COPE

Triannual Unionid Report

Report No. 8

November 1995

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

Compiled by

Richard G. Biggins
U.S. Fish and Wildlife Service
160 Zillicoa Street
Asheville, North Carolina 28801

Telephone: 704/258-3939, Ext. 228
FAX: 704/258-5330

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.

TABLE OF CONTENTS

TRIANNUAL UNIONID REPORT NO. 8
NOVEMBER 1995

David E. Neils, VA Coop. Fish and Wildlife Research Unit, VPI&SU, 106 Cheatham Hall, Blacksburg, VA 24061 Phone: 703/231-5927

Progress Report: Holston River Mussel Relocation Project

Initial work for the relocation of freshwater mussels to 2 sites in the North Fork (Click Island and Cloud Ford) and 1 site in the main stem Holston River was begun in July 1995. As of August 4, 1995 3 trips have been made to Camden, TN to collect a total of 5,409 animals of 7 species from Kentucky Lake (see Table 1 for species collected). Collection of mussels was completed by the purchase of fresh animals from a commercial shell buyer, use of a commercial diver, and TWRA biologists. All mussels were thoroughly inspected for adult zebra mussels and subsequently scrubbed with a stiff bristled brush. Although only 4 adult zebra mussels were seen during the collection period, this protocol was strictly followed at all times.

Following each trip, mussels were transported to the State Fish Hatchery at Morristown, Tennessee where all animals were held in five 600 gallon circular tanks for a minimum of 14 days. With the exception of the ebonyshell mussel, *Fusconaia ebena*, collected during the first trip, survival of mussels during the quarantine period has been excellent. Temperature and dissolved oxygen readings are taken in each tank on a daily basis, and ground up fish food is added every other day.

Once the quarantine period has been satisfied, mussels are transported to the relocation site and individually placed in the substratum. Currently, one relocation of 1000 large three-ridge mussels (*Amblema plicata*) has been completed (Jul. 31) at Click Island, with a second relocation scheduled for (Aug. 8). Cloud Ford will receive mussels sometime during the week of Aug. 13. Relocations of mussels to the main stem site will be completed this fall depending on the availability of mussels. Initial surveys to assess survival of mussels relocated to Click Island and Cloud Ford are scheduled for September 1995 and will resumed again in April 1996.

Table 1. Species composition of mussels to be relocated into the Holston River

Trip Date	Method of Collection	Species		Number Collected
		Common Name	Scientific Name	
7/7/95	purchase from shell buyer	three-ridge	*Amblema p. plicata*	1082
		ebony shell	*Fusconaia ebena*	327
		purple wartyback	*Cyclonaias tuberculata*	12
		monkeyface	*Quadrula metanevra*	2
		pimpleback	*Quadrula p. pustulosa*	3
7/19/95	commercial diver	three-ridge	*Amblema p. plicata*	378
		ebonyshell	*Fusconaia ebena*	579
		washboard	*Megalonaias nervosa*	34
7/20/95	commerical diver	three-ridge	*Amblema p. plicata*	418
		ebony shell	*Fusconaia ebena*	170
		washboard	*Megalonaias nervosa*	52
8/2/95	purchase from shell buyer	three-ridge	*Amblema p. plicata*	420
8/3/95	commerical diver	three-ridge	Ambelma p. plicata	670
		washboard	Megalonaias nervosa	85
8/3/95	purchase from shell buyer	monkeyface	Quadrula metanevra	460
8/3/95	TWRA divers	purple wartyback	*Cyclonaias tuberculata*	298
		pimpleback	*Quadrula p. pustulosa*	214
		monkeyface	*Quadrula metanevra*	99
		butterfly	*Ellipsaria lineolata*	66
		elephantear	*Elliptio crassidens*	40
Total				5409

MARIAN E. HAVLIK, Malacological Consultants, 1603 Mississippi Street, La Crosse, Wisconsin 54601-4969. Phone/FAX: 608-782-7958.

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

Minnesota's Root River system apparently has never been surveyed for unionids. We sampled from 6 - 17 June 1994 at 117 bridge and road access sites between the Root River headwaters and the Mississippi River. We also sampled on the nearby Upper Iowa (2 sites) and Little Iowa Rivers (8 sites), for a total of 127 sites.

A popular canoeing river, the main stem of the Root River starts NE of Lanesboro, MN, at the confluence of the North and Middle Branches of the Root River, and flows easterly to its confluence with the Mississippi River, between La Crescent and Brownsville, MN, opposite La Crosse, WI. Sampling consisted of wading and shoreline searches in the headwaters and middle reaches of the river system, and shoreline searches by boat in the lower six miles of the Root River from Hokah, MN, to the river's mouth.

This survey included the main stem and all four major tributaries, and yielded at least 16 unionid species. However, 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 one 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. A number of the remaining species were represented by fairly fresh-dead shells.

The most species (12) were found in the North Branch Root River, among 22 sites, however the most shells were found in the South Branch among 40 sites (nine species). Eleven species were found among eight sites on the Middle Branch 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, strangely enough, was not found in western Wisconsin for over 60 years, until 1992 - 1994.

Our data show severe impacts to the Root River system. Since we have not finished sampling the river system, we were unable to pinpoint the precise impacts that led to this situation. Our preliminary conclusions are that cumulative impacts, primarily agricultural (livestock in streams, and farm and road chemicals) are apparently responsible. The only refugia appear to be the headwaters and small tributaries. Since the Zebra Mussel is exploding in the Mississippi system, we must quickly identify tributary molluscan fauna, or risk losing unique populations before they can be identified. We hope to have additional funding to complete sampling of the river system, including tributary creeks.

This project was funded by the Minnesota Nongame Wildlife Program from contributions to the Minnesota Nongame Wildlife Tax Checkoff.

LEIGH ANN MCDOUGAL, U.S. Forest Service, 110 Southpark Drive, Blacksburg, VA 24060. Phone: 540-552-4641. FAX: 540-552-4376.

SOUTHERN REGION MUSSEL SURVEYS AND STUDIES.

In case anyone is interested in this information, listed below are mussel surveys and studies that have been funded by the Southern Region of the Forest Service in the last 5 years. For more detailed information, please call the contacts listed for each Forest.

ALABAMA - National Forests in Alabama

Contact: April Hargis, 334-832-4470.

1. A Mussel Survey of the Streams Draining Bankhead National Forest and the Oakmulgee Division of Talladega National Forest, Alabama. Conducted by Stuart McGregor with the Alabama Geological Survey (1992).
2. A Survey of the Unionid Mussels of the Talladega National Forest, Shoal Creek and Talladega Ranger Districts. Conducted by Malcolm Pierson, an aquatic biologist with Alabama Power (1992).
3. A Qualitative Assessment of the Unionid fauna Found in Streams in and near the Tuskegee National Forest. Conducted by Monte McGregor, a graduate student at Auburn University (1993).
4. A Survey of the Mollusks of Conecuh National Forest, Escambia and Covington Counties in South-Central Alabama. Conducted by Doug Shelton with Vittor & Associates, Inc (1995).
5. Mel Warren and Wendell Haag with the Southern Forest Experiment Station in Oxford, MS began a mussel study on the Bankhead District in 1993. The objectives of this study were to characterize aspects of the mussel communities including species composition and density, demographic structure, fish hosts, and physical habitat characteristics; and to develop survey and monitoring protocols that could be used by National Forest personnel. The study was expanded in 1995 to include the Shoal Creek District. Call Mel or Wendell at 601-234-2744 for more information.

ARKANSAS/OKLAHOMA - Ouachita National Forest

Contact: Rich Standage, 501-321-5202 or Betty Crump, 501-356-4187.

1. Stream Inventory of Lampsilis powellii Populations on National Forest Lands. Conducted by Arthur and Kristine Brown with ECOLAB (1989).
2. Survey of the Freshwater Mussels of the South Fourche LaFave River and Major Tributaries. Conducted by John Harris with Arkansas State University (1992).
3. Mussels of the Phase III Ecosystem Management Project Watershed (Alum Fork, Saline River Drainage, Arkansas). Conducted by Carol Johnston with the Southern Forest Experiment Station, Oxford, MS (1993).
4. Survey for Arkansia wheeleri and Other Rare Unionids in the Tiak District. Conducted by Caryn Vaughn, Christopher Taylor, Kelly Eberhard and Mathew Craig with the Oklahoma Biological Survey, Oklahoma Natural Heritage Inventory (1994)
5. Microhabitat and Population Analysis of Lampsilis powelli in the South Fork Ouachita River, Montgomery County, Arkansas. Conducted by John Harris (1994).
6. Survey of the Freshwater Mussels of the Poteau River Drainage in Arkansas. Conducted by John Harris (1994).
7. 1996 - Cooperative agreements signed for Caryn Vaughn to survey a portion of the Glover River in Oklahoma; and John Harris to survey mussel beds in the upper Ouachita River.

Ozark-St. Francis National Forests
Contact: Craig Hilburn, 501-968-2354.
1. Mulberry River Freshwater Mussel Survey. Conducted by Joe Stoeckel, Lindsey Lewis, and Shannon Shook with Arkansas Tech University (1995).

FLORIDA - National Forests in Florida
Contact Bob Grinstead, 904-669-3153.
1. St. Johns River System Preliminary Mollusk Survey - conducted by TVA, Forest Service and Fish and Wildlife Service personnel (1993).

GEORGIA - Chattahoochee and Oconee National Forests
Contact: Mitzi Pardew, 770-536-0541
1. Mussel Survey of some streams on the Armuchee District. Conducted by Forest Service personnel (1995).

KENTUCKY - Daniel Boone National Forest
Contact: Vicki Bishop, 606-745-3100
1. A Survey of the Unionids of Middle Fork, Rockcastle River, Kentucky. Conducted by Ron Cicerello with the Kentucky State Nature Preserves Commission (1992).
2. A Survey of the Unionids of the Rockcastle River, Billows, Kentucky, to the Cumberland River. Conducted by Ron Cicerello, KSNPC (1994).
3. A Survey of the Unionids of Marsh Creek, McCreary County, Kentucky. Conducted by Ron Cicerello, KSNPC (1995).
4. A survey of the Redbird River is in progress this year (1995).

LOUISIANA - Kisatchie National Forest
Contact: Emlyn Smith, 318-765-3554 or Dave Peterson, 409-639-8541.
1. Field Notes from a Survey of Margaritifera Hembeli on U.S.F.S. property, Catahoula Ranger District, Kisatchie National Forest. Conducted by Paul Johnson and Kenneth Brown with Louisiana State University (1994).

MISSISSIPPI - National Forests in Mississippi
Contact: Rick Dillard, 601-965-5484
1. Current Distributional Information on Freshwater Mussels in Mississippi National Forests. Literature and museum review conducted by Wendell Haag and Mel Warren with the Southern Forest Experiment Station (1995).

NORTH CAROLINA - National Forests in North Carolina
Contact: Donley Hill, 704-257-4205.
1. Croatan National Forest Inventory: Mollusks, Crayfish, and Mammals. Conducted by John Alderman, Therese Conant, Thomas Henson and Chris McGrath with the NCWRC Nongame and Endangered Wildlife Program (1994).
2. Uwharrie Mountains Inventory: Mollusks, Crayfish, and Mammals. Conducted by John Alderman and Chris McGrath, NCWRC (1994).
3. Mussel Survey on a portion of the Nolichucky River. Conducted by Forest Service personnel (1995).
4. Mills River and tributaries. Conducted by Jim Layzer and Lesa Madison with TN Tech University (in progress).

SOUTH CAROLINA - Francis Marion and Sumter National Forests
Contact: Kelly Russell, 803-561-4067.
1. Freshwater Mussels of the Chattooga River. Conducted by Jenny Adkins with NRCS (1995).

2. Freshwater Mussel Inventory of the Stevens Creek Subbasin, Long Cane Ranger District, Sumter National Forest, South Carolina. Conducted by John Alderman (1995).

TENNESSEE - Cherokee National Forest

Contact: Jim Herrig, 423-476-9751.

1. The Cherokee National Forest has been conducting mussel surveys in the de-watered section of the Hiwassee River since 1993 with the help of biologists from many different agencies. In 1996, they hope to initiate a study with the Southern Forest Experiment Station to compare the contents of muskrat middens to actual mussel populations in the Hiwassee.

TEXAS - National Forests in Texas

Contact: Dave Peterson, 409-639-8645.

1. Stephen F. Austin University conducted mussel surveys of the Davy Crockett and Angelina National Forests in 1994 and the Sam Houston and Sabine National Forests in 1995.

VIRGINIA - George Washington and Jefferson National Forests

Contact: Mark Hudy, 540-564-8300.

1. Annual Reports, Distribution of the James Spinymussel in Streams of the Jefferson and George Washington National Forests - conducted by Martin O'Connell and Dick Neves with Virginia Tech (1991 & 1992).
2. Mussel Survey of Clinch River tributaries on the Clinch Ranger District - conducted by Forest Service personnel (1995).

SUBMITTED BY: Don Hubbs, Comm. Mussel Program Supervisor
(615)781-6575 wrk. or (901)584-9032 Hm.
Tennessee Wildlife Resources Agency
P.O. box 70
Camden, Tn 38320

Commercial Mussel Harvest Status : Exploitation of Federal listed endangered mussel species by Kentucky Reservoir mussel harvesters continues. Thus far eight specimens of endangered mussel species (7 *Plethobasus cooperianus, 1 Lampsilis abrupta)* have been confiscated from commercial shell buyers and harvesters. Five of the eight specimens were fresh dead (all were *Plethobasus cooperianus)*. Commercial mussel harvesters and shell buyers have demonstrated their inability to separate this species from *Cyclonaias tuberculata*, which constitutes approximately 0.1% of the shells normally harvested. Based on this information, I have recommended that the Tennessee Wildlife Resources Commission (TWRC) remove all species which might be confused with *P. cooperianus*. This list includes *Cyclonaias tuberculata, Quadrula pustulosa, and Q. nodulata.* This action would not impose significant economic hardship on the mussel harvesters or buyers, since all three species combined make up only 0.16% of the annual shell harvest. I expect the TWRC to take action on this matter during their November meeting. If the TWRC does not remove these species, I expect commercial musselers will continue indiscriminately harvesting *P. cooperianus*. This would be a tragedy, in that the majority of the *P. cooperianus* examined from the harvest appear to be relatively young specimens, evidence of recruitment within the last 10 to 15 years.

Commercial Mussel Stock Restoration: During October, 1994 approximately 300 blue and channel catfish were infected with *Megalonaias nervosa* glochidia. A conservative estimate of 50 glochidia per fish yields a total infection of about 15,000 encysted glochidia released into Kentucky and Barkley reservoirs. Transformation was not confirmed, however a sample of both fish species held in a floating cage in Kentucky Reservoir carried the glochidia until May, when the water temperature reached 65 - 70 °F. In August, heavy infections of *Amblema p. plicata* on hybrid sunfish (*Lepomis macrochirus x L. microlophus*) were obtained via an improved infection technique. Transformed juveniles were collected within 5 days post infection (water temp. 80°F), from fish held in test aquariums. Propagation test sites were established on Old Hickory and Kentucky reservoirs. At each site a quantity of sunfish bearing *A. p. plicata* glochidia were held in floating cages anchored over favorable substrate. Approximately 14 days post infection, fish were inspected for unshed glochidia and released. The cages were constructed to allow the transformed juveniles to pass through the cage and settle in the vicinity. These test sites will be monitored for evidence of production during 1997.

Zebra Mussel status: The sky has yet to fall on Kentucky Reservoir. Although zebra mussels were encountered with greater frequency during Spring harvester surveys; Summer surface water temperatures exceeding 95°F (83°F at depth 50 ft.) and predation by fish appear to have thwarted a zebra mussel explosion for another year. TVA's zebra mussel monitoring station at TRM 100.5, New Johnsonville, TN Fossil Plant, revealed fewer zebra mussels per square meter at Summers end than were collected earlier in the year during both 1994 and 1995 (Bennie Kerley and Johnny Buchanan, personal communication). Scientists who years earlier predicted that the zebra mussel would destroy Kentucky Reservoir's commercial mussel industry within 2 years of the first collection failed to adequately consider the predation power of the existing fish assemblage and veliger mortality during the spawning season. If the zebra mussel ever does develop into a threat to the mussel industry, it will require several more years than predicted.

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

Authors: Teresa Naimo[1], Pamella Thiel[2], and Kurt Welke[3]

Address: [1]National Biological Service, Upper Mississippi Science Center, LaCrosse, WI
[2]USFWS, LaCrosse Fishery Resources Office, Onalaska, WI
[3]Wisconsin Department of Natural Resources, Prairie du Chien, WI

Phone: Naimo (608-783-6451), Thiel (608-783-8431), Welke (608-326-0233)

In many large rivers, unionid mussels are at risk from the exotic zebra mussel. The use of artificial ponds, such as those found in National Fish Hatcheries, are being evaluated as temporary holding locations for mussels until the immediate threat of zebra mussels has passed or until artificial propagation has been successfully developed. Data on growth and survival of mussels relocated to an artificial pond was compared to similar data obtained from mussels treated similarly but relocated to a natural setting within the upper Mississippi River (UMR). In May 1995, we obtained 1392 mussels representing five species (*Amblema plicata, Fusconaia flava, Leptodea fragilis, Obliquaria reflexa* and *Quadrula quadrula*) from the UMR. Each mussel was scrubbed 'free' of zebra mussels and placed into a quarantine pond. After 34 days, unionids were re-inspected for zebra mussels, individually tagged, and length, height, and wet weight were recorded. Mussels were randomly assigned to treatments at either a 1.2 acre pond at a National Fish Hatchery, or the UMR. The treatments were the physical structures used to hold the mussels and consisted of suspended mesh bags, buried and suspended trays containing dredge spoil, and corrals around the natural substrate. There were four replicates of each treatment, each containing 24 mussels.

We found no zebra mussels on any live unionids after the 34-day incubation. Mean survival of mussels during the quarantine period was 83% and ranged from 55% in *L. fragilis* to 97% in *Q. quadrula*. In September 1995, we randomly retrieved mussels from the treatments. We found no zebra mussels on any unionid relocated to the pond, but mussels relocated to the UMR contained an average of 3.1 zebra mussels per unionid. Survival, combined over all five species, was significantly different between the pond (71%) and river-relocated mussels (95%). In addition, survival was significantly different among treatments; highest survival rates were found in the suspended trays, while poorest survival was generally found in the buried trays. Finally, we observed species-specific differences in survival. In the pond, fragile papershells (*L. fragilis*) did not fare well, with only 49% surviving the first few months. In contrast, survival ranged only from 91% to 97% among all species in the river. Both the pond and river-relocated mussels will be monitored for growth and survival at least once a year for a minimum of two years.

Host research on round pigtoe glochidia

Mark C. Hove
University of Minnesota, Department of Fisheries & Wildlife, 1980 Folwell Avenue, St. Paul, MN 55108
(612) 624-3019, e-mail mh@finsandfur.fw.umn.edu

The round pigtoe is a freshwater mussel found in rivers throughout a large portion of the Mississippi River drainage, and parts of the Great Lakes drainage (Williams et al. 1993). *Pleurobema coccineum* is listed as Endangered in Iowa and of Special Interest in Ohio (Cummings and Mayer 1992).

Little is known about the host requirements of *P. coccineum* glochidia. Round pigtoe glochidia have been observed naturally infesting the gills of bluegill, *Lepomis macrochirus* (Surber 1913, Coker et al. 1921).

A gravid *P. coccineum* collected from the St. Croix River released glochidia in the laboratory on 17 July 1995. Glochidia were tightly packed into conglutinates which were slightly negatively buoyant. Conglutinates were white, thin, tapered at both ends, and 4-6 mm wide, 10-15 mm long. Most conglutinates were released individually, although some were released in groups of two to four attached at one end.

Seven species of fish collected from lakes and streams not known to contain *P. coccineum* were exposed to glochidia in the laboratory. Three cyprinid genera facilitated glochidia metamorphosis to the juvenile stage (Table 1).

Table 1. Suitable and unsuitable fish hosts for *Pleurobema coccineum* glochidia.

