.4 mg/l of D.O. in a one-mile stretch of the main channel. During summer 1994, the Illinois River dropped to extremely low levels, water temperatures in the main channel remained above 28°C for four to six weeks, and dissolved oxygen was consistently recorded below 3 mg/l (low of 1.7 mg/l) at main channel sites throughout July and August.

In riverine systems, dense populations of zebra mussels (>1000 • m^{-2}) result from settlement of larvae produced by upstream populations. Given the man-made connection with Lake Michigan and existing adult populations throughout the river, we expect zebra mussel numbers in the Illinois will fluctuate dramatically over the next few years, with populations building under favorable conditions and then crashing when they reach levels which create stressful conditions.

Table 1. *Zebra Mussel densities at selected sites in the Illinois River during 1993 and 1994.*

Zebra Mussels — Site	RM 162.3 (Peoria)						RM 66.8 (Meredosia)				
Date	8/10/93	10/8/93	3/28/94	6/13/94	8/9/94	10/05/94	7/21/93	9/30/93	6/20/94	8/05/94	10/13/94
Avg. Live Density (m2)	1793	6998	4165	3268	5836	1816	10905	12587	1144	420	74
Avg. Dead Density (m2)	0	25	89	92	3611	2914	0	8219	9691	25110	---
Avg. % Dead Shells	0.0	0.4	2.4	2.1	37.3	56.7	0.0	40.8	89.9	98.1	---
Avg. Live Biomass (g/m2)	447.6	782.4	---	1420.7	4038.3	1828.5	498.2	2286.2	768.7	367.0	53.3

Zebra Mussels — Site	RM 50.0 (Montezuma)				RM 5.5 (Grafton)				
Date	10/01/93	6/22/94	8/5/94	10/12/94	9/18/93	10/2/93	6/27/94	8/04/94	10/11/94
Avg. Live Density (m2)	8443	3103	2603	1630	61126	34812	1528	3807	657
Avg. Dead Density (m2)	1123	2496	8518	5520	12	10254	2232	5262	156
Avg. % Dead Shells	10.8	47.9	77.0	74.3	0.0	22.1	66.6	52.5	17.0
Avg. Live Biomass (g/m2)	1614.3	2047.7	1675.0	1356.7	1283.2	1577.6	699.8	1522.8	141.1

Illinois River native mussels experiencing increased mortality

Since the discovery of the first Illinois River zebra mussel in June 1991, numbers of native unionids colonized by zebra mussels have increased steadily. By summer 1993, zebra mussel densities and infestation of native unionids at our sites in the lower Illinois River had reached their highest levels (Table 2). Since this peak, densities, infestation rates, and degree of infestation (number of zebra mussels per unionid) have declined at the majority of our sites (Tables 1 and 2). However, the numbers of recently dead native unionids have continued to increase.

Unionid mortality was greatest in the lower Illinois River where the highest zebra mussel densities were reported in 1993. There is a significant positive correlation ($r^2=0.9689$) between June 1994 native mussel mortality and 1993 zebra mussel densities at the five Illinois River sites. Infested mussels were probably unable to obtain adequate food during the 1993 growing season and subsequently died over winter because they lacked sufficient energy reserves. Further native mussel mortality observed in fall 1994, may have been the result of the stressful environmental conditions which persisted during summer 1994. The majority of mussels identified as recently dead were either severely infested or covered with "byssal tufts" indicating previous heavy infestations.

Interspecific differences in mortality were evident among native species commonly collected at all sites (Table 2). *Truncilla truncata* (Deertoe) and *Leptodea fragilis* (Fragile papershell) suffered higher mortalities than *Amblema plicata* (Three ridge) and *Quadrula quadrula* (Mapleleaf). We believe this differential mortality was due to distinct traits (i.e. burrowing behavior, shell morphology, etc.) which influence their susceptibility to zebra mussel infestation. However, even the most resistant native species were suffering increased mortality.

Infestation of native mussels dropped dramatically at most of our sites following the zebra mussel crash. At RM 5.5, average numbers of zebra mussels per unionid dropped from 254.5 in August 1993 to 3.9 in October 1994 (Table 2). This decline may offer native mussels a much needed reprieve, allowing them to resupply their depleted energy reserves. However, the continued presence of zebra mussels and the probability for additional explosions will continue to threaten the native mussel resources of the Illinois River.

