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ABSTRACTS
of
PRESENTATIONS

(1) MUSSEL SURVEYS AS AN ADAPTIVE MANAGEMENT TOOL PERFORMED BY THE COMMERCIAL DREDGING INDUSTRY IN THE PITTSBURGH AREA. **Jerry Diamond**, Ph.D., Tetra Tech, Inc., 10045 Red Run Blvd., Suite 110, Owings Mills, MD 21117. 410 356-8993. Jerry.Diamond@tetratech.com.

Sand and gravel have been commercially dredged from the Allegheny and Ohio Rivers in Pennsylvania for over 100 years. With the decline in many native mussel species following impoundments and poor water quality in the mid-1900s, resource agencies were concerned about potential effects of dredging on remaining native mussel fauna and other aquatic life. The Pennsylvania Department of Environmental Protection (PaDEP) addressed this concern by requiring mussel surveys prior to dredging so that viable mussel populations would be avoided and thereby protected. As part of a current Environmental Impact Statement regarding commercial dredging, several refinements have been made in the mussel sampling protocol including the use of qualitative dive transects and not brailing, increased number of transects per 0.1 mile of river proposed for dredging, and refinements in the criteria defining sensitive or viable mussel populations needing protection. Data collected from over 70 dives using a refined sampling protocol suggest that most areas requested for dredging have sparse mussel populations (< 0.001 mussels per sq. meter). However, these surveys also show that some species previously considered rare (e.g., *Leptodea fragilis*) may be widely distributed and that the federally listed species, *Epioblasma torulosa rangiana*, is now present in the study area. The sampling protocol is a living document which, in the EIS, is used as an adaptive management tool to mitigate potential adverse effects of dredging on native mussels.

(2) TVA TAILWATER IMPROVEMENTS LEAD TO RECOVERY OF FISH AND AQUATIC MACROINVERTEBRATES COMMUNITIES. **Charles L. Bach**, Tennessee Valley Authority, P.O. Box 1649, Norris, TN, 37828, clbach@tva.gov. **Charles F. Saylor**, Tennessee Valley Authority, Norris, TN 37828, cfsaylor@tva.gov

TVA has improved dissolved oxygen levels and flows in its tailwaters. During a 5-year period starting in 1991, TVA installed aeration systems at 15 of its dams and implemented minimum flows. Since 1996, TVA has continued to improve these aeration systems to increase availability and performance. These improvements are relieving intermittent drying of riverbed in 180 miles of tailwater and increasing the levels of dissolved oxygen in over 300 miles of tailwater. Annual biological monitoring has accompanied these improvements to measure the response of tailwater fish and macroinvertebrate communities. Results indicate that biological communities have responded positively. This has encouraged government agencies and conservation organizations to begin recovery efforts for several species of mollusks and fish in two of the tailwaters.

(3) CONSERVATION OF ENDANGERED FRESHWATER MUSSEL POPULATIONS: RIVER MANAGEMENT, PARTNERSHIP WORKING AND CONFLICT RESOLUTION**.**
Dr Peter Cosgrove and **Dr Lee Hastie**, Cairngorms Biodiversity Officer, The Cairngorms Partnership, 14 The Square, Grantown on Spey, Morayshire PH26 3HG, Scotland, UK

Appropriate river management is crucial to the survival of endangered freshwater mussel populations. In theory, heightened awareness, legal protection, maintenance of water quality, control over river engineering works and reliable information on the distribution of local mussel populations means that their conservation should be relatively straightforward. However, in practice, the presence of freshwater mussels is just one of many factors that riparian stakeholders have to consider when managing a river. Using the example of the freshwater pearl mussel *Margaritifera margaritifera* in Scotland, we discuss the theoretical and practical considerations needed to appraise river engineering developments on mussel populations. In the context of a 'mussel river', the potential impact or risk associated with any proposed development will principally be determined by three components: (1) the physical nature and scale of the engineering

activity, (2) the distribution and abundance of the mussel population in relation to the physical disturbance, and (3) the ecological requirements of the mussels themselves at a given locality. In this presentation we show how, through partnership working, the integration of ecological and socio-economic factors can help reduce potentially acrimonious conflicts and ensure that river management activities complement and enhance, rather than oppose, the conservation of endangered mussel populations.

(4) DEVELOPMENT OF A NAVIGATION MAINTENANCE PLANNING PROCESS TO MINIMIZE IMPACTS TO UNIONID COMMUNITIES IN THE WHITE RIVER, ARKANSAS. **John L. Harris**, Department of Biology, Arkansas State University, Post Office Box 599, State University, Arkansas 72467. 501 569-2522. jlhd170@ahtd.state.ar.us. **Patricia L. Jones**, Environmental and Economic Analysis Branch, Memphis District, U.S. Army Corps of Engineers, 167 N. Main Street B202, Memphis, Tennessee 38103. 901 544-0705. Patricia.L.Jones@mvm02.usace.army.mil. **Joseph J. Krystofik**, U.S. Fish and Wildlife Service, Arkansas Ecological Services Field Office, White River Basin Suboffice, 26320 Highway 33, Augusta, Arkansas 72006. 870 347-1506. joe_krystofik@fws.gov. **William R. Posey, II**, Fisheries Division, Arkansas Game and Fish Commission, 915 E. Sevier Street, Benton, Arkansas 72015. 501 7760-218. brposey@agfc.state.ar.us. **Alan D. Christian**, Department of Zoology, Pearson Hall Room 190, Miami University, Oxford, Ohio 45056. 513 529-3193. christad@muohio.edu.

Approximately 395 km of the White River (Arkansas) navigation channel are annually maintained by means of snagging and dredging operations. From the 1970's through the 1990's, conflict often arose between conservationists and the Corps of Engineers regarding impacts from navigation channel maintenance to unionid communities. The White River was surveyed for unionid communities from 1991-1995. In 2000, procedures for White River navigation maintenance dredging and conservation of unionids were implemented. A key component is submittal of dredging plans for review that include existing bottom contours with overlays of proposed dredge plans, estimates of material removed, boundaries of known mussel communities, and locations of disposal sites. In addition, the Corps of Engineers has provided mussel identification training and a field manual specific to the White River to field personnel involved with navigation maintenance. If unionids are encountered at dredge sites, dredging operations cease immediately until a determination is made regarding significance. A protocol has been developed regarding agency personnel to be notified, sequence of notification, time frame for resolution, and provision of sufficient additional data to resolve the issue.

(5) ESTIMATING POPULATION PARAMETERS OF NATIVE FRESHWATER MUSSELS USING CAPTURE-RECAPTURE METHODS. **R. F. Villella**, **D. R. Smith**, **P. I. Young**, and **D. L. Lemarié**. Aquatic Ecology Lab, Leetown Science Center, 1700 Leetown Road, Kearneysville, WV 25430. 304 724-4472. rita_villella@usgs.gov.

To determine the dynamics of a population it is desirable to have estimates of abundance or population size. Knowledge of the variables that affect population size, rates of reproduction, mortality, immigration, and emigration are also necessary. Capture-recapture methods can be used to estimate these variables. Our objective was to determine survival rates, recruitment and dispersal of freshwater mussels in a mid-sized river. A long-term study site on the Cacapon River in West Virginia was established in 1996. This 240 meter long reach was divided into 12 20-meter bands, or strata. The bands represent specific habitat types, including upstream pool, run, head of riffle, main body of the riffle, and downstream pool. Each band was sampled for mussels using timed search, snorkeling and bucketing in areas too shallow to snorkel. Individuals of each species found within each band were tagged, with the number of animals tagged in each band depending on availability of animals at the stream bed surface. A tag with a unique code was applied to both valves to account for potential tag loss. Each animal was identified to species, and measured for length, width, and depth to examine variation among shell morphology and age distribution among bands. Surveys were conducted yearly with tags applied to previously untagged animals and recording animals recaptured during each sampling occasion. Site specific analyses of five years of tagging data will focus on estimating within and between year survival (_). Intersite, or among band, analyses will focus on movement of mussels within the site. Preliminary results indicate survival rates were high and probability of recapture varied depending on time of year. The average recapture rate was 16% for the summer sampling periods, with lower rates experienced during winter and spring sampling.

(6) INCORPORATING PROTECTION OF FRESHWATER MUSSELS INTO EARLY PROJECT PLANNING: THE ILLINOIS CONSULTATION PROCESS. **Robert E. Szafoni,** Illinois Department of Natural Resources, 1660 W. Polk, Charleston, IL 61920. rszafoni@dnrmail.state.il.us. **MaryJo Woodruff,** IDNR, Resource Review and Coordination, 524 S. Second St., Springfield, IL 62701. mwoodruff@dnrmail.state.il.us.

Currently, 27 of 62 (44%) extant species of mussels in Illinois are listed as threatened or endangered by the Illinois Endangered Species Protection Board. Additionally, mussel beds harboring 10 or more species are recognized by the Illinois Natural Areas Inventory as Unusual Concentrations of Flora or Fauna of Statewide Significance. The Illinois Endangered Species Protection Act and the Illinois Natural Areas Preservation Act require consultation with the Illinois Department of Natural Resources before environmentally-altering actions are funded, performed, or authorized/permitted by state agencies and local units of government. Both acts require government bodies to consider possible adverse impacts to state-listed endangered and threatened species and to Illinois Natural Area Inventory sites on the basis of best available information prior to acting, so that they may use their powers and authorities to protect these rare resources. Occurrences of these resources in a project area trigger further coordination under the consultation process, adding a level of protection to Illinois' listed mussels and diverse mussel communities. The goal of the department's consultation process is to provide information and expertise to state agencies and local units of government in meeting their responsibilities under these laws. While consultation is mandatory, it is not considered a regulatory program. The strengths and weaknesses of this process will be presented with case histories.

(7) EVALUATING FRESHWATER MUSSEL CONSERVATION BY STRUCTURING MANAGEMENT AS AN EXPERIMENT: OPPORTUNITIES TO LEARN BY DOING. **D. R. Smith**, **R. F. Villella**, **D. P. Lemarié**. USGS – Biological Resources Division, 1700 Leetown Road, Kearneysville, WV 25430. david_r_smith@usgs.gov.

In 1998 a study began on the Allegheny River and French Creek to evaluate the effectiveness of relocating mussels to save them from adverse affects of construction. The study included the elements of a classical experiment: replication, randomization, and control. However, it was implemented as part of a management program – an activity that would have been carried out even in the absence of the experiment. This study is an example of how including elements of experimental design into management activities can advance common goals of promoting effective and efficient conservation of freshwater mussels.

(8) THE NORTH CAROLINA DEPARTMENT OF TRANSPORTATION: PLAYING A ROLE IN THE CONSERVATION OF FRESHWATER MUSSEL SPECIES? **Tim Savidge**. North Carolina Department of Transportation Project Development & Environmental Analysis Branch, 1548 Mail Service Center Raleigh, NC 27699-1548. 919 733-3141. tsavidge@dot.state.nc.us.

Although its primary function is to construct public roadways, the North Carolina Department of Transportation (NCDOT) has played an active role in the conservation of freshwater mussels throughout the state in recent years. This role is continuing to expand as urban development across the state increases and aquatic resources become further imperiled. The Department’s involvement with mussel issues includes 1). Providing survey/distribution data for mussel fauna, including the recent discovery of a spiny mussel in the Roanoke River Basin. 2). Funding of life history research on specific species, 3). Development and implementation of design and construction measures to avoid impacts to mussels, 4). Conducting research on the long-term impacts of roadways on mussel populations and 5). Provide funding for watershed level conservation targeting mussel populations. Through cooperation with the various state and federal agencies responsible for protecting mussel resources, the NCDOT has made a commitment to help conserve one of the state’s most imperiled resources. Transportation departments in other states should also be encouraged to take a proactive approach to natural resource conservation.

(9) A COMPARISON OF THE TRAITS OF ENDANGERED AND EXOTIC SPHAERIIDAE TO THOSE OF OTHER FRESHWATER BIVALVE FAMILIES IN NORTH AMERICA. **G. L. Mackie**. University of Guelph, Guelph,Ontario, Canada NlG 2WI. glmackie@uoquelph.ca.

Unlike the Unionidae that are represented by a plethora of species at risk (~70%) and no exotic species, the sphaeriids are represented by both exotic (4 species, or 10.8%) and endemic (33, or89.2%) species in North America. Of the endemic sphaeriids, only one, *Pisidium ultramontanum*, can be considered to be at some potential level of risk largely because of its small area of occupancy (western U.S.A.). Three other species (*Sphaerium patella*, *Sphaerium fabale*, *Pisidium cruciatum*) have small areas of occurrences; the remaining species are common and generally distributed. Life history traits (including number of broods per generation (i.e. semelparity vs itaroparity), number of broods per year (i.e. voltinism), life span, brood size and larval size), maximum size, numbers and kinds of dispersal agents and ecological and physiological tolerances and requirements of the dispersal stage(s) are examined in relation to the degree of endemicity (e.g. rare and confined to specific regions of North America; common and generally distributed throughout North America; generally distributed throughout Eurasia and North America; world-wide distribution) of representative species of Sphaeriidae. These traits (and others) are also examined in the Unionidae and Margaritiferidae, both endemic to North America, and the Eurasian Dreissenidae and Corbiculidae that have been introduced to North America and compared to those of the Sphaeriidae. In general, it seems that bivalve species that are large, have long life spans, low fecundity and/or natality, are iteroparous, have low dispersal potential and narrow ecological and physiological tolerances and requirements are more likely to become at risk than are species with opposite traits that often emulate exotic, "weed" species. The corollary of this is species at risk have inherited traits that make the bivalves more sensitive to anthropogenic factors than those with traits of exotic species.

(10) VOYAGE OF DISCOVERY: MAXIMIZING OUR EFFORTS.
Daniel R. Brooks, Centre for Comparative Biology & Biodiversity, University of Toronto.

The only illustration ever to appear in any edition of *Origin of Species* was a phylogenetic tree. Ironically, the true import of this has only been recognized within the past decade, when an explosion of comparative phylogenetic studies contributed to virtually every areas of biological research, basic and applied. As our appreciation for the importance of phylogenetic information has expanded, our human desire to find the truth has sometimes overtaken our rational understanding that scientists never find the truth, but only the best answer given available data. This has led to a somewhat complicated debate in which arguments about the best methods of phylogenetic inference and about the best type of data for phylogenetic inference have become entanglked and confused. I will claim that on theoretical and empirical grounds, there is no reason to prefer one form of data a priori over another; for example, the same logic of character analysis applies to anatomy, behavior and nucleotide sequence data. I will also argue that the only reason to use an a priori model to infer a phylogenetic tree from a given set of data is if we know that the model will give us the true tree. And how will we ever know that, since such analyses eliminate the data used to infer the tree from being used to test the model which is used to infer the tree? In 1872, Darwin wrote "…it has been found that a classification based on any single character, however important that may be, has always failed; for no part of the organisation is invariably constant." It is time for systematic biology to heed his words, and embark on the laborious, yet rewarding journey of discovery made possible by phylogenetic systematic analysis of multiple sources of data.

(11) FEEDING IN FRESHWATER MUSSELS: LABORATORY STUDIES RELATED TO GILL STRUCTURE IN UNIONIDS. **Harold Silverman**, **Thomas H. Dietz**, and **John W. Lynn**. Department of Biological Sciences. Louisiana State University, Baton Rouge, LA 70803, cssilv@lsu.edu

In laboratory studies, the clearance rate of bacteria from pond water is higher in *Dreissena polymorpha* and *Corbicula fluminea* than any unionid specis we have studied. Further, clearance rate by riverine unionids and by *Margaritifera hembeli* is higher than that found in unionid specis collected from pond environments. These differences correlate with differences in structure of gill latero-frontal cirri. Mussels having cirri composed of large numbers of fused cilia (40 pairs) appear better able to filter small particles than those having a lesser number of fused cilia. It may be important to consider such differences when planning mussel transplantation projects.

(12) EVALUATION OF THE CURRENT STATUS OF FRESHWATER MUSSELS AT SELECTED SITES IN THE GRAND RIVER, MICHIGAN. **R.R. Goforth** and **P. J. Badra**. Michigan Natural Features Inventory, Michigan State University Extension, Mason Bldg., P.O. Box 30444, Lansing, MI 48909-7944. 517 335-4850, goforthr@pilot.msu.edu.

Updated unionid status and distribution surveys are essential for identifying conservation needs. Past surveys of the Grand River (MI) main stem reported a rich freshwater mussel fauna, including at least 28 species. Extensive historical mussel surveys by van der Schalie provide a valuable reference for evaluating the current status of native mussel populations in this system. We surveyed transects using SCUBA at selected historic survey sites to evaluate mussel community population trends over a 55-year period. *Truncilla truncata* and *Epioblasma triquetra* were observed during the 1999 surveys but were not reported from the 1945 surveys. The relative abundance of *Actinonaias ligamentina* was strikingly lower during the 1999 surveys, and while *Elliptio dilatata* was observed at most sites during the 1945 surveys, no *E. dilatata* were observed in 1999. *Pleurobema sintoxia* and *Alasmidonta marginata* also declined in relative abundance compared to the 1945 surveys. Most other species appeared to be largely stable between the historical and current surveys. *Lampsilis ventricosa* and *Amblema plicata* were more abundant during the 1999 surveys, while *Quadrula pustulosa*, *Fusconaia flava* and *Quadrula quadrula* comprised relatively large portions of the mussel communities at multiple sites during both surveys. Rarer species occurred in low but comparable numbers between the surveys, including *Cyclonaias tuberculata*, *Ligumia recta*, *Lasmigona costata* and *Strophitus undulatus.* No zebra mussels (*Dreissena polymorpha*) were observed during the surveys, although a few Asiatic clams (*Corbicula fluminea*) were observed at three of the survey sites. The native mussel communities surveyed appear to be largely stable, although significant declines in the abundance of several species is cause for concern and indicates a need for status assessments of these species throughout their ranges in Michigan.

(13) A COMPARATIVE ANALYSIS OF THE UNIONID FAUNA OF THE CAHABA AND SIPSEY RIVERS, ALABAMA: BIODIVERSITY & ECONOMICS. **Wallace Holznagel**, The University of Alabama, Biodiversity & Systematics, Department of Biological Sciences, Box 870345, Tuscaloosa, Alabama, **Samuel N. Addy**, The University of Alabama, Center for Business and Economic Research, Box 870221, Tuscaloosa, Alabama 35487 and **Charles Lydeard**. The University of Alabama, Biodiversity & Systematics, Department of Biological Sciences, Box 870345, Tuscaloosa, Alabama

The Cahaba and Sipsey Rivers are two of the few remaining larger rivers that are not impacted by a series of locks and dams in the state of Alabama. Each river has a cumulative total of over 40 unionid species based on historical records plus results from recent surveys. Presently, the Sipsey River has 35 species, while the Cahaba River has only 23. Here we explore the differences in biological diversity of unionids in the two rivers and discuss factors attributing to the decline of the unionid malacofauna in the Cahaba versus the Sipsey River. We also examine the association of economics and biodiversity protection and compare current efforts to protect the fauna and habitat.