Transformation observed			No transformation observed		
Species	Number tested	Days to metamorphosis	Species	Number tested	Period of attachment
spotfin shiner	6	25-29 d	northern pike	3	11-14 d
bluntnose minnow	6	25-29 d	Iowa darter	4	11-14 d
northern redbelly dace	8	29-33 d	bluegill	3	9-11 d
			smallmouth bass	6	16-18 d

Average water temperature was 19 ± 2°C.

Results from this study conflict with earlier studies. A centrarchid is reported in Surber (1913) and Coker et al. (1921) as a host for *P. coccineum*. Foot and adductor muscle development has been observed in *P. coccineum* glochidia infesting bluegill (Surber 1913). However, bluegill and smallmouth bass in this study, and eight largemouth bass from an earlier study were unsuitable hosts. An additional study should be conducted on a larger number of bluegill to determine if they serve as suitable hosts for *P. coccineum* glochidia.

Literature Cited

Coker, R. E., A. F. Shira, H. W. Clark, and A. D. Howard. 1921. Natural history and propagation of fresh-water mussels. Bull. U. S. Bur. Fish. 37: 75-181.

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

Surber, T. 1913. Notes on the natural hosts of fresh-water mussels. Bull. U.S. Bur. Fish. 32: 101-115.

Williams, J. D., M. L. Warren, Jr., K. S. Cummings, J. L. Harris, and R. J. Neves. 1993. Conservation status of freshwater mussels of the United States and Canada. Fisheries 18(9): 6-22.

Suitable fish hosts of the lilliput, *Toxolasma parvus*

Mark C. Hove
Univ. of Minnesota, Dept. Fish. & Wild., 1980 Folwell Ave., St. Paul, MN 55108
(612) 624-3019, e-mail mh@finsandfur.fw.umn.edu

Toxolasma parvus is found in streams and rivers throughout east-central North America. The distribution and abundance of this species is currently considered stable (Williams et al. 1993).

Various centrarchids are believed to serve as hosts for *T. parvus* glochidia. *Toxolasma parvus* glochidia have been observed infesting the gills of *Lepomis gulosus* (Wilson 1916). *Lepomis gulosus*, *L. cyanellus*, *L. humilus*, *L. macrochirus*, and *Pomoxis annularis* are considered hosts for *T. parvus* glochidia (Fuller 1974).

A gravid *T. parvus* was collected from sandy substrate at 10 cm depth from the Mississippi River north of Minneapolis, MN during July 1995. The female released individual glochidia in the laboratory. Three fish species collected from lakes not known to contain *T. parvus* were exposed to a bath of glochidia for 2.75 hours. Fish species were held in separate aquaria which were siphoned three times a week to collect juvenile mussels.

Of three species exposed to *T. parvus* glochidia, only *L. cyanellus* facilitated glochidia metamorphosis (Table 1). Over 300 juveniles were collected from the aquarium holding the year-old *L. cyanellus*.

Table 1. Suitable and unsuitable fish hosts for *Toxolasma parvus* glochidia.

Transformation observed			No transformation observed		
Species	Number tested	Days to metamorphosis	Species	Number tested	Period of attachment
Lepomis cyanellus	6	30-35 d	*Cyprinella spiloptera*	5	13-17 d
			Perca flavescens	4	15-17 d

Average water temperature was 19 ± 2°C.

Literature Cited

Fuller, S. L. H. 1974. Clams and mussels (Mollusca: Bivalvia). Pages 215-273 in C. W. Hart and S. L. H. Fuller, eds. Pollution ecology of freshwater invertebrates. Academic Press, Inc., New York, New York. 389 pp.

Williams, J. D., M. L. Warren, Jr., K. S. Cummings, J. L. Harris, and R. J. Neves. 1993. Conservation status of freshwater mussels of the United States and Canada. Fisheries 18(9): 6-22.

Wilson, C. B. 1916. Copepod parasites of fresh-water fishes and their economic relations to mussel glochidia. Bulletin of the U.S. Bureau of Fisheries 34: 331-374.

FRESHWATER MUSSEL SURVEYS OF RIO GRANDE TRIBUTARIES IN CHIHUAHUA, MEXICO

Robert G. Howells and Gary P. Garrett
Texas Parks and Wildlife Department, Heart of the Hills
Research Station, Ingram, TX 78025

Within the Rio Grande drainage of Texas and Mexico, four freshwater mussel species (Unionidae) were endemic and a fifth occurred both in the Rio Grande and in Central Texas. Relatively few studies have addressed these species in this century (Taylor 1967; Metcalf 1974, 1982; Neck and Metcalf 1988) and their recent status is largely undocumented. After Texas Parks and Wildlife Department's (TPWD) Heart of the Hills Research Station began statewide unionid surveys in 1992, it quickly became apparent the continued secure existence of these five species was in doubt.

Among the endemic taxa, Quadrula couchiana has not been reported in many decades. Truncilla cognata has not been reported since 1972 (Metcalf 1982). Popenaias popei was last reported by Murray (1975) and not found again until TPWD recovered a single, recent shell in 1992. Potamilus (Disconaias) salinasensis has been represented recently only by fresh shells in 1972 (Metcalf 1982) and a single, recent shell found by TPWD in 1992. Additionally, Quincuncina mitchelli has been found only as subfossil fragments in Central Texas rivers in TPWD surveys; none were found in the Rio Grande drainage.

In an effort to determine if any of these species persist within the Mexican drainage of the Rio Grande, G.P. Garrett and the HOH staff incorporated collection of freshwater mussels as part of TPWD desert fishes surveys in Chihuahua in 1994 and 1995. In August 1994, sites were sampled on the Río Conchos (Cuchillo Parado, below Julimes and Valle de Zaragosa), the Río Chuviscar and the hot springs at San Diego de Alcalá, Ojo de Talmantes (Río Florido tributary), Río San Pedro south of Satevó, Río Santa Isabela (upstream and at Riva Palacio), headwaters of the Río Conchos, and Ojo del Rey near Angostura. In October 1995, seven more sites in northern Chihuahua were also sampled. These were Ojo del Alamo (NW of Coyame), Río Coyame and adjacent hot springs at Coyame, Ojo de Laguna (endorheic drainage N of Ciudad Chihuahua), headwaters of the Río Chuviscar in two locations, and the Río Chuviscar and the hot springs at San Diego de Alcalá.

No living unionids were found at any of these locations. Indeed, the only evidence of freshwater mussels obtained was the collection of one long-dead and several subfossil valves of an unidentified unionid taken in the Río Conchos just downstream of Julimes. Many sites showed signs of dewatering, scouring, agricultural impacts, or general lack of acceptable mussel habitat. Many of the Mexican tributaries of the Rio Grande appear to have suffered the same habitat modifications and mussel losses found during TPWD surveys on the Texas side of the border.

Several more wide-ranging taxa (e.g., Cyrtonaias tampicoensis, Quadrula apiculata, and others) still persist at a number of sites in the Rio Grande. Other locations both in Texas and Mexico remain to be surveyed. However, except for one shell each of P. popei and P. salinasensis in 1992, no evidence of these five, unique Rio Grande unionids has been found by TPWD. Thus far, Mexican tributaries appear to have offered little refuge for these mussels.

REFERENCES

Metcalf, A.L. 1974. Fossil and living freshwater mussels (Unionacea) from the Pecos River, New Mexico and Texas. Bulletin of the American Malacological Union 1973:47-48.

Metcalf, A.L. 1982. Fossil unionacean bivalves from three tributaries of the Rio Grande. Pages 43-59 in J.R. Davis (ed.). Proceedings of the symposium on recent benthological investigations in Texas and adjacent states. The Texas Journal of Science, Austin, 278 pp.

Murray, H.D. 1975. Melanoides tuberculata (Muller) in Las Moras Creek, Brackettville, Texas. Bulletin of the American Malacological Union 1975:43.

Neck, R.W., and A.L. Metcalf. 1988. Freshwater bivalves of the lower Rio Grande, Texas. The Texas Journal of Science 40:259-268.

Taylor, D.W. 1967. Freshwater mollusks collected by the United States and Mexican boundary surveys. The Veliger 10:152-158.

Society for the Conservation of Margaritiferidae

A new society was formed at the Twelfth International Malacological Congress in Vigo, Spain, September 1995, to promote the conservation and management of margaritiferid species around the world. The freshwater pearlshells of the family Margaritiferidae include 25 nominal genera that inhabit rivers of North America and Eurasia, with some species and many populations in imminent danger of extinction or extirpation, respectively. The SCM was formed by a multinational cadre of scientists for the purpose of coordinating international efforts for research, management, and the protection of habitats critical to these species. We propose to evaluate and respond through correspondence to threats to this faunal group, as identified by members throughout the world.

At this time, we seek new members to SCM, to further the conservation goals of the society. There are no membership fees currently, and we ask only that you assist the society by providing information on the status of pearlshells in your locale, and informing us of new threats to which SCM can voice its opinion. One of the long-term goals of SCM is to create an international monograph on the systematics, distribution, ecology, and status of margaritiferids globally. A symposium and possible field expeditions are contemplated within the next few years.

If you are interested in joining SCM, please send your name, mailing address, telephone and fax numbers, email address, and main interest (species or topic) to the SCM Secretary or President identified below.

Richard Neves, Secretary, SCM
Department of Fisheries and Wildlife Sciences
106 Cheatham Hall, Virginia Tech
Blacksburg, VA 24061-0321
PHONE: 540-231-5927 FAX: 540-231-7580
email: FISHHEAD@VTVM1.CC.VT.EDU

Valery Ziuganov, President, SCM
Institute of Developmental Biology
Russian Academy of Sciences
Vavilov Str. 26
Moscow, 117808, Russia
FAX: 095-135-8012
email: VZIUG@IBRRAN.MSK.SU

G. Thomas Watters & Scott O'Dee
Aquatic Ecology Laboratory, Ohio State University, 1314 Kinnear Rd., Columbus, OH 43212
voice: 614-292-6170
fax: 614-292-0181
email: gwatters@magnus.acs.ohio-state.edu

New publications:

Watters, G. T. 1995. Sampling freshwater mussel populations: the bias of muskrat middens. **Walkerana** 7: 63-69.

Shells of freshwater mussels collected from middens of muskrats (*Ondatra zibethicus*) often are used in unionid survey work as indicative of the *in situ* population. The relative abundance of mussel species in samples collected from middens was compared with adjacent beds in the lower Muskingum River in Ohio. All samples from middens differed significantly in both mussel diversity and relative abundance from the beds from which they were derived. Samples collected from muskrat middens represent a biased sample that may lead to erroneous conclusions concerning population and community structure of the parent bed.

Watters, G. T. & H. L. Dunn. 1995. The Unionidae of the lower Muskingum River (RM 34.1-0), Ohio. **Walkerana** 7: 225-263.

The lower 55 km (34 miles) of the Muskingum River were surveyed in October 1992 for Unionidae by hand-picking, brailing, and diving. Muskrat middens were examined from October 1992 through October 1993. Forty species and 11,145 individuals were found. Nine of these were encountered only as weathered shells and are presumed extirpated from the study area. Five federally endangered taxa were found, although only *Cyprogenia stegaria* (Rafinesque, 1820) was collected alive. Other federally endangered taxa found as weathered shells were: *Lampsilis abrupta* (Say, 1831), *Plethobasus cicatricosus* (Say, 1829), *Pleurobema clava* (Lamarck, 1819), and *Pleurobema plenum* (Lea, 1840). Fourteen Ohio endangered species were found (including federally endangered species). Four of these appear to be reproducing and may occur nowhere else in the state: *Ellipsaria lineolata* (Rafinesque, 1820); *Plethobasus cyphyus* (Rafinesque, 1820); *Pleurobema cordatum* (Rafinesque, 1820); and *Quadrula cylindrica cylindrica* (Say, 1817). Mussels are distributed in six beds located downstream of the first five km of each of four locks and dams. Average bed densities ranged from 3.1 to 41.9 individuals/m^2, with a maximum density reaching 124 individuals/m^2. The fauna is dominated by five species, all of which have some commercial value: *Obliquaria reflexa* Rafinesque, 1820; *Quadrula pustulosa* (Lea, 1831); *Amblema plicata* (Say, 1817); *Pleurobema cordatum*; and *Quadrula quadrula* (Rafinesque, 1820). The commercially valuable *Megalonaias nervosa* (Rafinesque, 1820) is becoming established in the lowest pool with recruitment evident. The State of Ohio is closed to commercial collecting, although poaching pressure for the cultured pearl industry is a serious threat to these beds.

(13)

Towards "natural" reproduction of freshwater mussels in enclosures - preliminary results

With the current efforts to remove mussels to hatcheries and other enclosures to avoid mortality from zebra mussels, it is important to determine if mussels can reproduce while in captivity. We have established two host-mussel populations in outdoor enclosures to determine whether this is feasible. The first enclosure contains twenty hatchery raised largemouth bass and twenty *Amblema plicata.* The sex ratio of the mussels has not been determined. The second enclosure contains twenty hatchery raised largemouth bass and ten male and ten female *Lampsilis radiata siliquoidea.* Enclosures are 3028 liter [800 gallon] tubs with a 1.8 m base diameter. Mussels are kept in sediment-filled containers. Glochidia samplers are placed in the bottom and checked every other day. No effort is made to control water temperature or quality. *Lampsilis* individuals have been in place for four months, *Amblema* individuals three. To date, no mussels have been lost. Five bass have died, primarily to leaping out of the tubs. To date, no glochidia have been found in the *Amblema* tub.

We have recorded three *Lampsilis* "release events," in which living glochidia were found in the samplers. These events have diminished in strength and become less narrowly focused over time as water temperatures have fallen. The initial event involved approximately 4000 glochidia, subsequent ones several hundred glochidia. No metamorphosed glochidia have yet been found in the samplers. However, a dead bass was examined and found to have numerous glochidia attached to its gills. These glochidia appear to be overwintering on the hosts rather than metamorphosing at this time.

We believe that this is the first published report of freshwater mussels completing their parasitic life cycle in an enclosure under "natural" conditions. If we must salvage mussels by removing them to hatcheries, these results suggest that we may be able to maintain reproducing populations where hosts are known, rather than simply holding individual mussels for an uncertain future. We plan to continue these studies for as long as possible. This project is a cooperative effort between the Ohio Division of Wildlife, the Ohio State University, and the Ohio River Mussel Mitigation Trust Fund.

Jennifer Szymanski
U.S. Fish and Wildlife Service
620 South Walker Street
Bloomington, IN 47403
(812)334-4261.204

The U.S. Fish and Wildlife Service (FWS) is soliciting data for a rangewide status assessment for Leptodea leptodon. To date, the following information is lacking: historic and current status information for Mulberry, Saline, and Casatot rivers and Frog Bayou; existing threats to these waterbodies; and historic and current records for the St. Lawrence drainage. Although this information is critical, any data on the distribution and status of L. leptodon would be helpful.

Cristian R. Altaba
Institut d'Estudis Avançats de les Illes Balears (CSIC-UIB)
ctra. de Valldemossa Km 7.5 , 07071 Palma de Mallorca (Illes Balears, Spain)
phone: (34) (71) 41 98 32 fax: (34) (71) 17 32 48 e-mail: ieacra4@ps.uib.es

Research and conservation plan on *Unio elongatulus aleroni*

The genus *Unio* includes several distinctive taxonomic entities in the Mediterranean region. Most often, these have been lumped under the name *U. elongatulus*. However, it is clear from anatomical, conchological, and distribution data that five geographically isolated taxa are present in the Mediterranean drainages of the Iberian Peninsula. In order to keep the legal protection given by European law to *U. elongatulus*, I prefer for the time being to consider them "subspecies".

Unio e. aleroni was described from French Catalonia, although it lived on the mountain streams of the Eastern Pyrenees at both sides of the Spanish-French border. In the last 20 years virtualy all populations became extinct as a consequence of increased pollution and hydraulic works. Three years ago, a living population, possibly the last surviving one, was found. A special recovery plan was then started for this taxon.

The studied population consists of ca. 5000 mussels, and is restricted to the lower five Km of the Ser river, a tributary of the Fluvià. This part of the Ser valley is narrow, totally forested, and with no settlements. Its fish fauna is considered one of the best preserved in Spain. Although it benefits from no protection status, it is adjacent to the Garrotxa Volcanic Zone Natural Park. However, urban areas and pig farms further upstream are responsible for the dramatic lowering of water quality observed in the last two years. The impact of wastewater is the main factor causing the decline of this population: its age structure shows that there has been no recruitment in the last four or five years.

In order to ensure the survival of *Unio e. aleroni*, a captive population was established at the Park's headquarters. Infection of fish hosts was successful, and this summer large numbers of juveniles were recovered. The conservation plan to be carried during the next five years involves further study of the wild population, large-scale infecton of fish hosts, and artificial propagation to restored habitats. All freshwater mussels are now protected by law in Catalonia, the Ser valley is proposed as a nature reserve, and acceptable wastewater management is expected to be operational in the next few months. We are now planning to extend these activities to other endangered unionoids, such as *Margaritifera auricularia*.

(15)

(15)

New record of *Pleurobema clava* in Middle Island Creek drainage, West Virginia

Janet L. Clayton and Craig Stihler
WVDNR
PO Box 67
Elkins, WV 26241
304-637-0245

Only one record of *Pleurobema clava* had previously been recorded for Middle Island Creek north of West Union, West Virginia. The record was reported by Taylor and Spurlock in 1980 but did not indicate if it was alive or relic. In September and October 1995, 5 live individuals of *Pleurobema clava* (range 66.4 to 85.4 mm) were found in Meathouse Fork of Middle Island Creek, upstream of Smithburg. Meathouse Fork and Buckeye Creek join to form Middle Island Creek. While surveying 16 additional sites in 1994 and 1995 between Smithburg and the mouth, no additional *P. clava* were found. This indicates the importance of surveying upstream portions of a drainage before determining this species is not present.

Bernard E. Sietman[1], Mary A. Furman[1] and F. Allen Pursell[2]
[1]Ecological Specialists, Inc., 114 Algana Ct., St. Peters, MO 63376 (314-447-5355)
[2]The Nature Conservancy, P.O. Box 5, Corydon, IN 47112 (812-738-2087)

A Qualitative Unionid Mussel Survey of the Blue River, Indiana

The Blue River drainage is considered to be one the most significant natural areas in southern Indiana. As a result, The Nature Conservancy funded a survey to determine the current status of unionids in this drainage.

From 18 - 24 September 1995, we searched for unionids at 80 sites along a 91km section of the Blue River main stem between Fredricksburg and Leavenworth, IN. Snorkeling and wading were the primary methods of collecting.

We found evidence of 35 species including 3 species not previously recorded, however, only 20 of these species were represented by live animals. Weilbaker *et al.* (Proc. Ind. Acad. Sci. 94:687-691, 1985) and Baker and Forsyth (unpubl. report) found 8 additional species, bringing the total to 43. *Amblema plicata*, *Cyclonaias tuberculata*, *Elliptio dilatata*, *Lampsilis cardium*, *Lampsilis siliquoidea*, and *Tritogonia verrucosa* were the most common species, comprising 67% of the live individuals collected. These spesies were also the most widely distributed, occurring at most of the sample sites. Although previously reported, we found no specimens of the federally endangered *Pleurobema rubrum* or *Obovaria retusa*, and we found only extremely weathered shells of *Pleurobema clava*.

At least one live mussel was found at 64% of the sites, but 60% of the 620 live individuals were collected from only 8 sites, indicating a patchy distribution. At sites where live mussels were collected, the mean number of live species was 3 (range 1 - 9), whereas the mean number of live and dead species combined was 9 (range 3 - 21).

These data suggest that a significant portion of the Blue River's historic unionid fauna has been lost, as is the case with many rivers in the Ohio River drainage.

Lydeard Charles, and Kevin J. Roe
University of Alabama
Department of Biological Sciences
Box 870344
Tuscaloosa, AL. 35487
205-348-1792 (fax:1786)
E-mail: clydeard@biology.as.ua.edu, kroe3@ua1vm.ua.edu

We are continuing with our research on systematics, conservation and evolution of unionids. One of us (CL) has submitted an article in collaboration with Dr. Margaret Mulvey (Savannah River Ecology Lab, Drawer E, Aiken, S.C. 29802) and Dr. George Davis (Academy of Natural Sciences of Philadelphia) to the Journal of the Royal Society of London on generic level relationships of North American unionids based on the 16S rRNA, and another article on the conservation genetics of two unionid genera (*Amblema* and *Megalonaias*) also co-authored with Dr. Mulvey and others is in preparation.