Table 2. *Impacts of zebra mussels (ZBM) on native mussels in the Illinois River during 1993 and 1994.*

Site	RM 162.3 (Peoria)			RM 66.8 (Meredosia)			RM 50.0 (Montezuma)			RM 5.5 (Grafton)		
Native Mussels / Date	7/15/93	6/13/94	10/27/94	7/21/93	6/20/94	10/13/94	10/01/93	6/22/94	10/12/94	8/18/93	6/27/94	10/11/94
Overall Mortality (%)	0.0	0.0	4.6	2.1	6.0	47.7	1.8	2.1	9.5	1.6	22.2	16.6
Avg. Infestation (%)	88.2	90.7	71.3	95.0	59.0	56.8	89.4	88.2	95.2	99.5	85.5	59.1
Avg. No. ZBM/Unionid	7.7	59.4	14.2	105.3	38.4	4.3	28.0	34.5	---	254.5	24.7	3.9
Common Species	Average Mortality (%) by Species											
Amblema plicata	0.0	0.0	4.5	3.6	0.0	21.4	2.4	0.9	6.8	4.2	6.8	9.9
Leptodea fragilis	0.0	0.0	12.5	1.7	13.3	77.8	0.0	3.6	33.3	0.0	50.0	25.0
Quadrula quadrula	0.0	0.0	0.0	0.0	0.0	66.7	0.0	1.4	7.1	0.0	0.0	0.0
Obliquaria reflexa	0.0	0.0	0.0	0.0	0.0	33.3	11.1	10.0	0.0	0.0	24.0	28.6
Truncilla truncata	0.0	0.0	5.7	2.9	14.3	60.0	2.4	4.5	---	0.0	77.4	90.9

Mississippi River populations approaching exponential phase

The first confirmed zebra mussel in the Upper Mississippi River (UMR) above its confluence with the Illinois was discovered at La Crosse, WI on 12 September 1991. Although reports throughout the UMR indicate locally abundant and expanding populations, an explosion with densities as high as those observed in the Illinois in 1993 has yet to be documented. Sampling at three sites in Pool 15 during summer and fall 1994 (see map), revealed increasing zebra mussel densities. In July 1994, densities at our sampling sites averaged $1.5 \cdot m^{-2}$; fifty-nine percent of the zebra mussels were between 8 and 10 mm long with the remainder greater than 17 mm. In August, densities had increased to $35.7 \cdot m^{-2}$, with 71% of the population being less than 15 mm long. By December, three cohorts were apparent in length frequency distributions, indicating at least two settlements occurred during 1994. It is apparent that a substantial adult population has been established and the stage is set for a population explosion in 1995.

Negative impacts to native mussels are expected to be similar to those demonstrated in the Illinois River. Average densities of native mussels ranged from $50\text{-}150 \cdot m^{-2}$ at the three Pool 15 sites sampled in 1994. From 19 to 24 different species were collected at each site, including two federally listed species (*Lampsilis higginsi* and *Cumberlandia monodonta*). Infestation of native mussels at one site steadily increased from 0% in July to 2% in August to 14% in December. Only a few (1-4) zebra mussels were attached to each individual unionid. However, infestation of unionids and subsequent mortality are likely to increase, following the pattern already observed in the Illinois River.

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DEFORMED UNIONIDS IN NEW YORK

During some stream surveys this past summer, I found strikingly deformed unionids at two sites. These animals had very short posterior ends, to the extent that species like Elliptio complanata and Lasmigona costata were scarcely longer than high. I saw these deformed animals at two sites, one a badly degraded urban stream and the other a stream with an agricultural watershed. Deformed animals were abundant at both of these sites (>10% of all mussels), and included most of the species I saw.

Has anyone else been seeing animals like these? Does anyone have any idea what causes such deformities?

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SOUTHERN REGION FRESHWATER MOLLUSK COORDINATOR

I recently began working as the Southern region mollusk coordinator. The Southern Region of the Forest Service includes National Forests in Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Tennessee, Kentucky, Mississippi, Louisiana, Texas, Oklahoma, Arkansas, and Puerto Rico. Forest Service land in the south provides habitat for many of the region's rare species and may eventually serve as refugium if streams on private land continue to be degraded. The mollusk coordinator position was created because Forests in the South are all on different levels concerning mollusks; some have completed distributional surveys and are now monitoring populations while others are just beginning baseline surveys. I would like to put together a list of biologists who are working with snails or mussels in the southern states. If you are currently working in areas on or near National Forests in the states listed above or you are interested in conducting surveys or research on Forest Service land, please contact me at the address or telephone number listed above. Thanks!