(14) CURRENT STATUS OF FRESHWATER MUSSELS IN THE MUSCLE SHOALS AREA OF THE TENNESSEE RIVER IN ALABAMA (MUSCLE SHOALS REVISITED AGAIN). **Stuart W. McGregor**, Geological Survey of Alabama, P. O. Box 869999, Tusclaoosa, AL, 35486. 205 553-0671. smcgregor@gsa.state.al.us. **Jeffrey T. Garner**, Alabama Division of Wildlife and Freshwater Fisheries, P. O. Box 366, Decatur, AL, 35602. 256 767-7673. bleufer@aol.com.

One of the most diverse freshwater mussel faunas ever known was in the middle reaches of the Tennessee River in northern Alabama. In the vicinity of the Muscle Shoals the Tennessee River leaves the region of the Interior Low Plateaus and enters the East Gulf Coastal Plain. There, the centers of distribution of two major molluscan faunal groups, the Cumberlandian and Ohioan, overlap. In addition to being located within the overlap area of these two faunal groups, species diversity also benefitted from extensive shoal habitat, well-sustained flow rates provided by numerous tributaries, and the availability of many species of host fishes. A total of 79 species of mussels, adjusted to currently understood taxonomy, were known from this region, but impoundment and other anthropogenic factors have modified the physical habitat and caused a severe decline in species diversity. From 1995-1999 various studies performed by the Alabama Division of Wildlife and Freshwater Fisheries and Geological Survey have documented 39 mussel species in the Tennessee River from Muscle Shoals area upstream to the Guntersville area. This includes four federally endangered species including one, *Plethobasus cicatricosus*, that was feared to be extinct.

(15) MUSSELS OF THE ALABAMA RIVER, PAST AND PRESENT. **Paul Hartfield**, U.S. Fish and Wildlife Service, Jackson, MS, (601) 321-1125, paul_hartfield@fws.gov. **Jeff Garner**, Alabama Department of Conservation and Natural Resources, **Jim Williams**, U.S. Geological Survey, and **Royal D. Suttkus**, Tulane Museum of Natural History.

The Alabama River historically supported about 45 species of unionid mussels, 13 of which were first described from that river. During this century, the River has been extensively modified to improve navigation by the construction of locks and dams, dredging and deepening of shoal areas, cutoff of some bendways, and construction of channel training devices. Three dams collectively impound about 250 miles of the rivers 305 mile length. Mussel collections archived at the Tulane Museum of Natural History taken from the lower Alabama River (1964-1974) prior to, during, and shortly after construction of Millers Ferry and Claiborne Locks and Dams, contained 25 species, suggesting significant changes in the fauna had occurred prior to impoundment. Since 1991, we have examined over 190 sites in the main channel between Alabama River Mile (ARM) 0 and ARM 260 using SCUBA or surface supplied air. Only 22 unionid mussel species have been encountered during these surveys, including the endangered heavy pigtoe *(Pleurobema taitianum)* and Alabama clubshell *(Pleurobema decisum)*, and the threatened inflated heelsplitter (*Potamilus inflatus*). Our surveys indicate the extirpation of about one half of the historic mussel fauna, including nine of those species that were originally described from the River. The majority of extirpations have occurred within the subfamily Lampsilinae. These faunal losses are believed to be due to the deepening of crossover and other shoal and shallow water habitats by navigation dredging during the first half of the 20th century, compounded by impoundment in the latter half. The Alabama River, however, continues to support an important mussel resource. Today, mussel beds in the Alabama River are found at depths of 3-15 meters, and are associated with the thalweg, the deepest portion of the channel, even in reaches where there are no navigation maintenance activities.

(16) PRELIMINARY SURVEY OF THE FRESHWATER MUSSELS (BIVALVIA:UNIONIDAE) OF THE BIG SOUTH FORK CUMBERLAND RIVER WITHIN THE NATIONAL RIVER AND RECREATION AREA OF TENNESSEE AND KENTUCKY. **S. A. Ahlstedt**, U. S. Geological Survey, 1820 Mid-park Drive, Suite A, Knoxville, TN 37921. ahlstedt@usgs.gov **S. Bakaletz**, National Park Service, Big South Fork National River Recreation Area, 4564 Leatherwood Ford Road, Oneida, TN 37841. steve_bakaletz@nps.gov and **M. T. Fagg,** Tennessee Wildlife Resources Agency, 6032 West Andrew Johnson Highway, Talbott, TN. mfagg@mail.state.tn.us

The Big South Fork Cumberland River is formed in the north-central portion of the Cumberland Plateau in Tennessee by the New and Clear Fork rivers, and by North White Oak Creek. The river system drains an area of 876,000 acres before emptying into Lake Cumberland at Burnside, Pulaski County, Kentucky. The river flows through a deep, narrow gorge that is inaccessible and sparsely populated. Historically, the drainage suffered extensively from coal mining, forestry and agricultural practices, domestic runoff, and oil and gas exploration. Little information is available concerning the freshwater mussel fauna of the Big South Fork because only a few sites in the lower river (Kentucky) were sampled before impoundment. The mussel fauna in the upper reaches of Tennessee was largely unknown because access to the river prevented adequate surveys and past pollution problems were thought to have been severe enough that all mussels were extirpated. The Big South Fork had access to the rich mussel fauna of the Cumberland River before impoundment and it's possible that the river could have contained as many as 70 species. During the mid-1980s, 22 mussel species were reported live in the Big South Fork and some of its larger tributaries. Preliminary surveys in summer 2000 have documented 25 mussel species including five federally listed species (*Alasmidonta atropurpurea*, *Epioblasma brevidens*, *E. walkeri*, *Pegias fabula*, and *Villosa perpurpurea*) and three (Alasmidonta viridis, Elliptio crassidens, and *Leptodea fragilis*) that were thought extirpated. The identification of *E. walkeri* is tentative until tissue samples can be DNA sequenced and compared with other populations of *E. walkeri* and closely related *E. capsaeformis.* The Big South Fork contains some of the best mussel populations that remain in the Cumberland River system and appears to be recovering based on the number of smaller individuals present.

(17) CONSERVATION ASSESSMENT OF THE FRESHWATER MUSSEL FAUNA OF THE EASTERN GULF:4 0 OF MEXICO DRAINAGES IN ALABAMA, FLORIDA, AND GEORGIA. **Jim Williams**, **Holly Blalock-Herod**, and **Jayne Brim Box**. USGS Florida Caribbean Science Center, 7920 NW 71st Street, Gainesville, FL 32653. jim_williams@usgs.gov.

There are six major drainages (Escambia, Yellow, Choctawhatchee, Apalachicola, Ochlockonee, and Suwannee) in the eastern Gulf of Mexico region. Historically, these drainages harbored a diverse mussel fauna consisting of 58 taxa, one species of Margaritiferidae and 57 species of Unionidae. Of the 58 taxa, 30 species (52%) are endemic to the area, five are endemic primarily to the eastern Gulf and adjacent drainages and 23 occur in the eastern Gulf but are also widely distributed outside of this area. Of the 58 taxa, four species (*Alasmidonta wrightiana*, *Elliptio nigella*, *Fusconaia apalachicola*, and *Lampsilis binominata*) are extinct with an additional three species (*Lampsilis haddletoni*, *Medionidus simpsonianus*, and *M. walkeri*) considered endangered or possibly extinct. Two species (*Elliptio fraterna* and *Medionidus acutissimus*) endemic to the eastern Gulf and adjacent drainages, along with two of the more widely distributed species (*Arcidens confragosus* and *Lasmigona subviridis*), have been extirpated. Thirty-four species (59%) are considered endangered (17), threatened (8), or of special concern (9). There are currently eight species (*Amblema neislerii*, *Elliptio chipolaensis*, *Elliptoideus sloatianus*, *Lampsilis subangulata*, *Medionidus acutissimus*, *M. penicillatus*, *M. simpsonianus*, and *Pleurobema pyriforme*) in the eastern Gulf drainages that are recognized as federally endangered or threatened representing 14% of the entire mussel fauna in this area. Fourteen (24%) of the 58 species in the area are considered to have currently stable populations. Threats and recommendations for conservation of the mussel fauna will be presented.

(18) EFFECTS OF TEMPERATURE ON LONGEVITY AND VIABILITY OF GLOCHIDIA OF FRESHWATER MUSSELS (BIVALVIA: UNIONIDAE). **Lora L. Zimmerman** and **Richard J. Neves**. Virginia Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0321. (540) 231-5703. lzimmerm@vt.edu.

Glochidia from gravid females of *Villosa iris* (Lea, 1829) and *Actinonaias pectorosa* (Conrad, 1834) were extracted from marsupia and tested for viability over several days. Glochidia that were flushed from the gill and those retained in the excised gill marsupium were tested at three holding temperatures; 0, 10, and 25 degrees C. Viability was tested by exposing glochidia to a sodium chloride solution, and then confirmed by infesting known host fish with glochidia at 1 wk and 2 wk post-extraction from the female mussel. Results indicate that extracted glochidia remained viable for significantly longer than intra-marsupial glochidia. There was no significant difference in viability of glochidia between 0 and 10 degrees C in extracted treatments ($p>0.05$). Extracted glochidia of V. iris maintained >75% viability for 180, 192, and 46 h at 0, 10, and 25 degrees C, respectively. Similarly, glochidia extracted from *A. pectorosa* maintained >75% viability for 345, 310, and 108 h at 0, 10, and 25 degrees C, respectively. Long-term viability of glochidia at cool temperatures would promote dispersal of progeny and has practical applications in captive propagation.

(19) DIET EVALUATION FOR CAPTIVE ADULT *ELLIPTIO COMPLANATA* (BIVALVIA: UNIONIDAE). **William F. Henley** and **Richard J. Neves**. Virginia Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife Sciences, Virginia Tech, Blacksburg, Virginia 24060. (540) 231-8865 email: whenely@vt.edu.

Adult *Elliptio complanata* (56-106 mm) collected from the Nottoway River, Virginia were held in 350 L closed recirculating systems and fed different algal diets for 8 months to compare differences in physiological condition. Mantle tissue from 2 algal diets, a no-feed treatment (NF), and reference samples from the Nottoway River (NR) were analyzed: one diet consisted of *Scenedesmus* sp. (S), and the other was a mixture of *Neochloris* and *Bracteacoccus* spp (NB). The percentages of total protein in mantle tissue from mussels held in these treatments were significantly different ($p<0.001$). The protein percentages from the S and NB diets generally declined over the duration of the experiment, while they declined and then stabilized within the NF treatment. Protein from the NR reference samples increased during the summer, sharply fell in the fall and winter, and increased in the spring. This pattern is likely to be related to

gametogenesis of *E. complanata* as a short-term brooder. The percentages of moisture from mussels of all treatments and the NR reference were not significantly different (p<060). Pending statistical analyses of, it appears that the energy reserves of mussels in the S and NB were depleted compared to those of the NR reference.

(20) GROWTH AND SURVIVAL OF JUVENILE *LAMPSILIS FASCIOLA* IN SIX SUBSTRATUM TYPES. **Monte A. McGregor**1, Virginia Department of Game & Inland Fisheries, 11132 Thomas Jefferson Road, Forest, VA 24551, 804-525-7522, mmcgregor@dgif.state.va.us, **M.J. Pinder**, 22206 S. Main Street, Suite C, Blacksburg, VA 24060, 540-552-6992, mpinder@dgif.state.va.us, and **J.J. Ferraro,** Rt. 3 Box 391, Marion, VA 24354, 540-783-4172, jferraro@dgif.state.va.us.

Freshwater mussels are often associated with a particular substratum type, such as sand or gravel. However, there is limited information available on the influence of substratum type on growth and survival of mussels, especially juveniles. We began a study in the spring (May 2000) to examine growth and survival of 480 age-2 wavyrayed lampmussels, *Lampsilis fasciola*, in six substratum types. The study was conducted at the Buller Fish Cultural Station in the South Fork Holston watershed, Virginia. The substratum types included river mix (collected from a dense mussel bed in the North Fork Holston River), artificial river mix (collected from a rock quarry), limestone sand, sandstone sand, silt, and no substratum (i.e., control). We tagged 480 individuals and randomly distributed 20 mussels among 24 (6 substratum types x 4 replicates) containers (~20 x 38 cm) in 3 hatchery raceways. Mean total length of juvenile mussels was significantly higher (17 versus 11 mm, $P < 0.0001$) at the end of the study (November 2000), indicating an average growth of 6 mm. Growth was significantly ($P < 0.0006$) lower in silt and in the control compared to the other four substratum types. We recovered 466 mussels (97%) and found empty valves of eight individuals (< 2% mortality). Seven of the eight mussels that had died were recovered from silt or the control. We speculate that growth was inhibited in the control and silt containers due to the inability of mussels to position siphons for optimum filtration. Processing speed (time needed to locate mussels) was significantly longer (6.4 minutes) in the artificial river mix compared to all other substratum types (1.6 to 3.5 minutes).

(21) PROPAGATION AND RECOVERY OF FRESHWATER MUSSELS AT THE UPPER TENNESSEE RIVER IN VIRGINIA. **Michael J. Pinder,** Virginia Department of Game and Inland Fisheries, 2206 South Main Street, Suite C, Blacksburg, Virginia, 24060, (540) 552-6992. mpinder@dgif.state.va.us , **M.A. McGregor**, 1132 Thomas Jefferson Road, Forest, Virginia 24551, (804) 525-7522,_ mmcgregor@dgif.state.va.us, and and **J.J. Ferraro**, Rt. 3, Box 391, Marion, Virginia 24354, (540) 783-4172, jferraro@dgif.state.va.us.

Since the spring of 1998, the Buller Fish Cultural Station on the South Fork Holston River has been used to develop techniques to recover freshwater mussel species from the Upper Tennessee River, Virginia. Mussels held at the facility are monitored for growth, gravidity, and survival. Growth has been documented for all mussel species, especially young individuals. Of the 24 species held at the facility, 14 have successfully spawned in hatchery raceways. Mortality has been low (<20% for 3 years) for most species. The slabside pearlymussel (*Lexingtonia dolabelloides*) has experienced high mortality rates (~87%). We attributed mortality to handling, unsuitable conditions, or both. We conducted studies in the summer of 2000 to determine suitable host fish for the pink heelsplitter, *Potamilus alatus.* We found that the white sucker (*Catostomus commersoni*) and northern hogsucker (*Hypentelium nigricans*) are not suitable host fishes. In addition, we were able to retrieve 180 juveniles of the pink heelsplitter using the only known host fish, the freshwater drum (*Aplodinotus grunniens*). We were able to obtain mature glochidia from released conglutinates of Tennessee clubshell (*Pleurobema oviforme*) without handling the adult. We used these glochidia to infest whitetail shiners (*Cyprinella galactura*) from which we retrieved 350 juveniles. To improve conditions for mussel growth and survival, a 0.25-acre pond was established to increase water temperature and supplement food. We plan to apply techniques developed with common species to recover threatened and endangered mussels.

(22) THE MISSISSIPPI RIVER UNIONOID SURVEY OF 1907. **David H. Stansbery**, The Ohio State University Museum of Biological Diversity, 1315 Kinnear Rd., Columbus, OH 43212. 614 263-2133 stansbery.1@osu.edu

There have been several unionoid surveys of the upper Mississippi River since the development, near the end of the last century, of commercial uses of North American river shell. These studies provided a database for at least some understanding of which species were present and in what numbers at linear sites along the river over the last hundred years of human modification. One of the earliest efforts was that of the United States Bureau of Fisheries conducted by Dr. Paul Bartsch during July and August of 1907. The voucher specimens of this survey were, for the most part, deposited in the Smithsonian Institution's United States National Museum of Natural History. The length of the Mississippi sampled extended from just below St. Paul downstream to the mouth of the Ohio at Cairo. Several Mississippi tributaries as well as the lowermost Ohio and Tennessee Rivers were included in the survey. Material was obtained from both commercial shellers and the personal collecting of Dr. Bartsch and his crew. The value of the unionoid fauna of the Mississippi River revealed by this survey was instrumental in the construction of the Bureau of Fisheries Laboratory at Fairport, Iowa, to study this natural resource. Perhaps incidentally, it also provided a database for the evaluation of this fauna on into the future.

(23) A COMPARATIVE STUDY OF MISSISSIPPI RIVER UNIONOID SURVEYS, ST. PAUL, MN, TO CAIRO, IL. **Marian E. Havlik**, Malacological Consultants, 1603 Mississippi Street, La Crosse, WI 54601-4969. 608 782-7958. havlikme@aol.com

Prior to agency unionoid studies started in the 1970's, most Upper Mississippi River (UMR) researchers were aware of surveys by Utterback, Grier, and Ellis. Almost unknown was a survey done in 1907 by Dr. Paul Bartsch, from Mississippi River Mile 838.5-0.0. In 1907, unionoids were found at 88 of 140 sites. These locations have been converted to Mississippi River Miles. Bartsch recorded 15 negative mainstem sites upstream of the Missouri River, and 17 negative sites downstream. Overall, four species were found more frequently than *Fusconaia ebena*, although the latter was the most abundant species. Three common species, and several rare species, were not found/not retained. Even in 1907 5-10 species appeared to be extralimital, but the areas with the highest diversity continue today: Pools 10 (36 species), Pool 3 and 13 (35 species), Pool 8 and 9 (34 species), and Pool 14 and 15 (33 species). No more than 2 species were retained at 28 sites. *Lampsilis higginsi* were retained from 39 sites, *Potamilus capax* at 13 sites, *Cumberlandia monodonta* at 8 sites, but *Leptodea leptodon* was retained from only a single site. Havlik and Sauer (2000) reported 51 unionoid species from the UMR. Forty-four of these species have been recorded since 1968, with 38 species being reported alive since 1991. All of the rare species in the UMR today were rare in 1907, but all of those rare species still survive in tributaries. I compared early Mississippi River unionoid distributions, rank, and frequency of occurrence, with present day UMR records by Pool. The 1907 survey retained 39 unionoid species, and the Ellis survey reported 39 unionoid species. Over the past century, the total fauna has remained stable, but some species have become more abundant, while others have become rare, or locally extirpated.

(24) RESULTS OF A PARTIAL SURVEY OF FRESHWATER GASTROPODS IN A PORTION OF THE UPPER COOSA RIVER BASIN IN GEORGIA. **Paul D. Johnson** and **R. Ryan Evans**. Southeast Aquatic Research Institute, 5835 Red Clay Road, Cohutta, Georgia 30710, pdj@sari.org, and revans@sari.org.

We report the preliminary results of a distribution survey of freshwater gastropods in the upper Coosa River basin. Gastropod diversity was surveyed at over 300 localities in the Conasauga, Coosawattee, Oostanaula, and Chattooga and Big Cedar Creek basins in northwest Georgia and northeast Alabama resulting in the location of 30 extant species including *Leptoxis downiei* (= *L. foremani*), a species previously considered extinct. The Conasauga River basin, with 23 gastropod species, contains the greatest species richness, followed by the Oostanaula, Chattooga, and Coosawatee drainage systems. Species richness was greatest in the Pleuroceridae, followed by Physidae, Ancylidae, Hydrobiidae, Planorbidae, and Viviparidae respectively. The high number of endemic species within the Pleuroceridae was greatest with 7 endemic species and 7 recognized subspecies occurring within the basin. Although, species comparisons of contemporary and historic records for members of the Pleuroceridae indicate no species loss in the upper Coosa Basin, several species are in danger of extinction.