One of us (KJR) has begun generating DNA sequence data for an examination of the systematic relationships within the genus *Potamilus*. In addition KJR has completed a summer study and identified the fish host of the threatened inflated heelsplitter (*Potamilus inflatus*) as the freshwater drum (*Aplodinotus grunniens*). This finding confirms suspicions that the genus *Potamilus* parasitizes *A. grunniens* almost exclusively. This fact has implications for the recovery of this species, which is restricted to several populations in the Black Warrior River in Alabama, and the Amite River in Louisiana.

Karen Moore
TNC-Clinch Valley Bioreserve
102 S. Court Street
Abingdon, Virginia 24210
540-676-2209

The Clinch Valley Bioreserve office of The Nature Conservancy is conducting a muskrat midden monitoring program at Pendleton Island preserve on the Clinch River in Virginia. The monitoring program is designed to determine if muskrat predation is a serious threat to mussels at Pendleton Island. With the help of TNC volunteers, we are collecting middens every two to four weeks between June and October along the banks of the entire island. Significant middens (middens with eight or more native shells) are mapped, and any observed muskrat lodges along the banks are mapped. All mussel shells are counted and sorted and the native shells are sent to Dr. Dick Neves at Virginia Tech for identification and size information.

We will be conducting a muskrat census at the island with help from Virginia Tech's Wildlife Biologist Dr. Jim Parkhurst. We will combine baseline data on local muskrat population with midden data and evaluate to determine next steps. We plan to continue monitoring during 1996.

Data from both monitoring seasons will be compiled and interpreted by early 1996.

(17)

Author: Madeleine Lyttle
Address: Lake Champlain Fish and Wildlife Resources Office
11 Lincoln Street
Essex Junction, Vermont 05452
Phone Number: (802)951-6313

Report: ASSESSMENT OF MUSSEL POPULATIONS ON SELECT DELTA AREAS OF LAKE CHAMPLAIN FOLLOWING THE APPLICATION OF BAYER 73 (GRANULAR).

ISSUE: The Lake Champlain Fish and Wildlife Resources Office is conducting an assessment of the ecological impacts of Bayer 73 (5% granular) used in lamprey control treatments on mussel and snail populations and participating in a lake-wide survey of mussels and snails. Previous studies concluded that pelecypoda (mussels) and gastropoda (snails) did not recover to pre-treatment numbers one year after the initial lampricide treatments (1990). Concern over the potential loss of mussel and snail species on deltas treated with Bayer 73 has prompted this study.

STATUS:

- The Lake Champlain Fish and Wildlife Resources Office, in cooperation with the Vermont Department of Environmental Conservation and the Lake Champlain Fish and Wildlife Management Cooperative has collected data to assess mussel and snail abundances and population structures on the Ausable and Little Ausable Deltas.

- The occurrence of the species of mussels and snails found on the two deltas will be qualitatively assessed at sites throughout the lake. This project will provide information on the potential lakewide impacts to mussels and snails by repeated treatments of selected deltas with Bayer 73.

- New England Interstate Water Pollution Control Commission (NEIWPCC) approved the work plan on June 26, 1995. Christopher Buerkett was hired as a full time NEIWPCC employee, stationed at LCFWRO under the supervision of Madeleine Lyttle, Principal Investigator.

- U.S. Fish and Wildlife divers from the Ohio River Islands NWR completed mussel surveys on the Ausable and Little Ausable Delta areas during July 10-14, 1995. Vermont Department of Environmental Conservation assisted with on-site mussel identification and aging.

- An interim report is due December 31, 1995. It will compare data from previous studies with the data collected in 1995.

- A GIS map of the lakewide locations of targeted mussel and snail species and a GIS map and literature review of waterfowl usage will be included in this report.

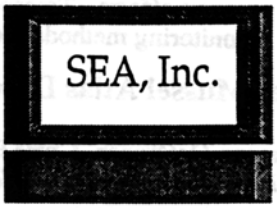
- A final report developing the draft and incorporating all reasonable comments of representatives of the New York Natural Heritage Group, staff from the Adirondack Park Agency, and the Fisheries and Wildlife Working Groups is due March 3, 1996.

The Conservation and Management of Freshwater Mussels II Initiatives for the Future

October 16 - 18, 1995
Embassy Suites Hotel, St. Louis, Missouri

NOTE: ***The following presentation and poster abstracts are not presented in the same order as they appeared in the symposium program. They have been reordered, cut, and pasted to reduce the length of the report and save duplication and mailing costs.***

ABSTRACTS



Sponsored by:
Upper Mississippi River Conservation Committee
U.S. Fish and Wildlife Service, Region 3 Federal Aid Office
Mussel Mitigation Trust
Shell Exporters of America, Inc.

(19)

National Strategy for the Conservation of Freshwater Mussels

Richard J. Neves
Virginia Polytechnic Institute and State University, Department of Fisheries and Wildlife Sciences, Blacksburg, Virginia.

The molluscan garden of eden in North America has been plundered of productivity and diversity, and now sown with exotic seeds of destruction in the form of zebra mussels (*Dreissena polymorpha*). The decline of freshwater mussels in the 20th century has accelerated in the last decade, resulting in a prognosis for widespread extirpations and extinctions in the next decade. Although numerous agencies, organizations, and individuals are working feverishly to reverse the downward trend in mussel populations, there has been no document of national scope to focus research, technology, and facilities on conservation management through protection and propagation of species of risk. That document is now drafted and available for review by all interested parties. The current euphoria for the noble but elusive goals of ecosystem management must be implemented through habitat protection and artificial propagation, for those mussel species with greatest potential for recovery. Big river mussel communities are at greatest risk from the zebra mussel, and stream mussel communities are jeopardized by habitat degradation and genetic isolation. Luminary biologists must decide on the allocation of limited resources, targeting those species most amenable to salvation, and those that must fend for themselves. Partnerships involving managers of hatcheries, water supply reservoirs, private lakes and ponds, and protected riverine environments offer the greatest hope to adaptable mussel species. Conversely, benign neglect will fall on the highly specialized, endemic species, for a gloomy hereafter in the 21st century. The planning and use of natural and artificial refugia, and multiple use of fish hatcheries, provide options presently under evaluation in several states. The role of some federal hatcheries may be expanded to accommodate the needs of aquatic fauna of national significance and mandated for conservation by federal law. As biologists and resource managers, our mission must be to create partnerships, protection plans, propagation options, and public awareness for the conservation of mussels and associated aquatic species headed toward extinction.

Comparison of Three Unionid Relocation Efforts

Heidi L. Dunn and Bernard E. Sietman
Ecological Specialists, Inc., St. Peters, Missouri

The need to move endangered unionids from construction areas, out of zebra mussel infested areas, or reintroduce species into their historic range is probably greater now than ever due to the endangered status of many species. However, current data suggest that relocation efforts have been only minimally successful. Previous relocations were reviewed and current researchers were interviewed to identify factors contributing to poor relocation success. This information was used to develop a relocation protocol and design three relocation projects in 1994: one in the Elk River in West Virginia, one in the Meramec River in Missouri, and one in the St. Croix River in Wisconsin/Minnesota. Stream size, collection and transplanting conditions, and species varied among efforts. Transplanted unionids were monitored in all three areas in 1995. Relocation and monitoring methods used, relocation success, and further research needs will be discussed.

Freshwater Mussel Atlas Development for Three New England States

Susanna von Oettingen, Chris Fichtel, Mark McCollough, and Marea Gabriel
U.S. Fish and Wildlife Service, Concord, New Hampshire

The U.S. Fish and Wildlife Service, Maine Department of Inland Fisheries and Wildlife, Vermont Fish and Wildlife Department and New Hampshire Fish and Game are coordinating the inventory of streams and rivers for freshwater mussels in an effort to develop state atlases. To date, little information particular to the New England states is available for freshwater mussels. These atlases will an important step in educating the general public and regulatory authorities on the importance of freshwater mussel conservation. Massachusetts, Connecticut and Rhode Island are also establishing comprehensive databases of freshwater mussel locations with the future possibility of developing state atlases. Since 1993, biologists in Maine, New Hampshire and Vermont have been systematically surveying streams and rivers and documenting freshwater mussel presence and absence. Site locations are then entered into GIS (Geographic Information Systems) format. Each state is developing atlases that are particular to that State's needs, but will cover similar information such as an overview of freshwater mussel life history, species specific descriptions, and general information regarding conservation. An atlas for Vermont is in the final stages of completion, four counties in New Hampshire have been surveyed, mapped and a mini-publication completed and four counties in Maine have been surveyed.

Monitoring Components of a Relocation Project on the St. Croix River

Diane L. Waller[1], W. Greg Cope[1], and Heidi L. Dunn[2]
[1]*National Biological Service, Upper Mississippi Science Center, La Crosse, Wisconsin*
[2]*Ecological Specialists, Inc., St. Peters, Missouri*

We conducted a mussel relocation in the St. Croix River in conjunction with a bridge replacement by the Wisconsin Department of Transportation (WIDOT). A two year monitoring program was developed to address the concerns of state and federal cooperators, particularly the fate of special status species and the cost-effectiveness of proposed methods. The monitoring program included evaluation of: (1) overall mussel survival, (2) growth and survival of special status species, (3) handling methods, (4) placement methods, and (5) mussel condition and survival from different source sites. A suitable destination site was identified and sampled prior to relocation to characterize the mussel community and physical habitat. About 8000 mussels were relocated to a general site by two methods: hand-placement by a diver or surface broadcasting by boat. Mussels in the two treatments were uniquely marked to compare mortality during future monitoring. Two 5 x 5-m areas, each composed of 25 1-m^2 cells, were designated within the destination site for placement of special status species. These species were uniquely marked, measured, aged, and placed into a cell. A third area, a 6 x 4-m grid divided into 24 1-m^2 cells, was designated for placement of mussels in handling and source site treatments. Resident unionids were removed from 18 of the cells and replaced with mussels in the experimental treatments. Six cells served as resident controls. Source site treatments included mussels from opposites sides of the river channel; handling treatments included processing mussels underwater or in air for 40 minutes. During processing, mussels were marked, identified, measured, and aged. They were then placed into the grid. Mortality was assessed one month after relocation by a cursory search of the general destination area and of all three monitoring grids. One year after relocation, more intense monitoring was conducted of the three grid areas and the general area. This study demonstrates several different methods for monitoring mussels after relocation.

An Evaluation of Relocation of Unionid Mussels into an Artificial Pond

Teresa Naimo[1], Pamella Thiel[2], and Kurt Welke[3]
[1]*National Biological Service, Upper Mississippi Science Center, LaCrosse, Wisconsin*
[2]*U.S. Fish and Wildlife Service, LaCrosse Fishery Resources Office, Onalaska, Wisconsin*
[3]*Wisconsin Department of Natural Resources, Prairie du Chien, Wisconsin*

In many large rivers, unionid mussels are at risk from the exotic zebra mussel. The use of artificial ponds, such as those at National Fish Hatcheries (NFH), are being evaluated as temporary holding locations for mussels until the immediate threat of zebra mussels has passed or until artificial propagation has been successfully developed. Our objective was to compare data on growth and survival of mussels relocated to a pond with data on mussels processed similarly, but returned to the upper Mississippi River (UMR). In May 1995, we obtained five species (*Amblema plicata, Fusconaia flava, Leptodea fragilis, Obliquaria reflexa*, and *Quadrula quadrula*) of mussels from the UMR. Each mussel was scrubbed "free" of zebra mussels and placed into a quarantine pond for 35 days. After 35 days, all mussels were re-inspected for zebra mussels, individually tagged, and length, height, and wet weight were recorded. Mussels were randomly assigned to treatments (placement or orientation of mussels into the substrate) at either a 0.25 acre pond at the Genoa NFH or the UMR. There were four replicates of each of four treatment; each replicate contained a total of 24 mussels of three to eight mussels from each species. A total of 384 mussels were assigned to each location. We found no zebra mussels on any live mussels after the 35-day incubation. Mean survival during the 35-day quarantine was 83% and ranged from 55% in *L. fragilis* to 97% in *Q. quadrula*. There were no significant differences in mean length, height, or wet weight of mussels among treatments within a location. Both the pond- and river-relocated mussels will be monitored for growth and survival twice a year for a minimum of two years.

Evaluation of Various Facilities for Maintaining Freshwater Mussels in Captivity

Curtis S. Dunn and James B. Layzer
Tennessee Cooperative Fishery Research Unit, Tennessee Technological University, Cookeville, Tennessee

Between September 1993 and September 1994, we collected about 1200 mussels of 17 species from the Cumberland, Licking, and Tennessee rivers and Elkhorn Creek. Mussels were brought to one of four facilities: a fish hatchery pond, a raceway, a farm pond, or an embayment of Kentucky Lake. Mussels were broadcast throughout the raceway; most mussels burrowed into the sand-

(21)

gravel substrate within 15 hours. At the other three locations, mussels were placed into pocket nets suspended 0.6 m below the water surface. After one year in captivity, survival ranged from 85% to 100% for most groups of most species at all facilities; however, variable survival rates occurred between different groups of the same species at the hatchery pond. Survival ranged from 12% to 100% between groups of *Elliptio dilatata*, *Lampsilis siliquoidea*, and *Lasmigona costata* collected on two different occasions from Elkhorn Creek, the water supply for the hatchery. Most mortality occurred within the first 30 to 60 days of captivity. Although most areas of the Tennessee River no longer support reproducing populations of *Actinonaias ligamentina*, *E. dilatata*, and *Ptychobranchus fasciolaris*, survival of these species has been 85% to 98% in pocket nets suspended in Kentucky Lake.

Are Unionid Translocations a Viable Mitigation Technique? The Wolf River, Wisconsin, Experience: 1992 - 1995

Marian E. Havlik
Malacological Consultants, La Crosse, Wisconsin

In August 1992, 8120 unionid mollusks were hand-translocated from a 1.5 m buffer zone around two piers, Wolf River, Shawano, Wisconsin. Mean densities at the bridge were 9.7/m^2, 20.7/m^2 in the translocation area. Malacological Consultants funded follow-ups. In 1993, six - 1.0 m^2 quads yielded a mean density of 62.2/m^2. The 122 marked specimens (32.2%) had a mean density of 20.3/m^2, confirming doubled translocation site density; one year survival was 98.36%. Of the remaining 251 living unionids, 33.3% were from pre-project (ambient) density and 34.5% (21.2/m^2) were from an unknown source. Perhaps pre-project densities were the result of diver efficiency, or we did not sample mussel concentrations, and/or densities increased after 1993 floods. The Conchologists of America co-sponsored a 1994 follow-up. Thirty-one - 0.25m^2 quadrats yielded 478 live unionids (mean 61.9/m^2). The 1994 survival of 152 marked mussels (31.8% of total) was 98.9% at 19.9/m^2. In August 1995, 27 - 0.25 m^2 quadrats yielded 358 living unionids (mean 53.04/m^2). The three year survival of 97 marked mussels (27.1% of total) was 97.94%. Marked and unmarked densities decreased to 14.37 and 38.67/m^2 respectively, perhaps the result of lateral movement and/or a recent spate. Marks on anterior shells remain very legible. *Elliptio dilatata* (Rafinesque, 1820) has increased from 71.4% to 73.3% (1993), 78.9% (1994), and 77.9% (1995). No mortalities have been found among 33 marked, threatened unionids. Most empty shells were sub-fossil. Our data show a very successful translocation project, three years post-project.

An Evaluation of Relocation Techniques for Freshwater Mussels of the Apalachicola River: River and Laboratory Trials

Hannah Hamilton, Jayne Brim-Box, and James D. Williams
National Biological Service, Gainesville, Florida

The Apalachicola River is one of Florida's most significant natural resources and home to a diverse population of freshwater mussels. This river is also the site of Jim Woodruff Lock and Dam which requires regular maintenance dredging to maintain a navigation channel. In July 1993, four species of freshwater mussels were removed from a gravel bar scheduled for dredging, for a year long relocation study. One of these species, *Elliptoideus sloatianus*, is federally proposed for endangered species status. Mussels were relocated to corrals in different habitats within the river and also held under various laboratory conditions. Substrate and its affect on survivorship of relocated mussels was examined. Survivorship of all four species in the river nearly one year after relocation was high, in some cases all (100%) of the relocated mussels survived. In the laboratory overall survival was approximately 50% after one year. Mortality tended to occur in the first and last months of the study. *Megalonaias boykiniana* had the highest percent survival of the four species studied in the laboratory, and *E. sloatianus* the lowest. Mortality rates could be attributed to a number of factors: water quality, lack of or poor quality of food, laboratory habitat, as well as other unknowns. Pond trials survival was greater than 75%. Starvation trial survival rates corresponded to mussel size, the larger the mussel the higher the rate of survival.

Long Term Evaluation of Large-scale Mussel Transplants

John J. Jenkinson[1] and Ralph O. Brinkhurst[2]
[1]*Tennessee Valley Authority, Chattanooga, Tennessee*
[2]*Aquatic Resources Center, Franklin, Tennessee*

In 1982, Tennessee Valley Authority biologists transplanted 1000 specimens of the birdwing pearly mussel, *Lemiox rimosus* (= *Conradilla caelata*), from the central Duck River in Tennessee to each of four locations where the species no longer occurred. Marked animals were placed in a regular pattern within a well-identified 250 m^2 area at each receiving site. During the past 12 years, these transplants have been monitored often and in a variety of ways. Quantitative and qualitative techniques have been used several times to estimate population size and distribution in each stream, females have been routinely checked for gravidity, and various techniques have been used to search for juveniles. The recovery of two small, unmarked birdwing mussels indicates that at least one of these transplanted populations has reproduced successfully. Various types of data and observations will be presented to document what has occurred at these transplant sites with the intention of assisting others in achieving similar, or better, transplantation success.

The Kankakee River Story; Long-Term Monitoring of Translocated Freshwater Mussels

H.E. Kitchel[1], J.M. Berlocher[2], and Mark J. Wetzel[2]
[1]*Wisconsin Department of Natural Resources, Madison, Wisconsin*
[2]*Illinois Natural History Survey, Champaign, Illinois*

Concern for the decline of the freshwater mussel fauna has led federal and state governments to recommend that significant mussels populations be protected. To this end, the U. S. Fish and Wildlife Service (a.k.a. National Biological Service) recommended that mussels be relocated from a bridge that was to be replaced over the Kankakee River at Kankakee, Illinois. INHS biologists translocated over 3,000 mussels, representing 29 species, in 1987. Survival, recruitment, and growth of these mussels has been monitored through 1994. Mussels were collected by hand, marked, and translocated to two sites upstream. One site has been monitored intensively. Mussels occurring naturally at the transplant sites were tagged and monitored as well. Percent recovery of marked mussels varied between sites, but consistently declined over the seven years of the study. Retrieval of live mussels and shell material after the first year was estimated at 57%, the second year 24%, and seven years later only 5.6% of the original marked mussels were recovered. These rates were based on recovery of individuals encountered in subsamples from both inside and outside the transplant boundaries. Loss of mussels may be a result of movement into or out of the plot boundaries, which may also account for the origin of an increasing number of unmarked mussels in the plots. Growth, as measured by increased shell length, was evaluated individually over time, and averaged 3 to 5 mm for most of the transplanted species. Juveniles of most of the mussel species have not been collected to date, but gravid females have been observed for many of the species. Little data exist to compare long-term monitoring of transplanted populations with natural mussel beds. Many concerns remain as to whether transplanting mussels is a reasonable method to protect the continued existence of mussel populations.