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The Virginia Department of Game and Inland Fisheries is requesting information from state and federal agencies, and other entities, regarding decision criteria used to predict the likelihood of presence or absence of endangered or threatened mussels, and survey protocols applied, especially as they relate to review of proposed instream activities. We are most interested in decision criteria and survey methods appropriate for small to medium-sized, wadeable streams.

Dan Kelner, 518 Mead St., Eau Claire, WI. 54703. 715-834-7987

A qualitative and quantitative survey of unionid populations from portions of the Red Cedar and Flambeau Rivers, Wisconsin.

This study was conducted for the purpose of establishing baseline data on the unionid fauna in portions of the Red Cedar and Flambeau Rivers. Both rivers are tributaries of the Chippewa River and are located in west-central Wisconsin. The study areas consisted of about 13 km reaches. This study served as my thesis project at the University of Wisconsin-Eau Claire under the supervision of Dr. Terry Balding.

The data revealed that the Flambeau River was dominated by more thick-shelled species, and supported higher numbers of species and overall densities of unionids than the Red Cedar River. A total of 15 species were found in the Flambeau whereas 10 were found in the Red Cedar. The reason for these results could be because the Flambeau River has a higher discharge (subjecting unionids to a more erosive flow), supports a larger watershed area with more fish species (possible fish hosts), and the study site was in closer proximity to the Chippewa River with no dams in-between allowing for the upstream movement of fish hosts into the river. The Flambeau River supports two Wisconsin State endangered species, Cyclonaias tuberculata and Plethobasus cyphyus. C. tuberculata is a relatively abundant species (relative abundance of 5.2%) and is represented with many young individuals whereas P. cyphyus is not as abundant (1.1%) with very few young individuals found.

Only a quantitative assessment of the Flambeau was conducted because the densities of unionids of the Red Cedar were to low to be analyzed. Mean densities of four unionid beds within the Flambeau ranged from 13.85/sq.m to 35.58/sq.m with the highest densities found in substrates consisting of equal proportions of sand, gravel, and boulder. The lowest densities occurred in a more homogenous substrate type consisting primarily of either sand or boulder. For each unionid bed, species association analyses were conducted using 2 x 2 contingency tables with no significant associations found. Chi-square tests of species distribution revealed that the species were distributed evenly throughout the beds regardless of substrate type or depth. For the most part the result of the relative abundances and species rank of the unionid bed areas and non-bed areas were consistent.

Here is the species list of each study area (listed in order of rank of relative abundance)

Red Cedar River	Flambeau River	
Alasmidonta marginata	Actinonaias ligamentina	Strophitus undulatus
Anodonta grandis	Elliptio dilatata	Alasmidonta marginata
Pluerobema sintoxia	Lampsilis radiata	Lasmigona costata
Lampsilis ventricosa	Lampsilis ventricosa	Amblema plicata
Lasmigona costata	Pluerobema sintoxia	
Elliptio dilatata	Ligumia recta	
Ligumia recta	Cyclonaias tuberculata	
Strophitus undulatus	Quadrula pustulosa	
Fusconaia flava	Plethobasus cyphyus	
Lampsilis radiata	Fusconaia flava	
Actinonaias ligamentina	Obovaria olivaria	

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Chemosensory Abilities of Gravid Freshwater Mussels and Glochidia

These studies seek to answer several questions. First, can gravid *Villosa iris* and *Lampsilis fasciola* detect host (*Micropterus dolomieu*) and non-host (*Cyprinus carpio*) fishes, and do they behave differently to them, as measured by behavioral changes over controls? Second, do gravid females of these species use chemosensory cues from host fishes to determine when to release glochidia? Finally, do glochidia of these species respond differently to mucus, blood, and blood by-products of host and non-host fishes (*M. dolomieu* and *C. carpio*), and what substances in these fluids do they respond to?

Behavioral observations of adult mussels included degree of mantle presentation, mantle pulse rate, glochidial ejection, shell spread, and inhalant aperture length. Observations were conducted within a controlled chamber where photoperiod approximated summer solstice and temperature was maintained at 25° C. Glochidial measurements included elapsed time to first valve closure after the introduction of a substance, and percentage of total glochidia closed after one minute post-substance introduction.