(25) RESULTS OF A PARTIAL SURVEY OF FRESHWATER BIVALVES (UNIONIDAE) IN THE UPPER COOSA RIVER BASIN IN GEORGIA. **R. Ryan Evan**s and **Paul D. Johnson**, Southeast Aquatic Research Institute, 5835 Red Clay Road, Cohutta, Georgia 30710, revans@sari.org and pdj@sari.org.

We report preliminary results of detailed distribution study of survey of freshwater mussels in the upper Coosa River basin. The upper Coosa Basin, especially the Conasauga and Chattooga river basins had an historically rich fauna with 37 and 38 species respectively. Our survey efforts have focused extensively on the Conasauga River drainage basin (over 200 sites) with additional examination of another 100 sites in the Oostanaula, Coosawattee, and Chattooga river basins, and Big Cedar Creek drainage basin. The survey located 28 species of live freshwater mussels in the basin. Survey efforts have failed to locate any evidence of *Epioblasma* spp., but did find 3 rare *Pleurobema* spp. that were previously considered extinct (*P. chattanoogaense*, *P. hanleyianum*, and *P. troschelianum*). Genetic studies of the *Pleurobema* spp. are currently ongoing. Our survey results indicate that the largest unionid extirpation event in the upper Coosa River basin occurred in the Chattooga River, where only 5 species have been located to date. Size frequency distribution and locality information indicate that several species in the basin are in imminent danger of extinction. Additional, preliminary information from the Conasauga River suggests land use applications in the basin have negatively impacted mussel populations by creating sections of the river with toxic sediments.

(26) FRESHWATER MUSSELS OF THE UPPER OHIO RIVER. **Heidi L. Dunn**, Ecological Specialists, Inc., 114 Algana Ct., St. Peters, MO 63376. Ecologists@aol.com

Post 1975 unionid studies between Pittsburgh (ORM 0) and Meldahl Locks and Dam (ORM 436) were compiled to determine the status of unionids in the upper Ohio River. A total of 117 unionid studies were compiled into a database and summarized by unionid bed and river pool. Unionids were found upstream to New Cumberland Pool (ORM 32) and unionid beds were found as far upstream as Willow Island Pool (ORM 128.5). Recruitment was only apparent in a few upstream areas and density was low ($<5/m^2$). Density was low to moderate ($<10/m^2$) between Belleville and Meldahl Pools (ORM 162-436), but species richness increased and recruitment was apparent. The present fauna is a mix of historical species and species recently colonized from tributaries and/or downstream pools. Evidence of 54 species was found, 35 appear to be part of the historical fauna and 19 appear to have recently established residence in the upper river. Of the 35 historical species, 10 appear to be extirpated and nine do not appear to be reproducing. Many of the remaining historical species populations currently consist of both older (perhaps relics) and young individuals (recent recruitment), suggesting that some of the historical fauna is reinvading the upper river. Recruitment for several of the colonizing species was generally quite high (i.e., *Potamilus alatus*, *Leptodea fragilis*, *Truncilla truncata*, *Truncilla donaciformis*). Without zebra mussel infestation, unionid communities would undoubtedly continue the trend of expanding distribution and increasing abundance, although species composition in the future would differ from the historic fauna. Since many areas that were apparently void of unionids 10 years ago now contain federally endangered species, any development in the study reach should consider unionids. A plan should be formulated to maintain diversity and protect suitable habitat. Genetic differences between historic and recent fauna should be considered in this plan.

(27) SPERMATOZEUGMATA OF THE FRESHWATER MUSSEL *ELLIPTIO COMPLANATA*. **W. A. Lellis** U.S. Geological Survey, Northern Appalachian Research Laboratory, RD 4, Box 63, Wellsboro, PA 16901. 570 724-3322. lelliswm@usgs.gov

Spermatozeugmata of the freshwater mussel *Elliptio complanata* were photographed and described. Mussels were collected from Pine Creek, Tioga County, Pennsylvania and held in aquaria with temperature and photoperiod adjusted to natural conditions. Males released sperm in late May and early July 2000 (16-17_C) during the peak of female glochidia release. Male spawning was only observed in the morning hours prior to 9:00 am. Sperm were loosely associated with fluid-filled spheres (globes), on which they were able to shift position and jump on/off. At spawning, globes measured 40-60 µm and all surface area was occupied with sperm. Within one hour after release, the globes expanded to approximately 80 µm, increasing surface area and allowing sperm to gather on one side and directionally propel the globe with flagella. Sperm seemed strongly attracted to light and moved the globes in that direction. Sperm remained active for at least 12 hours following release (23_C), at which time the globes measured approximately 100 µm with a third of the surface covered with sperm. Observations suggest that an active *Elliptio complanata* spermatozeugmata continuously propelled towards light could travel many miles downstream in a riverine system to fertilize a female.

(28) SEASONAL ECOSYSTEM PROCESSING AND NUTRIENT RECYCLING OF FRESHWATER MUSSELS IN HEADWATER STREAMS. **Alan D. Christian**, Miami University, Pearson Hall, Oxford, OH 45056, (513) 524-3036, christad@muohio.edu, **David J. Berg**, Miami University, 1601 Peck Boulevard, Hamilton, OH 45011, (513) 529-3174, bergdj@muohio.edu, and **Betty Crump**, Ouachita National Forest, 912 Smokey Bear Lane, Glenwood AR 71943.

The purpose of this study was to determine the significance of nutrient processing by freshwater mussels in headwater streams. Two headwater streams, Little Darby Creek, OH and the Ouachita River, AR, were investigated. Nutrient-diffusing clay pots were placed in the streams seasonally to determine nutrient limitation. Nutrient analysis of carbon, nitrogen and phosphorus was conducted on FPOM, mussel tissues and mussel shells. Freshwater mussel excretion experiments were conducted seasonally to determine soluble and bio-depositional nutrient production. Spatial and temporal variation in nutrient limitation were observed within and among sites. Differences in excretion rates and ratios within and among four species, *Elliptio dilatata*, *Ptychobranchus fasciolaris*, *Actinonaias ligamentina*, and *Lasmigona costata*, were observed within and among sites. Larger individuals excreted more nutrients per unit time but at a lower mass specific rate. These results indicate that freshwater mussels are important ecosystem processors and individual species vary in rates and ratios of nutrient production.

(29) THE FUNCTIONAL ROLE OF MUSSELS IN STREAMS: EFFECTS OF BIOMASS AND SPECIES. **Caryn C. Vaughn**, **Keith B. Gido**, and **Daniel E. Spooner**. Oklahoma Biological Survey and Department of Zoology, University of Oklahoma, Norman, OK 73019. 405 325-4034. Cvaughn@ou.edu

Do unionid species perform similar functional roles in streams? We begin addressing this question by comparing rates of ecosystem processes for two common mussel species, *Actinonaias ligamentina* and *Amblema plicata*, from the Kiamichi River, Oklahoma. Using a regression approach, the two species were stocked in recirculating, laboratory streams at eight densities under low and high productivity conditions. Community respiration, ammonia and nitrate concentrations, and algal clearance rates, were all linearly related to overall unionid biomass, but not significantly influenced by species. Phosphate concentrations were linearly related to biomass under low productivity conditions, but confounded by algal dynamics under high productivity. Measurement of individual excretion rates indicated different N:P ratios for the two species, but no significant differences in overall ammonia or phosphorus excretion. Biodeposition increased with increasing algal concentrations, but was only slightly different between species. We found that unionid functional effects in streams are linearly related to biomass, indicating the potential for strong effects when unionid biomass is high and hydrologic residence times are long. Subtle differences in some species roles occur at small spatial scales; how these differences will play out at larger scales in unknown.

(30) INTERACTIONS BETWEEN FRESHWATER MUSSELS AND PARASITIC MITES IN OPINTLOCCO CREEK, ALABAMA. **Michael M. Gangloff** and **Jack W. Feminella**. Department of Biological Sciences, Auburn University, Alabama, 36849.

Freshwater mussels (Bivalvia: Unionidae) have long been known to harbor high densities of larval and adult mites (Acari: Unionicolidae) within their gill tissues or shell cavity. Although the benefits of this symbiosis to mites are obvious, the consequence to mussels in terms of reduced growth or reproduction is unclear. Surveys of the mussel *Pyganodon cataracta* in Opintlocco Creek, Lee Co. Alabama, revealed high densities of mites (up to 324 mites per mussel, in February 2000), with 100% of mussels surveyed containing mites. We assessed the relationship between mite abundance and mussel size (N = 23), and the number of gill chambers within female mussels containing glochidia, a measure of reproductive success. We observed a significant negative relationships between the number of mites per g of female mussel tissue and 1) the number of gill chambers with glochidia (r^2 = - 0.348, p = 0.003), 2) mussel tissue weight (r^2 = - 0.429, p = 0.001, and 3) shell length (r^2 = - 0.354, p = 0.003. These data suggest that parasitism by mites may influence mussel reproductive success and life history. Further, they clarify the nature of this symbiosis and suggest that parasites may affect mussel population dynamics.

(31) AGE AND GROWTH OF *VENUSTACONCHA* (BIVALVIA: UNIONIDAE) INFERRED FROM SHELL ANNULI: EFFECTS OF THE 1993 FLOOD. **Christopher Barnhart** and **Frank A. Riusech**. Biology Department, Southwest Missouri State University, 901 S. National, Springfield, MO 65804. 417-836-5166. chrisbarnhart@smsu.edu

The shells of freshwater mussels preserve a record of growth throughout the lifespan of the individual. However, few studies have attempted to validate the annual nature of growth lines in freshwater bivalves. We investigated age and growth of the ellipse (*Venustaconcha ellipsiformis*) and Pleas' mussel (*Venustachoncha pleasii*) at 7 sites in the Ozarks region of southern Missouri. Length at age was determined from measurements of external shell annuli. Inferred age and growth were compared among sexes, species, sites, and calendar years. Growth rates increased with age from 0-4 years, then declined precipitously, presumably coincident with sexual maturity. Ellipse were consistently larger than Pleas' mussels at similar age. Males were consistently larger than females at similar age. Average peak growth rates were 7.9 and 9.5 mm/y for female and male Pleas' mussel, and 9.7 and 9.4 mm/y for male and female ellipse, respectively. Comparison of growth rates by calendar year showed that growth rates were significantly depressed in 4 of the 7 populations during 1993. This depression of growth coincided with unusually heavy precipitation and high flows in these streams. The appearance of 1993 as a "signature year" supports the annual nature of external growth lines in this species.

(32) MUSSEL RESOURCE OF THE LITTLE SOUTH FORK CUMBERLAND RIVER: REQUIEM OR RECOVERY**?** **Melvin L. Warren, Jr**., **Wendell R. Haag**, **Donovan B. Henry**, and **Brooks M. Burr**. Center for Bottomland Hardwoods Research, USDA Forest Service, 1000 Front Street, Oxford, MS 38655. (662) 234-2744 x34. fswarren@olemiss.edu.

We surveyed freshwater mussels at 29 sites along 47 km (546 0.5-m^{-2} quadrats) of the Little South Fork Cumberland River, Kentucky, in 1997-98. Our objectives were to document the current status of the resource and compare our results with previous surveys. In 1981, the river supported a diverse and abundant mussel fauna (25 species, 1.9-7.2 individuals m^{-2}). By 1987, the fauna had all but disappeared in the lower half of the river (0.0 to 1.1 individuals m^{-2}) ostensibly due to strip-mining impacts, but the upper river continued to support dense communities (3.0 to 5.5 individuals m^{-2}). By 1997-98, the mussel fauna had declined dramatically throughout the entire Little South Fork. We found a sparse and depauperate mussel community remaining in the river composed of 9 species with densities ranging from 0.88 individuals m^{-2} in the upstream segment to 0.20 individuals m^{-2} in the downstream segment. Relict shell collections closely resembled the historical fauna (22 of 26 species) and indicated most species once occurred commonly throughout the entire river. No recovery was detected at any historically impacted reach of the river, and recruitment has been low to non-existent for a decade or more. Three species (*Villosa taeniata*, *Pytchobranchus subtentum*, and *Lampsilis fasciola*) comprised most living individuals (85%). Two other species (*Medionidus conradicus* and *Villosa iris*) comprised 13% of living individuals. Four species were rare, being represented by only one or two living individuals each (*Pleurobema oviforme*, *Actinonaias pectorosa*, *Ptychobranchus fasciolaris*, and *Potamilus alatus*). In sum, 64% of the mussel species known from the river likely are extirpated, including the federally listed *Pegias fabula* and *Villosa trabilis*. Our results indicate that impacts in addition to strip-mining have decimated the once rich mussel fauna of the entire Little South Fork in less than two decades.

(33) RECENT RESEARCH ON FRESHWATER MOLLUSKS IN BRITISH COLUMBIA, CANADA. **Jacqueline S. Lee**, Westwater Research, 1175 Chapman St., Victoria, BC, Canada. 250-382-3824. jacquie_lee@telus.net.

British Columbia (BC) is a large and diverse geographic area in which the freshwater mollusk fauna is not well characterized. In 1997 and 1998, I undertook a study in northern BC in which 49 species of freshwater mollusks where collected from 150 sites in the area between 54ºN and 60ºN latitude. I compared species distribution with biogeoclimatic zone, geographic barriers, and hypothesized post-glacial dispersion routes. Range plots were used to assess species occurrence in relation to water conditions of temperature, dissolved oxygen, conductivity and pH. Concurrently, I assessed the status of three potentially endangered freshwater gastropods recorded from BC, and examined the effects of forest practices on freshwater mollusks in a northern BC watershed. The outcome of the assessment was very

different for each species, showing that the concept of risk has many bases. *Physella wrighti* is now considered endangered, the western population of *Acroloxus coloradensis* is considered to be not at risk, and *Physella hordacea* is considered data deficient due to taxonomic uncertainty. Forest practices appeared to have a favourable impact on local freshwater mollusks in the watershed examined in that landscape alterations, such as stream culverting and roadside excavation, had created additional habitat. Much remains to be studied about the freshwater mollusks of BC and this work will provide a basis on which further research can be undertaken.

(34) CONSERVATION STATUS OF THE ALTAMAHA SPINYMUSSEL (*ELLIPTIO SPINOSA* LEA, 1836).**Christopher E. Skelton**[1] and **Eugene P. Keferl**[2]. [1]Georgia Natural Heritage Program, 2117 US Hwy. 278, SE, Social Circle, GA 30025. (770)-918-6411. chris_skelton@mail.dnr.state.ga.us. [2]Coastal Georgia Community College, Brunswick, GA.

Since 1993, 432 surveys for unionid mollusks have been conducted at 305 sites in the Altamaha River and its major tributaries. As a result of this work, nearly 16,000 live animals and 3,300 shells were observed. One of the goals of the surveys was to determine the distribution and relative abundance of the Altamaha spinymussel (*Elliptio spinosa*). This species is one of seven Altamaha River endemics and is recognized as a species of management concern by the U.S. Fish and Wildlife Service. Evidence gleaned from these surveys indicates that this species is declining and may be extirpated from the Ohoopee River. Reasons for its decline may include destabilization of river substrates, over-collecting, and extended drought conditions in Georgia.

(35) STATUS AND ECOLOGY OF THE ENDANGERED NORTHERN CLUBSHELL (*PLEUROBEMA CLAVA*) IN MICHIGAN. **P.J. Badra** and **R.R. Goforth**. Michigan Natural Features Inventory, Michigan State University Extension, Mason Bldg., P.O. Box 30444, Lansing, MI 48909-7944, (517) 241-4179, badrap@state.mi.us.

Pleurobema clava (the northern clubshell) was once widely distributed in the Midwest. It now exists in isolated populations scattered throughout its historic range. Conservation of this species relies on updated status assessments and a better understanding of its ecology. This project updates the current range and status of *P. clava* in Michigan and describes aquatic communities and habitat associated with *P. clava* populations. *Pleurobema clava* densities among study sites ranged from 0.2 ±0.1 individuals/ m^2 to 2.9±0.7 individuals/m^2. Individuals ranged from age two to 50+ years based on external annuli and age-length analysis of internal annuli. All three fish hosts identified for *P. clava* were found in low densities throughout the survey area. Eighteen mussel species co-occurred with *P. clava*, including two strongly associated species that may serve as indicators for suitable *P. clava* habitat**.** Biological integrity indices based on benthic and fish communities were calculated and physical and chemical measurements of habitat components were taken at sites with and without *P. clava.* These measures were used to describe associated community characteristics and suitable habitat parameters for *P. clava* and should aid in the identification of potential habitat and translocation/reintroduction sites outside of the current range. The exotic Asian clam (*Corbicula fluminea*) was found at one site within the study area, although no *Dreissena polymorpha* were present. Results of the study suggest that the viability of this *P. clava* population is high and could play a key role in the conservation and potential recovery of the species.

(36) MINNESOTA STATEWIDE MUSSEL (BIVALVIA: UNIONIDAE) SURVEY: STUDY DESIGN, OUTREACH, AND CONSERVATION. **Daniel E. Kelner**[1], **Mike Davis**[2] & **Rick A. Hart**[3]. Minnesota Department of Natural Resources, Division of Ecological Services, [1]500 Lafayette Rd., St. Paul, MN 55155, [2]1801 South Oak St., Lake City, MN 55981 & [3]1601 Minnesota Dr., Brainerd, MN 56401. 651-282-2509. dan.kelner@dnr.state.mn.us

Freshwater mussels are the most imperiled group of animals in North America, yet prior to 1999 we knew their status in relatively few of Minnesota's many river systems. This paucity of information hinders our ability to sustain the mussel resource for future generations. To fill this information gap, we initiated the first statewide freshwater mussel survey in 1999. Prioritization of river systems to be sampled was done by; 1) compiling all recent and historical mussel survey information, 2) comparing poorly surveyed rivers to the historical range of rare mussel species, and 3) identifying rivers with existing threats to their health. A qualitative sampling design

using timed visual and tactile searches allows us to rapidly; 1) define the distribution of species, 2) locate rare species, 3) compare the present and historic fauna, and 4) determine species richness, abundance, and some limited population demographics. Two survey crews targeted two person hrs./site with the intent of maximizing our ability to sample many sites over a large geographical area. Sample sites were selected by identifying access points (e.g., canoe landings, bridge crossings, etc.) that were distributed between a river's headwaters to its mouth and spaced no more than 3 km apart. We also contacted local resource agency personnel and landowners about potential mussel communities and conducted cursory investigations via brail and/or bank searches. The data we collect are compatible with Geographic Information Systems and managed by the MN DNR's Natural Heritage and Nongame Research Program. We have focused the dissemination of our results on developing educational materials and providing technical assistance within DNR and other resource agencies on a wide range of projects (e.g., mussel relocation, mussel population viability workshop, development of an aquatic classification system, etc.). Ultimately, the data will be used to avoid or minimize impacts from development projects, measure the success of watershed management projects, assign legal conservation status to mussel species, and integrated into the conservation planning process for mussels in Minnesota.