The Paint Rock River Initiative

Douglas N. Shelton
Barry A. Vittor & Associates, Inc., Mobile, Alabama

The three major tributaries to the Paint Rock River Drainage originate in Franklin County, Tennessee and flow generally southward through Jackson, Madison, and Marshall counties in Alabama until they join the Tennessee River. The Paint Rock River watershed in past decades was subjected to various impacts including channelization, agricultural runoff, sedimentation from erosion, and other point and non–point sources of pollution. The diversity of aquatic life in the system is among the highest in the southeast. The diversity of mussel and fish species in the watershed is greater (for its size) than any other watershed in the state of Alabama. Historically, the Paint Rock River Drainage supported 51 species of mussels and 98 species of fish. Several species have been lost, but recent surveys have revealed the continued presence of 44 species of mussels and 90 species of fish. The Paint Rock River Initiative is a newly formed coalition of federal, state, and independent agencies and local landowners who are seeking to assist the watershed's recovery process through the use of federal, state, and independent funds to restore the riparian zone in impacted areas as a means of reducing flooding, erosion sedimentation, and preserving aquatic habitat.

(23)

Current Distributions of Freshwater Mussels (Bivalvia: Unionidae) in Rivers of Southwestern Ontario

Todd J. Morris and Joanne Di Maio
University of Windsor, Dept. of Biological Sciences, Windsor, Ontario, Canada

With the drastic decline during the past century of the once rich unionid populations in North America, concern has increased over the conservation status of freshwater mussels. Information on the current distribution and abundance of mussels is required before effective conservation measures can be implemented. Nine drainages in southwestern Ontario were sampled to assess the status of unionid species and comparisons were made with available historical data. Nineteen species represented by 1120 individuals were encountered during two years of sampling. Rivers of the Lake Huron Drainage possessed the richest unionid communities of the area with 16 species compared to 13 species in the Lake St. Clair - Detroit River Drainage and only 4 species in the Lake Erie Drainage. Six of the nine drainages were dominated by the locally common *Pyganodon grandis*, however, several rare and uncommon species were detected in the Lake Huron and Lake St. Clair drainages. Two species (*Ptychobranchus fasciolaris* and *Lampsilis fasciola*) not previously reported from the Lake Huron Drainage were detected during the second sampling year. Rivers of the Lake Huron drainage appear to have maintained their unionid fauna over the past century while rivers of the Lake St. Clair - Detroit River Drainage appear to have undergone serious declines.

Monitoring the Swift Creek Freshwater Mussel Community

John M. Alderman
North Carolina Wildlife Resources Commission, Pittsboro, North Carolina

In terms of aquatic biodiversity, mollusk diversity and abundance, and viable populations of federally listed or candidate freshwater mussel species, Swift Creek in the Tar River Basin is North Carolina's best Atlantic Slope lotic refuge. Swift Creek is 138 km long and covers 690 km^2. A 20 km segment of Swift Creek located in the center of the subbasin was chosen as the study area. Trends in the health of the mussel species populations of Swift Creek were assessed by evaluating relative abundances, evidence of recent recruitment, and lengths of all fresh mussel shells collected from muskrat middens (nearly 10,000 shells) within the study area during the six years 1989 - 1994. Three of the mussel species (*Lampsilis radiata*, *Elliptio roanokensis*, and an undescribed lanceolate *Elliptio* species) were extremely rare during the study; therefore, they are simply documented as being present. Also, because of taxonomic uncertainties, the health of populations in the *Elliptio complanata* complex and *E. icterina* complex cannot be determined. For *Alasmidonta undulata*, *Villosa constricta*, *Lampsilis cariosa*, *Elliptio steinstansana*, *Strophitus undulatus*, *Fusconaia masoni*, and *Elliptio lanceolata* changes in relative abundance and evidence of recent recruitment could be determined. For the last three species, length class structure changes were documented.

Range Reduction of Kansas Unionids

Brian K. Obermeyer[1], David R. Edds[1], Carl W. Prophet[1], and Edwin J. Miller[2]
[1]*Emporia State University, Division of Biological Sciences, Emporia, Kansas*
[2]*Kansas Department of Wildlife and Parks, Independence, Kansas*

During summer 1994, we studied freshwater mussel assemblages at 52 sites in 11 streams of eastern Kansas and caught 11,705 mussels of 32 species. We targeted four federal candidate (C2) mussel species: the Neosho mucket, *Lampsilis rafinesqueana*; the western fanshell, *Cyprogenia aberti*; the Ouachita kidneyshell, *Ptychobranchus occidentalis*; and the rabbitsfoot, *Quadrula cylindrica cylindrica*. Comparison of present distributions with historical records dating to 1885 suggests substantial range reductions for several unionid species, including these four candidates, as well as the inferred extirpation of the snuffbox, *Epioblasma triquetra* and black sandshell, *Ligumia recta*. Dissimilarity between extant species and species represented by only weathered and relic valves revealed a significant decrease in species richness in four targeted streams, with about 12% of the historical unionid fauna presumed extirpated from these streams. Little evidence of recruitment was noted from most sites. We believe the broadest factor responsible for these declines is siltation, which has especially degraded the deeper, slow current habitats that were once likely important juvenile nursery areas and refugia from drought; though other factors such as effluence, dams and channel alterations, and excessive harvesting have also contributed to the decline.

The Status of Unionids in Michigan

Renee Sherman[1], Richard Trdan[2], and Paul Marangelo[3]
[1]*University of Michigan Museum of Zoology/Mollusk Division, Ann Arbor Michigan*
[2]*Saginaw Valley State University, Department of Biology, University Center, Michigan*
[3]*University of Michigan Museum of Zoology/Mollusk Division, Ann Arbor, Michigan*

Forty-six species of unionids are found in Michigan. Of these, three are federally endangered, four are considered endangered by the state, and two are state threatened. The greatest diversity and concentration of threatened and endangered species is in southeastern lower Michigan, where human population pressures are increasing. The Michigan Department of Natural Resources has enforced protection when construction will affect watersheds with listed unionids. However, prevention of zebra mussel introductions is needed. Zebra mussels now occur in inland areas of seven river basins. This distribution includes the upper Clinton River in Oakland County, which contains an abundant population of the snuffbox mussel, *Epioblasma triquetra*, as well as three other state listed species. Healthy unionid populations unlikely to be affected by high zebra mussel densities remain in areas such as the lower Belle River in St. Clair County. However, lands surrounding these waters are privately owned, making enforcement of quality watershed practices more difficult. Although rivers with listed species have been studied, surveys throughout the rest of the state are needed to monitor common species and update distribution records. This information will also help assess impacts of illegal harvests, particularly on the Grand River.

Status of the Freshwater Unionoid Bivalve Fauna of Pennsylvania

Arthur E. Bogan[1] and Thomas Proch[2]
[1]*Freshwater Molluscan Research, Sewell, New Jersey*
[2]*Department of Environmental Resources, Pittsburgh, Pennsylvania*

The historic freshwater unionoid bivalve fauna consisted of 64 species including *Margaritifera margaritifera*. Historically, the greatest diversity occurred in the upper Ohio River Basin in western Pennsylvania, 53 species. Twenty-two species have been extirpated but two of the extirpated species have recently re-invaded the upper Ohio River. Twenty-four species have been reported from Lake Erie and it's tributaries before the introduction of the zebra mussel (*Dreissena polymorpha*). Thirteen species have been reported historically from the Susquehanna River Basin in Pennsylvania (2 of the 13 species were reported from the basin in error). Fifteen species have been reported from the Delaware River Basin, seven species have been reported from the Potomac River Basin in Pennsylvania. Nine federally endangered species historically occurred in the state but only two are known to be living in the state: *Pleurobema clava* and *Epioblasma torulosa rangiana*. Thirty species are considered endangered, including the federally listed species, and eight species threatened at the state level. The decline of the freshwater bivalve fauna has been tied to impoundments, pollution, acid mine drainage and the introduction of the zebra mussel.

A Survey of Mussels in the Upper Platte River and Associated Irrigation Canals and Lakes of Central Nebraska (Mollusca: Bivalvia)

Mark M. Peyton and Jeremiah L. Maher
Central Nebraska Public Power and Irrigation District, Gothenburg, Nebraska

There is limited data on historic or present diversity, distribution, and abundance of freshwater mussels in the Platte River System of Nebraska. In association with FERC relicensing of Project No. 1417 we surveyed a 120 km stretch of the upper Platte River and associated irrigation canals and lakes for mussels. Over 8,000 specimens representing ten species were identified. Eighteen specimens representing five species were identified from the Platte River, 589 specimens representing six species were identified from ten lakes, and 8,206 specimens representing nine species were identified from seven irrigation canals. Three species, *Toxolasma parvus* Barnes, *Sphaerium* sp., and *Strophitus undulatus* Say, not previously collected in the Platte River system or whose existence within the system was questioned, were identified. The disproportionate number of specimens located in the irrigation canals and associated lakes indicate these canals and lakes provide more habitat for freshwater mussels than do the channels of the Platte River.

(25)

(25)

Individual-Based Models of Mussel-Fish Interactions: A Cautionary Study

G. Thomas Watters
Ohio Division of Wildlife, Columbus, Ohio and
Aquatic Ecology Laboratory, Ohio State University, Columbus, Ohio

Individual-based models of host-parasite interactions between mussels and fishes may simulate unionid reproductive strategies. Reproduction by specialists, those having few potential hosts, result in low population sizes. Often, this renders specialists more susceptible to extirpation and extinction. Conversely, generalists may exist in great numbers given the proper conditions. Generalists are opportunistic, and have evolved to cope with random fluctuations in their population size. Specialists have evolved to cope with fluctuating host numbers. Simulations indicate that stable populations are very sensitive to host numbers. Threshold levels of host numbers exist below which mussel populations will become extirpated. Therefore, extirpation may result from a decrease of host numbers, although hosts are still available. Mussel population sizes and incidence of recruitment may fluctuate because of purely stochastic events. Average or stable population sizes of mussels are therefore difficult to assess without long-term monitoring. Consistent annual recruitment may not be necessary to maintain a stable population. Introduction of immune exotic hosts may drive both specialists and generalists to extirpation. Introduction of exotic mussels capable of parasitizing any host may result in the extirpation of generalists, but specialists may coexist.

Comparison of Juvenile Mussel Acute Testing Methods With Variation on Artificial Transformation Media, Age, and Diet

Margaret L. Barfield, Sarah A. Clem, and Jerry L. Farris
Arkansas State University, Ecotoxicology Research Facility, Arkansas

Availability of juveniles for toxicity testing has been enhanced by the development of artificial transformation techniques with *Utterbackia imbecillis*. Two distinct acute testing methods have been outlined which include 24-96 hr. static nonrenewal conditions without food or sediment and 9-day static renewal conditions with food and sediment. Initial comparisons of LC50 values for both methods indicate much lower LC50 values from acute testing without food or sediment (35-88 ug Cu/L versus 900-1700 ug Cu/L) Tests comparing responses of juveniles transformed in vitro using fish media and a substitute rabbit sera indicate little difference in LC50 values of 1 day old juveniles in no food/no sediment acute testing and 10 day old juveniles in food/sediment testing. Seven day old juveniles tested without sediment or food indicate slightly lower LC50 values for fish media transferred versus rabbit sera transferred juveniles. Age comparison testing without food and sediment available showed a slight increased sensitivity of 7 day old juveniles versus 1 day old juveniles transformed in fish media but not rabbit. Preliminary testing with food and sediment showed resistance to Cu increases with age. Comparable LC50 values for 10 day old and 40 day old juveniles were reached in 9 and 22 days, respectively. Increased sensitivity with age in no food/sediment acutes may be explained by lower LC50 values for diet deprived juveniles.

An Investigation of Freshwater Mussels, Fish, and Fine Sediments in the ACF Basin, With a Special Emphasis on Imperiled Mussel Species

Jayne Brim-Box, James D. Williams, Robert Dorazio, and Christine O'Brien
National Biological Service, Gainesville, Florida

The Apalachicola, Chattahoochee, and Flint (ACF) rivers harbor approximately 40 species of freshwater mussels, including six species that have recently been proposed for federal E & T status. In general, mussel populations in the ACF Basin are depressed, and many localities that historically had abundant and diverse mussel populations are currently depauperate. Although many possible reasons have been given for the decline of mussel populations in the basin, little quantitative work has been done to establish direct causes of these declines. This study examined two possible causes of the decline: the impact of fine sediments on mussel populations, and the correlation between fish and mussel abundance and diversity. Quantitative methods were used to collect fish, mussels, and sediment data from 30 sites in the coastal plain of the basin. A total of 2,688 mussels were collected from 2,832 quadrats, and over 2,500 sediment cores were also collected. Preliminary analysis showed there were few differences in mussel density or species richness among three arbitrary habitat types (bank, slope, and middle). Associations between the abundance of mussels and various characteristics of their habitat, including percentage of fine sediment, will be examined statistically. Fish-mussel associations will likewise be discussed.

Status of the Freshwater Mussel (Unionacea) Fauna in Illinois

Kevin S. Cummings and Christine A. Mayer
Illinois Natural History Survey, Center for Biodiversity, Champaign, Illinois

Approximately 79 species of freshwater mussels are known from Illinois. Twenty-one species have been extirpated from Illinois or are thought to be extinct. Of the 58 remaining species, nine are federally endangered or candidates for listing and 14 are endangered, threatened, or species of special concern in Illinois. Of the remaining 35 species, five are considered uncommon or limited in distribution leaving only 30 species that currently have relatively stable populations. The greatest remaining diversity occurs in the Wabash River and its tributaries. The Kankakee, Embarras, and Vermilion River drainages support the highest species diversity and/or extant populations of rare species. Threats to mussel populations are the same as those impacting all freshwater riverine species: siltation, chemical pollution, impoundments, instream disturbances (gravel mining, construction, dredging, channelization, etc.), and competition from exotics. Commercial harvest seems to have had relatively little impact on mussel populations, but the data are not conclusive. Species losses are most pronounced in rivers not open to commercial harvest. Conservation efforts have been focused almost entirely on terrestrial habitats. Stronger emphasis needs to be placed on protecting aquatic habitats, particularly streams, in order to preserve remaining mussel diversity and other riverine species.

Conservation Status of Selected Freshwater Mussels in Texas

Robert G. Howells[1], Charles M. Mather[2], and Joseph A.M. Bergmann[3]
[1]*Texas Parks and Wildlife Department, Heart of the Hills Research Station, Ingram, Texas*
[2]*University of Science and Arts of Oklahoma, Chickashia, Oklahoma*
[3]*Boerne, Texas*

Recent surveys of freshwater mussels in Texas find many species to have declined dramatically in recent years. Among the 52 species recognized in the state, the American Fisheries Society lists 17 as threatened, endangered or of special concern, and an additional federally endangered species has recently been found in the state. However, recent statewide surveys now indicate many species appear far less secure than initially believed. Several species appear to occur at only one to three locations, and a number have not been found alive in recent years. Mussel harvest regulations first put in place in 1992 and 1993, offer limited degrees of protection to some of these species. Among 28 no-harvest mussel sanctuaries designated throughout Texas, several contain populations of some of the most threatened species. Additionally, minimum size limits of 63.5 mm (shell height) completely preclude harvest of several species and offer protection to all but a few very large individuals of several others. However, population declines largely reflect poor land and water management practices with subsequent loss of natural aquatic habitat. Commercial and sport mussel harvest appear to have had little impact on the most seriously threatened species. Because poor land and water use practices are continuing, prospects for reversing mussel declines are not encouraging.

A Survey of the Unionid Mussels of the Illinois River: A Recovering Resource

Scott D. Whitney, K. Douglas Blodgett, and Richard E. Sparks
Illinois Natural History Survey, S.A. Forbes Biological Station, Havana, Illinois

The last comprehensive mussel survey of the Illinois River, conducted in 1966-69, revealed that 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. In the past three decades, mussel populations have been subject to three major changes: (1) commercial harvest for the Japanese cultured pearl industry; (2) dramatic improvement in water quality; (3) invasion of two non-indigenous bivalves, the Asiatic Clam (*Corbicula fluminea*) and the European 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 comparison with previous studies. However, the majority of the collections were made by divers using quantitative and qualitative collection techniques. The information we have collected indicates that mussel populations are showing signs of recovery. The most dramatic improvements have been recorded in the upper river where we found numerous live mussels representing 12 unionid species, including juveniles. Throughout the entire river, we have collected a total of 24 species to date, including several species once listed as extirpated. Average densities ranged from less than $1/m^2$ to $38/m^2$, with population density and species abundance increasing in the downriver direction. Within specific mussel beds species composition has improved from a population composed of a few species to one with several abundant species. Shell annuli and length frequency distributions

(27)

of different species indicate that most populations are comprised of both adults and juveniles. Despite signs of improvement in unionid density and species diversity, the recent invasion and proliferation of the zebra mussel threatens to set back years of recovery for the Illinois mussel populations.

Quantitative Reassessment of the Freshwater Mussel Fauna in the Clinch and Powell Rivers, Tennessee and Virginia

Steven Ahlstedt and Jack Tuberville
Tennessee Valley Authority, Clean Water Initiative, Norris, Tennessee

Quantitative reassessment of the mussel fauna in the Clinch and Powell rivers was completed in September, 1994. The survey included sites sampled in 1979, 1983, and 1988. In 1994, 428 (0.25 m^2) quadrat samples were collected at 14 sites in the Clinch and 468 quadrats were taken at 16 sites in the Powell. Trends in species composition, abundance, and recruitment are reported. Dead and dying mussels observed in 1988 sampling may be related to the severe five-year drought which ended in 1989. Recent reproduction of federally listed and candidate species found in quadrat samples in the lower Clinch were *Cyprogenia stegaria, Dromus dromas, Epioblasma brevidens, E. capsaeformis, Fusconaia cor, F. cuneolus, Hemistena lata, Lemiox rimosus*, and *Quadrula cylindrica strigillata*. Sites in Virginia had limited reproduction and consisted of *Actinonaias pectorosa, Medionidus conradicus, Ptychobranchus fasciolaris*, and *Villosa iris*. However, recent reproduction of federally listed *Epioblasma florentina walkeri* and *Villosa perpurpurea* (candidate species) were found at one site in Virginia. The mussel fauna in the Powell River changed little since sampling in 1988. Some species continue to decline or were not found. Reproduction was noted at a few sites and consisted of *Actinonaias pectorosa, Fusconaia subrotunda, Lampsilis fasciola, Medionidus conradicus*, and *Ptychobranchus fasciolaris*. Federally listed and candidate species found in quadrat samples were *Dromus dromas, Epioblasma brevidens, Fusconaia cor, F. cuneolus, Quadrula intermedia*, and *Q. sparsa*. A mussel die-off was documented in the Powell River beginning in 1983 and continuing until 1986. The cause of this decline remains unknown and mussel populations are presently at extremely low levels.

Chemosensory Abilities of Female Freshwater Mussels and Glochidia (Unionidae)

William F. Henley and Richard J. Neves

Virginia Polytechnic Institute and State University, Virginia Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife Sciences, Blacksburg, Virginia

Behavioral responses in gravid *Lampsilis fasciola* and *Villosa iris* indicate their ability to distinguish host fish (*Micropterus dolomieu*) and non-host fish (*Cyprinus carpio*), and their mucus. Behavioral observations of adult mussels included degree of mantle presentation, pulse rate, glochidial ejection, shell spread, and inhalant aperture length. Measurements associated with these observations were used to create a composite behavioral index. Whereas *L. fasciola* was more active with exposure to host fish and mucus, behavioral responses decreased with exposure to non-host fishes and mucus. Also, activity levels were higher with exposure to host fish than to their mucus. Similar behavioral responses were noted with *V. iris*. *Lampsilis fasciola* was found to be more active during the day, whereas *V. iris* was more active at night. Glochidia of *V. iris* were tested for valve closure time and percentage of total glochidia closed after one minute with exposure to components of host fish and non-host fish mucus and blood. Fibrinogen was found to induce the strongest responses in glochidia.