Although study and analysis are ongoing, the following results have been determined:

1. Activity of *V. iris* increases nocturnally, whereas the activity of *L. fasciola* increases diurnally.
2. Activity of *L. fasciola* increases when subjected to the presence of *M. dolomieu* (host) mucus and fish, whereas activity decreases in the presence of *C. carpio* (non-host).
3. Glochidia of *V. iris* and *L. fasciola* responded more quickly and in greater numbers to non-host (*Cyprinus carpio*) mucus. Other substances tested were non-host (*Cyprinus carpio*) blood, plasma, and serum, as well as heparin, fibrinogen, thrombin, and a fibrinogen/thrombin combination. Glochidia of *V. iris* responded more quickly and in greater numbers to fibrinogen and the fibrinogen/thrombin combination.

During this study the following have also been documented:

1. Rocking and rhythmic pulsing behaviors in *V. iris* (nocturnal), and *V. taeniata* (?)(diurnal). These behaviors included a rhythmic waveform beating of mantle papillae in *V. iris* and mantle appendages in *V. taeniata* (?).
2. Rhythmic waveform beating of mantle papillae in *V. vanuxemensis* (diurnal).
3. *M. dolomieu* was found to support glochidial transformation to juveniles for *Lexingtonia dolabelloides*.

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Commercial Mussel Harvest Status and Trends: Compilation of recent mussel harvest data for the period 1990-94 reveals a disturbing trend of declining resource available for harvest. Furthermore, the catch per unit of effort (CPUE), at which the resource is being exploited appears to be increasing. Commercial mussel harvesters on Kentucky Reservoir were surveyed during a three year period (1992-94) to collect information regarding the mussel resource. Approximately 60 to 90 harvesters were surveyed per year with a total catch of 11,000 to 15,000 shells. Each musseler's catch was grouped by species, divided into size categories, counted and weighed. Time spent musseling and location also were recorded. Data collected were analyzed to determine species composition, CPUE, and average individual mussel weight. Ebony shell (*Fusconaia ebena*) and threeridge (*Amblema plicata plicata*) ranked first and second in number and pounds harvested each year. Average CPUE ranged from a low of 25.76 pounds/hour in 1992 to a high of 33.56 in 1994. The average individual weight of a legal size mussel dropped from 0.46lbs. to 0.39lbs. from 1992 to 1993 and 1994. The decline in average weight reflects both a shift in species composition and a reduction of the percentage of larger mussels of all species present for harvest. Because of the reduction in the portion of the resource available for harvest, annual shell harvest (as reported through the wholesale mussel buyer receipt system) has declined from 4,760 to 1,643 tons during 1990-93.

This decline in receipted tons of shell has lead to a short-fall in revenue with which to operate TWRA's commercial mussel projects. In 1994, wholesale mussel buyers paid an average of $1.02/lbs (all price categories of shell combined according to the relative percentage of the harvest) for the shells purchased from musselers. The current shell tax rate of ~ $0.01/lbs. was expected to generate ~ $94,000/year with an annual harvest of ~ 4,700 tons. However, since implementation, TWRA has never received more than ~ $59,000/year in revenue. To obtain sufficient funds, the tax rate needs to be increased to ~ $0.05/pound.

This would help cover past short-falls and insure that sufficient revenue is available for expansion of the musseling program. Some research is being conducted on the propagation of commercial mussels to help alleviate the over exploited condition of the resource. With sufficient funding, this research could be expanded in order to bolster existing and establish additional populations of commercial mussels.

The current extremely low rate of ~$0.01/lbs comprises only 0.90% of the average **wholesale** value of mussel shell. An increase to $0.05/lbs would pose no significant burden on the mussel shell industry, which sells shells for export at prices ranging from $2,000 to $8,000 per ton, but would provide much needed additional funds.

	YEAR			
	1990	**1991**	**1992**	**1993**
Lic. Mussel Harvesters	2,355	1,431	962	1,361
Lic. Wholesale Buyers			21	32
Tons Mussels, TN waters	4,760**	2,429*	2,258*	1,643*
Est. Wholesale Value $	8,808,581	6,172,118	4,613,120	4,572,809
Shell Tax Revenue $			56,533	41,382

*TWRA Wholesale Mussel Buyer Receipt Data
**TWRA Region I Commercial Shell Exporter Survey Estimate

Effects of Zebra Mussels on the Condition and Reproductive Potential of Riverine Unionid Mussels

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The purpose of this study is to determine the effects of zebra mussel density and encrustation on the condition and reproductive potential of pocketbook mussels (*Lampsilis cardium*) in the upper Mississippi River. Information obtained during this study will be useful in determining when unionids should be relocated to refuge areas, as well as when unionids can be returned to their native habitats if and when zebra mussels decline below harmful levels.