(37) A QUANTITATIVE STUDY OF FRESHWATER MUSSELS AND THE ASIAN CLAM IN THE SHIPPING CHANNEL OF THE ALLEGHENY RIVER. **Gregory Zimmerman**. EnviroScience, Inc., 3781 Darrow Road, tow, OH 44224. (330) 688-0111. gzimmerman@enviroscienceinc.com. **Steve Pernick**. Skelly and Loy, Inc. 520 Seco Road, Monroeville, PA 15146. (412) 856-1676. spernick@skellyloy.com Pennsylvania Department of Transportation, Engineering District 10-0. 22550 Oakland Avenue, PO Box 429, Indiana, PA 15701

The United States Geological Survey-Biological Resource Division has been developing standard methods for determining species specific density, abundance, and distribution information for transportation-related unionid mussel surveys. While these methods have been used with considerable success, they have not been extensively used in deep water (>4m) or under low visibility conditions. We used the USGS-BRD protocol with only minor modifications to survey potential PennDOT bridge alignment locations on the Allegheny River in East Brady, PA. In total, 1,443 0.25 m^2 quadrat samples were excavated to a depth of 10 cm using systematic, multiple random starts over a 60,000 m^2 area. Substrate from each quadrat was sorted at the surface. Live mussels were identified to species, measured, and sexed, and federally-endangered species photo-documented. The Asian clam (*Corbicula fluminea*) and fourteen species of unionids were detected during this survey, including the federally endangered northern riffleshell (*Epioblasma torulosa rangiana* (=*biloba*)) and the clubshell (*Pleurobema clava*). Results were entered into a GIS for spatial analysis. The northern riffleshell was found to have a relatively even distribution mid river while the clubshell was only detected along the left descending bank. We found that the quantitative portion of the USGS sampling protocol could be successfully implemented in deep water conditions on a large scale. Here we present population estimates for selected species and spatial distribution results.

(38) NONLETHAL HEMOLYMPH COLLECTION FOR ASSESSING FRESHWATER MUSSEL HEALTH **L. Gustafson**, **J. Levine, M. Stoskopf, W. Showers, A. Bogan and S. Hanlon**. College of Veterinary Medicine, North Carolina State University, 4700 Hillsborough, Raleigh, NC. Llgustaf@unity.ncsu.edu & Jay_Levine@ncsu.edu

Assessments of electrolyte status and metabolic enzyme values are routine components of animal health examinations performed by veterinary clinicians. Values above or below established reference ("normal") values provide clues for the diagnosis of health problems. Similar nonlethal techniques are needed for the low-impact health evaluation of imperiled freshwater mussel populations. A technique for hemolymph collection has been adapted and tested for use in a common species of freshwater mussel. Sixty *Elliptio complanata* were obtained from Mocassin Creek near Raleigh, N.C., and housed indoors in a recirculating water tank. Approximately 0.5 cc hemolymph was collected, through slightly opened valves, from the anterior adductor muscle of thirty randomly selected animals. Three month survival was compared to a control group of thirty animals from this same population. Both the sampled and the control cohorts showed 97% survival at 4 and 8 weeks, and 90% survival at 13 weeks. The results suggest that hemolymph sampling does not adversely affect animal survival. Studies are currently underway to generate reference hemolymph parameters for animal health profiles. This is a simple, rapid technique that may greatly facilitate health monitoring of imperiled freshwater mussel populations.

(39) PREDICTION OF MUSSEL COMMUNITY STRUCTURE IN SOUTHWESTERN ONTARIO RIVERS FROM ENVIRONMENTAL AND SPATIAL FACTORS AND THE FISH ASSEMBLAGE. **Janice L. Metcalfe-Smith**[1], **Lee C. Grapentine**[1], **Shawn K. Staton**[1] and **Erling Holm**[2]. [1]Environment Canada, National Water Research Institute, Burlington, ON, Canada, L7R 4A6; [2]Royal Ontario Museum, 100 Queens Park, Toronto, ON, Canada, M5S 2C6. Janice.Smith@cciw.ca

The rivers of southwestern Ontario support the richest mussel communities in Canada; 32 species were found alive during surveys of 65 sites in 4 rivers in 1997-98. Richness and abundance varied greatly among sites (0 to 21 species and 0 to 1025 individuals in 4.5 p-h timed searches), as did the mussel assemblage. We examined relationships between mussel community structure and environmental (water chemistry, habitat) and spatial (geographic, stream connectedness) variables using partial canonical correspondence analysis. Environmental variables accounted for 14% (P = 0.03) and spatial variables 25% (P = 0.005) of the total mussel variation. Explained variation shared between the two sets of predictors was 36%, leaving 25% of the variation unexplained. In a subset of 19 sites for which data on the fish community were also available, the same analyses were performed using three sets of predictors. Here, the environmental, spatial and fish variable sets explained 15, 12 and 14%, respectively, of the variation in the mussel community. Explained variation shared between pairs and among sets of predictors was again large at 58%, indicating a high degree of interaction among the factors that account for mussel community structure in these rivers. The most important predictors were latitude, stream width, turbidity, drainage subbasin, and the presence/absence of several fish species, including Ghost Shiner, Greater Redhorse and Fantail Darter. The importance of environmental variables was greater than reported in other recent studies, probably because our sites ranged from undisturbed to impacted by municipal, industrial or agricultural sources.

(40) SUBSTRATE COMPACTION AND PARTICLE SIZE AFFECT LONG-TERM CULTURE OF JUVENILE FRESHWATER MUSSELS. **Tony R. Brady** and **James B. Layzer,** U.S. Geological Survey, Tennessee Cooperative Fishery Research Unit, Tennessee Technological University, Cookeville, TN 38505. tonybrady@tntech.edu & jim_layzer@tntech.edu

Large-scale propagation and long-term culture of juveniles may be required to reverse the trend of declining freshwater mussel populations. Although large numbers of juveniles can be propagated; the techniques and physical conditions required for long-term culture remain elusive. We designed two experiments to determine if substrate characteristics affect juvenile survival and growth. One-day old juveniles were cultured in 0.25 mm mesh baskets containing sand (0.5 – 1 mm), gravel (2 – 4 mm), or no sediment. The baskets were suspended in a hatchery raceway in a 3 X 3 Latin square design, and the juveniles were cultured for 120 days. Growth of *Lampsilis cardium* was significantly greater in gravel. Although survival of *Actinonaias pectorosa* was low in all treatments, the largest individuals occurred in gravel. We also examined the effects of reducing the amount of fines (≤ 0.25 mm) and substrate compaction in one of two raceways used for juvenile culture. Equal numbers of glochidial infested fish were introduced into each raceway. At the end of the growing season, we found juvenile mussels in the treated raceway, but none in the untreated raceway.

(41) A METHOD FOR MEASURING GROWTH IN LIVING FRESHWATER MUSSELS. **R. Molina, J. Levine, and S. Hanlon**, College of Veterinary Medicine, North Carolina State University, 4700 Hillsborough St., Raleigh, NC 27606. 919 513-6302. rmolina@unity.ncsu.edu, Jay_Levine@ncsu.edu & Shane_Hanlon@ncsu.edu, **T. Savidge,** NCDOT-Project Development & Environmental Analysis Branch, 1548 Mail Service Center Raleigh, NC 27699-1548. tsavidge@dot.state.nc.us, and **A. Bogan**, [3]North Carolina State Museum of Natural Sciences, Research Laboratory, 4301 Reedy Creek Road, Raleigh, NC 27607. 919 733-7450 ext. 753. arthur.bogan@ncmail.net.

Monitoring changes in mussel body weight can serve as a valuable tool for assessing the growth and health of captive freshwater mussels. A buoyant weight method is described that is nondestructive and minimizes disturbance. Mussel weight is measured under water. Estimations of air fresh weight, total dry weight, shell weight and tissue dry weight are obtained from species specific regression equations. Standard regression curves were developed for two common freshwater bivalve species of different length measurements: *Elliptio complanata* complex (17.10 to 111.70 mm) and *Corbicula fluminea* (12.70 to 24.45 mm), held in

the Freshwater Mussel Research Facility (FMRF) at the College of Veterinary Medicine, North Carolina State University (CVM-NCSU), in a closed recirculating ~200 gal. system for two months. The total dry weight of the animals ranged from 0.57 to 41 g for *E. complanata* complex and 0.31 to 1.7 g for *C. fluminea*. *E. complanata* complex regression coefficients (R^2) for log-transformed buoyant weight with log-transformed air weight, shell dry weight and tissue dry weight were 99.4%, 88.8% and 100%, respectively. Logarithmic relationships for *C. fluminea* of buoyant weight to air weight and tissue dry weight were R^2 of 94.4% and 72.6%, respectively. Untransformed shell dry weight for this species yielded an R^2 of 100%. Variability in tissue dry weights of both species reflected in lower R^2 compared to the other variables, may be attributed to fluctuations in body size due to fecundity. The buoyant weight method has been used to measure shell growth of $7e^{-04}$ to $1.7e^{-02}$ g d^{-1} in mussels of 1.06 to 7.63 g mean initial buoyant weight cultured at the FMRF (CVM-NCSU) for 116 days. The buoyant weight method provides a simple nonlethal means of monitoring growth in captive freshwater mussels.

(42) BIOCHEMICAL COMPOSITION OF FOUR ALGAE PROPOSED AS FOOD FOR CAPTIVE FRESHWATER MUSSELS. ***Catherine M. Gatenby[1]**, **Daniel A. Kreeger[1]**, **Vanessa A. Jones[2]**, **David M. Orcutt[2]**, **Bruce C. Parker[3]**, and **Richard J. Neves[4]**. [1]Patrick Center for Environmental Research, Academy of Natural Sciences, Philadelphia, PA 19103. [2]Department of Plant Pathology and Weed Science, Virginia Tech, Blacksburg, VA 24061. [3]Department of Biology, Virginia Tech, Blacksburg, VA 24061. [4]Department of Fisheries and Wildlife Sciences, Virginia Tech, Blacksburg, VA 24061.

Microalgae play an important role in mariculture as food for molluscs, some crustaceans, and fish species. Growth and development of cultured animals reared on microalgae is dependent on the proportion and availability of the biochemical constituents in the algae. To identify suitable diets for the care of mussels in captivity, we compared carbohydrate (CHO), protein, and lipid contents (% dry w/w) of three green algae, *Neochloris oleoabundans*, *Bracteacoccus grandis*, *Scenedesmus quadricauda* and one diatom, *Phaeodactylum tricornutum*, at different phases of growth. The sterol and fatty acid composition also was identified and quantified. The percentages of protein showed only minor differences among the species of algae examined. Protein ranged 60.6% to 70.3 % of algal dry wt in all algae, irrespective of growth phase. CHO content differed between species depending on growth phase, and was greatest at late stationary phase (LS) for most algae (43.4 to 33%); *S. quadricauda* had highest CHO content (38.05%) at log phase. The lipid content increased with growth phase for *N. oleoabundans* and *P. tricornutum*, but decreased with age in *B.grandis*. *S. quadricauda* showed no difference in lipid content among growth phases. Highest Lipid content (58.3%)was in *N. oleoabundans* at stationary phase. The mean fatty acid content of the four algae ranged 15.5% - 45% of the total lipid dry wt. The unsaturated fatty acid (UFA) concentration generally increased with growth phase for all algae, and was highest (433.1_g/mg lipid) in *N. oleoabundans*. On the basis of previous work with marine bivalves, these algae would seem to have adequate protein for biosynthesis and tissue regeneration. Similarly, seasonal demands for carbohydrate for energy storage and energy maintenance could be met by these algae. Finally, the UFA content and composition of the diet will likely be very important to developing pedal-feeding juvenile mussels.

(43) TRANSMISSION, VIA *AMBLEMA PLICATA*, OF THE FISH PATHOGEN *AEROMONAS SALMONICIDA* TO ARCTIC CHAR IS INTERRUPTED BY QUARANTINE OF THE BIVALVES. **Clifford E. Starliper**. USGS, National Fish Health Research Laboratory, 1700 Leetown Road, Kearneysville, WV 25430. 304 724-4433 cliff_starliper@usgs.gov

A relocation program is one strategy of the conservation efforts employed to protect native freshwater bivalves. With relocation, native bivalves are removed from their natural environment prior to the detrimental effects of advancing zebra mussels. Then, they are placed in threat-free facilities for maintenance and propagation with the ultimate goal of reintroduction at an appropriate future date. Holding facilities include hatcheries that intensively rear salmonid fishes and this led to concerns regarding the potential to introduce fish pathogens via the relocated native bivalves. After collection and prior to relocation bivalves undergo a minimum 30-day quarantine to ensure zebra mussels are not inadvertently spread. This study was done to determine if a quarantine would also provide for bivalves to depurate fish bacterial pathogens they might be harboring. A model system was developed for study utilizing the bivalve *Amblema plicata*, the salmonid fish Arctic char (*Salvelinus alpinus*) and *Aeromonas salmonicida*, the bacterium that causes furunculosis (disease) in salmonids. Clinical furunculosis was established by

injecting (IP) two groups of Arctic char (60 fish each) with 2.26 X 10^2 or 2.26 X 10^0 of viable *A. salmonicida* cells per fish. These fish were placed in a tank with non-injected char, which became infected via cohabitation. Once the non-injected fish began to die, 120 *A. plicata* were placed in the tank. When the *A. plicata* had become carriers of, and potential vectors for *A. salmonicida*, they were transferred to four different tanks and pathogen-free Arctic char were added after the *A. plicata* were allowed to depurate for 1, 5, 15 or 30 days. Transmission of *A. salmonicida* from *A. plicata* to char was determined by bacterial culture. It was found that a quarantine period of sometime less than 15 days was effective in preventing transmission of the bacterial fish pathogen.

(44) RECOVERY AND SURVIVAL OF UNIONID MUSSELS AFTER RELOCATION TO A MARGINAL HABITAT. **C. S. Howard** and **H. L. Dunn**. Ecological Specialists, Inc., 114 Algana Ct, St. Peters, MO 63376, ecologist3@aol.com and ecologists@aol.com, (636) 447-5355

Relocation of unionid mussels is often used to mitigate impacts of in-stream construction near mussel beds; however, recovery appears directly related to substrate stability. Over 1000 unionids representing 20 species were relocated from a future effluent site (750m^2) in the Mississippi River (Cordova, IL) to an area (1500m^2) considered marginal unionid habitat (<10 unionids/m^2). The relocation area had relatively soft, shifting substrate but was much less infested with zebra mussels than alternative relocation habitat with more stable substrate. Two grids (common species grids, 5mx5m) containing 25 1mx1m cells and one grid (threatened and endangered [T&E] grid, 3mx5m) containing 15 1mx1m cells were established within the relocation area to quantitatively monitor recovery, mortality, immigration, and density. Ten individuals of five abundant species (i.e., *Amblema p. plicata, Fusconaia flava, Lampsilis cardium, Quadrula p. pustulosa, and Q. quadrula*; except only five Q. quadrula) from the collection area were placed in 10 randomly selected cells in each of the two common species grids. Additionally, 10 individuals each of the five species were collected near the relocation area and also placed in 10 randomly selected cells (but different from cells with relocated mussels) within each of the two grids. The five remaining cells in each grid were used as controls. Lastly, 21 *L. higginsi* and one *E. lineolata* from the collection area were placed into 11 of the 15 cells (2 unionids/cell; random block design) in the T&E grid. Recovery (68-83%) and mortality (2-6%) within all grids after 1y was higher and lower than expected, respectively. However, flow was only moderate throughout the year. Grids will be monitored for at least one more year. Results to date suggest that relocated unionids can survive in marginal habitat, which may be preferable over relocation to areas with more suitable substrate but heavily infested with zebra mussels.

(45) EFFECTS OF URBAN GROWTH IN THE ATLANTA AREA ON FRESHWATER MUSSELS IN THE LINE CREEK WATERSHED. **J. Brim Box**[1], **J. Williams**[1], **R. Gillies**[2], **E. Rodemaker**[2], **J. Mossa**[3], and **J. Howard**[4]. [1]Florida Caribbean Science Center, Gainesville, FL, [2]Utah State University, Logan, UT, [3]University of Florida, Gainesville, FL, and [4]UC Berkeley, Berkeley, CA. jayne_brim_box@usgs.gov.

Line Creek, a major tributary of the upper Flint River drainage, has its headwaters in Fulton County, southwest of Atlanta. Historically Line Creek harbored a diverse mussel fauna comprised of at least 14 species, including four federally listed as endangered or threatened, and a fifth species now extinct. Unprecedented urban growth in the Atlanta area is often cited as a factor in the decline of aquatic species in the upper Flint River system, but empirical data are lacking. In this study, a multidisciplinary approach was used to examine if changes in land use, vegetation cover, stream channel geomorphology, and hydrology were associated with the decline of mussels in Line Creek over the past 40 years. An increase in impervious surface area, derived from satellite-based measurements, was used to determine how much of the watershed had been urbanized since the 1970s, and this data was correlated to changes in channel morphology and bank erodibility. Since the 1960s, the width-depth ratio of Line Creek's channel has increased three-fold, signifying both channel widening and shallowing. These data suggest that changes in runoff patterns due to urbanization have caused significant changes in the channel geomorphology of Line Creek, and the subsequent decline of five species of rare mussels.

(46) THE FRESHWATER MUSSEL FAUNA OF THE KNIFE RIVER, MINNESOTA, TEN YEARS FOLLOWING A ROTENONE TREATMENT. **Rick A. Hart**[a], **Tim Brastrup**[b], **Dan Kelner**[c], and **Mike Davis**[d] Minnesota Department of Natural Resources, [a]Division of Ecological Services, Brainerd, MN 56401, [b]Division of Fisheries, Brainerd, MN 56401, [c]Division of Ecological Services, St. Paul, MN 55155, [d]Division of Ecological Services, Lake City, MN 55041. 218 828-2646 rick.hart@dnr.state.mn.us.

In October 1989, the Minnesota Department of Natural Resources, Section of Fisheries, treated the Knife River, its tributaries, and Knife Lake with rotenone to eliminate the rough fish population in the system. Knife Lake was also drawn down to facilitate the rotenone treatment. At the time of the treatment it was believed that the rotenone application and subsequent drawdown would not have an adverse impact upon the mussel fauna residing in the Knife River system. Therefore, a pre- and post-treatment survey of the mussel community was not immediately conducted. During 1999 the Minnesota Department of Natural Resources, Division of Ecological Services, initiated a statewide mussel survey program. This program facilitated a mussel survey of the Knife River, allowing the assessment of its pre- and post-rotenone treatment mussel assemblage. Using timed searches, divers surveyed 9 sites along the Knife River collecting both live and dead mussels. Divers collected and identified over 900 mussels representing 17 species. Catch per unit effort (CPUE) for live mussels was similar in the Knife River when compared to other Minnesota streams surveyed. No collected mussel species were represented by dead shells only. Individuals from several of the species that were collected were greater than 10 years of age. Mussels less than 10 years of age were also collected, indicating that successful reproduction has occurred since the rotenone application. This reveals that the mussel fauna that inhabited the Knife River before the rotenone treatment and lake drawdown is still intact. Therefore, we believe the rotenone application did not have any long term impacts on the mussel assemblage of the Knife River, MN.