Reproduction and Fish Hosts of Unionids From the Ozark Uplifts

M. Christopher Barnhart, Andrew D. Roberts, and Ashley P. Farnsworth
Southwest Missouri State University, Department of Biology, Springfield, Missouri

We made field observations of reproductive status and performed laboratory tests to determine potential fish hosts of *Ptychobranchus occidentalis* (Ouachita kidneyshell), *Lampsilis reeviana brevicula* (broken rays), *L. rafinesqueana* (Neosho mucket), and *Anodonta suborbiculata* (flat floater). Kidneyshells in the North Fork of the White River (Douglas County, Missouri) released mimetic glochidial packets resembling larval fish between March 6 and April 8. Transformation of glochidia to juveniles occurred in 26-31 days at 21°C on darters (*Etheostoma blennioides, E. juliae, E. caeruleum*). Broken rays in White River tributaries displayed the mantle lure between April 10 and August 8. Transformation occurred in 22-34 days at 21°C on smallmouth bass (*Micropterus dolomieu*), green sunfish (*Lepomis cyanellus*), and banded sculpin (*Cottus carolinae*). Neosho

muckets in the Elk River (McDonald County, Missouri) displayed the mantle lure in July and August (previous reports of display in September and October). Transformation occurred in 27 days at 21°C on *M. dolomieu* and *M. salmoides*. Flat floaters (Marais des Cygnes drainage, Linn County, Kansas) released glochidia between December 19 and February 25. Transformation occurred in 51-63 days at 10°C on golden shiners (*Notemigonus crysoleucas*), warmouth (*Lepomis gulosus*), white crappie (*Pomoxis annularis*), and *M. salmoides*; transformation was generally unsuccessful at 21°C.

The Distribution, Habitat Preference, and Population Biology of the Louisiana Pearl-Shell Mussel *Margaritifera hembeli*

Paul D. Johnson[1] and Kenneth M. Brown[2]
[1]*University of Texas at Arlington, Department of Biology, Arlington, Texas*
[2]*Louisiana State University, Department of Zoology, Baton Rouge, Louisiana*

We examined the distribution, habitat preference, and intra-specific variation in density, size, dispersion, growth and shell morphology in the Louisiana pearl-shell mussel *Margaritifera hembeli*, a species classified as endangered until October 1994. Populations of *M. hembeli* were located in 11 streams in the Bayou Rigolette drainage, from which it was previously unknown, doubling its previously known distribution. Temperature, dissolved oxygen, conductivity, Ca+2, pH and redox potential were poor predictors of mussel abundance within a stream, but good predictors of abundance across drainages. Physical habitat characters such as channel width and depth, granulometry, sediment organic content, sediment compaction and current velocity were more successful in predicting mussel habitat in a Canonical Discriminant Analysis (Wilks = 0.71 p = 0.02); with sediment size, compaction and channel width explaining most of the variation. Mussel densities were estimated both randomly and inside mussel beds. Random measurements were different among sites, whereas densities inside beds were not, and acontagious distribution pattern was found at each site. Size frequency differed among sites, with evidence of recruitment at a few sites. Growth rates measured as increase in shell length of tagged individuals averaged from 1-3 mm mean increase in shell length per year, suggesting a 15-20 year variation in life-span among sites.

Discontinuity in the Genetic Population Structure of the Green Floater *Lasmigona subviridis* and Recommendations for Genetic Conservation in Freshwater Mussel Salvage Programs

Tim L. King, Rita F. Villella, Mary E. Smith, Michael S. Eackles, and David P. Lemarié
National Biological Service, Leetown Science Center, Aquatic Ecology Laboratory, Kearneysville, West Virginia

Green floaters (*Lasmigona subviridis*) from four geographic populations were subjected to polymerase chain reaction amplification and restrictionase digests of the internal transcribed spacer region (ITS–1) of nuclear ribosomal DNA and the cytochrome oxidase I (COI) region of mitochondrial DNA. Diagnostic genetic differentiation was observed in both ribosomal and mitochondrial DNA among geographic populations of *L. subviridis*. The 570 base–pair (bp) ITS–1 fragment, digested with the enzyme *Dde* I, produced a restriction site polymorphism between a Sideling Hill Creek, Pennsylvania population and populations in West Virginia and North Carolina. The Pennsylvania population also exhibited a restriction site polymorphism in the 710bp COI region of mtDNA when digested with the enzyme *Cfo* I. Preliminary results suggest the presence of considerable genetic differentiation between Sideling Hill Creek, Pennsylvania *L. subviridis* and southern populations, and possibly the absence of gene exchange. The USFWS has proposed collection or salvage of native species in areas of heavy zebra mussel infestations in the Ohio River drainage. The primary concern of conservation efforts in any salvage program should be conservation of the gene pool. In the absence of definitive population genetics data, we suggest a conservative approach (i.e., assume genetic distinctness) to the management and conservation of *Lasmigona subviridis* and all freshwater mussel species. Recommendations for genetic conservation in freshwater mussel salvage programs will be discussed.

The American Mussel Crisis: Effects on the World Pearl Industry

(29)

C. Richard Fassler
State of Hawaii Department of Land and Natural Resources, Aquaculture Development Program, Honolulu, Hawaii

The success of the world cultured pearl industry can be attributed to the discovery by Japanese pearl farmers in the early 1950's that the American freshwater mussel was ideally suited for making the bead nucleus they needed for culturing. Since then, farmers have tried other molluscan species from other areas of the world (Giant clam, abalone, pearl oysters) and synthetic materials (glass, ceramics), but nothing has equaled the effectiveness of the American mussel in producing the finest pearls. The Japanese discovery led to a multi-million dollar shell export industry in the midwestern United States, employing some 10,000 people. However, such factors as damming, gravel dredging, stream channelization and, more recently, infestation by zebra mussels, have resulted in a substantial reduction in populations of those mussels that have traditionally been used for nuclei. American mussels and the American mussel export industry are at a critical stage, where experts are now predicting such a drastic decline in the mussel resource over the next seven years that the industry will be close to extinction. The world pearl industry has responded to the crisis through such means as: 1. Re-exploring the use of a synthetic nucleus (the Japanese have reportedly applied for 5-7 patents); 2. Experimenting with non-mussel species for nuclei, such as the Giant clam; and 3. Utilizing the freshwater mussel resource of other nations, principally China. The American mussel industry has, likewise, reacted by instituting such measures as: 1. Restricting the harvest of mussels in such bodies of water as the Illinois River; and 2. Investigating the possibility of aquaculturing certain mussels. For example, discussions are underway with the U.S. Fish & Wildlife Service for the utilization of Federal hatcheries.This presentation will consider the above measures and others, in order to determine both the short-term and long-term consequences. A preliminary conclusion is that profound changes are likely to occur within the next ten years that will greatly effect the quantity and quality (hence value) of American mussels and pearls throughout the World.

Developmental Shifts in the Feeding Biodynamics of Juvenile *Utterbackia imbecillis* (Mollusca: Bivalvia)

Richard A. Tankersley[1], J.J. Hart[2], and M.G. Wieber[2]
[1]*University of Maryland, Department of Biological Sciences, Baltimore County, Maryland*
[2]*Gonzaga University, Biology Department, Spokane, Washington*

Ontogenetic shifts in the feeding mechanisms utilized by juvenile mussels (*Utterbackia imbecillis*) immediately following transformation were determined and associated with morphological changes in pallial feeding structures. Video recordings of feeding activities indicated juvenile *U. imbecillis* utilize a combination of interstitial suspension and deposit feeding to capture and ingest particles. Cilia located on the foot, gills, and anterior edge of the mantle produce anterior inhalant currents that draw suspended particles into the mantle cavity for ingestion. Deposited particles were collected and drawn toward the pedal gape using both pedal-sweep and pedal locomotory feeding. The relative contribution of each feeding mode to the ingestion rate of 8, 14 and 24 day old juveniles was determined by examining the gut contents of mussels fed fluorescently labeled latex beads. Dominant feeding mode varied with age, with younger juveniles relying more heavily upon deposit feeding mechanisms than older mussels. The rate of deposit feeding was enhanced by the presence of fine silt (<202 μm) suggesting that particles too large to ingest may serve as important substrata for deposit feeding. Ontogenetic shifts in the mode of particle acquisition were accompanied by changes in the functional morphology of suspension feeding structures, including the size and number of ctenidial filaments and ciliary tracts.

Difference in Growth Between Two Populations of *Villosa taeniata* in Horse Lick Creek, Kentucky

Bradley S. Houslet and James B. Layzer
Tennessee Cooperative Fishery Research Unit, Tennessee Technological University, Cookeville, Tennessee

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 indicate that mussels in the lower portion of the creek were significantly smaller than those upstream of mine run-off. We collected samples of 50 *Villosa taeniata* at one site in the upper portion of the creek and at one site in the lower portion to determine if the difference in mussel size was related to differences in growth or were indicative of colonization

following possible post-mining improvements in water quality. Examination of thin-sections of shells indicated that age distributions were similar between sites (most mussels were 15 to 25 years old) but shells from the upper site weighed more and were significantly larger in all dimensions measured. The slower growth of mussels in the lower portion of the creek may reflect residual effects of strip-mining.

Micro- and Macro-geographic Genetic Differentiation Among Mussel Populations

David J. Berg[1], Sheldon I. Guttman[2], and Emily G. Cantonwine[3]
[1]*Miami University, Department of Zoology, Hamilton, Ohio*
[2]*Miami University, Department of Zoology, Oxford, Ohio*
[3]*Savannah River Ecology Laboratory, Aiken, South Carolina*

Recent work has shown that unionid bivalves contain significant levels of intrapopulation genetic variation. Variation among populations is a function of gene flow, which in the case of unionids, is almost certainly dependent on transport of glochidia by vertebrate hosts. We used starch gel electrophoresis to examine the partitioning of genetic variation within and among populations of *Quadrula quadrula* in the Mississippi River basin. Individuals were collected from seven sites: four sequential mussel beds in a 31 km stretch of the Ohio River near Middleport, Ohio; 80 km downstream near Huntington, West Virginia; Kentucky Lake, Kentucky (>800 km downstream of the first sites); Tensas River, Louisiana (>1,500 km downstream). Results show no differentiation in allele frequencies among the four upstream sites and extremely low genetic distances. Comparisons among more distant sites show that allele frequencies vary over greater geographic distances. These results indicate that individual mussel beds are not isolated and that metapopulations, composed of several mussel beds, exist within a river system. Most likely, this is due to movement of host fishes. Changes in allele frequencies that occur over large geographic distances represent a combination of isolation by distance and selection in response to environmental conditions.

Selected Community Characteristics of Freshwater Mussels (Unionacea) in the White River, Arkansas

Alan D. Christian[1], John L. Harris[2], and George L. Harp[2]
[1]*Miami University, Department of Zoology, Oxford, Ohio*
[2]*Arkansas State University, Dept. of Biological Sciences, State University, Arkansas*

The White River originates in northwest Arkansas and flows approximately 1,210 km through two states (Arkansas and Missouri) until its confluence with the Mississippi River in southeastern Arkansas. Research was conducted on the lower 433 km of the White River. Beds were mapped. Divers used a hookah and randomly sampled using a 1 m^2 quadrat of 2.5 cm PVC pipe. Four regions were delineated. Seventeen major beds (minimum area of 500 m^2) and 34 minor beds (area < 500 m^2) were found. Two hundred eighty-four 1 m^2 samples were taken and 5,183 individuals identified with a mean of 18.2 individuals per m^2 from Mbeds. Thirty-four species were identified. *Quadrula quadrula* dominated numerically with 29.2% of the total in Mbeds. Percent legally harvestable mussels on collected individuals was 19.3%. Significant differences in shell depths of five species were observed among the four regions delineated. One federally endangered species, *Lampsilis abrupta*, was represented by four individuals at four sites within the survey area.

Instream Flow and Habitat Requirements of Freshwater Mussels: A Case Study of the Lower St. Croix River

Shawn L. Johnson[1] and Daniel J. Hornbach[2]
[1]*Minnesota Department of Natural Resources, 1221 E. Fir Ave., Fergus Falls, Minnesota*
[2]*Macalester College, Department of Biology, 1600 Grand Ave., St. Paul, Minnesota*

The instream flow and physical habitat requirements of freshwater mussels were examined downstream of a hydroelectric peaking dam on the Lower St. Croix River, a large tributary of the Upper Mississippi River. Hydraulic and habitat modeling were executed using the Physical Habitat Simulation System. Hydraulic data were collected along nine transects established across the channel. Habitat-use data were collected from 150 samples, representing 29 species and 1174 individuals. Mussel densities and species richness were highest in habitat having moderate to deep depths (>50 cm depth), moderate velocities (20-65 cm/s), and substrate comprised of sand, gravel, and cobble. Shallow areas with low velocities supported few mussels. Suitable mussel habitat was relatively abundant over the range of naturally occurring flows (from 2000 to 10,000 cfs). Suitable mussel habitat was limited at

(31)

flows of 800 and 1600 cfs, the minimum releases from the dam during winter and summer peaking operations. Habitat was limited at these low flows due to low velocities, shallow depths, and loss of wetted area. Mussels were rare or absent from areas of the stream channel dewatered during peaking operations. These results were used to develop flow recommendations to protect the habitat of mussels, including numerous rare species, in the Lower St. Croix River.

Population Increase of *Quadrula metanevra* in Southeast Kansas

Edwin J. Miller[1] and Brian K. Obermeyer[2]
[1]*Kansas Department of Wildlife and Parks, Independence, Kansas*
[2]*Division of Biological Sciences, Emporia State University, Emporia, Kansas*

While many unionid species have declined markedly in the last century, the monkeyface, *Quadrula metanevra*, has become one of the most abundant in the Neosho, Verdigris, and Fall rivers of southeast Kansas, despite commercial harvest pressure. Comparisons of past surveys with sampling conducted in the 1990s from 48 sites in these streams reveal a substantial surge in the relative abundance of *Q. metanevra* during the past two decades. However, this increase is limited to shallow habitats downstream from three major impoundments located in these streams; in fact, *Q. metanevra* is apparently extirpated upstream from these impoundments. We postulate that *Q. metanevra*'s increase downstream from these impoundments may be related to improved water quality, the increase of two suitable fish hosts (bluegill and green sunfish), and regulated stream flows during droughts. Regulated releases, however, have also degraded habitats due to excessive scouring, thus tempering the apparent benefits. The absence of *Q. metanevra* upstream from these impoundments may be the result of isolation from downstream populations, thus eliminating the possibility for recolonization following mortality from drought and effluence. We are unable to explain the decrease of other unionid species despite their habitat and host similarities to *Q. metanevra*.

Kentucky Reservoir Commercial Mussel Harvester Survey

Don Hubbs
Tennessee Wildlife Resources Agency, Camden, Tennessee

This survey was conducted to capture species composition, average individual mussel weight (AIW) and harvest rate data from the mussel harvesters working the Tennessee portion of Kentucky Reservoir. Musselers were interviewed in areas receiving the heaviest harvest pressure. Approximately sixty to ninety musselers were surveyed per year during 1992–94, total mussels creeled ranged from 11,593 (1992) to 15,824 (1993). Each musseler's catch was grouped by species, divided into size categories, counted and weighed (dead mussels were omitted). Time spent musseling and location were recorded. Data collected were analyzed to determine species composition, catch per unit of effort (CPUE), and average individual weight. Ebony shell (*Fusconaia ebena*) and threeridge (*Amblema plicata plicata*) ranked first and second in number and weight harvested each year. Ebony shell increased from 43% of the harvest by number, 37% by weight to 75% and 68% respectively during 1992–94. Annual CPUE ranged from 25.76 pounds/hour in 1992 to 33.56 in 1994. AIW of all species combined dropped from 0.46 to 0.39 pounds during the survey. Species specific AIW's decreased from 1992–93, then rebounded slightly in 1994. Decline in AIW reflects a shift in species composition and a reduced percentage of larger mussels of all species.

Determining an Appropriate Design for a Freshwater Mussel Survey

Barry S. Payne[1], Andrew C. Miller[1], and Robert Whiting[2]
[1]*U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi*
[2]*U.S. Army Engineer St. Paul District, St. Paul, Minnesota*

A tiered approach to designing a mussel survey is presented based on survey objectives, practical considerations, and site-specific characteristics. Survey objectives range from determining presence of endangered species to quantifying detailed aspects of population and community demography. Qualitative and quantitative methods of obtaining mussels often must be used in combination to meet survey objectives. Qualitative methods include shoreline searches for shells at low water, diving without breathing apparatus, snorkeling, use of rakes and similar devices, and brailing. Quantitative methods range from visual or tactile searches within quadrats or along transect line to substrate removal and processing to obtain virtually all mussels regardless of size. Basic aspects of study design, such as use of systematic versus random sampling and sampling

effort, also determine if a survey can meet its objectives. Practical considerations include existence of information from previous surveys, total area that must be sampled, and availability of funds, equipment, and personnel. Influential site characteristics include substrate type, water depth, velocity, and clarity, mussel density, and mussel size. Implications of survey design and sampling method on estimation of species richness, relative abundance, diversity, density, population size, and recruitment are discussed.

Distribution and Abundance of Mussel Beds in the West Fork of the White River in and around Muncie, Indiana

Thomas A. Sobat and Jennifer K. David
Bureau of Water Quality, Muncie, Indiana

Observations have shown a decline in mussel densities in the West Fork of the White River. For the last four years, the Bureau of Water Quality has been conducting a study designed to give a better understanding of some factors which affect the distribution of freshwater mussels in the White River, Muncie, Indiana. It is the intention of the Bureau to increase mussel densities in the White River within the city through glochidial host infection if the stream bed is deemed receptive. With the primary objective to determine the characteristics of a true mussel bed, four sites were visited annually between June 1992 and July 1995. Sample sites consisted of three densely populated mussel beds above Muncie and one station within the city that historically contained a healthy mussel community. In addition to mussel concentration information, each site was examined for: canopy cover, substrate profile, flow, depth, width, and ground water recharge/discharge zones. The Bureau has also been collecting baseline information for the last 23 years on 47 physiochemical parameters, fish, and macroinvertebrate communities. These data will be used to aid in characterizing these stations. These data as well as the conclusions from our study and our future plans for host infection will be discussed in detail.

Mussel (Bivalvia: Unionidae) Habitat Suitability Criteria for the Otter Tail River, Minnesota

Rick A. Hart
North Dakota State University, Department of Zoology, Fargo, North Dakota

Habitat suitability data for 4851 mussels, representing 13 species, were collected from five sampling sites on the Otter Tail River, Minnesota. Habitat suitability criteria were developed for seven species of unionid mussels. Threeridge (*Amblema plicata*), Wabash pigtoe (*Fusconaia flava*), fluted shell (*Lasmigona costata*), and squawfoot (*Strophitus undulatus*) all had similar suitability values for water velocity, depth, substrate, and cover. Velocities most suitable were about 80 cm/s with velocities < 25 cm/s having zero suitability. Depths of 150 cm had the highest suitability; depths < 60 cm had zero suitability. These four mussel species were found most often in gravelly substrates with no instream cover. Areas most suitable for fat muckets (*Lampsilis siliquoidea*) and plain pocketbooks (*Lampsilis cardium*) were characterized by fast (90 cm/s and 115 cm/s respectively), deep water (175 cm), with large, coarse substrates. Threeridge, pigtoes, fluted shells, squawfoots, fat muckets, and pocketbooks were found most often in the run habitats of the Otter Tail River, Minnesota. Habitat suitability values for giant floaters (*Anodonta grandis*) were the highest in slow moving (about 10 cm/s), deep waters (135 cm) where aquatic vegetation was present. These suitability criteria will be used in the Instream Flow Incremental Methodology, aiding in the establishment of protected stream flows, preserving the run habitats most suitable for the mussels residing in the Otter Tail River, Minnesota.

Reproduction by Individuals of a Non-Reproducing Population of *Megalonaias nervosa* Following Translocation

Jackie H. Oven and James B. Layzer
Tennessee Cooperative Fishery Research Unit, Tennessee Technological University, Cookeville, Tennessee

Reproduction of *Megalonaias nervosa* 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. 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. One year later, samples of *M. nervosa* were taken from the Cumberland River, Kentucky Lake, and the translocated group. Histological examination indicated that translocated mussels and mussels originating in Kentucky Lake had undergone normal reproductive development and

females of both samples had mature glochidia in their marsupium. In contrast, there was no indication of reproductive activity in gonads or marsupium of individuals collected from the Cumberland River. Our results indicate that the altered temperature regime is disrupting the normal gametogenic cycle, and that translocation to a more normal thermal regime will reinitiate a normal cycle. We suspect that the altered thermal regime is also disrupting the gametogenic cycle of endangered mussel species occurring in the Cumberland River. These relict populations will disappear unless they are translocated or the thermal regime returned to normal.