In October 1994, 10 to 20 adult pocketbook mussels were obtained from a site in Pools 4, 7, 10, and 13 of the upper Mississippi River. These mussels were processed by removing and preserving zebra mussels from the pocketbook's shell, removing and preserving tissue from the pocketbook's foot muscle, determining glochidial viability of gravid females, and removing and preserving the marsupial gills of gravid females. As well, we collected eight 0.25-m^2 quadrant samples at each site to determine zebra mussel density.

In the laboratory, we will enumerate the zebra mussels sampled from quadrants and the zebra mussels encrusted on pocketbook mussels at each site. We will assess the condition of the collected pocketbook mussels by determining the glycogen content of their foot tissue and a tissue dry weight to shell size ratio. Reproductive potential of female pocketbooks will be estimated by their fecundity to shell size ratio and by the ratio of unfertilized eggs to glochidia. Regression analyses will be conducted to determine if these condition and reproductive potential variables are related to zebra mussel density and encrustation. This study will be continued in the fall of 1995 if zebra mussels become more abundant.

An Evaluation of Relocation and Holding of Unionid Mussels in an Artificial Pond

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The purpose of this study is to obtain quantitative data on the growth and survival of freshwater mussels following removal from the upper Mississippi River and subsequent relocation into an artificial pond at the Genoa National Fish Hatchery, in Genoa, Wisconsin. Data obtained from this project will estimate the growth and survival of mussels relocated to the holding pond, compared to similar data obtained from mussels native to the upper Mississippi River, not subject to relocation but processed similarly. Once the mussels are relocated, we will estimate which treatment option yields the highest growth and survival.

In May 1995, freshwater mussels will be obtained from Navigation Pool 9 of the upper Mississippi River. We will attempt to obtain a total of 640 individuals of several species, representing several size classes within each species. Target mussels will be measured for shell length and shell height, and one valve will have an individual identification number etched into it with an engraving tool.

The treatments for this study are the different placement and orientation of mussels into the holding pond or the River. The four treatments include placing mussels in suspended substrate-filled trays, buried substrate-filled trays, hardware cloth cages, and vertically-suspended nylon mesh pockets. There will be four replicates of each treatment, with each replicate containing a total of 20 mussels representing five individuals from four mussel species.

Mussels to be used in the relocation effort (320 individuals) will be randomly assigned to each of the four treatments. All mussels will be physically located in an artesian-well fed pond located at the hatchery. Mussels to be returned to the upper Mississippi River (320 individuals) to measure "natural" rates of growth and survival will be randomly relocated into treatments. Both the field and pond relocated mussels will be monitored for growth and survival twice a year for a minimum of two years. This study is partially funded by the Mississippi Interstate Cooperative Resource Agreement, the Mussel Mitigation Trust Fund, and the Shell Exporters Association.

Life history research on the creek heelsplitter, *Lasmigona compressa*

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Lasmigona compressa is found in streams and rivers throughout central United States, and portions of Manitoba, Ontario, Quebec, and Saskatchewan (Williams et al. 1992). *L. compressa* is listed as threatened in Iowa and Illinois (Cummings and Mayer 1992).

Little is known of the fish host requirements for this species. Field observations reported in Kakonge (1972) showed that various minnows are parasitized by *L. compressa* glochidia. Laboratory tests have revealed that guppies are suitable hosts for *L. compressa* glochidia (Tompa 1979).

Five gravid *L. compressa* were collected from a tributary (Sandy River drainage) to the Mississippi River in northern Minnesota during August 1994. The outer gills of gravid females were bright orange in color when filled with glochidia. Most hooked glochidia were released in conglutinates although some glochidia were not in conglutinates. Conglutinates were flattened, 5-10 mm long and 3-5 mm wide. Conglutinates were oval shaped, tapering at either end to a point. The conglutinates were comprised of glochidia and what appeared to be unfertilized ova. Ova were bright orange, glochidia were translucent yellow.

Nine species of fish collected from lakes and streams not known to contain *L. compressa* were exposed to *L. compressa* glochidia. Spotfin shiners, slimy sculpins, yellow perch, and black crappie facilitated glochidia metamorphosis to the juvenile stage (Table 1). Many more juveniles were collected from slimy sculpins than from any other species tested.