(47) A REVIEW OF ZEBRA MUSSEL POPULATION DYNAMICS IN THE UPPER MISSISSIPPI RIVER: THE INTERACTION OF LARGE RIVER HABITAT ATTRIBUTES WITH UNIONID INFESTATION PATTERNS. **Paul J. Marangelo**, Ecological Specialists, Inc., 114 Algana Ct; St. Peters MO 63376. 636 447-5355 Ecologist4@aol.com

While zebra mussels have substantially impacted unionids in the Mississippi River, colonization patterns have left unionids in some area of the river less impacted than others. We synthesized zebra mussel monitoring and population dynamics studies in large rivers (primarily the Upper Mississippi) to describe the mechanisms and relative importance of various factors governing zebra mussel population trends in the Upper Mississippi River. This synthesis was then examined to provide insights into the relationship between large-river zebra mussel population dynamics and the infestation of unionid bivalves over large and small spatial scales. Over small scales, zebra mussels appear to be differentially distributed between habitat types within pools, probably on account of interactions between hydrology and larval distribution and dispersal. For example, in Pool 14, portions of some unionid beds are persisting thus far in habitats that are less heavily colonized by zebra mussels. Such areas may provide the best possibility for long-term unionid survival. Over larger scales, habitats with semi-lentic attributes (e.g. Lake Pepin) play a key role in the distribution of zebra mussels (and thus unionid impacts) in the Upper Mississippi insofar that they provide the most favorable conditions for zebra mussels. Unionids in the downstream settlement zone of veliger propagules originating in such areas have a poorer prognosis than other areas in the Upper Mississippi. A large number of ecological factors appear to influence large-scale zebra mussel trends in the Upper Mississippi. The product of their interactions are complex spatial/temporal patterns of population increases and crashes. While it is clear that some areas of the Upper Mississippi River possess habitat attributes that diminish the threat of zebra mussels to unionids, the ability of unionids to withstand the effects of variable levels of infestation over the long term will determine the probability of survival in the Upper Mississippi.

(48) ENDANGERED SNAILS IN THE INTERMOUNTAIN WEST - THE BRUNEAU HOT SPRINGSNAIL CASE STUDY. **G.V. Wood** and **S. D. Duke**. U.S. Fish and Wildlife Service, Snake River Basin Office, 1387 S. Vinnell Way, #368, Boise, ID 83709. jeri_wood@fws.gov

The Bruneau hot springsnail (*Pyrgulopsis bruneauensis*) is an endangered springsnail that occurs only in a small complex of flowing thermal springs arising from a single source aquifer in southwestern Idaho. The species currently occupies 89 of the 155, small flowing geothermal springs and seeps along a 6.9 kilometer reach of the Bruneau River and Hot Creek, a tributary to the Bruneau River in southwestern Idaho. Range-wide surveys show a decline in the springsnail available thermal habitats with total number of geothermal springs declining by 27% since 1991 and total number of geothermal springs occupied by the species declining by 32% since 1991. The Bruneau hot springsnail has had a long and arduous listing history and it is a true indicator species of the health and survival of the geothermal aquifer from which the geothermal spring habitat for Bruneau hot springsnail originates. Water in the confined geothermal aquifer has been estimated to be greater than 10,000 years old. Recent (beginning in the 1960's) developments in well technology has allowed increased access and use of geothermal water for irrigated agriculture in three valleys located west of the Bruneau River. As these uses have increased, water levels in the geothermal aquifer have declined, resulting in the decline in the number and size of springs arising from the aquifer in the Bruneau River. Efforts to conserve and reduce the use of geothermal water will be addressed in a recovery plan under preparation by the Fish and Wildlife Service.

(49) CONSERVATION OF FRESHWATER MUSSELS ON THE GEORGE WASHINGTON AND JEFFERSON NATIONAL FORESTS, VIRGINIA. **Dawn Kirk**, USDA Forest Service, 5162 Valleypointe Parkway, Roanoke, VA 24019. dkirk@fs.fed.us **Fred Huber**, USDA Forest Service, 5162 Valleypointe Parkway, Roanoke, VA 24019 fhuber@fs.fed.us. **Monte McGregor**, VA Department of Game and Inland Fisheries, 910 Thomas Jefferson Road, Forest, VA 24551. mmcgregor@dgif.state.va.us

Watersheds on or near the George Washington and Jefferson National Forests support one of the most diverse freshwater mussel faunas in the world. Approximately 73 mussel species occur in Virginia, of which there are viability concerns for 54 species. Seventeen mussel species that could be influenced by U.S. Forest Service actions are listed as endangered by the U.S. Fish and Wildlife Service, and 8 more are considered sensitive by the U.S. Forest Service. To assist with the recovery of federally listed species and to ensure that our activities do not result in declines of mussel species or habitat, the George Washington and Jefferson National Forests recognized that a comprehensive mussel conservation plan was needed. To develop this, we looked at broad scale watershed assessments, hydrologic modeling of sediment movement, field measurement of riparian areas and instream habitat. The conservation plan was developed with input from a variety of state and federal agencies, and academic institutions. The plan guides forest management in watersheds with rare mussels, outlines actions to augment mussel populations, and emphasizes habitat restoration through public/private partnerships**.**

(51) EFFECTS OF TRANSLOCATION, MICROHABITAT, AND DENSITY ON GROWTH AND MOVEMENT IN THE THREATENED LOUISIANA PEARLSHELL, *MARGARITIFERA HEMBELI***. Susan R. Bolden** and **Kenneth M. Brown**. Louisiana State University, Department of Biological Sciences, 508 Life Sciences Building, Baton Rouge, LA 70803. 225 578-1740. sbolden@unix1.sncc.lsu.edu or kmbrown@lsu.edu

We studied the effects of translocation, habitat and density on growth and movement in the Louisiana pearlshell, *Margaritifera hembeli*. *M. hembeli* is a federally threatened species found in 22 small, headwater streams in central Louisiana. In two streams, mussels were translocated into both riffle and pool habitats, at both low and high densities. Four and eight months after translocation, individual growth, survival, and movement were compared to two reference populations in each stream. Translocation did not effect growth or survival, but did increase movement. Mussels grew more in a more oligotrophic stream, but moved more in a more eutrophic stream. Habitat type did not affect growth, but mussels moved more in riffles than pools. There was a density-dependent decrease in growth in the less productive stream, suggesting food may be limiting. These mussels, common in clear, oligotrophic streams, may use bacterial populations as a food source. A laboratory feeding study using ^{35}S-labeled *E. coli*, indicated that *M. hembeli* can clear bacteria from the water column. Overall, our study indicates translocation is a viable strategy to protect populations of *M. hembeli* from disturbances, such as bridge construction, as long as sites are carefully selected, and proper methods followed.

(52) *LASMIGONA DECORATA* IN GOOSE CREEK, NORTH CAROLINA: A PILOT PROJECT IN THE CONSERVATION OF A FEDERALLY ENDANGERED FRESHWATER MUSSEL. **Kate Pipkin**. North Carolina Wildlife Resources Commission, 13339 Hagers Ferry Rd., Mail Code: MG03A3, Huntersville, NC. 28078. 704 875-5412. pipkinks@mindspring.com

The Carolina heelsplitter (*Lasmigona decorata*) is the most critically endangered mussel species in North and South Carolina. There are six extant populations of the Carolina heelsplitter: Catawba River drainage (Waxhaw Creek, NC, Gills Creek, SC); Yadkin/Pee Dee River drainage (Goose Creek, NC, Lynches River, SC); and Savannah River drainage (Turkey Creek, SC, Cuffytown Creek, SC). Less than 100 individual live specimens have been found in modern history (20th century). The US Fish and Wildlife Service listed this mussel as endangered in 1993. Historically, the decline in this species is chiefly attributed to poor agricultural practices and poor forestry practices in the 19th and early 20th centuries. The other critical factor in its decline was the growth of Charlotte, NC. into a major metropolitan area. The heart of the Carolina heelsplitter's historic range is in the city limits of Charlotte. Current threats to the continued existence of the six populations and recovery of the species are: development, pollution, and poor forestry practices. The population closest to Charlotte and most in peril is the Goose Creek population. In 1997, the NC Wildlife Resources Commission, in cooperation with he USFWS, started a pilot project with a full-time conservation biologist on Goose Creek. The objectives of this pilot project are to protect the current Goose Creek population of the Carolina heelsplitter and enhance its habitat. The conservation biologist identified current threats to this population- wastewater, poor agricultural practices, and development- and predictable future threats- increased development and pollution. The biologist then developed strategies to address each of these threats. Results thus far include an increased awareness in the public of the Carolina heelsplitter and its endangered status, a better understanding of threats, research into solutions, a riparian buffer program and proposals for limiting the impact of development on Goose Creek habitat.

(53) THE CORRELATION BETWEEN MOLLUSK DISTRIBUTIONS AND CHARACTERISTIC STREAM CATAEGORIES IN THE CUMBERLANDS AND SOUTHERN RIDGE AND VALLEY ECOREGION. **Braven B. Beaty**[1] and **Ryan K. Smith**[2], [1]Clinch Valley Program, The Nature Conservancy, 146 E. Main St., Abingdon, VA 24210, and [2]Southern Resource Office, The Nature Conservancy, 6114 Fayetteville Rd., Suite 109, Durham, NC 27713.

The need for rapid methods to identify and prioritize stream reaches for inventory and conservation efforts is prevalent in most organizations with land stewardship responsibilities. The amount of faunal distribution information available for aquatic organisms is far less than needed for fully informed decisions. Additionally, conservation decisions based solely on the knowledge of rare biota occurrences may miss prime examples of intact biological communities and unknown species. The Freshwater Initiative of The Nature Conservancy developed an approach to direct conservation action, especially in areas that are data poor, utilizing an array of physical, geological, hydrological, and climatological parameters to divide stream reaches into categories predicted to share similar biotic compositions. Early assessments of the approach using fish distributions in Great Lakes tributaries indicated the identified categories matched the biota. However, the Tennessee River and upper Mobile Bay drainages are much more diverse, with a rich mollusk fauna. Approximately 35 categories of streams (called Aquatic Ecological Systems) were identified in the Cumberlands and Southern Ridge and Valley ecoregion. Comparisons were made between the known distributions of freshwater mollusks and the Aquatic Ecological Systems to determine whether this approach helps refine conservation and survey efforts in biologically diverse areas. A finer delineation of stream categories, referred to as aquatic Macrohabitat types, was tested for selected watersheds. The relationship between mollusk distributions and stream categories will be discussed. The correlation of mussel assemblages with physical, hydrological, and geological characteristics can help elucidate the environmental requirements and preferences of various species.

(54) THE REPRODUCTIVE STATUS IN RELATION TO AGGREGATE SIZE OF *ALASMIDONTA HETERODON* AND ITS DARTER HOST-DISPERSAL RELATIONSHIPS IN THE MILL RIVER IN WESTERN MASSACHUSETTS. **D.C. McLain** & **M.R. Ross**. Department of Natural Resources Conservation, University of Massachusetts, Amherst, MA 01003. 413 584-6940

Riverine mussels may exhibit characteristics of metapopulations. The structure of the satellite aggregations may be limited by reproduction success and the dispersal capacity of the host fish. I studied the distribution, abundance, reproduction, and shell size structure of the endangered dwarf wedgemussel (*Alasmidonta heterodon*) at different levels of abundance, and the dispersal potential of its host, the tessellated darter (Etheostoma olmstedi) in the Mill River in Massachusetts. At 5 study sites varying in abundance of *A. heterodon*, the level of reproduction was positively proportional to aggregation size. The site with the highest abundance of *A. heterodon* had a 1:1 ratio of gravid to non-gravid individuals and the highest levels of glochidia release (1.2 per 10 m^3), host infection rate (31% from 3 May to 28 June), and juvenile recruitment (17 per 10 m^2). Reproduction at low-density sites was nominal or undetected. Mean shell length decreased significantly ($p < .001$) from upstream (35 mm) to downstream (27 mm). Downstream sites also had a narrow range of sizes (7-14 mm). Dispersal of marked darters was minimal during the period of glochidia release by *A. heterodon*. Most darters (94%) remained in the same pools in which they were originally marked. The results of this study show that reproduction by *A. heterodon* in the Mill River is contingent upon aggregation density. The intermediate aggregation containing 17 gravid females may represent a minimum level for successful reproduction. The lack of dispersal via host darters may have implications for recovery of *A. heterodon* populations. High discharge storm events may be important for downstream mussel dispersal.

(55) THE EVOLUTION OF FRESHWATER MUSSELS IN NORTH AMERICA: EVIDENCE FROM THE FOSSIL RECORD. **G. T. Watters**. Museum of Biological Diversity, The Ohio State University, 1315 Kinnear Road, Columbus, OH 43212. Watters.1@osu.edu

Recognizable unionaceans appear in North America in the Triassic (250 MYA). At this time all present continents were assembled into a single land mass, Pangaea. Species referable to the "classic" Hyriidae, Mycetapodidae, Mutelidae, Margaritiferidae, and Unionidae all existed in North America at this time. By the close of the Mesozoic (65 MYA) a diverse freshwater mussel fauna flourished in western North America. This fauna was composed of species that had convergently evolved shell shapes amazingly similar to Recent taxa. Most of this fauna was extirpated by the beginning of the Cenozoic, largely due to changes in climate and orogenic processes. However, this fauna persisted well into the Cenozoic in Europe and Asia — some Recent Asian taxa appear to be direct ancestors of this group. A new faunal assemblage arose in North America in the Cenozoic, culminating in our present freshwater mussel diversity. Examples of Recent lampsiline genera appear by the Eocene (55 MYA) in the Gulf states. Anodontines (including *Gonidea*) and the ancestor of *Margaritifera falcata* apparently crossed the Bering Land Bridge from Asia to colonize western North America. Another group of anodontines and *Margaritifera margaritifera* crossed Greenland from Europe to colonize eastern North America. This resulted in two unrelated anodontine stocks and two unrelated margaritiferid stocks co-occurring in present North America. Anodontines as a whole represent a group distinct from the Unionidae at least as far back as the Oligocene (35 MYA). Lampsilines and amblemines also are distinct lineages, separated for perhaps 60 MY.

(56) A PHYLOGENETIC ANALYSIS OF THE SPHAERIIDAE (MOLLUSCA, BIVALVIA) BASED ON MORPHOLOGY AND DNA SEQUENCE DATA. **Taehwan Lee**, Museum of Zoology, University of Michigan, 1109 Geddes Avenue, Ann Arbor, MI 48109-1079, 734 764-0470. taehwanl@umich.edu

Sphaeriid systematics has been confused by considerable ecophenotypic and allometric variation in shell shape, and by the difference in systematic philosophies among Western and Russian malacologists. Recently a few studies have independently attempted to understand sphaeriid phylogeny by using either morphological characteristics or molecular sequence data. Although these two independent character sets, morphology and DNA sequences, produced a congruent interpretation on subfamily-level relationships, suggested generic-level evolutionary relationships among the Sphariidae are contradictory. In addition, intrageneric sphariid relationships are not phylogenetically tested or still poorly understood. Therefore, I have compiled morphological evidence together with molecular sequences in order to test a number of phylogenetic hypotheses proposed for various levels of sphaeriid relationships. Here I present a phylogenetic analysis of the Sphaeriidae based on a morphological dataset including brooding and life history characters, and molecular data from the fragments of three different regions, nuclear ITS (ca. 550-680bp), mitochondrial COI (ca. 500bp), and mitochondrial 16S rRNA (ca. 500bp).

(57) TAXONOMY OF FRESHWATER PHYSIDS: A MOLECULAR EXAMINATION OF *PHYSA HETEROSTROPHA*, *P. INTEGRA*, AND *P. ACUTA*. **Amy R. Wethington**. University of Alabama; Dept. of Biological Sciences; Box 87035; Tuscaloosa, AL 35487. 205 348-5828; wethi001@bama.ua.edu or amyw65@juno.com

Most species of freshwater snails of the family Physidae have were initially described on the basis of seemingly trivial shell differences. Here, I present preliminary findings of a genetic analysis within selected species of the integra species complex (i.e., *P. heterostropha*, *P. integra* and the Old World *P. acuta*). DNA sequence data was generated from individuals from several populations within each species using DNA primers for the portions of the mitochondrial 16S rRNA and cytochrome c oxidase subunit I genes. Intraspecific phylogeography is examined within and among the currently recognized species and current taxonomic views are explored.

(58) A GENETIC ANALYSIS OF REPRESENTATIVE UNIONID SPECIES OF THE GENERA *VILLOSA* AND *LAMPSILIS*. **Jennifer Buhay**. The University of Alabama, Biodiversity and Systematics, Department of Biological Sciences, Box 870348, Tuscaloosa, AL 35487. 205 348-5828. Jenbuhay@hotmail.com.

Conservation and management of unionid bivalves is still hindered by a lack of understanding of evolutionary relationships within and among species. Here, I present a genetic analysis of representative *Villosa* and *Lampsilis* species to test the monophyly of each genus and examine phylogenetic relationships within and among selected species from the Tennessee and Mobile drainage basins.

(59) A PHYLOGENETIC COMPARISON OF TWO MAJOR FRESHWATER BIVALVE RADIATIONS (BIVALVIA: UNIONOIDA): THE SOUTHEASTERN UNITED STATES AND CHINA. **Walter R. Hoeh**[1], **Arthur E. Bogan**[2], and **Wu Xiao Ping**[3] [1]Dept. of Biology, Kent State University, Kent, OH; [2]North Carolina State Museum of Natural Sciences, Research Laboratory, 4301 Reedy Creek Road, Raleigh, NC 27607; [3]Dept. of Biology, Nanchang University, Jiangxi Province, P.R. China.

The freshwater bivalve fauna of the World as currently perceived is comprised of six families in two superfamilies in the Order Unionoida. Representatives of the Order are found on six of the seven continents today. These animals, because they live in freshwater and have an obligate intermediate parasitic stage on a host fish, are the most endangered group of animals. Our current understanding of the relationships is based on a visual examination of shells and some anatomical characters. We have previously presented a preliminary phylogeny for the order. Here we address the phylogenetic relationships of the two largest radiations in freshwater bivalves: the southeastern United States in North America and eastern China. The southeastern United States is home to 269 species in 47 genera. The freshwater bivalve fauna of China is represented by 53 species in 15 genera. We compare representative species of the genera from the two regions using mtDNA sequences. These analyses test the previous taxonomic placement of genera and examine the problems of shell shape convergence between the two faunas.

(60) HISTORICAL BIOGEOGRAPHY AND LATE GLACIAL ORIGIN OF THE FRESHWATER PEARLY MUSSEL (BIVALVIA: UNIONIDAE) FAUNAS OF LAKE ERIE, NORTH AMERICA. **Daniel L. Graf**. Department of Biology and Museum of Zoology, University of Michigan, Ann Arbor, Michigan 48109-1079, USA. dgraf@umich.edu

The objectives of this paper are two-fold: (1) to review the historical distributions of the freshwater pearly mussels (Bivalvia: Unionidae) of the Lake Erie Basin of North America and (2) to test the traditional hypothesis that all Ohio Basin mussels present in Lake Erie migrated there during the stand of Glacial Lake Maumee (between 14,400 and 13,900 years ago). Forty-four mussel species occur in the Lake Erie Basin, and these are herein divided into five faunas based upon their shared distribution patterns in the Great Lakes: the Great Lakes Fauna, the Central GreatLakes Fauna, the Erie-Michigan Fauna, the Erie Fauna, and the Northern Atlantic Slope Fauna. The spatial and temporal distributions of those faunas do not support the Glacial Lake Maumee dispersal hypothesis; this is corroborated by the vicariant distributions of the Great Lakes fishes. It is concluded that, although some species may have colonized Lake Erie through Glacial Lake Maumee, many other species arrived perhaps as recently as Nipissing time (6000 to 4000 years ago).