Dry Tissue Weight as an Indicator of Mussel Condition - A Cautionary Note

James B. Layzer and Lesa M. Madison
Tennessee Cooperative Fishery Research Unit, Tennessee Technological University, Cookeville, Tennessee

The spread of zebra mussels threatens the continued existence of many species of native unionids. Because it is unknown if breeding populations of native unionids can be maintained long-term (>10 years) in captivity, management agencies are faced with making a decision as to if and when unionids should be brought into captivity. We examined the use of dry tissue weight as an indicator of mussel condition. We collected samples of 50 *Fusconaia ebena* each month over a one year period from the same site in Kentucky Lake to determine seasonal variation in tissue weights. Samples of 50 *F. ebena* were also collected from three other sites on the Tennessee River during one month to assess among site differences. All regressions of dry tissue weight on dry shell weight or shell length were significant. Analysis of covariance indicated significant differences ($P < 0.05$) among some sites and months. Because our samples of *F. ebena* were not infested with zebra mussels, these seasonal and site differences in tissue weight reflect normal variation and may be due to reproductive activity or other factors. We recommend that potential seasonal and site differences be investigated for other methods of determining mussel condition before management recommendations are made.

Application and Efficiency of Adaptive Cluster Sampling in Freshwater Mussel Surveys

David R. Smith, David P. Lemarié, Rita F. Villella, and David A. Weller
National Biological Service, Leetown Science Center, Aquatic Ecology Laboratory, Kearneysville, West Virginia

Precise quantitative estimates of mussel density are difficult (some say impossible) to attain because mussel distributions are clustered. Thompson (1990, Journal of American Statistical Association 85, 1050–9) recently developed an intuitively appealing method to sample clustered populations which allows sampling effort to increase in response to observations at randomly selected locations. Because of its potential efficiency, we evaluated this method, called adaptive cluster sampling (ACS), in freshwater mussel surveys. We simulated sampling of known mussel populations which permitted us to evaluate a wide range of specific designs and sample sizes. Our computer simulation was based on mussels in a 1200 m^2 pool and a 1800 m^2 riffle which were mapped at a resolution of 0.25 m^2. Three species were mapped: *Elliptio complanata*, *Elliptio fisheriana*, and *Lampsilis cariosa*. We compared variances from ACS and simple random sampling for fixed effort to determine efficiency. In addition, we applied ACS in a survey of freshwater mussels in the Cacapon River, West Virginia to evaluate the practicality of the method. Sampling unit size, initial sample size, and the criteria to adapt all help determine the efficiency of ACS. Final sample size is a random variable in ACS which can result in exhausted resources prior to completing a survey. Because of theoretical and practical reasons, ACS tends to be a good idea, when sampling low density mussel populations.

A Comparison of the Effectiveness of Timed Searches vs. Quadrat Sampling in Mussel Surveys

Caryn C. Vaughn, Christopher M. Taylor, and Kelly J. Eberhard
Oklahoma Biological Survey, University of Oklahoma, Norman, Oklahoma

We compared data collected from qualitative timed searches with quantitative quadrat samples for 31 sites in small to medium-sized streams in the Red River drainage. For each site, the area within 15, 0.25 m^2 quadrats was sampled to a depth of 15 cm. The entire mussel bed was then searched by hand by at least two experienced surveyors for a minimum of 60 minutes. Species richness for timed searches vs. quadrats was positively correlated ($r = 0.65$, $P < .001$), but more species were found in timed searches. There were significant differences in individual species occurrences in timed searches vs. quadrats (Friedman test statistic = 10.62, $P < .001$); in general, most species were more likely to be found in timed searches but some smaller species occurred more often in

quadrats. The relative abundance of *Amblema plicata* was significantly higher (Friedman statistic = 6.82, P = .009) and the relative abundance of *Actinonaias ligamentina* was significantly lower (Friedman statistic = 5.26, P = .022) in timed searches than in quadrats. This probably reflects differences in sampling efficiency related to the burrowing habits of these species; in our study area *A. plicata* tends to protrude from the substrate while *A. ligamentina* does not. Overall, our results suggest that both qualitative and quantitative surveying methods should be used when possible.

Assessing Unionid Populations With Quadrats and Timed Searches

David L. Strayer, Stephanie Claypool, and Sandra J. Sprague
Institute of Ecosystem Studies, Millbrook, New York

We assessed unionid populations at 53 sites on wadable streams between New Hampshire and North Carolina by conducting timed searches and by searching 0.25 m^2 quadrats placed in adaptive cluster designs. Timed searches were inexpensive and successfully detected even sparse (<0.01/m^2) populations. Timed searches done with mask and snorkel had higher catch rates and detected more species than searches done on foot. Quadrats detected far fewer species per hour than timed searches. The time required to place and search quadrats varied with experience of the field crew and mussel density. Nevertheless, quadrats were surprisingly inexpensive to use (<5 min./quadrat under most conditions), and produced reasonably precise estimates of population densities of the more abundant species. Catch rates from timed searches were well correlated with actual population densities of mussels, suggesting that timed searches may offer an inexpensive and quantitative index of population density, *if applied under carefully defined conditions.*

Longitudinal Changes in the Mussels of the Amite River: Endangered Species, Effects of Gravel Mining, and Shell Morphology

Kenneth M. Brown and Jason Curole
Louisiana State University, Department of Zoology, Baton Rouge, Louisiana

We surveyed unionid mussel assemblages in the Amite River, in south–eastern Louisiana, in Summer 1994. Twelve species, dominated by *Elliptio crassidens*, inhabited the cobble and gravel substrata and high current–velocity sites of the upper 25 km. Mussel diversity and abundance declined dramatically in the unstable, sand channels of the middle 23 km, subject to intense gravel mining. The unimpacted lower 47 km, with silt and fine–sand substrata and slower flow, supported 21 species, with healthy populations of the endangered Alabama heelsplitter, *Potamilus inflatus*. We found mixed support for changes in shell morphology predicted to be important along river continua. Morphological shell anchors were just as common in down river areas with slow flow, although alate shells were more common in the softer sediments, as predicted. Multivariate analyses revealed clear differences among species in shell anatomy, but no clear site–based trends.

Cooperative Conservation Plan for the Freshwater Mussel Fauna in the Ohio River as a Result of the Invasion of Zebra Mussels (*Dreissena polymorpha*)

Cindy M. Chaffee
U.S. Fish and Wildlife Service, Ecological Services Field Office, Bloomington, Indiana

The globally significant freshwater mussel diversity of the Ohio River and its tributaries is currently critically threatened by the invasion of the exotic zebra mussel. Zebra mussels were first found in the lower Ohio River in 1991. By 1994, zebra mussel densities were immense in the lower half of the river (every native unionid observed in the lower river was infested with zebra mussels) and low densities were observed in the upper river. The immediate threat posed by the zebra mussel led to efforts by concerned natural resource management agencies, researchers, and organizations to cooperatively develop an action plan to preserve and manage the diverse unionid fauna of the Ohio River. This cooperative effort takes an ecosystem approach to develop and implement a conservation plan in an effort to prevent a wave of extirpations. Because time is critical, we could not wait for all research results before implementing urgent management steps, thus, this plan involves simultaneous activities including monitoring, rescue of rare fauna, research, and public outreach. The results and implications of this management strategy will have wide application to other watersheds throughout the country as we battle the zebra mussel invasion and try to secure a future for native mussels.

Discrimination of Environmental Factors Affecting Unionid Mussel Distribution in the Clinch River, Virginia

John H. Van Hassel[1], Donald S. Cherry[2], Mindy M. Yeager[2], and Jerry L. Farris[3]
[1]*American Electric Power Service Corporation, Columbus, Ohio*
[2]*Virginia Polytechnic Institute and State University, Blacksburg, Virginia*
[3]*Arkansas State University, Jonesboro, Arkansas*

The Clinch River of Virginia and Tennessee historically contained 45 species of unionid mussels. Currently, there are 11 federally listed endangered species, and recent surveys indicate that the mussel fauna is in decline in several areas of the river. A four-year study of factors affecting the structure and function of mussel assemblages at sixteen sites, encompassing 200 miles of the Clinch River in Virginia, was initiated in 1991. Significant spatial and temporal associations were found between mussel densities or physiological condition and differences in several physical and chemical habitat variables. Fish host availability was found not to be a factor in the decline. Significant factors were validated using reciprocally transplanted mussels among selected sites. Validation of these factors will allow evaluation of specific management options for the protection and enhancement of unionid mussel resources of the Clinch River.

The Environmental Effects of Commercial Navigation Traffic on Freshwater Mussels in the Upper Mississippi River -- Is There Really a Problem?

Andrew C. Miller[1], Barry Payne[1], Sherrie Zenk-Read[2], and Dan Ragland [2]
[1]*U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi*
[2]*U.S. Army Engineer District, St. Louis, Missouri*

Environmental effects of commercial navigation traffic at five mussel beds in Pools 24, 17, 14, 12, and 10 in the upper Mississippi River were studied, 1988-94. The purpose was to determine if temporary increases in water velocity and suspended solids, caused by vessel passage, affected freshwater mussels including the endangered *Lampsilis higginsii* (Lea). Based upon 60 vessel passages, 20% had a major effect, 37% had a minor effect, and 43% produced no measurable effect on ambient water velocity. Data from 0.25 m^2 total substratum samples were used to determine, using previously established criteria, if there were changes in mussel density, population demography, and other parameters at beds adjacent to navigation lanes. *Lampsilis higginsii* was regularly collected at beds within its range in Pools 10, 12, and 14; percent abundance varied from 0.09-1.72. Density of eight species declined, and density of two species increased significantly ($p = 0.1$). Although parameters varied among years, based upon established criteria mussel populations appear unaffected by commercial traffic. Results of future studies, to be conducted after traffic has increased because of completion of the second lock at Melvin Price Locks and Dam, will be used to further investigate effects of commercial navigation traffic.

Modifying Cumberland River System Reservoir Operations to Improve Mussel Habitat

Richard N. Tippit[1], Jackson K. Brown[1], James F. Sharber[1], and Andrew C. Miller[2]
[1]*Nashville District Corps of Engineers, CEORN-EP-H, Nashville, Tennessee*
[2]*U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi*

The Cumberland River and its tributaries once supported a rich and diverse mussel fauna of about 60 species. An alarming reduction in the diversity and abundance of the mussel fauna inhabiting the Cumberland River basin has occurred during the 20th century. Losses were caused in part by construction and operation of several major dams. These dams now regulate river flows, drastically modifying water quality. Releases for hydroelectric power prevent water temperatures from rising above 22°C, which interferes with mussel reproduction and restricts the occurrence of host fish. By employing DORM (dissolved oxygen routing model), the Corps of Engineers has identified a 40 mile reach of the main stem Cumberland River where summer water temperatures can be raised 2-4°C by modifying release patterns from upstream dams. This stretch of the Cumberland River contains at least two federally endangered mussel species, *Dromus dromas* and *Lampsilis abrupta*. There is a unique challenge to improving biotic conditions in a regulated river system where competing demands are placed upon water resources for energy production, industrial and municipal water supply, navigation, flood control, and aquatic life.

Risk Assessment of the USEPA Great Lakes Water Quality Guidance on Endangered Freshwater Mussels

Amelia Orton-Palmer[1] and Anne Keller[2]
[1]*U.S. Fish and Wildlife Service, Barrington, Illinois*
[2]*National Biological Service, Gainesville, Florida*

In 1995, the U.S. Environmental Protection Agency (USEPA) completed an Endangered Species Act consultation with the U.S. Fish and Wildlife Service (USFWS) to ensure that the Great Lakes Water Quality Guidance (Guidance) would not jeopardize the continued existence of three Federally endangered freshwater mussels in the Great Lakes watershed. The purpose of the Guidance is to establish consistent water quality standards for the watershed among all Great Lakes states, through numerical limits on pollutants and through implementation policies. To determine the level of protection of aquatic life criteria for listed mussels, USFWS conducted a risk assessment using data from the limited studies available on toxicity to unionids, and on endangered species safety factors from the USEPA Office of Pesticides Program. The results indicated that the proposed acute criteria for nickel and chronic criteria for copper, zinc, nickel, cadmium, and chromium may not be protective of endangered unionids. To better assess contaminants effects on endangered mussels, USEPA will conduct acute and chronic toxicity tests on listed mussels or surrogate species for selected contaminants. This information will be used to determine if Guidance criteria should be revised, and will be valuable for evaluating other water quality standards affecting freshwater mussels.

Responses of *Utterbackia imbecillis* Early Lifestages to Copper (Transformation Method Comparisons)

Sarah A. Clem, Margaret L. Barfield, and Jerry L. Farris
Arkansas State University, Ecotoxicology Research Facility

As freshwater mussel populations are diminishing consideration is being given to determining effects levels of contaminants to the more sensitive early lifestages. Levels thus far have been based upon water quality criteria using standard toxicity test organisms which may be under protective of these early lifestages. In order to protect future populations criteria should include glochidia and juvenile responses to contaminants. The toxicity of copper to the early lifestages of *Utterbackia imbecillis* was examined using 24-hr. acute glochidia tests, 72-hr. acute tests using 7-day old juveniles reared by in vivo and in vitro methods, and post exposure transformation counts. Comparisons of LC50 values revealed juveniles from in vivo transformation were less sensitive than glochidia and in vitro transformed juveniles. Glochidia were less sensitive than in vitro transformed juveniles. Post-exposure in vitro transformation counts revealed a decrease in transformation in glochidia as exposure levels increased. Nine-day static renewal acute tests are being used to reinforce results of in vivo and in vitro comparisons.

Unionid Relocation and Monitoring, Meramec River Bridge Construction Site, Jefferson and St. Louis Counties, Missouri

Heidi L. Dunn[1] **and Gene Gardner**[2]
[1]*Ecological Specialists, Inc., St. Peters, Missouri*
[2]*Missouri Highway and Transportation Department, Design Division, Jefferson City, Missouri*

Bridge construction involving instream work can seriously disturb unionids and their habitat, however, impact area can be minimized and unionids in impact areas can be relocated. MHTD coordinated with regulatory personnel to design temporary causeways (necessary for construction) that would impact a minimum area and allow uninterrupted river flow. However, *Lampsilis abrupta*, a federally endangered species, and several species with special status in Missouri would be affected by causeway and pier construction. Instream construction areas and a buffer zone around construction areas were delineated and all unionids (4,514 of 21 species) were removed from these areas and relocated to an existing unionid bed upstream of the bridge. *Lampsilis abrupta*, as well as *Fusconaia ebena* (endangered in Missouri), *Arcidens confragosus* (rare in Missouri), and *Obovaria olivaria* (on Missouri's watch list) were measured, aged, marked with a unique number, and placed in grids for future monitoring. No mortality was observed one month following the relocation. Animals will also be monitored in 1995 and 1996.

Using Sidescan Sonar to Define River Bottom Environments for Resource Assessment and Management

Ronald C. Circé[1] and Patricia A. Morrison[2]
[1]U.S. Geological Survey, Reston, Virginia
[2]U.S. Fish and Wildlife Service, Parkersburg, West Virginia

In February, 1993, a workshop on freshwater mussel survey design was hosted by the Ohio River Islands National Wildlife Refuge in Parkersburg, West Virginia. Refuge staff established four objectives for monitoring the freshwater mussels: (1) identifying and characterizing native mussel populations around the islands in the Ohio River; (2) establishing a baseline for monitoring populations and contaminants; (3) monitoring colonization of zebra mussels and their effect on native mussel populations; and (4) implementing a salvage operation of native fauna if necessary. An interagency pilot project to address the objectives of the Ohio River Islands National Wildlife Refuge was undertaken by the U.S. Geological Survey, U.S. Fish and Wildlife Service, the National Biological Survey, and the West Virginia Division of Natural Resources. This two year project was designed to augment existing data and data collections techniques by utilizing non-destructive, acoustical methods for delineating and defining sedimentary environments of the river bottom. Two hypotheses were tested: (1) that sidescan sonar is an effective tool for river bottom habitat mapping; and (2) that sidescan sonar can actually delineate discrete areas of the riverbed inhabited by freshwater mussels. By using sidescan sonar techniques and ground-truthing areas with scientific divers, four primary sedimentary environments were defined and delineated along the river bottom surrounding eleven islands in the study area. These areas included: (1) silt/clay/sand/gravel: found primarily in the main river channel; (2) silt/clay: observed on both sides of islands (main channel and back channel), when seen in the main river channel it appears in long stretches of the river; (3) sand/gravel/cobble: found primarily at the heads of islands in both the main channels and back channels; and (4) submerged aquatic vegetation beds seen predominantly along the shoreline of the islands and riverbank especially in the back channel areas. As a result of this pilot study, the first hypothesis was accepted. The second was rejected, in part because areas of the upper Ohio River inhabited by freshwater mussels are hard substrates which reflect sonar signals strongly. The acoustic signal of the hard bottom is indistinguishable from that of the mussels. However, there is a strong correlation, through brailing and ground-truthing, of sedimentary type 3 and freshwater mussels.

Bivalve Survey of the Sandy River Drainage, Minnesota

Mark C. Hove[1], Chris E. Freiburger[2], and Robin A. Engelking[1]
[1]University of Minnesota, Department of Fisheries and Wildlife, St. Paul, Minnesota
[2]Department of Natural Resources, Grand Rapids, Minnesota

Freshwater mussels have been shown to be useful bioindicators of water quality. A qualitative bivalve survey of the Sandy River basin, located in north central Minnesota, was conducted during August - September 1994. The Sandy River drainage, composed of the West Savanna, Prairie, Tamarack, and Sandy Rivers, was surveyed at thirty-two sites for freshwater bivalves. Pill clams (Sphaeriidae) and eight species of unionids were observed, including: *Anodonta grandis, A. imbecillis, Anodontoides ferussacianus, Lampsilis cardium, L. siliquoidea, Lasmigona compressa, Ligumia recta*, and *Strophitus undulatus*. Numerous populations of *Lampsilis siliquoidea, Anodonta grandis, Anodontoides ferussacianus*, and Sphaeriidae were observed throughout the drainage. Populations of *Lasmigona compressa, Ligumia recta*, and *Anodonta imbecillis* were scattered among 2-3 of the four tributaries. Very few *Lampsilis cardium* or *Strophitus undulatus* were observed. Greatest unionid diversity occurred in the Prairie River; most of which flows through the Savanna State Forest. Highest CPUEs were recorded at sites in the West Savanna River, situated primarily in the Savanna Portage State Park. Lowest unionid diversity and CPUEs were observed in channelized reaches of the Sandy River. Lower unionid abundance and diversity were observed in agriculturally developed areas with channelized stream beds than in pristine portions of the drainage.

Suitable Fish Hosts of Six Freshwater Mussels

Mark C. Hove, Eric M. Peterson, Robin A. Engelking, Margaret E. Peteler, and Elaine R. Evers
University of Minnesota, Department of Fisheries and Wildlife, St. Paul, Minnesota

Most unionids briefly attach to a fish in order to complete their life cycle. Management of rare unionids frequently demands knowledge of their fish host(s). Suitable fish hosts were determined by artificially exposing fish to mussel glochidia and determining if they facilitated glochidia metamorphosis to the juvenile stage. Six fish species were infested with *Cyclonaias tuberculata* glochidia, but only the

yellow bullhead (*Ameiurus natalis)* served as a suitable host. Four of ten fish species tested were found to be suitable hosts for *Lasmigona compressa*: spotfin shiner (*Cyprinella spiloptera*), slimy sculpin (*Cottus cognatus*), black crappie (*Pomoxis nigromaculatus*), and yellow perch (*Perca flavescens*). Only one fish (slimy sculpin) of four species tested was a suitable fish host for *Lasmigona costata* glochidia. The bluegill (*Lepomis macrochirus*) was the only suitable fish host of eight species infested with *Ligumia recta* glochidia. Six of eleven species tested were found to be suitable hosts for *Strophitus undulatus* glochidia: spotfin shiner, fathead minnow (*Pimephales promelas*), bluegill, largemouth bass (*Micropterus salmoides*), yellow bullhead, and black bullhead (*Ameiurus melas*). Both the spotfin shiner and black crappie served as suitable fish hosts for *Anodontoides ferussacianus* glochidia. Except for *Ligumia recta*, this study identifies several previously unknown suitable fish hosts.