Table 1. Suitable and unsuitable fish hosts for *Lasmigona compressa* glochidia.

transformation observed			no transformation observed		
Species	Number tested	Days to metamorphosis	Species	Number tested	Period of attachment
spotfin shiner (I)	5	12	spotfin shiner (II)	8	5-8 d
slimy sculpin	3	12-14	mudminnow	6	5-8 d
black crappie	6	12-15	black bullhead	3	13-15 d
yellow perch	2	11	brook stickleback	4	12-14 d
			largemouth bass	1	5-7 d
			green sunfish	1	5-7 d

Average water temperature was 19 ± 2°C.

No juvenile *L. compressa* were collected from spotfin shiners during the second test. This may be due to shiners consuming the juveniles. In another test we found that installing a separation screen between the shiners and the aquarium floor dramatically increased the number of juveniles collected.

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Anodontoides ferussacianus and *Anodonta imbecillis* host suitability tests

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Gravid *Anodontoides ferussacianus* and *Anodonta imbecillis* were collected from a tributary (Sandy River drainage) to the Mississippi River in northern Minnesota during August 1994. Gravid females were held in beakers placed in aquaria at the University of Minnesota wet laboratory.

Both species released glochidia in the laboratory. Two gravid *Anodonta imbecillis* released glochidia not in conglutinates. Twelve gravid *Anodontoides ferussacianus* released glochidia in the laboratory. Most females released multiple glochidia not in conglutinates, although five females also produced transparent strands of mucus which frequently held 5-20 glochidia. These strands appeared to be neutrally buoyant and would stretch between the female's excurrent siphon and aquarium walls, beaker walls, and beaker floor. Strands were between 5-25 cm long and 1-2 mm wide.

Test fish were collected from lakes and streams not known to contain *Anodontoides ferussacianus* or *Anodonta imbecillis*. Spotfin shiners and black crappie facilitated *Anodontoides ferussacianus* glochidia metamorphosis to the juvenile stage (Table 1).

Table 1. Suitable and unsuitable hosts for *Anodontoides ferussacianus* glochidia.

transformation observed			no transformation observed		
Species	Number tested	Days to metamorphosis	Species	Number tested	Period of attachment
spotfin shiner	6	12-20	fathead minnow	11	6-9 d
black crappie	6	12-15			

Average water temperature was 19 ± 2°C.

Black crappie and spotfin shiners also facilitated metamorphosis of *Anodonta imbecillis* glochidia (Table 2).

Table 2. Suitable hosts for *Anodonta imbecillis* glochidia.

Species	Number tested	Days to metamorphosis	Number of juveniles recovered
spotfin shiner	4	12-20	1
black crappie	6	12-15	29

Average water temperature was 19 ± 2°C.

Although a variety of fish species have been recorded as hosts for both *Anodontoides ferussacianus* and *Anodonta imbecillis*, the species we tested have not been previously identified as suitable hosts (Watters 1994).

Mucus strand production has not been reported for *Anodontoides ferussacianus* although it has for *Anodonta grandis* (Utterback 1915). It would be interesting to know if females produce these strands under natural conditions. If they do, perhaps passing fish might brush against a strand and expose itself to the glochidia resting in the mucus.

Utterback, W. I. 1915-1916. The naiades of Missouri. American Midland Naturalist, 4: 1-29, 41-53, 97-152, 181-204, 244-273 (1915); 311-327, 339-354, 387-400, 432-464 (1916).

Watters, G. T. 1994. An annotated bibliography of the reproduction and propagation of the Unionoidea (Primarily of North America) Ohio Biological Survey, Misc. Contributions No. 1. 162 pp.

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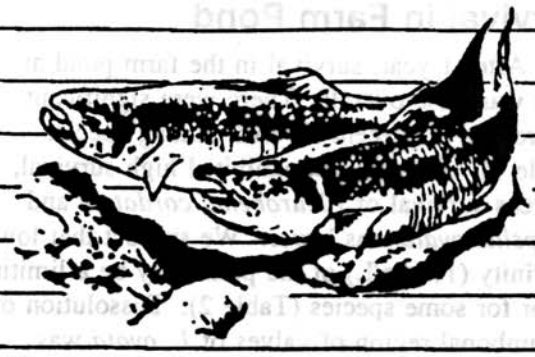

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Use of Ponds to Protect Native Freshwater Mussels

The exotic zebra mussel (*Dreissena polymorpha*) is spreading rapidly throughout the interior basin rivers of the United States. Since its introduction into Lake St. Clair in 1986, it has eliminated the native freshwater mussel fauna from Lake St. Clair, much of Lake Erie, the Detroit River, and other localized areas in this region. Zebra populations now infest native mussel beds in the upper Mississippi River, Illinois River, lower Ohio River, Tennessee River, Hudson River, and numerous other mainstem rivers throughout the central United States. Our prognosis for native mussel populations is decimation, with widespread extirpations and some extinctions expected before the year 2000. This project is evaluating the use of ponds as refugia for mussel species at greatest risk of extirpation or extinction in large rivers.