(61) TRIASSIC FRESHWATER BIVALVES (UNIONOIDA) OF THE RIFT LAKES IN THE EASTERN UNITED STATES. **Arthur E. Bogan[1], Vince P. Schneider[1], Patricia G. Weaver[1]**, and **Earle E. Spamer[2]**. [1]North Carolina State Museum of Natural Sciences, 11 West Jones St., Raleigh, NC 27601; [2]Academy of Natural Sciences of Philadelphia, 1900 Benjamin Franklin Parkway, Philadelphia, PA 19103

The East Coast of the United States during the Late Triassic was marked by a number of rift lakes resulting from the development of the Atlantic Ocean. These lakes were home to a variety of freshwater invertebrates including freshwater unionoid bivalves. We provide a comparison of the northern lake faunas with unionoid specimens discovered in rift lake deposits in North Carolina. The North Carolina specimens are from the Durham sub-basin of the Deep River Basin, a part of the Triassic and Jurassic Newark Supergroup. The described species have come from deposits in Massachusetts and Pennsylvania. The four species described from Massachusetts have been placed in the Unionidae. While those species described from Pennsylvania were subsequently placed in the South American unionoid families Hyriidae and Mycetopodidae, and the family Myalinidae. Placement of the Triassic unionoid taxa in the genera *Diplodon* and *Mycetopoda* is questioned.

(62) MOLECULAR PHYLOGENETICS AND BIOGEOGRAPHY OF THE FRESHWATER MUSSEL GENUS *Ptychobranchus* (BIVALVIA: UNIONIDAE). **K.J. Roe[1]** & **K. S. Cummings[2]**. [1]Biodiversity and Systematics, Department of Biological Sciences, University of Alabama, Tuscaloosa, AL 35487-0345. roe001@bama.ua.edu; [2]Illinois Natural History Survey, Center for Biodiversity Champaign, IL 61820 ksc@inhs.uiuc.edu.

Phylogenetic knowledge of species and information on their geographic distributions in both time and space are of paramount importance to the development of our understanding of evolutionary biology. The field of historical biogeography attempts to integrate the phylogenetic relationships of organisms with their geographic distributions to in turn develop hypotheses for the relationships of the areas where the taxa occur. The freshwater mussel genus *Ptychobranchus* Simpson, contains five nominal taxa which are distributed throughout the following biogeographic provinces: *Ptychobranchus subtentum* Say - Cumberlandian, *P. fasciolaris* Rafinesque - Ohioan, *P. occidentalis* Conrad - Ozarkian, *P. greeni* Conrad - Mobile Bay, and *P. jonesi* van der Schalie - Conecuh and Chochtawhatchee. Simpson (1900) erected the genus and the character, which serves to unite all members of the genus, is the presence of a folded marsupial demibranch. No explicit phylogenetic hypotheses have been proposed for this group other than the putative sister relationship of *P. occidentalis* and *P. fasciolaris* proposed by Johnson (1980). The generation of phylogenetic hypotheses based on the DNA sequences of two mitochondrial genes will provide a needed test of the monophyly of this genus and its constituent species and provide a framework upon which ecological and further systematic research can be conducted. The distribution of the freshwater mussel genus *Ptychobranchus* provides an opportunity to use this information to test existing biogeographic hypotheses proposed by Mayden (1988), and Crandall and Templeton (1999) for the historical relationships of fishes and crayfishes of the river systems of the Central Highlands region.

(63) A PHYLOGENETIC PERSPECTIVE ON HOST-PARASITE ASSOCIATIONS AND THE EVOLUTION OF LURES IN NORTH AMERICAN MEMBERS OF THE FRESHWATER MUSSEL TRIBE LAMPSILINI (BIVALVIA: UNIONIDAE). **K. J. Roe** & **C. Lydeard**. Biodiversity and systematics, Department of Biological Sciences, University of Alabama, Tuscaloosa, AL 35487-0345. roe001@bama.ua.edu.

The Lampsilini contains approximately 1/3 of all North American unionid taxa, and was first recognized by von Ihering (1901) as a subfamily of the Unionidae. Ortmann (1912) recognized this assemblage of mussels based on six characters including the restriction of the marsupium to the outer two demibranchs (or a portion of them). Members of this tribe display an astonishing variety of conchological and reproductive adaptations including placement and shape of the marsupium, and the use of mantle displays as well as conglutinate and superconglutinate lures to attract potential host fishes. In this study we present a phylogenetic analysis of 40 species of North American lampsiline mussels based on morphological characters, host associations and the DNA sequences of two mitochondrial genes. By examining a variety of characters simultaneously we hope to provide a robust test of the monophyly of the Lampsilini and provide hypotheses for relationships within this group. In addition we wish to examine host associations and the phenotypic diversity of marsupium placement and lure production within a phylogenetic context in order to provide insight into the mode and tempo of evolutionary change in this diverse group.

(64) MOLECULAR PHYLOGENETICS OF THE *QUADRULA PUSTULOSA* SPECIES GROUP (BIVALVIA: UNIONIDAE). **J.M. Serb**. Biodiversity and Systematics, Department of Biological Sciences, University of Alabama, Tuscaloosa, AL 35487-0345. serb001@bama.ua.edu.

The *Quadrula pustulosa* species complex is a morphologically diverse assemblage of mussels distributed across eastern North America. The complex includes *Q. pustulosa*, a widely distributed species in the Mississippi River basin, and *Q. asperat*a of the Gulf Coast river drainages, among others. Over the last 150 years, the number of recognized taxa in the genus *Quadrula* has varied from 32 (Simpson 1900) to 10 (Ortmann 1912) to 20 (Williams et al. 1993). Past descriptions of taxa in the genus *Quadrula* have been confounded by an extreme amount of conchological variation . For example, within the Mobile River drainage two taxa (*Q. keineriana* and *Q. cahabensis*) were described primarily based on shell sculpture. Currently, these taxa are treated as part of as a single, highly variable species *Q. asperata*, because there appears to be a morphological grade between the forms. Preliminary ND1 sequence data will be presented to examine: 1. the relationships among taxa, and 2. the validity of varieties and subspecies within the *Q. pustulosa* species group using the phylogenetic species concept.

(65) THE THREAT OF CLIMATE CHANGE TO FRESHWATER MUSSEL POPULATIONS. **Lee C. Hastie** and **Peter J. Cosgrove.** University Of Aberdeen, Culterty Field Station, Newburgh, Aberdeenshire AB41 0AA, Scotland UK. Tel: 01358 789631, Fax: 01358 789214, hastiel@abdn.ac.uk

It is now widely accepted that changes in climate are occurring around the world and that the effects on different ecosystems will vary, depending on the extent and nature of these changes. In northern Europe, the most recent and conservative estimates predict that average rainfall will increase significantly, along with dramatic storm events and large-scale flooding in the next 50-100 years. Already in north-west Scotland, there is evidence that significant changes in the hydrological behaviour of rivers occurred during the late 1980s. These include new maximum flood records, increases in frequencies of high flow occurrence and greater annual run-off. The rivers in this area are a global stronghold of the endangered freshwater pearl mussel, *Margaritifera margaritifera* , and there is concern that a number of internationally important populations of this species will be threatened by these changes. For example, large floods have been shown to adversely affect local mussel populations, and although these stochastic events were historically rare, there is evidence to suggest that they may now be occurring more often as a result of climate change. In this presentation, we provide quantitative and anecdotal data of the effects of large floods on Scottish *M.margaritifera* populations, investigate the direct and indirect threats posed by suggested climate scenarios, and discuss the general implications of climate change for the conservation management of threatened freshwater mussel populations and their habitats.

(66) USE OF TRANSPLANTED *ELLIPTIO COMPLANATA* AS BIOINDICATORS OF HABITAT QUALITY. **Daniel A. Kreeger**[1], **Catherine M. Gatenby**[1], and **Deborah Raksany**[1].
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Like their marine counterparts, freshwater mussels can serve as sentinel bioindicators of habitat quality. As a natural extension of programs that monitor existing populations, transplanted mussels offer great promise as a tool for examining the quality of suspect waters and for assessing the viability of possible re-introductions to reclaimed areas. Our first objective was to determine whether the eastern elliptio (*Elliptio complanata)* could be successfully transplanted between streams in a common watershed, the Delaware River drainage. Our second goal was to examine whether the subsequent health of mussels relocated to different areas could be used to gauge relative differences in habitat quality of the receiving waters. Mussels were collected from the Brandywine River, Chester, Co. PA and were relocated to the Manatawny Creek, Montgomery Co., PA. Adult mussels were stocked in groups of 16 to nylon-mesh cages. Four cages were deployed into suitable mussel habitats at 3 locations in the Manatawny Creek: below Manatawny Dam, in the impounded reach above the dam, and 1 mile above the impoundment. Mussels were similarly deployed in the Brandywine as a control for handling stress. The transplant was performed 1 d prior to removal of the Manatawny Dam. Following dam removal, 3 mussels were collected from each cage at 30, 60, and 90 d; the remaining animals will be collected at 9 mos. Mussels were examined for body size, condition index, and tissue biochemical composition (protein, lipid, carbohydrate). Success of the transplant was evaluated by comparing the health of caged mussels in the Brandywine to non-

transplanted mussels in the Brandywine. We also contrasted the health of mussels in the Manatawny with caged mussels in the Brandywine to assess habitat conditions in the Manatawny. To determine if the dam removal process affected *E. complanata*, we compared health of caged mussels above and below the dam.

(67) MICROSATELLITE DNA MARKERS IN *LAMPSILIS ABRUPTA*: A MOLECULAR TOOL TO HELP BIOLOGISTS MAXIMIZE GENETIC DIVERSITY IN CAPTIVE POPULATIONS, EVALUATE THE SUCCESS OF AUGMENTATION PROGRAMS, AND IDENTIFY POPULATION STRUCTURE.
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In light of the nearly unprecedented pace at which unionid species are diminishing, conservation efforts should be focused on protecting the fundamental constituent of biological diversity - genetic diversity. The increased use of cultured unionids for supplemental stocking underscores the need to understand the genetic composition of natural and managed populations. To help avoid inbreeding and outbreeding pitfalls, knowledge of the amount of genetic diversity present within wild and captive groups and a thorough understanding of the evolutionary relationships among geographic populations of the species are required. The pink mucket *Lampsilis abrupta* is a declining unionid species that has been under the protective auspices of the Endangered Species Act (ESA) since 1976. *L.abrupta* is the focus of considerable artificial propagation. However, no information exists on the relatedness among wild geographic populations or the levels of genetic variation that exist within the captive broodstock used for propagation. Codominant genetic markers are required to fully assess introgression, population structure, gene flow, and kinship (i.e., parentage). We report the development of a suite of polymorphic microsatellite DNA markers in *L. abrupta*. We will discuss how the variation detected can be used to maximize genetic diversity in *L. abrupta* culture programs, demonstrate the utility of unique multilocus microsatellite DNA genotypes as a marker to assess augmentation programs, describe how the markers are to be used in the assessment of genetic population structure within and among selected geographic populations, and test the cross-species utility of these markers in other Lampsilis species.

(68) RECRUITMENT AND OTHER DEMOGRAPHIC CHARACTERISTICS IN THREE MUSSEL COMMUNITIES.
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We sampled three "healthy" mussel communities for two years to determine recruitment and other demographic features that might be characteristic of self-sustaining populations. Number of adult mussels was stable from year to year for seven species (*Elliptio arca*, *Fusconaia cerina*, *Pleurobema decisum*, and *Quadrula asperata* at two sites in the Sipsey River, AL, and *Quadrula pustulosa* and *Amblema plicata* at one site in the Little Tallahatchie River, MS). In contrast, *Corbicula fluminea* fluctuated significantly among years and between rivers; density was higher at both Sipsey River sites in 2000 than in 1999, but this pattern was reversed in the Tallahatchie River. Unionid recruitment varied among species, years, and sites, but was similar to trends in C. fluminea density. Overall, recruits comprised from 0-60 % of populations (mean = 19%). Recruit density for all species combined was higher at both Sipsey River sites in 2000 than in 1999; again this pattern was reversed in the Little Tallahatchie River. *Corbicula fluminea* populations showed length-frequency distributions typical of short-lived, fast-growing organisms with high annual mortality. In contrast, unionid length-frequency distributions described long-lived, slow-growing organisms with low annual mortality. Unionid length-frequencies varied among years, species, and sites, but in general were not dominated by strong year classes. Distributions for many species approached normality, suggesting constant, low levels of recruitment and that individuals of many age classes accumulate in intermediate length classes. Notable exceptions were *E. arca* and *Q. pustulosa* which experienced order of magnitude differences in recruitment between years. Our results indicate that large-scale factors may influence recruitment success for multiple species throughout a river, but these influences may vary substantially among river systems. Unionid mussel populations may be able to survive extended periods of low recruitment but likely cannot sustain excessive adult mortality, thus presenting management challenges typical for long-lived organisms.

(69) EFFECTS OF DROUGHT ON FRESHWATER MUSSELS IN COASTAL PLAIN TRIBUTARIES OF THE FLINT RIVER, SOUTHWEST GA. **Paula Johnson** and **Stephen Golladay**. Jones Ecological Research Center, Route 2 Box 2324, Newton, GA 31770. 912 734-4706. pjohnson@jonesctr.org or sgolladay@jonesctr.org

We conducted weekly monitoring of mussel survivorship and habitat conditions at nine locations in the lower Flint River Basin, southwest Georgia, during extreme drought conditions. Stream habitat and mussel community responses to drought were not uniform across our study sites, reflecting the variable nature of hydrologic conditions in the region during the study period. Native mussel species demonstrated a range of tolerances to dissolved oxygen (D.O.), water depth, and temperature fluctuations. Riffle-dwelling and rare mussel species were more sensitive to drought conditions than widespread, common species. Unionid mortality peaked when flow velocity at the substrate surface fell below 0.01 m/s. Most species survived D.O. levels from 2-5 mg/L for short periods, however *Elliptio crassidens*, *Lampsilis subangulata* and *Medionidus pencilatus* were identified as extremely sensitive to hypoxic conditions, and *Pleurobema pyriforme* was identified as very sensitive. *Elliptio complanata* and *Villosa vibex* withstood long term (>20 d) emersion.

(70) A SURVEY OF ALLOZYME VARIATION AMONG *GONIOBASIS* POPULATIONS INHABITING ATLANTIC DRAINAGES OF THE SOUTHEASTERN UNITED STATES. **R. T. Dillon** & **A. J. Reed**. Department of Biology, College of Charleston, Charleston, SC 29424. (843)953-8087. DillonR@cofc.edu

Over the last two centuries, intensive agricultural practices have eliminated populations of benthic organisms, such as the pleurocerid snail *Goniobasis catenaria*, from many rivers and streams draining to the Atlantic in North Carolina, South Carolina, and Georgia. We estimated gene frequencies at 8 polymorphic enzyme loci in 12 populations of *Goniobasis* from this region: 4 populations of *G. proxima* from the western Piedmont, 5 populations of *G. catenaria catenaria*, 1 population of *G. catenaria postellii*, and 2 populations of *G. catenaria dislocata* from the coastal plain. The fit to Hardy-Weinberg expectation was good within all populations of both species (F_{IS} = 0.042 *proxima*, 0.035 *catenaria*), while levels of interpopulation divergence were high (F_{ST} = 0.461 *proxima*, 0.564 *catenaria*). In spite of slightly overlapping geographic distributions, and instances of striking similarity between the two species in shell morphology, *G. proxima* and *G. catenaria* were quite distinct genetically (average values of Nei's D near 1.0) with no evidence of hybridization. So although their ranges are fragmented into numerous isolated and genetically distinct populations, both species remain broadly recognizable across states, drainages, and physiographic regions. [Pleuroceridae, *Goniobasis*, *Elimia*, Carolina, Georgia, protein electrophoresis, allozymes, population genetics.

(71) RELEASE OF JUVENILES OF THE WAVEYRAYED LAMPMUSSEL (*LAMPSILIS FASCIOLA*) TO A FISH HATCHERY RACEWAY: A COMPARISON OF TECHNIQUES. **S. D. Hanlon** and **R. J. Neves**. Virginia Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife Sciences, Virginia Tech, Blacksburg, VA 24061. shane_hanlon@ncsu.edu, mussel@vt.edu

Two experiments were conducted releasing juveniles of the wavyrayed lampmussel (*Lampsilis fasciola* Rafinesque, 1815) to a fish hatchery raceway, to determine the best time of year and developmental stage to release mussels to natal streams. In the first experiment, newly metamorphosed juvenile mussels were released during June, September and March. Juveniles released in June experienced a gradual decline in survival rate, with 50% survival after 72 days and stable survival thereafter up to 200 days. Juveniles released in September and March experienced high mortality within the first month, and were unsuccessful in surviving the cool water conditions typical of those seasons. Temperature was strongly associated with growth; thus, juveniles released in June exhibited considerably greater growth than those released in September and March. Fall and spring survival values, and shell length-frequency data, suggest that overwinter survival is size-dependent. In the second experiment, infested fish (IF), newly metamorphosed juveniles (NMJ) and juveniles cultured for 1 month (CJ) were released to determine the most appropriate life stage for releasing juveniles to streams. Mean growth (± SE) was 2.47 mm ± 0.02, 1.86 mm ± 0.02, and 1.34 mm ± 0.02 for CJ, NMJ and IF, respectively. Significant differences in growth were found among all release methods ($p < 0.0001$). Survival among release methods was not statistically different because of high variability within each method. High mortality from predacious fish was presumably the cause of this variability. In the absents of predation, juvenile mussels experienced 82.2% (± 3.6) survival at 90 days. Results of these experiments suggest that growth of juveniles varies considerably, depending on the time of year and their level of development upon release to streams.

(72) THE EFFECT OF PHYSICAL FACTORS ON GLOCHIDIAL RELEASE PATTERNS OF UNIONID MUSSELS IN THE ASHUELOT RIVER, NEW HAMPSHIRE. **Barry J. Wicklow**. Department of Biology, Saint Anselm College, 100 Saint Anselm Drive, Manchester, NH O3102-1310. 603 641-7163. bwicklow@anselm.edu

Unionid mussels have complex life cycles with stages that may overlap temporally and, at times, spatially but show different degrees of vulnerability to environmental stress. In this study I used drift net sampling to determine glochidial release phenologies of *Alasmidonta heterodon, Alasmidonta undulata, Strophitus undulatus* and *Elliptio complanata.* These species occur downstream of the Surry Mountain flood control dam in the Ashuelot River, New Hampshire. I used *in situ* monitors to record changes in flow, light intensity, and temperature. Glochidia of *A. heterodon* and *S. undulatus* were released intermittently beginning in late winter (water temperature 1º C), ending in late spring (water temperature near 20º C). Release of *A. undulata* glochidia began in late April and continued to late June whereas *E. complanata* glochidia were released from mid-May to early July. Results indicate weak or no correlation between glochidial release and changes in light intensity or temperature but a strong correlation between extreme high flows and the timing of glochidial discharge by *A. heterodon.* Glochidia are released after peak flows when flows moderate. This pattern may be explained by (1) dilution and rapid displacement of discharged glochidia downstream during extreme floods or (2) as a result of a behavioral, flow-induced glochidial discharge delay that is triggered by extreme flow. Juveniles of *A. heterodon* may begin to be released from host fish as early as mid-April and are easily dislodged from sediments by turbulence and swept downstream. Thus they are exposed to a series of extreme flood release events from the Surry Mountain Dam during an especially vulnerable life stage. Extreme episodic flooding resulting from unregulated water releases from dams may disrupt mussel life cycles by exposing larvae and juveniles to flood-induced damage, mortality, or displacement downstream to potentially unfavorable habitat. As a consequence, mussel populations may experience reduced recruitment rates, decreased population densities, and local extinctions.