Feasibility of Reintroducing Threatened and Endangered Mussels into Shoal Creek in Alabama and Tennessee

James B. Layzer, Annette Morgan, and Nathan J. Welker
Tennessee Technological University, Tennessee Cooperative Fishery Research Unit, Cookeville, Tennessee

In 1991, we begin 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 the substantial improvements in water quality. Between 1992 and 1994, we introduced 23 species of mussels: 4,600 adults of 20 species, 6,000 juveniles of two species, and an estimated 15,000 juveniles of one species by infesting 174 host fish and releasing them into the creek. We have found few dead mussels but numerous live mussels in qualitative sampling of the two introduction sites; however, many of the adult mussels have been transported downstream as much as 1,000 m during high flows. Samples of fish are being collected regularly at each site and are being examined for glochidial infestations. An intense survey of the entire Shoal Creek drainage is underway to identify additional reintroduction sites and host fish distributions.

Evaluation of Tag Types and Adhesives for Marking Freshwater Mussels

David P. Lemarié, David R. Smith, Rita F. Villella, and David A. Weller
National Biological Service, Leetown Science Center, Aquatic Ecology Laboratory, Kearneysville, West Virginia

External identification of individual mussels is highly desirable for following passive and active movements, population studies, and labeling for studies of growth, reproduction, genetics, and physiology. Ideally, tags must be easy to apply, inexpensive, and provide excellent long term legibility and retention. In this study we evaluated three varieties of tags (Northwest Marine Technology Visual Implant Tag, Floy Fingerling Tag, and Hallprint Shellfish Tag), two types of adhesives (3M two–part epoxy and Krazy Glue cyanoacrylate), and four bonding times before immersion in water (2, 5, 10, and 15 min). Tags were applied to shells of dead animals. Tag/glue combinations showing good initial legibility after complete curing of the adhesive were further tested under natural conditions in a shallow stream and in a standard gem tumbler containing coarse metal shavings. This poster provides an illustrated summary of the advantages and disadvantages of each of the tag types and adhesives tested. Preliminary results suggest that the best combination is a flexible polyethylene shellfish tag bonded to the shell with cyanoacrylate. Cyanoacrylate can be immersed in water in as little as two minutes after application.

Use of a Diver-Operate Suction Device to Collect Mussels in the Upper Mississippi River

Andrew C. Miller[1], Barry Payne[1], and Larry Neill[2]
[1]U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi
[2]Tennessee Valley Authority, Muscle Shoals, Alabama

Mussels were collected from silt, sand, gravel, cobble, and large rock substratum using a suction device in the upper Mississippi River, 1993-94. Suction was created by pumping high pressure water from a 2.5 cm line into a 7.6 cm line which created suction via a venturi device. Mussels were taken from within a 0.25 m^2 quadrat or between large rocks on wingdams. Mussels larger than approximately 7.6 cm were retrieved by hand. Sediments were pumped into a nested screen series on a 21 ft. boat and live mussels were removed from the screen by hand. Unionid size demography was virtually identical using a suction pump and total substratum removal by hand; percent of total individuals less than 30 mm total shell length was 13.9% and 12.8% in samples collected by suction and total substratum removal,

39

respectively. Comparisons of total density, species richness, and other parameters indicate that quantitative samples collected with suction are similar to those collected with total substratum methods. With appropriate equipment and personnel, suction is an efficient and effective way to collect mussels from a variety of substratum types in large rivers.

Upper Mississippi River Shallow Channel Border Habitat as a Refuge and Nursery for Unionid Mussels

Richard V. Anderson and Jennifer Eichelberger
Western Illinois University, Department of Biological Sciences, Macomb, Illinois

Mussel die-offs, commercial harvest, and zebra mussel colonization have all reduced density in mussel beds of the upper Mississippi River (UMR). However, quantitative sampling in the shallow channel border habitats of UMR Pool 19 has shown that density has not changed over the past 15 years in this habitat. Recent studies have found that the mussel community in this habitat has a higher proportion of young, 1 and 2 year old, mussels than in traditional mussel bed areas. Growth rates in this habitat were as good as or better than those determined from mussels collected in mussel bed areas. The density of zebra mussels which had colonized on native mussels was lower in shallow channel border habitats than in deeper water areas containing native mussel beds. Native mussels have also rapidly inhabited shallow channel border habitat where aquatic macrophytes have been eliminated following the 1993 flood. These characteristics of the mussel community of shallow channel borders may indicate that this habitat serves as a nursery and refuge for native mussels in the UMR.

Responses of Freshwater Mussels from Different Habitats to Declining Dissolved Oxygen

L.Y. Chen[1], A.G. Heath[1], and R.J. Neves[2]
[1]*Virginia Polytechnic Institute and State University, Department of Biology, Blacksburg, Virginia*
[2]*Virginia Polytechnic Institute and State University, Fisheries and Wildlife, Blacksburg, Virginia*

The primary objective of this study is to determine the dissolved oxygen levels below which normal physiological function begins to fail in adult freshwater mussels so that the dissolved oxygen criteria can be derived. For this purpose oxygen consumption and heart rate of several species has been measured under declining dissolved oxygen levels. The effects of temperature, diurnal behaviors and sex were also investigated for some species. The results show that species living in lakes (i.e. *Pyganodon grandis*), pool areas (i.e. *Elliptio complanata*), sand areas (i.e. *Elliptio lanceolata*), and bank margins (i.e. *Elliptio fisheriana*) of the river have better ability to regulate oxygen consumption than those found in the riffles (i.e. *Villosa iris* and *Villosa constricta*). *Villosa iris* is especially sensitive to hypoxia and handling stress. *Pyganodon grandis* is tolerant of handling stress and a good regulator of heart beat under declining dissolved oxygen. The ability to regulate oxygen consumption was improved considerably at lower temperature for *Pyganodon grandis* and *Villosa iris*. Diurnal behavior was found in the lake-living species *Pyganodon grandis* but not found in riverine species in this study. For *Villosa constricta*, the brooding females have higher oxygen consumption and lower ability to regulate oxygen consumption than the males.

Observations on the Life History and Behavior of the Alabama Pearl Shell, *Margaritifera marrianae* R.I. Johnson, 1983

Douglas N. Shelton
Barry A. Vittor & Associates, Inc., Mobile, Alabama

The range of the Alabama Pearl Shell, *Margaritifera marrianae* R.I. Johnson, 1983, is limited to headwater streams in the Conecuh and Alabama River drainages in South–Central Alabama. Within its range, population densities are generally low, although certain streams do show higher abundances, relative to other areas. *Margaritifera marrianae* is a candidate species currently under status review by the U.S. Fish and Wildlife Service. Aspects of the life history and behavior patterns of this species may prove valuable in evaluating its current status. The low frequency of occurrence within a reach of stream indicates the rarity of *M. marrianae* relative to other resident species. Field observations of *M. marrianae* reveal that population density and sex distribution often show unusual patterns. Typically, individuals may be found in male–female pairs at irregular intervals within the stream bed. This phenomenon has not been observed among other Unionacean clams. Earlier workers had considered *M. marrianae* synonymous with its Louisiana analog, *Margaritifera hembeli* (Conrad, 1838), a federally protected species. Behavior patterns of *M. marrianae* vary considerably from those of *M. hembeli*, in that *M. hembeli* is a gregarious species, showing much higher population densities. The unique behavior patterns of *M. marrianae* further reinforce the taxonomic split from *M. hembeli* and may illustrate the need for similar federal protection.

Superconglutinate -- The Movie

Paul Hartfield[1] and Robert S. Butler[2]
[1]U.S. Fish and Wildlife Service, Jackson, Mississippi
[2]U.S. Fish and Wildlife Service, Jacksonville, Florida

Superconglutinates, an extraordinary method of glochidial expulsion/host fish attraction in freshwater mussels, was first observed in 1988 and associated with a specific mussel, *Lampsilis perovalis*, in 1993. During the spring of 1995, field observations were made on timing and duration of the release of superconglutinates in an Alabama population of *L. perovalis*. These observations indicate superconglutinate production, from emergence of the glochidial mass from the excurrent aperture to release of the strand, occurs in eight hours or less. The duration of the process may be related to temperature and/or individual variation. Two mussels, observed in mid-release, produced over 30 cm of mucous strand/hr at 16° C. However, another individual monitored from conglutinate expulsion to release of the strand took approximately eight hours to complete the process, and produced less than 10 cm/hr at 14° C. Three mussels, along with substrate and water from their stream of origin, were placed in an aquarium in an attempt to monitor and photograph the process in more detail. In the aquarium, where water temperature was 22° C, two individuals produced about 1-2 meters of mucous strand and completed the release process in less than 5 hours. All releases observed, both in the field and aquarium, began in the early hours of daylight.

Habitat Characteristics and Mussel Community Parameters Associated with Endangered Species in the St. Croix River, Minnesota and Wisconsin

Daniel J. Hornbach, Tony Deneka, and Patrick Baker
Macalester College, Department of Biology, St. Paul, Minnesota

Due to the rarity of endangered mussels it is often difficult to examine their biology and ecology. We examined the habitat characteristics associated with endangered species and compared these with habitat characteristics for the mussel community in general. Our hypothesis was that endangered mussels are found in high quality mussel habitat rather than in peculiar niches. If this hypothesis is supported, endangered mussels can be managed by improving overall mussel habitat and mussel community measures can be used to signal the status of endangered mussels. We conducted this study in the St. Croix River, a Mississippi River tributary, which contains 38 mussel species including two federally endangered species: *Lampsilis higginsii* and *Quadrula fragosa*. Using SCUBA, 266 - 0.25 m^2 quadrats were examined to characterize the mussel community. The sediment size, water depth and flow were measured. We also conducted searches specifically for *Q. fragosa* and *L. higginsii*. When a specimen was located a 0.25 m^2 quadrat was sampled to examine the habitat and mussel community associated with the mussel. The most dense and rich mussel communities were associated with specific substrate types in conjunction with particular water depth and flow regimes. *Quadrula fragosa* and *L. higginsii* were found in areas of rich and diverse mussel assemblages. Consequently these endangered species did not have peculiar niches, indicating that a community assessment technique may be helpful in endangered mussel management.

Potential for the Kentucky Dam Tailwater of the Tennessee River to Serve as a Mussel Refuge from Invading Zebra Mussels

James B. Sickel and Jeffrey J. Herod
Murray State University, Department of Biological Sciences, Murray, Kentucky

The lower Tennessee River, especially the tailwater reach of Kentucky Dam from river mile 22.4 to the Ohio River, continues to support a diverse unionid mussel fauna. Although no listed endangered species have been reported from there in the last eight years, previous surveys reported *Plethobasus cooperianus, Lampsilis abrupta, Cyprogenia stegaria* and *Obovaria retusa*. Twenty-eight species of unionid mussels still are known to occur in the river. The recent invasion and rapid colonization of the Ohio River by zebra mussels has threatened the unionid mussels of that river including the four endangered species listed above. However, few zebra mussels occur in the Tennessee River. Data from Europe and recent studies by us suggest that the calcium concentration in the Tennessee River may be below that required for successful zebra mussel reproduction and colonization. The zebra mussels that have been found living in the Tennessee River may have fallen from barges traveling from the Ohio River. Current investigations are underway to test this hypothesis. If zebra mussels are not successful in the Tennessee River, endangered or rare mussels from the Ohio River and other rivers colonized by zebra mussels, could be moved into the Tennessee River to provide a refuge until such time as the populations of zebra mussels in those rivers decline. If males and females are place in close proximity,

(41)

a reproducing population might be established. The section from river mile 17.8 to the dam at mile 22.4 is a state mussel sanctuary which prohibits commercial musseling. We have marked an area with iron bars driven into the sediment and monitored the mussels within the area for the past two years. The position can be located with GPS (global positioning system) which, with a differential beacon receiver, provides better than 1m, real-time accuracy. This work indicates that mussels can be planted and recovered successfully in a large river, and the Tennessee River may be an excellent refuge for endangered mussels.

Quantitative Ecological Survey of a Mussel Bed at Ohio River Miles 617.0 to 617.5

Carl M. Way and Douglas N. Shelton
Barry A. Vittor & Ass., Inc., Mobile, Alabama

We conducted a quantitative survey of mussels in a bed located between Ohio River miles 613.5 and 617.5. Thirty-five 0.5 m^2 quadrats were sampled along 10 depth transects by surface-supply divers. Mussel densities in the bed averaged 6.3 individuals/m^2 (SD = 8.5) and ranged from zero to 36 individuals/m^2. Mussels were collected in water depths ranging from 3 - 9 meters. Twelve species of live mussels and 12 species of dead mussels were collected. Forty-six live mussels were collected and the assemblage was dominated by *Obliquaria reflexa* and *Ellipsaria lineolata*, each representing 19.6% of the total number of mussels collected. Three dead specimens of endangered species were collected: *Plethobasus cooperianus*, *Cyprogenia stegaria* and *Epioblasma torulosa*. We observed zebra mussels in every quad sampled that contained hard substrates and 100% of the live mussels collected had zebra mussels attached. Hundreds of shells from recently dead mussels (particularly *Megalonaias nervosa*) and *Corbicula fluminea* were collected that were covered by zebra mussels. It is probable that a major portion of the mussel mortality observed was due to zebra mussel infestation.

Population Dynamics of Zebra Mussels in the Illinois River 1993-95

Scott D. Whitney, K. Douglas Blodgett, and Richard E. Sparks
Illinois Natural History Survey, S.A. Forbes Biological Station, Havana, Illinois

Since 1993, we have quantitatively assessed the demographics of newly established zebra mussel (*Dreissena polymorpha*) populations in the middle and lower Illinois River. This research is designed to provide a better understanding of riverine zebra mussel populations and their impacts on specific riverine species and on the riverine ecosystem. In summary, zebra mussel populations in the Illinois River display two patterns. In the middle reach of the river populations increased gradually from the initial invasion (1989-91) to densities of 3,000 to 7,000 in 1993-94, where they have remained relatively stable. In contrast, populations in the lower river exploded in 1993, reaching densities near 100,000/m^2, and crashed to less than 1,000/m^2 in 1994. The population explosion was attributable to a massive settlement event in 1993, most likely due to one pulse of veliger larvae carried far downriver by the record flood of 1993. The crash was most likely attributable to unfavorable environmental episodes, particularly the low oxygen levels that the zebra mussels may have contributed to because of the respiratory demand exerted both by the live mussels and by the decay of dying mussels. We believe the upriver/downriver differences in mortality, growth, and recruitment have been greatly influenced by overpopulation and environmental conditions of the river. Dramatic fluctuations in flow and water quality factors in the Illinois River are expected to continue to result in a "boom or bust" cycle in the lower river while populations in the middle river remain relatively stable (<10,000/m^2) and continue to serve as source of veligers to resupply the lower river.

Ohio River Mussel Survey

U.S. Army Corps of Engineers, Louisville District

A brail survey was carried out during the summers of 1993 and 1994 to determine the geographical limits and other characteristics of mussel (Mollusca: Unionidae) beds in the lower Ohio River from its mouth at Cairo, Illinois to near Foster, Kentucky. A total of 31 species was found, including two federally listed endangered species, *Potamilus capax* and *Pleurobema clava*, and two federal candidate species, *Quadrula cylindrica* and *Plethobasus cyphyus*. All 48 mussel beds described on the basis of the last comprehensive survey (1982) were investigated; 40 of them were found to still qualify as beds. In 30 of those cases their geographical limits have now contracted, in four they have remained the same, and in six they have expanded.

Distribution and Population Structure of Mussel Beds in the Flambeau River, Wisconsin

Daniel E. Kelner and Terry A. Balding
Eau Claire, Wisconsin

The overall purpose of this study was to determine the distribution and population structure of unionids within beds and define the physical boundaries of the beds within a portion of the Flambeau River, Wisconsin. A systematic sampling design with 0.25 m^2 quadrants was used by a diver in SCUBA which determined the boundary and as a result the total area of the bed. For each mussel bed, species association analyses were conducted using 2 x 2 contingency tables with no significant associations found. Chi-square tests of species distribution revealed the species were distributed evenly throughout all the beds regardless of substrate type or depth. However, the distribution of unionid densities (without respect to species) within the beds and their relation to substrate type was statistically significant for three of the four mussel beds. Among the beds the lowest density occurred in a sand/gravel substrate. Overall, the highest densities occurred in a sand, gravel, or combination of sand/gravel substrate with a boulder composition of 50%. This study establishes baseline data on the community composition within these well defined beds which could be used in future studies to determine any adverse changes within the beds. This is of particular concern because two state endangered species, *Cyclonaias tuberculata* and *Plethobasus cyphyus*, and a species of special concern, *Pleurobema coccineum*, were all found within the beds.

Genetics and Systematics of Freshwater Mussel Species: A Tissue Repository

Tim L. King, Mary E. Smith, Rita F. Villella, Priscilla I. Washington, and David A. Weller
National Biological Service, Leetown Science Center, Aquatic Ecology Laboratory, Kearneysville, West Virginia

Recognizing a need for phylogenetics research, the National Biological Service – Leetown Science Center's Aquatic Ecology Laboratory has established a tissue repository and associated database to coordinate tissue samples collected for genetics and systematics research. The repository provides a centralized location for researchers to obtain properly catalogued and preserved adductor muscle, mantle, foot, gill (including glochidia), and digestive gland tissue samples. All data generated for the repository are maintained in the PARADOX for Windows relational database package. Collection information compiled for each specimen includes date, site name, site description, and habitat characteristics. Database content reports are generated and provided to interested researchers. Currently the database contains 254 individuals representing 46 species inhabiting Atlantic slope and interior basin drainages. All researchers utilizing the repository are required to accommodate a standard numbering scheme to allow comparisons of the same individuals among diverse studies and methodologies. Potentially, the repository would reduce the number of animals sacrificed and sampling time while providing comprehensive data to multiple researchers. A single collection of mussels can provide ecophenotypic, protein, DNA, and immunological information for species and population structure delineation. This poster describes the development of the repository and presents data collection protocols, preservation methods, database structure, and a current report of the database contents.

A Flexible Multi–Stage Design for Sampling Freshwater Mussel Populations Using Double Sampling for Stratification

David R. Smith, Rita F. Villella, David P. Lemarié, and David A. Weller
National Biological Service, Leetown Science Center, Aquatic Ecology Laboratory, Kearneysville, West Virginia

We present a sampling design for estimating mussel density within a watershed. The stages of sampling are stream reaches within a watershed and quadrats or line transects within a stream reach. A distinctive feature is the use of a rapid assessment at each selected stream reach as a basis for further sampling. Implementation of the design is as follows. An initial sample of stream reaches is selected from the target population, and the density of mussels is rapidly assessed at each. The rapid assessment could be a timed search for live mussels, for example. As a result, stream reaches are classified into density strata (e.g., low/high density). For high density strata, all (or most) of the reaches are sampled quantitatively; however, fewer of the low density reaches need to be sampled further. As a result, the time spent sampling where mussels are at low density (or absent) can be minimized. Average estimates within each strata are combined using appropriate weighting to arrive at an estimate of density for the population of interest. An added advantage of the design is that quantitative sampling method within a reach can depend on density strata, thereby increasing the flexibility and efficiency of the design.

(43)

Spatial Distribution Patterns of Freshwater Mussels in Rivers of Open and Forested Riparian Zones

Todd J. Morris and Lynda D. Corkum
University of Windsor, Department of Biological Sciences, Windsor Ontario, Canada

To investigate the roles played by terrestrial inputs and streamside vegetation in shaping unionid distributions, six drainage basins in southwestern Ontario were selected: three basins with grass dominated riparian zones (open sites) and three with densely treed riparian zones (forested sites). Environmental variables related to the riparian classes and relative abundance of mussel species were measured at a total of 24 sites (4 sites per drainage basin). Forested sites had significantly wider riparian zones ($n=144$, $p<0.001$), steeper valley ($n=144$, $p<0.05$) and plain slopes ($n=144$, $p<0.01$) and tended to receive less incident solar radiation. A total of 17 species was found in all six drainage basins. Mean species richness did not differ between the two riparian types ($n=24$, $p>0.05$). Discriminant analysis on the basis of mussel species abundance confirmed a priori riparian zone classification in 100% of the cases. Open sites were characterized by *Pyganodon grandis* and *Strophitus undulatus* whereas forested communities were characterized by *Elliptio dilatata*, *Lampsilis radiata*, *Lampsilis ventricosa* and *Alasmidonta marginata*. It is apparent that some mussel species are associated with particular riparian types and that their distribution can be predicted on the basis of riparian characteristics.