Ponds as Refugia

To protect native species at greatest risk from this exotic mussel, a project was initiated in 1992 to test the feasibility of pond refugia for riverine mussel populations. Samples of adult mussels were collected from the Tennessee and New rivers and are being held in suspended cages within a 0.10-ha farm pond at Critz, Virginia. Mussels are held in 1- × 1- × 0.5-m plastic-screen cages fastened to PVC float collars. Large species are held unrestricted on the cage bottoms. Small species are held within 100-mm mesh plastic sleeves hung horizontally from the cage tops.

In 1993, three ponds at the state fish hatchery in Marion, Virginia, were made available to expand the project. Adult mussels collected from the Tennessee and Cumberland rivers in summer–fall 1993 are being maintained at this hatchery. Because these mussels were collected within the known range of the zebra mussel, they were scrubbed at the collection site and transported to a small quarantine pond (36 × 36 m) at Virginia Tech, in Blacksburg, Virginia. This lined irrigation pond has no inlet or outlet, and has a maximum depth of about 2 m. Mussels were quarantined for 1 month, inspected for zebra mussels, and then transported to the hatchery ponds for long-term monitoring.

Survival in Farm Pond

After 1 year, survival in the farm pond at Critz was 72% overall. There were significant differences in percent survival among species (Table 1). *Elliptio* spp. exhibited high survival, whereas survival of *Pleurobema cordatum* and *Lampsilis ovata* was lower. We suspect that low alkalinity (17 mg/L) of the pond may be a limiting factor for some species (Table 2). Dissolution of the umbonal region of valves of *L. ovata* was evident after several months, and perforations likely contributed to mortality of this species.

Survival in Hatchery and Quarantine Ponds

Survival of most mussel species has been good after 6 months of confinement (Tables 3 and 4). The variation in survival among study sites, however, was considerable. We suspect that the deposition of particulates derived from unconsumed trout pellets at the cages contributed to the low survival at the Marion Hatchery. Mussels on the cage bottoms experienced greater mortality than those suspended in the cage, likely due to reduced dissolved oxygen or ammonia production from pelleted feed decomposition. Most of these deaths were recorded after 5 months of confinement.

Because many populations of federally listed and state-protected freshwater mussels will be colonized by zebra mussels, we encourage natural resource agencies to consider ponds or other refugia as a means to protect native species from the impending impacts anticipated by the continuing spread of this prolific competitor and fouler. We presently maintain about 1,500 mussels of 15 species and will continue to monitor survival and reproductive condition in 1995. Additional species will be collected in 1995 to expand our captive stocks. We anticipate that caged mussels will spawn and become gravid, so that glochidia will be available for ongoing propagation efforts in field and laboratory experiments.

For further information contact

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Table 1. Survival of mussels being held in the farm pond at Critz after 1 year.

Species	Number held	Percent survival
Pleurobema cordatum (Ohio pigtoe)	39	54
Elliptio dilatata (spike)	2990	
Elliptio complanata (eastern elliptio)	53	87
Elliptio producta (Atlantic spike)	13	77
Cyclonaias tuberculata (purple wartyback)	33	91
Lampsilis ovata (pocketbook)	1414	

Table 2. Water chemistry of holding ponds in Virginia, summer 1993.

	Chemical Measurement		
Location	Alkalinity (mg/L)	pH	Dissolved oxygen (mg/L)
Critz	17	8.0–8.5	10–12
Marion	154	8.5–9.0	10
Blacksburg	154–205	8.0	10–11

Table 3. Survival of adult mussels in the quarantine pond at Blacksburg.

Species	Number held	Percent survival
Elliptio crassidens (elephant-ear)	120	88
Ellipsaria lineolata (butterfly)	34	15
Lasmigona c. complanata (white heelsplitter)	59	92
Megalonaias nervosa (washboard)	102	72
Pleurobema cordatum (Ohio pigtoe)	213	74
Quadrula p. pustulosa (pimpleback)	144	83

Table 4. Survival of adult mussels at the Marion State Fish Hatchery.