(73) BROOD REDUCTION AS A REPRODUCTIVE STRATEGY IN SPHAERIUM STRIATINUM. **Mark A. Beekey**. Department of Biological Sciences. University of Delaware,Newark, DE 19716. mbeekey@udel.edu

Understanding factors which affect reproductive output of native freshwater bivalves is important when considering conservation and re-introduction efforts. Numerous life history studies indicate bivalve populations exhibit high degrees of inter- and intra-specific variation. Environmental conditions are most likely responsible for variation in life histories. However, in *Sphaerium striatinum*, brood reduction is a common trait exhibited by every population. Brood mortality may result in the loss of up to 97% of offspring parents initially produce. Yet studies investigating factors which regulate brood reduction and secondarily, what mechanisms are responsible for brood mortality are lacking. Although brood mortality is often indicative of costs associated with brooding,brood reduction may offer certain advantages to parents and offspring. My research indicates brood reduction is regulated by size limited brood capacity, variation in resource levels, and size-dependent offspring survivorship. Offspring size at independence is the bottleneck to reproductive output in this species. The mechanisms responsible for brood reduction are developmental failure, hatching asynchrony, and sibling competition. The evolution of brood reduction in *S. striatinum* is the result of phylogenetic constraints associated with the evolution of reproductive strategies in freshwater bivalves.

(74) LATITUDINAL CLINE IN GLOCHIDIAL METAMORPHOSIS THRESHOLD TEMPERATURES IN *LAMPSILIS CARDIUM*. **G. T. Watters, S. H. O'Dee & S. W. Chordas.** Museum of Biological Diversity & Ohio Biological Survey, The Ohio State University, 1315 Kinnear Road, Columbus, OH 43212. Watters.1@osu.edu

Recent studies have shown that there is a threshold temperature below which glochidia will not transform. Because many mussel species have extensive latitudinal ranges, it is of interest to ask whether there are latitudinal trends in this threshold. Decreased thresholds in northern populations would be needed to confer the same growth period during the first year as those of more southerly populations. This study determined the threshold metamorphosis temperatures for individuals of the widespread mussel *Lampsilis cardium* from Michigan, Ohio and Arkansas populations on the host Largemouth Bass. We found that threshold

metamorphosis temperatures increased with decreasing latitude, representing a latitudinal cline in threshold temperatures. Michigan mussels metamorphose at a lower temperature than do the Arkansas mussels, allowing them to experience a similar growing season. Ohio mussels were intermediate in their threshold temperature. This study has serious implications for the conservation and management of freshwater mussels. Recovery plans for endangered species often involve relocating individuals between different latitudes. The result of this relocation may not have the desired effect. Using *Lampsilis cardium* as a surrogate endangered species we see that transplanting Michigan individuals to Arkansas would result in early metamorphosis, the effects of which are not understood. Conversely, transplanting Arkansas mussels to Michigan may delay metamorphosis, certainly deleterious to the mussels. Many rare and endangered species have wide historical ranges. We urge that great care be given to transplantation efforts to ensure that such "conservation" plans do not put these species in even greater peril.

(75) HOST FISH SUITABILITY AND POPULATION DEMOGRAPHICS OF THE ENDANGERED TAN RIFFLESHELL (*EPIOBLASMA FLORENTINA WALKERI*) IN VIRGINIA. **S. O. Rogers***, Arkansas Field Office, USFWS, 1500 Museum Road, Suite 105, Conway, AR 73032, **R. J. Neves**, Virginia Cooperative Fish and Wildlife Research Unit, Virginia Tech, Blacksburg, VA 24061, and **B. T. Watson**, North Carolina Wildlife Resources Commission, 205 Cloverdale Drive, Durham, NC 27703. Susan_Rogers@fws.gov, mussel@vt.edu, watson@ncdial.net.

The federally endangered tan riffleshell (*Epioblasma florentina* walkeri) is restricted to only one reproducing population in Indian Creek of the upper Clinch River. To compare the suitability of various populations of its host, the fantail darter (*Etheostoma flabellare*), specimens from four drainages were collected and infested with glochidia. The number of juvenile mussels obtained from fantail darters collected from Indian Creek (= 59.22 10.01) was significantly higher than those transformed on fantail darters from the Roanoke River (= 9.45 10.64). Numbers of juveniles that transformed on fantail darters collected from Elk Garden (Clinch River tributary) and South Fork Holston River were not significantly different from those of either Indian Creek or Roanoke River. Variation in transformation success supports the hypothesis that host fish suitability is mediated by varying immune responses, and that coadaptation of sympatric host fish and mussel populations seemingly enhances compatibility. Using Schumacher's modification of Schnabel's maximum likelihood estimator, the population of tan riffleshells in Indian Creek is approximately 2000 adults. Sex ratio and size frequency distribution of males and females were not significantly different. Maximum age in the population, determined by thin-sectioning of valves, is 11 years; and roughly 70% of the population is less than age 6. This small but reproducing population is threatened by two coal mines in the headwaters of Indian Creek.

(76) LIFE HISTORY ASPECTS OF THE ENDANGERED DROMEDARY PEARLYMUSSEL, *DROMUS DROMAS*. **Jess W. Jones** and **Richard J. Neves.** Virginia Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife Sciences, Virginia Tech, Blacksburg, VA 24061. vtaquaculture@hotmail.com

Aspects of the reproduction, age class structure, growth, fish hosts, and juvenile culture were determined for the endangered dromedary pearlymussel (*Dromus dromas*) in the Clinch River, Tennessee. Female *D. dromas* were gravid from October through June, indicating the species is bradytictic. Glochidia are contained in conglutinates that are red to white in color and resemble freshwater leeches or flatworms in appearance. Conglutinates are 20-40 mm in length and are released through the excurrent aperture. An estimate of fecundity, obtained by determining mean number of mature glochidia in 4-6 conglutinates from each of four females, ranged from 55,110 to 253,050 glochidia per mussel. Sixty-six valves of *D. dromas*, aged by thin-sectioning ranged from 3 to 25 years. Annual growth averaged 5 mm/yr through age 10 and decreased to about 1.2 mm/yr thereafter. Of nineteen fish species tested, ten hosts were identified through induced infestations of glochidia on the following fish: black sculpin (*Cottus baileyi*), greenside darter (*Etheostoma blennioides*), fantail darter (*Etheostoma flabellare*), snubnose darter (*Etheostoma simoterum*), tangerine darter (*Percina aurantiaca*), blotchside logperch (*Percina burtoni*), logperch (*Percina caprodes*), channel darter (*Percina copelandi*), gilt darter (*Percina evides*) and Roanoke darter *(Percina roanoka*). Newly metamorphosed juveniles were cultured in non-recirculating aquaculture systems within dishes containing substratum of <105 µm (fine sediment), and fed the green alga *Scenedesmus* sp. every 2 days. Survival of 2,810 newly metamorphosed juveniles after 1-2 wk was 836 (29.7%), which were released in 1999 in the Clinch River, Hancock County, Tennessee.

(77) KETTLE RIVER DAM REMOVAL: IMPACTS OF SEDIMENT ON DOWNSTREAM MUSSEL POPULATIONS. **Shawn L. Johnson**. Minnesota Department of Natural Resources, 1221 E. Fir Avenue, Fergus Falls, MN 56537. 218 739-7449. shawn.johnson@dnr.state.mn.us

The damming of rivers has severely impacted native mussel assemblages across North America. As such, the increasing number of dams being removed represents an opportunity to restore mussel populations and their habitats. While benefiting river ecosystems, a major concern with dam removal is the release of sediments from the reservoir to downstream habitats. An 80-year accumulation of sediment (primarily sand) behind the Kettle River Dam in east-central Minnesota was mobilized into the stream channel when the dam was removed in 1995. An ongoing study is monitoring changes in mussel populations and their habitats as this sand moves through the river system. Prior to removal, the downstream mussel community was described (e.g., species composition and relative abundance, presence of rare species, and habitat preferences). Fifteen mussel species were identified, including seven state listed species (one endangered, two threatened, and four special concern species). Mussel densities were highest in habitats with a mix of coarse substrates (gravel to large boulder), moderate depths (80-150 cm), and moderate velocities (20-50 cm/s). After the dam was removed, mussel densities declined dramatically in these habitats as the coarse substrates were covered by sand. Overall mussel density has continually declined following dam removal, from 5.3 mussels/m^2 in 1994 to 0.6 mussels/m^2 in 2000. These results highlight the need for developing strategies to minimize the release of sediment to downstream habitats when removing dams.

(78) A MOLECULAR PHYLOGENY OF THE GENUS *LITHASIA*. **Russell L. Minton**, Ecology and Systematics, University of Alabama, Box 870345, Tuscaloosa, AL 35487. (205) 348-0380. into001@bama.ua.edu

The family Pleuroceridae are gill breathing, operculate snails found in North America and Asia, which reach their greatest diversity in the southeastern United States. *Lithasia* Haldeman, 1840 occurs in the Ohio, Wabash, Cumberland, Tennessee, and Mississippi River drainages. A study of *Lithasia* is important because of the conservation status of pleurocerids in North America. Like many other freshwater invertebrate groups, pleurocerids are experiencing declines in the number of species and individuals because of river impoundment, habitat degradation, and poor land-use practices. Despite their importance as a large component of freshwater systems, little effort has been made to understand the systematics within the family. This lack of understanding hinders conservation and management. The majority of work treating *Lithasia* has concentrated on the taxonomy of the genus and synonymizing nominal species using shell characters, and not on resolving relationships within the group or among other pleurocerid genera. I present a phylogeny of all currently recognized *Lithasia* species, including putative sister taxa (*Leptoxis* and *Io*), based on partial cytochrome oxidase I mtDNA sequences. A discussion of the genus and species, along with *Lithasia*'s position among the pleurocerids, is presented.

(79) INVASION OF THE CLONAL CLAMS: CORBICULA IN THE NEW WORLD. **Diarmaid Ó Foighil**, **Taehwan Lee** and **Sirirat Siripattrawan**. Museum of Zoology, University of Michigan, Ann Arbor, MI 48109-1079. diarmaid@umich.edu

The exotic freshwater clam *Corbicula* has established itself throughout much of the Americas. Although relatively well-studied, there has been little consensus on the systematic status of New World populations. We have genetically characterized replicate samples of New World *Corbicula* morphotypes and representatives from the Old World generic range of *Corbicula* for a mitochondrial gene fragment. Three groupings of New World genotypes were encountered and all three produce biflagellate sperm, a convenient marker for clonality in freshwater *Corbicula*. Two of the three occurred in both North and South America samples and were identical to, orwere minor variants of, haplotypes encountered in the Japanese triploid androgenetic *C. leana* and a Korean sample of triploid ameiotic *C. fluminea*.samples. This clonal lineage has apparently undergone an enormous New Worldrange extension over the past 80 years which is underpinned by a surprisingly narrow genetic base. A third New World *Corbicula* genotype, detected only in South America, was nested within the Australasian clade but was distinct from our limited sampling of Old World *Corbicula* mitochondrial diversity. Our results show that New World Corbiculalineages are genetically heterogeneous clones and caution against a blanket application of clonal lineage-specific ecophysiological datasets.

(80) BRIDGES, RIVERS AND MUSSELS: HOW PENNDOT DEALT WITH ENDANGERED SPECIES AND INFRASTRUCTURE PROJECTS. **A. Zawisa**, Pennsylvania Department of Transportation, Environmental Analysis Division, Forum Place, Harrisburg, PA. 17101. 814 765-0588. toniz_dot@yahoo.com.

Prior to the state mussel survey by Bogan and Proch, PennDOT was unaware of the presence of endangered mussel species near any of their bridge projects. The impact this had on the transportation agency was significant. In addition to the dilemmas of project delays and unprecedented levels of detail in the review of bridge design alternatives, there was the problem that this agency had not dealt with this sort of aquatic problem before. The agency needed to quickly develop new partnerships with agencies, private consultants and individuals with expertise in malacology. These experts assisted the agency in: educating its executives and engineers; developing sampling designs, developing relocation monitoring plans; and developing a positive coordination partnership with the United States Fish and Wildlife Service. A process was established for the collection and analysis of data for use in evaluating bridge alternatives for the purposes of minimizing harm to these species. This process continues to undergo modification as our knowledge of these unionids increases. For the process to develop to a point of comfort for the transportation agency more research, studies, coordination and multi-partner efforts will be necessary. The transportation agency sponsored a regionally specific research workshop to address the mussel issue in March 2000 with the purpose of identifying research needs and potential funding opportunities. The top five research needs identified are being advanced.

ABSTRACTS
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(81) RESOURCE PARTITIONING BETWEEN NICHE SPECIES: DETERMINING FOOD RESOURCES AND TROPHIC LEVEL INTERACTION BETWEEN FRESHWATER UNIONIDS AND ZEBRA MUSSELS. : **S.J. Nichols**, US Geological Survey-Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI 48105. 734-214-7218. S_Jerrine_Nichols@usgs.gov.

Food web dynamics of zebra mussels (*Dreissena polymorpha*) and a multi-species unionid community in a Michigan stream were surveyed in order to determine food preferences, resource partitioning and degree of interspecific competition. Sampling was done from March 1996-1997 using a combination of techniques including gut content, carbon and nitrogen stable isotope ratios, and tissue biochemical analysis. Gut contents showed that zebra mussels and all species of unionids appear to utilize same food resource, the <28µ fine particulate organic matter (FPOM). All bivalves were equally omnivorous, removing similar proportions of detritus, picoplankton, and phytoplankton from the FPOM. However, food assimilation as shown by stable isotope ratios varied significantly. Bacterial carbons dominated the soft tissue stores and by inference, diet, of most species of unionids. In contrast, zebra mussels and *Cyclonais tuberculata* were herbivorous, with tissue stores dominated by algal carbons. Trophic status as determined by nitrogen ratios also differed significantly. Nitrogen ratios were distributed along a gradient indicating some unionids were truly secondary consumers (e.g. *P. grandis*) while *Cyclonais tuberculata* and zebra mussels were true primary consumers. Although zebra mussels were more herbivorous than unionids in this small river, zebra mussel impact on unionid nutrition and food web dynamics was still substantial. While the food web in this river is detrital, not algal dominated, algae are one of the main sources for phytosterols that are critical to unionid nutrition. Continued removal of algae by large numbers of the herbivorous zebra mussels will alter food web dynamics to a greater extent than previously seen by the unionid community.

(82) FRESHWATER MUSSEL SURVEY OF THE UPPER DELAWARE SCENIC AND RECREATION RIVER. **W. A. Lellis[1], D. R. Hamilton[2], J. C. Cole[1],** and **A. L. Drummond[1].** [1] U.S. Geological Survey, Northern Appalachian Research Laboratory, RD 4, Box 63, Wellsboro, PA 16901. (570) 724-3322. National Park Service, UDSRR, RR 2, Box 2428, Beach Lake, PA 18405. lelliswm@usgs.gov.

A qualitative freshwater mussel survey was conducted of the main stem Delaware River within the National Park Upper Delaware Scenic and Recreational River (UDSRR) during the summer 2000. A continuous survey of the entire 73.4 mile stretch from below Hancock, NY to above Port Jervis, NY was accomplished by visual observation and hand-counting of mussels within approximate 200 meter sections while snorkeling downstream. In general, observers snorkeled straight-line transects from the upstream to the downstream border of each section, but unique habitats, channels, and eddies were also investigated. Pools were snorkeled to approximately 10 meters depth. A total of 596 sections were surveyed with a total search time of 851 hours (average 11.5 search hours per river mile). Eight species of unionids were identified, including *Elliptio complanata* (181,741 total individuals; 98.711% of mussel fauna), *Anodonta implicata* (2,075; 1.127%), *Pyganodon cataracta* (145; 0.079%), *Strophitus undulatus* (109; 0.059%), *Alasmidonta undulata* (15; 0.008%); *Alasmidonta heterodon* (13; 0.007%), *Alasmidonta varicosa* (13; 0.007%), and *Margaritifera margaritifiera* (3; 0.002%). *A. heterodon* were located from north of Equinunk, PA to south of Callicoon, NY and were generally associated with shallow water near islands. *M. margaritifera* were found just south of Hancock, NY below the confluence of the East and West Branches. *A. varicosa* were scattered throughout the survey area. A quantitative quadrat survey will be conducted on a subsample of sections during the summer 2001 to estimate total mussel population size within the UDSRR.

(83) AN ASSESSMENT OF POTENTIAL CONTAMINANT EFFECTS ON THE FLORIDA APPLE SNAIL IN CENTRAL FLORIDA WETLANDS. **Ruessler, D.S.[1], Sternberg, R.S.[2], Wieser, C.M[1], Darby, P.[3]** and **Gross, T.S.[1,]** [1]USGS-BRD-Florida Caribbean Science Center, 7920 N.W. 71st Street, Gainesville, Florida 32653-3071. 352-378-8181 Ext. 401, Fax: 352-378-4956. [2]College of Veterinary Medicine, Department of Physiological Sciences, University of Florida, Gainesville, FL. [3]University of west Florida, Pensacola, FL.

The long-term goal of the current project is to develop the Florida apple snail (*Pomacea paludosa*) as an indicator of ecosystem health and model for contaminant and endocrine-disrupting effects. The objectives were to develop and validate procedures for evaluating the health and reproductive status of apple snails using a body condition index (BCI), tissue sex steroid concentrations and tissue glycogen content. Procedures have been developed and validated for evaluating body condition (BCI) using soft tissue and shell wet weights as well as assays to detect tissue sex steroid concentrations and glycogen. Results demonstrate significant concentrations of the sex steroids: estradiol, progesterone and testosterone, as well as gender and age differences. Differences were also observed between sites for tissue sex steroid and glycogen concentrations. These procedures will enable a seasonal evaluation of sex steroid concentrations and comparison with histological assessments of sex and status, as well as, an ability to determine if natural populations of apple snails that are exposed to agricultural chemicals, such as endocrine disruptors, exhibit differences in endocrine or health status endpoints from un-exposed populations. Together, these efforts test the hypothesis that endocrine disrupting contaminants affect the reproductive function and physiological health of the Florida apple snail.