Host Fish Attraction Strategy and Host Fish Identification for *Lampsilis subangulata*

Christine A. O'Brien, Jayne Brim-Box, and Andre Daniels
National Biological Service, Gainesville, Florida

Lampsilis subangulata, the shinyrayed pocketbook, is one of five mussels currently proposed for endangered status from the Apalachicola, Chattahoochee and Flint river basins (ACF). Endemic to the ACF, this species has been described as one of the most beautiful mussels in North America. In June, 1995, the release of a superconglutinate by *L. subangulata* was observed for the first time and recorded on video. A superconglutinate is a "modified external structure" used to lure host fish by mimicking a small minnow in both size and color. The female mussel releases the mimic minnow on a translucent mucus strand. Once detached from the female, the translucent strand becomes snagged around rocks or branches in the stream, and the mimic minnow is suspended in the water column where it awaits a predator (Centrarchidae). When the predator attempts to consume the mimic minnow, thousands of glochidia are released into the mouth and gills of the deceived predator. The *L. subangulata* superconglutinate is similar in appearance to that of *Lampsilis perovalis* as described by Haag et al. (1995, in press). Centrarchids have been observed as hosts for *L. subangulata* in both field and laboratory studies.

Comparison of Quantitative and Qualitative Sampling Methods for Assessing Unionid Mussel Beds in the Neosho River, Kansas

Brian K. Obermeyer[1], Edwin J. Miller[2], David R. Edds[1], and Carl W. Prophet[1]
[1] *Emporia State University, Division of Biological Sciences, Emporia, Kansas*
[2] *Kansas Department of Wildlife and Parks, Independence, Kansas*

We surveyed nine sites in the Neosho River, Kansas, for unionid mussels during summer 1994 to compare quantitative and qualitative sampling methods for evaluating species richness, diversity, size structure, and evidence of recruitment. At each site, snorkel searches were employed in a 10 x 100 m stretch. Captured mussels were placed back into their original position, and then 40 1-m^2 random substrate samples were taken from the same stretch. A total of 856 mussels was caught from 12 h of snorkel searches and 889 from 360 1-m^2 quadrats, with *Quadrula metanevra* the most abundant species from both sampling methods. Species richness was 18 and 20 from qualitative and quantitative searches, respectively, whereas species diversity (Shannon's index, log $base_2$) was 2.6 and 2.4 in timed searches and quadrats, respectively. Both sampling methods revealed little evidence of recent recruitment.

(44)

NOTE: ***This following is not a complete list of all the conference abstracts. Only those abstracts that addressed freshwater mussels are included here***

Unitas Malacologica

Twelfth International Malacological Congress

Vigo, Spain, 3rd-8th September 1995

Abstracts

edited by

Angel Guerra, Emilio Rolán and Francisco Rocha

Published on behalf of Unitas Malacologica by the Instituto de Investigaciones Marinas (CSIC, Vigo), Spain. August 1995.

Printed by FEITO, S.L.
Hernán Cortés, 13-15 (Int.), 36203 Vigo, Spain.

Deposito Legal: Vg. -556 -95
ISBN: 84/606/2602/4

CONSERVATION OF NORTH AMERICA'S FRESHWATER MUSSEL FAUNA (UNIONIDAE) AND THE THREAT POSED BY THE EXOTIC ZEBRA MUSSEL (*Dreissena polymorpha*)

Richard J. Neves

National Biological Service, Department of Fisheries and Wildlife Sciences, Virginia Tech, Blacksburg, Virginia 24061-0231, USA.

The Unionid fauna of North America included 297 species and subspecies, distributed primarily in the Mississippi River Basin and Gulf Coast drainages of the southeastern United States. Roughly 213 taxa are considered to be endangered, threatened, or the special concern on the continent, and less than 25% of the taxa are considered stable at this time. The zebra mussel (*Dressenia polymorpha*) likely entered the Great Lakes in 1986, and first appeared in Lake St. Clair in 1988. Since its introduction, this species has spread rapidly and practically eliminated the native unionids from Lake St. Clair portion of take Lake, the Detroit River, and other localized water bodies in the region. Zebra mussels passed from Lake Michigran to the Illinois River in 1991, and now infest the Ohio, Mississippi, Missouri, Tennessee, Cumberland, Tombigbee, Hudson, and numerous other mainstem rivers in the eastern and central United States. Populations fluctuate widely in density, achieving maximum densities of more than 50,000/m^2 in the Illinois River in 1993, but declining to less than 10,000/m^2 in 1994.

To protect native unionids at greatest risk to the zebra mussel invasion, the feasibility of using ponds as refugia for riverine species is being tested in Virginia. Mussels collected from the Tennessee and Cumberland rivers were cleane and quarantined for 1 month, and distributed to ponds for long-term monitoring. Fifteen species of unionids are being held in plastic-screen cages with flotation collars, and in various racks and pocket nets to monitor survival. After one year, mean survival was 72% with significant differences among species. *Elliptio* spp. exhibited the highest survival rate (85%), whereas *Ellipsaria lineolata* and *Lampsilis ovata* had the lowest survival (14-15%). Unionids maintained at the lower end of a trout hatchery experienced high mortality, presumably due to low dissolved oxygen or elevated ammonia levels from the decomposition of pelleted feed. Because many populations of federally protected unionids will eventually be colonized by zebra mussels, a geographic network of refugia is being considered to prevent a spasm of extinctions in the United States unequaled in modern times.

REPRODUCTIVE ECOLOGY OF FRESHWATER MUSSELS (BIVALVIA: UNIONOIDA): SHELL VOLUME AND WEIGHT

William H. Heard and M. Bowie Kotrla

Department of Biological Science Florida State University Tallahassee, Florida 32306-2043, U.S.A.

Freshwater mussels brood embryos and subsequent larvae in all four (tetrageny) or only the outer two (ectobranchy) or only the inner two demibranchs (endobranchy) for about one month (tachytixis) or 8-12 months (bradytixis) before, in most species, the mature larvae (glochidia, lasidia, or haustoria) are discharged to undertake a two- to fourweek parasitic existence on the gills or fins of fishes or a few other aquatic vertebrates. Smaller individuals (i.e., younger or environmentally stunted animals, or different species) have smaller gonads that produce fewer gametes than do larger individuals. Moreover, smaller females house smaller broods in smaller marsupial demibranchs than do larger females.

Marsupial demibranchs undergo at least a five-fold increase in width upon becoming gravid, which observation suggests that females require and thus display a greater shell width (directly measured with calipers) or convexity (estimated by the volume of water contained between the two valves) than do males of the same size (shell length or height), especially in tetragenous species. In addition, if, as is claimed by developmental biologists, more energy is required to produce eggs than to produce spermatozoa, one might expect that the shells of females weigh less than do shells of conspecific males of the same size (length, height, or width).

However, none of the animals from the 31 populations of 15 tetragenous, ectobranchous, tachytictic, and bradytictic species showed a statistically significant sexually dimorphic difference in shell width or convexity, even in Unionidae: Lampsilinae with sexually dimorphic shape. And, only the tetragenous, tachytictic *"Fusconaia" succissa* had a statistically significant sexual difference in shell weight.

Studies on production, biomass, and energetics of unionoids should also compare conspecific males and females, especially in conjunction with the gametogenic/vitellogenic cycles because males and females do not always undergo the corresponding phase simultaneously.

NOTE: Statistical tests used include: stepwise discriminant function analyses and stepwise multiple regressions

TESTING HYPOTHESES OF DISPERSAL AND GENE FLOW IN EUROPEAN UNIONIDAE

Karl-Otto Nagel

Gebirgstraße 23 D, 79426 Buggingen, Germany.

Recent works have helped to clarify the general systematics of European Unionoidea by a multidisciplinary approach integrating anatomical and morphological studies with population genetics (Nagel *et al.*, in press).

While basic questions about the nature and number of species were settled at least for Western and Central Europe, the inter- and infraspecific relationships still offer some problems. For instance, the status of the two species *Unio pictorum* (L. 1758) and *U. mancus* (Lamarck 1819) (= *elongatulus* (C. Pfeiffer 1825)) as well as of the South European members of the genus *Anodonta* Lamarck 1799 is not yet clear. Furthermore, the extent to which species are differentiated on a subspecific level is under debate for most of the European unionids. I will address these problems by looking at the levels of

genetic differentiation among groups of populations using gene flow statistics (Porter, 1990; Weir, 1990). On a local scale, I will also use this method to evaluate possible genetic effects of man-made habitat fragmentation.

Besides the identification of taxonomic units their geographic distribution is a problem in itself. There are different opinions about the relative roles of geological and biological events or human activities that would explain the actual distribution of unionids. It seems, however, that hydrogeographic situations and landscape development in the past are the most important determinants (Ehrmann, 1950; Modell, 1951, 1964). Genetic distances between populations now can be used to evaluate different hypotheses of common history and dispersal pathways (Arter, 1990). For this purpose I will confront the patterns of genetic distances to physical distances derived from geographic connectivity matrices. These matrices will for instance depict various periods in the development of river systems in Western and Central Europe. In this case the degree of matrix correspondence will be used to test the explanatory power of the underlying paleohydrologic assumptions for the present distribution of unionid taxa.

Literature cited

Arter, H.E. 1990. Spatial relationship and gene flow paths between populations of the alpine snail *Arianta arbustorum* (Pulmonata: Helicidae). *Evolution* 44: 966-980.

Modell, H. 1951. Die Najaden Vorderasiens. *Rev. Fac. Sci. Univ. Istanbul, Ser. B*, 16: 351-366.

Modell, H. 1964. Das natürliche System der Najaden. 3. *Arch. Molluskenk*, 93: 71-126.

Nagel, K.-O., Badino, G. & Celebrano, G. Systematics of European naiades: a review and some new aspects. *Malacol. Rev.*, in press.

Porter, A.H. 1990. Testing nominal species boundaries using gene flow statistics: the taxonomy of two hybridizing admiral butterflies *(Limenitis:* Nymphalidae). *Syst. Zool.* 39: 131-147.

Thienemann, A. 1950. Verbreitungsgeschichte der Süßwassertierwelt Europas. *Die Binnengewässer* XVIII. Stuttgart, E. Schweizerbart'sche Verlagsbuchhandlung, xvi + 809 pags., 11 pls.

Weir, B.S. 1990. Intraspecific differentiation. Chapter 10: 373-410. In Hillis, D. & Moritz, C. (eds.): *Molecular Systematics*. Sunderland MA, Sinauer.

MODERN DISTRIBUTION OF FRESHWATER PEARL MUSSEL *Margaritifera margaritifera* L. IN THE RUSSIA

Victor V. Beletsky, Ekaterina G. Popkovich, Valery V. Ziuganov and Alexey A. Zotin

Institute of Developmental Biology, Vavilov Street 26, Moscow 117808, Russia.

The freshwater pearl mussel *Margaritifera margaritifera* L. has been entered in the IUCN Invertebrate Red Data Book as a vanishing species. Its number reduced by over 90% during the XX century. Therefore the investigations of modern distribution and number of *M. margaritifera* are of great importance. We found 8 populations of *M. margaritifera* in north-west of Russia. Four of them consist of more than 1 million specimens. The largest population inhabit Varzuga River, Kola peninsula consisting of more than 100 million individuals. The numbers of specimens in other populations are: 1, about 6 million (Keret River, Karelia), 2, about 4 mln (Umba River, Kola peninsula), 3, about 1 mln (Gridina River, Karelia), 4, more then 4,000 (Torma Creek, Kola peninsula), 5, about 3,000 (Olanga River, Karelia), 6, about 1,500 (Nuris River, Karelia), 7, about 300 (Vodopad Creek, Karelia). The age structure of large populations has been studied. The reasons of extinction and conservation measures are discussed.

THE PUMPING ACTIVITY OF UNIONID MUSSELS FROM THE RIVER THAMES

A.D. Berrie and Barbara J. Boize

Department of Zoology, University of Reading, Whiteknights, Reading, RG6 2AJ, U.K. and Freshwater Biological Association, River Laboratory, East Stoke, Wareham, BH20 6BB. U.K.*

Anodonta anatina and *Unio pictorum* were attached to perspex stands and kept in aquaria with water circulated from the river. Water entering the inhalant siphon of individual mussels was measured at intervals throughout the day with a flow meter. Maximum rates were not sustained for long and mean rates were calculated from the data.
Mean pumping rates ranged from 0.1 l hr^{-1} in small mussels to 1.0 l hr^{-1} in large mussels. Pumping rates were directly related to shell length and to ctenidial area.
Mussels rarely pumped water when the water temperature was below 10°C. This means that there was little pumping for 5 to 6 months of the year .
These results will be combined with data on the population densities and age structures of the mussels in the river to calculate the potential intake of food that could be achieved from the volumes of water filtered.

PHENETIC APPROACH TO THE STUDY OF THE INTRASPECIFIC ORGANISATION OF *Unio pictorum* (BIVALVIA, UNIONIDAE)

Sergey D. Scherbak

Institute of Hydrobiology, 254210, Kiev, Ukraine.

The intraspecific organisation of mollusks of Unionidae family, the group dominating in the benthic communities has been studied incompletely, while such a studing aspect has become especially actual within the population conception as an unite of exploitation and protection.

The present work was done with the purpose of searching the discret feature system, allowing to establish the horogenetic structure of some species of the family The wide spread mass species *Unio pictorum* Linneus, 1758 was chosen as a model. The material was collected at the depth of 0.3-1.5 m, on the sandy and sandy silt covered bottom in the lower reaches of the Desna river in summer, 1987. 143 specimens were treated. The value was determined and the full correlative analysis of the main exterior indexs was held. Values distribution of the exterior indexs submits to the normal distribution law. There is no discretancy, the low value of dispersion confirms indirectly the ecological homogeneity of the location.
On the basis of number of shell morphological structures forming on the early stages of the ontogeny, the author points out the three groups of features concidered as phenes: 1) "step" between the impresses of the front adductor and retractor of the right and left shell folds, 2) display symmetry of the first featur on the both fold, 3) morph in trees of the front pseudo-cardinal teeth of left and right folds. The left fold S-1 the tooth is rectangular. The surface is fine-serrated, straight, protuberant sometimes. S-2 is of the wrong shape, the the surface is undulating, the serration isn't pronounced or market feebly. S-3 is the teeth not corresponding to the description of S-1 and S-2. The right fold. D-1 is plastic, rounded triangle, the surface is fine-serrated. D-2 has the trapeziform shape, dividedby the depression into 2 (not obligatorilly equal) parts. D-3 is the teeth not

corresponding to the description of D-1 and D-2. *U. pictorum* local population of the lower reaches of the Desna river following phenocomplex characterise: S-1 -63%; S-2 -8%; S-3 -29% ; D-1 -7%; D-2 -16%; D-3 -77%; "step", 6%; symmetry of "step"-92%.
No discrepancy in distribution of the values of exterior indexs doesn't allow to mark out, the intraspecific classification of any rank on ther base. The studied phenocomplex defines the specific intraspecific classification of *U. pictorum*. The additional research of the marked phenes are necessary to make a conclusion the hereditary character.

Based on 118 bibliographical sources (after critical revision of their content) and taking into account a lot of unpublished information, the distribution of each species in Greece was mapped and ecological remarks added whenever necessary. The most studied zones are the infralittoral and circalittoral, while few published information exists on the mediolittoral and bathyal zones. From data collected up to December 1994, it was seen that the total number of species known today amounts to 301 in comparison to 190 (known at the end of 1900) and 275 (known in 1990).
Regarding the distribution of bivalvia in geographical unities, it was found that the Aegean presents the greatest variety (273 species) in relation to the Ionian (196 species), Sea of Kythira (83) and Libyan Sea (50). However, the variety encountered at each area, can be attributed to the plethora of the bibliographical sources referring to the area, rather than to differentiation between areas.
Conclusively, when considering the ecological preferences and the bathymetric range of the species occurrence in combination with the fact that the number of species constantly increases with new studies in either unexplored bathymetric zones or overlooked geographical areas, it is believed that the eastern Mediterranean is as rich as the western Mediterranean.

SYMBIOSIS OF FRESHWATER PEARL MUSSELS AND ATLANTIC SALMON

Valery V. Ziuganov and Alexey A. Zotin

Institute of Developmental Biology, Vavilov Street 26, Moscow 117808, Russia.

The symbiotic interrelations of freshwater pearl mussel *Margaritifera margaritifera* L. with Atlantic salmon *Salmo salar* L. are reported. Pearl mussel larvae (glochidia) develop in the gills of salmon and adult mussels effectively filter river water as well as improve bottom of the river. This creates optimal conditions for the reproduction of salmons. In this case it seems to be a matter of a principally new form of symbiosis with time-dissociated, mutually beneficial influence of the two species. Indeed, if the parasitising glochidia are taken as a starting point, it is only the fish that at this time can be said to be of use to glochidia that find the optimal osmotic mediums in their tissues, feed and disperse at its expense. Only several years later the grown up young mussel will pay their dept by filtering water and ensuring better survival of young salmons. Thus pearl mussels and salmonid fishes together form a new ecological system, in which each of the species finds optimal conditions for its existence.

DISTRIBUTIONAL DATA OF THE UNIONIDS IN BELGIUM (MOLLUSCA, BIVALVIA, UNIONIDAE)

E. Nijs and J. L. Van Goethem

Royal Belgian Institute of Natural Sciences, Malacology section, Vautierstraat 29, B-1040 Brussels, Belgium.

Six species of Unionidae belonging to three genera are currently fond in Belgium. The shells are more or less elongate, with a high variability in some species; adult shells always exceed 4 cm. in length. Diagnostic features are shape, umbonal sculpture, hinge characters and pattern of muscle scars. Unionids are dioecious and ovoviviparous; the number of eggs may be in the region of 500,000. The calcareously shelled glochidium larvae are first being brooded in the gills, which act as brood-pouches; later on, they are released as temporary parasites of fishes. The species inhabit slow rivers, canal, lowland lakes, reservoirs and ponds. For each species, a distribution map based on the UTM-grid with 10x10 km. squares is provided. Records pre-1950 and records 1950 onwards are marked by different symbols. At present 792 records of Unionidae pre-1950 and 294 records 1950 onwards are available. A dramatic decline of Unionid species in Belgium is not necessarily the first hypothesis. It rather seems that freshwater bivalve collecting in Belgium was more intensive and widespread before 1950. It is suggested to take advantage of the potential offered by large freshwater bivalves and develops their use for nature conservation issues, especially in the field of site protection.

THE SPECIES PROBLEM WITHIN MARGARITIFERIDAE FAMILY IN THE FAR EAST

Alexey A. Zotin and Valery V. Ziuganov

Institute of Developmental Biology, Vavilov Street 26, Moscow 117808, Russia.

Within the family Margaritiferidae (Henderson) (freshwater pearl mussels) the species problems exist only for genus *Margaritifera* (Schumacher). Previously there was described 3 species of this genus from Sakhalin Island and Kuril Islands (Russia) (Zatravkin & Bogatov, 1987): *Margaritifera laevis* (Haas), *M. kurilensis* (Zatravkin & Starobogatov), *M. shigini* (Zatravkin & Bogatov). These species are recognised by shell dimensions: height to length ratio and convexity to length ratio. Our investigations indicate that these ratios are highly variable and can hardly serve as discriminating characters. Values of size ratios in populations described as different species overlap. Hence there are no reasons to recognise different freshwater pearl mussel populations from Sakhalin Island and Kuril Islands as different species. It is very likely that the rivers in this region are inhabited by only one species, *Margaritifera laevis* (Haas).

Zatravkin M.N. & Bogatov V.V, 1987. *Large bivalve freshwater and brackish water molluscs of the Far East of the USSR*. Vladivostok, Izd. AN SSSR, 154 pags.