Species	Number held	Percent survival
Elliptio crassidens (elephant-ear)	120	50
Ellipsaria lineolata (butterfly)	60	33
Megalonaias nervosa (washboard)	90	22
Pleurobema cordatum (Ohio pigtoe)	120	34
Quadrula metanevra (monkeyface)	30	73
Quadrula p. pustulosa (pimpleback)	120	35

WISCONSIN DEPARTMENT OF NATURAL RESOURCES (David J. Heath). MARCH 1993. JUSTIFICATION AND FEASIBILITY ANALYSIS FOR FRESHWATER MUSSEL REESTABLISHMENT UPSTREAM OF THE PRAIRIE DU SAC DAM (FERC PROJECT # 11162), WISCONSIN RIVER, WISCONSIN. Wi. DNR, Bur. Endangered Res., End. Res. Rpt # ??. Avail. from: WI Dept. Nat. Res., Bureau of Endangered Resources, 101 S. Webster St., Box 7921. Madison, WI 53707. 608-264-6031

SUMMARY

1) This document represents an upstream freshwater mussel reestablishment (Bivalvia: Unionidae) feasibility analysis for the Prairie du Sac hydroelectric project (FERC # 11162). It responds to a request by the Federal Energy Regulatory Commission (FERC) to determine the feasibility of reintroducing freshwater mussels upstream of the dam.

2) Of the 16 mussel species absent upstream of the dam but present downstream, two were chosen for reestablishment. These two are the monkeyface and fawnsfoot. These two were chosen because of their confirmed historic upstream presence, verified recent upstream absence and availability of unoccupied upstream habitat.

3) Upstream loss of mussels is due to historic poor water quality. Operation and presence of the Prairie du Sac hydroelectric dam prevent natural recolonization of upstream reaches by serving as an effective biological barrier. Upstream water quality has improved since 1975 and now affords suitable mussel habitat. The license applicant is not responsible for the upstream extirpation of mussels. They are responsible for the absence of natural upstream recolonization into now suitable habitat due to project operations.

4) During 1993, underwater visual and biological sampling at several upstream locations verified the presence of high quality mussel habitat. Upstream mussel and gravel bar translocation sites were identified where downstream translocated mussels would have the greatest chance of survival and reproduction.

5) Removal of downstream mussels for upstream translocation would have little impact. Removal of 300 individuals of each species would comprise a maximum population loss of less than 1%.

6) Four reestablishment strategies were identified:

- upstream introductions via an upstream fish passage facility.
- active translocation of adult mussels
- active introductions of inoculated fish
- stocking of juvenile mussels transformed in artificial media and reared in the laboratory.

Of these four strategies, active translocation of adult mussels is the most economically and biologically feasible.

7) Based on economic and biological analyses, the reintroduction of monkeyface and fawnsfoot is best achieved via reintroduction of adult mussels in riverine reaches between the Prairie du Sac and Kilbourn dams.

8) The decision by FERC or any other entity to go forward with this freshwater mussel reestablishment will likely depend upon decisions and acceptable levels of risk surrounding two issues: economics and potential project success as related to upstream host fish availability.

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We are including a survey that is being sent to a list of people who may have interest in zebra mussel infestation of the Ohio River. We are attempting to determine if people out there feel we need a meeting to discuss this serious issue, and if so to solicit suggestions on the specifics of such a meeting. If this is a point of interest to you, please complete the survey form and return it to Cindy Chaffee or Bob Anderson. We will keep you updated on how this progresses (or doesn't progress) in future Trainnual Unionid Reports.

SURVEY FOR INTEREST IN MEETING TO DISCUSS ZEBRA MUSSEL INFESTATION PROBLEM IN THE OHIO RIVER.

Name_____

Affiliation_____

Address_____

_____

Phone_____ **Fax**_____

Is a meeting necessary?_____

Suggestions for when and where_____

_____

What should the objective of this meeting be?_____

_____

Can we satisfy the objective with one meeting or should this be the first of multiple meetings?_____

How much time should be allotted for the meeting?_____

Suggestions for topics on an agenda_____

_____

Who should be invited?_____

_____

Do we need a moderator?_____

Should we include guest speakers?_____ **If so, suggestions for speakers and topics**_____

_____

Ideas for funding sources if a complex meeting is determined necessary_____

_____

Do you have any other comments or suggestions for planning the proposed meeting? ___

_____

_____

_____

_____

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_____

_____

Please return completed form by XX/XX/XX to:

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