(84) SEXUAL DIMORPHISM IN A WISCONSIN UNIONID SPECIES. **J. P. Jass** & **J. Glenn**. Invertebrate Zoology Section, Milwaukee Public Museum, Milwaukee, WI 53233. 414-278-2761, jass@mpm.edu

Sexual dimorphism in the unionid *Lampsilis siliquoidea* [Fatmucket] was studied using museum specimens collected across Wisconsin between 1973 and 1977. Data on seven shell traits were gathered for each specimen: 1) width, 2) height, 3) length overall, 4) anterior-to-beak length of the right valve, 5) thickness of the right valve, 6) presence or absence of color rays, and 7) sexual morph. Comparison of males and females revealed statistically significant differences between ratios derived from the morphometric shell traits.

(85) EDUCATION AND OUTREACH FOR THE FEDERALLY ENDANGERED CAROLINA HEELSPLITTER IN GOOSE CREEK. **T.L. Moore**. North Carolina Wildlife Resources Commission, Nongame and Endangered Wildlife Program, 3119 Shenandoah Avenue, Charlotte, NC 28205. mooret1@mindspring.com.

The Carolina heelsplitter (*Lasmigona decorata*) is the most critically endangered mussel species of North Carolina. Goose Creek in Union County is one of only six remaining population sites for the Carolina heelsplitter. The goal of the education and outreach plan is to develop awareness of the Carolina heelsplitter, educate people on threats to the mussel, and to encourage them to take protective action. The education and outreach plan targets citizens who live in or very near the 42 square mile subbasin of Goose Creek. Various resource tools (factsheets, posters, postcards, magnets, slides, live mussels, and activities) are used and tailored to specific audiences to convey messages about the Carolina heelsplitter and ways in which people can protect it. Over this past year, the education and outreach effort has had many challenges and successes. Citizens have responded both positively and negatively to freshwater mussels and endangered species in general. Informing citizens through education and outreach, and developing responsible attitudes toward aquatic resources is not a simple task. The effort has required patience, persistence, and constant reevaluation of objectives and methods.

(86) SURVEYS OF THE UNIONIDAE OF THE KALAMAZOO RIVER, MICHIGAN. **Renee Sherman Mulcrone**, University of Michigan, Museum of Zoology, Mollusk Division, Ann Arbor, Michigan. Charles Mehne, DVM, Animal Clinic, Kalamazoo,Michigan.

Mussels were qualitatively and quantitatively surveyed on the Kalamazoo River drainage in southwestern Michigan in 1997 and 2000. Study sites in 1997 emphasized upstream areas of the mainstem and tributaries. Sites surveyed in 2000 were on the mainstem, at areas contaminated with PCBs. These areas are within the 80 miles designated on the National Priorities List (NPL) or Superfund. Live individuals were found for 16 species at all sites while only shells of nine species were found. Within the NPL sites, eleven species had reproducing populations (mussels aged three years or less were found). The most commonly collected species at upstream sites was the spike, *Elliptio dilatata*. The mucket, *Actinonaias ligamentina* was most common in mid-stream sites. No state or federally threatened or endangered species were historically found on the Kalamazoo River. However, the elktoe, *Alasmidonta marginata*, a state listed special concern species was found in our survey within the NPL sites. The purple wartyback, *Cyclonaias tuberculata*, historically found on the lower portion of the river, was not found alive at any of the sites. PCBs do not have significant detrimental effects on mussels, nor do they bio-accumulate in mussels. However, remediation activities by the potentially responsible parties (PRPs) will likely affect populations by directly killing mussels or further altering habitat.

(87) A FIFTY-YEAR HISTORY OF THE MUSSEL FAUNA OF THE SAVANNAH RIVER IN THE VICINITY OF THE U.S. DEPARTMENT OF ENERGY SAVANNAH RIVER SITE, GEORGIA AND SOUTH CAROLINA, U.S.A.. **Raymond W. Bouchard**[1], **Samuel L. H. Fuller**[2], **Roger L. Thomas**[1], **J. William Littrell**[3], **Paul F. Overbeck**[1], and **R. William Bouchard, Jr**[4]. [1] The Patrick Center for Environmental Research, The Academy of Natural Sciences, 1900 Benjamin Franklin Parkway, Philadelphia, PA 19103. (215) 299-1114 (RWB), -1105 (RLT), -1072 (PFO). Bouchard, Thomas or Overbeck@acnatsci.org; [2] SE 17th Street, Ocala, FL 34471; [3] Westinghouse Savannah River Site, Building 735-16A, Aiken, SC 29808. (803) 725-4211. Bill.littrell@srs.gov; [4] Department of Ecology and Evolutionary Biology and Central Plains Center for Bioassessment, Kansas Biological Survey, University of Kansas, Lawrence, KS. (785) 864-7699. Bouchard@falcon.cc.ukans.edu.

The Academy of Natural Sciences has been surveying the aquatic biota of the Savannah River in the vicinity of the Department of Energy Savannah River Site since 1951 to monitor impacts, if any, from the facility. The study area lies downriver from the Fall Line zone and the city of Augusta, Georgia. Collections from several stations have generally taken place every three to five years from 1951 to 1993 and yearly since 1997. The most abundant mussels in the 1990s were *Elliptio congaraea*, *Toxolasma pullus*, *E. icterina*, *E. producta*, and *Villosa delumbis*; the least abundant taxa were *Alasmidonta triangulata*, *Anodonta couperiana*, *Lampsilis cariosa*, *Pyganodon cataracta*, and *Uniomerus carolineanus*. The remaining moderately common mussels consisted of *L. splendida*, *Utterbackia imbecillis*, *E. complanata*, and *E. roanokensis*. Only *Strophitus undulatus* and *E. fraterna* were not collected in recent years. In the period from 1951 through 1965, *L. cariosa* was one of the dominant mussel species in the river but started declining before the 1972 investigation. *Elliptio complanata* (possibly consisting of more than one taxon) was dominant from 1951 through 1960. Two species that are presently common, *E. congaraea* and *E. icterina*, did not become so until 1960 and 1965, respectively. Taxa that were always rare include *A. triangulata*, *S. undulatus*,and *E. fraterna*. *Villosa delumbis* and *L. splendida*, rare in 1951-52, have increased in abundance over time and presently rank fifth and sixth, respectively, in numbers collected during the 1990s. *Toxolasma pullus* was unknown from the study area until 1962 and is now one of the most common species. Over this fifty-year period, changes in relative abundance and the faunal composition have been ascribed to (1) habitat differences, (2) channel modifications, (3) siltation, (4) river discharge patterns, (5) the introduced Asian clam, and (6) sampling effort. No impacts from the Savannah River Site on the mussel fauna have been noted to date.

(88) GUIDELINES FOR THE TREATMENT OF PREDACIOUS FLATWORMS (MACROSTOMUM SP.) DURING CULTURE OF JUVENILE FRESHWATER MUSSELS (BIVALVIA: UNIONIDAE). **Lora L. Zimmerman**(1) (presenting), **Doug G. Smith**(2), and **Richard J. Neves**(1). (1)Virginia Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0321 (2)Department of Biology, University of Massachusetts, Amherst, Massachusetts 01003-5810. (540) 231-5703. lzimmerm@vt.edu, dgsmith@bio.umass.edu, mussel@vt.edu

Flatworms of the genus *Macrostomum* have been observed to be voracious predators of newly metamorphosed juvenile freshwater mussels. Toxicity tests were performed with formalin (paracide-F, 37% formaldehyde) to determine appropriate levels of treatment for eradicating these flatworms from host fish tanks. Results indicate that a 1 hour shock treatment of 250 mg/L formalin or a 3 day continuous exposure to 20 mg/L of formalin is adequate to kill adult *Macrostomum*, but is not lethal to fish. Observations indicate that a single treatment is not adequate to kill *Macrostomum* eggs; therefore, a second treatment after 3 days is probably necessary in order to kill newly hatched flatworms. Newly metamorphosed freshwater mussels were exposed to similar concentrations of formalin, and were negatively affected. It is recommended that any fish purchased from fish hatcheries (especially hatcheries that raise non-native fish or plants), with the intent of using them for mussel propagation, be quarantined and treated prophylactically to avoid the infestation of freshwater mussel culture systems with predacious flatworms.

(89) FRESHWATER BIVALVE MOLLUSKS OF THE SANGHA RIVER, CENTRAL AFRICAN REPUBLIC. **James R. Cordeiro**. Division of Invertebrate Zoology, American Museum of Natural History, Central Park West at 79th Street, New York, NY 10024. cordeiro@amnh.org

The aquatic non-marine invertebrate fauna of African tropical regions is largely unknown. Mollusks are primarily documented from specimens collected by the American Museum of Natural History (AMNH) Belgian Congo Expedition of 1909-1915 and works by D.S. Brown and G. Mandahl-Barth, among others. Virtually all of the bivalve records are based on empty shells alone. Of the 500+ lots (21,000 specimens) of mollusks catalogued at the AMNH from the Belgian Congo Expedition, only 20 lots (approx. 700 specimens) are whole-preserved. A preliminary study focusing on systematically surveying the freshwater Mollusca of the Dzanga-Sangha region of the Central African Republic was conducted by the AMNH in June and July 1998. Specimens were collected along the Sangha River and its tributaries in this region. Despite extremely high water conditions following a particularly heavy rainy season, 20 lots comprising 6 species encompassing the families Etheriidae, Mutelidae, Sphaeriidae (= Pisidiidae), and Unionidae were collected. The greatest number of specimens and diversity of species was collected per unit effort when a variety of collecting means was employed. These included hand-picking, net collecting, sieving, benthic grab sampling, mussel raking, snorkeling, and temporary fluvial impoundment with subsequent water removal (an unusual but highly effective method employed by local peoples for sustenance). A follow-up to the expedition involved training World Wildlife Fund personnel from Central African Republic on scientific inventory methods including sampling methodology and the relevance of museum collections to conservation activities. Follow-up surveys are anticipated.

(90) AFFECTS OF FLOW ON JUVENILES OF *LAMPSILIS RADIATA RADIATA* REARED IN AN INDOOR RECIRCULATING CULTURE SYSTEM. **S. D. Hanlon**[1], **J. F. Levine**[1] and **T. W. Savidge**[2]. [1]Department of Farm Animal Health and Resource Management, North Carolina State University, Raleigh, NC 27606. [2]North Carolina Department of Transportation, Project Development and Environmental Branch, Raleigh NC 27611. shane_hanlon@ncsu.edu, jay_levine@ncsu.edu

Juveniles of the eastern lampmussel [*Lampsilis radiata radiata* (Gmelin, 1791)] were artificially propagated and reared in a recirculating culture system using 3 different flow regimes to identify affects of different flow rates on growth and survival of juvenile mussels. A recirculating culture system was designed and constructed with 6 separate flow channels. Water velocity for each channel was maintained at either high (~ 4.2 cm/sec), medium (~ 2.3 cm/sec) or low (~ 0.7 cm/sec). Juveniles were fed once a day, 5 times a wk, with a combination of two algal species (*Scenedesmus sp.* and *Chlorella vulgaris*). Growth and survival were compared among juveniles reared under different flow regimes after 62 days. Mean

growth (±1 SD) was 76.5 ± 15.8 mm, 74.5 ± 16.5 mm, and 78.67 ± 17.4 mm for juveniles exposed to high, medium, and low flow respectively, and was not statistically different among groups. Survival (±1 SD) was variable among groups with 13.0 ± 2.6, 4.3 ± 3.5, and 12.0 ± 6.4%, for high, medium, and low flow respectively with no statistically significant differences among groups. These preliminary results suggest that, within the range tested, different flow rates in our rearing system do not substantially affect juvenile mussel growth or survival.

HABITAT CHARACTERIZATION AND CURRENT STATUS OF *LAMPSILIS STRECKERI* (FRIERSON 1927) IN THE MIDDLE FORK LITTLE RED RIVER, ARKANSAS. **Rebecca Winterringer**[1], **Jerry L. Farris**[2], **John L. Harris**[3], and **Cristin D. Milam**[4]Ecotoxicology Research Facility, Arkansas State University, P.O. Box 599, State University Arkansas 72467, phone (870) 972-2570 fax (870) 972-2577. beccawint@smail.astate.edu, jfarris@navajo.astate.edu, jlhd170@ahtd.state.ar.us, cmilam@navajo.astate.edu

Lampsilis streckeri is a federally endangered freshwater mussel known to occur in approximately 14.5 km of the Middle Fork of the Little Red River, Arkansas (Stone and Van Buren Counties). Specific data regarding habitat of *L. streckeri* are generally lacking. Status surveys were conducted in August 1992 in which *L. streckeri* was located by both snorkeling and diving techniques. Qualitative surveys to identify *L. streckeri* occurrence upstream of its historical range were conducted in Fall 2000. *L. streckeri* shell material was observed at three sites and live *L. streckeri* were observed at two sites upstream of the previously known historical range. Stream and riparian habitat were characterized at ten sites, five of which were located upstream of previously documented *L. streckeri* range. Each site was scored according to US EPA's Rapid Bioassessment Protocol (RBP) for Wadeable Streams. Scoring criteria included channel condition, riparian zone composition, bank stability, water appearance, nutrient enrichment, barriers to fish, available fish cover, pool presence and composition, invertebrate habitat, canopy, embeddedness, and observed invertebrates. Additionally, sediment and water quality parameters were measured for each site. Habitat criteria scores were modified from the RBP and each criterion ranged from zero to ten, with a score of ten being optimal. The habitat scores for a site range from optimal (153-170), sub-optimal (103-119), marginal (51-85) and poor (0-34). Site scores ranged from 86.5 to 141. Statistical analysis (ANOVA) yielded no significant difference among overall site scores (α=.05, p-value = .754).

(92) MONITORING THE IMPACTS OF ZEBRA MUSSELS ON NATIVE MUSSELS IN THE OHIO RIVER. **Patricia A. Morrison**, U. S. Fish and Wildlife Service; Ohio River Islands NWR; P. O. Box 1811, Parkersburg, WV 26102-1811; 304-422-0752; patricia_morrison@fws.gov. and **Wayne L. Davis**. Kentucky Department of Fish and Wildlife Resources; #1 Game Farm Road, Frankfort, KY 40601; 502-654-7109 X 365; wayne.davis@mail.state.ky.us

The Ohio River is home to more than 50 species of native freshwater mussels, including recent and historic records for 14 federally endangered species. Zebra mussels *(Dreissena polymorpha)* first entered the lower Ohio River in 1991, and have since spread into upstream reaches. Beginning in 1995, federal, state and private partners have been working together to track the status of zebra mussels and assess their impact on native mussels along the mainstem Ohio River. Zebra mussel densities have shown a cyclical pattern of "boom" and "bust," but native mussels are experiencing significant declines in density, biomass, and recruitment. Native mussel mortality (expressed as percent fresh-dead animals) exceeds 40% at some of the sites. Published models attempt to predict at what threshold native mussels experience significant increases in mortality and, finally, extirpation, based on zebra mussel density and mean infestation intensity. This paper compares recent field results to those predicted values. In addition to the objective of providing a river-wide assessment of the zebra mussel problem, the data gathered provides critical information needed for management of the imperiled native fauna--identifying populations most at risk, and the "threshold" for rescue or relocation of at-risk species.

(93) BASELINE ASSESSMENT, PRE-CONSTRUCTION SURVEYS AND MITIGATION FOR RARE, THREATENED, AND ENDANGERED MUSSELS FOR THE CONSTRUCTION OF A NATURAL GAS PIPELINE IN MAINE. **Mary T. McCann** and **Gil A. Paquette**, Duke Engineering & Services, Inc, 500 Washington Ave., Portland, ME 04103. Phone: (207) 775-4495; E-mail: mtmccann@dukeengineering.com

With many freshwater mussel populations declining, documentation and protection of rare, threatened, and endangered mussels have become increasingly important. In 1996, Maritimes & Northeast Pipeline, L.L.C., proposed constructing a 400-mile pipeline in the state of Maine. Paucity of survey and mitigation techniques for rare mussels and over 600 waterbody crossings created a challenge for both consulting biologists and state and federal agencies. Working with state and federal agents, Duke Engineering & Services (DE&S) developed an innovative approach to assess impacts to rare mussels at waterbody crossings. Streams with a minimum 25-foot average width at the crossing were selected for evaluation. Based on anticipated impacts from pipeline construction in waterbodies, surveys were stratified into four levels of intensity: entire search of the proposed right-of-way (ROW); transects 50 meters downstream of the edge of the ROW; timed search 50-150 meters downstream of the ROW; and cursory search of species composition and habitat 5 meters upstream of the ROW. Sixty-five waterbodies were surveyed or field evaluated for the presence of rare mussels in 1997 and 1998. DE&S, in consultation with state agents, developed a mitigation measure of conducting pre-construction surveys specific to each waterbody where target species were found. Pre-construction surveys and relocations were conducted just prior to construction on a total of 4 waterbodies in 1999. A total of 71 state listed mussels (26 *Alasmidonta varicosa*, 44 *Alasmidonta undulata*, and 1 *Strophitus undulatus*) and many common mussels were relocated. Finally, all data was reported to MDIFW to add to their database. Due in part to the success of the mussel baseline assessment surveys and mitigation, Maritimes and Northeast received a letter of commendation from the Commissioner of the Maine Department of Environmental Protection for their teaming effort with various resource agencies and to complete the project with minimal environmental impacts.

(94) DEVELOPING A SAMPLING STRATEGY TO EXAMINE POPULATION TRENDS FOR THE ENDANGERED WINGED MAPLELEAF MUSSEL, *Quadrula fragosa*. **Daniel J. Hornbach**[1], **Mark Hove**[1,2], **Jill Medland**[3] & **Randy Ferrin**[3]. [1.]Dept. Biology, Macalester College, St. Paul, MN 55105 [2.]Bell Museum, University of Minnesota, Folwell Ave., St. Paul, MN 55108 [3.]St. Croix National Scenic Riverway, St. Croix Falls, WI 54024. Hornbach@macalester.edu

Sampling for endangered species is an extremely difficult task, especially in riverine systems where sampling involves SCUBA in areas of high current and low visibility. There are also statistical issues surrounding sampling rare species. Managers must decide the level of population change and the degree of statistical confidence that should be used to trigger management actions. If population density is low it takes a large sampling effort to detect small changes with great confidence. In 7 years of quantitative sampling in the area of the St. Croix River, MN & WI where the endangered *Q. fragosa* is found, we collected 4594 mussels from 30 species (mean density=22 mussels/m^2). Only 5 *Q. fragosa* were found. Given the rarity of *Q. fragosa*, it would require over 15,000 0.25 m^2 quadrat samples to detect a significant change in the population density of *Q. fragosa* with any degree of certainty. Given the difficulties of sampling this rare species quantitatively a two-step sampling approach is suggested. 1. Sample the entire mussel community, quantitatively, to examine whether there are major shifts in mussel density. 2. Qualitatively sample the Interstate Park area to determine whether the proportion of the community that *Q. fragosa* constitutes changes over time. To focus the sampling effort we will limit sampling to mussels that contain pustules. Of these species, *Q. fragosa* constitutes 3.7% (95% confidence range=2.5-5.0%). We developed a resampling model that allowed us to examine the statistical power obtained with a range of sample sizes. Based on this model if *Q. fragosa* constitute as little as 2.5% of the mussels with pustules, we could detect a 20% decline in the proportion of the population constituted by *Q. fragosa* with 85% confidence and 85% power with a sample size of 5500. The resampling model corresponds well with classical models of determining sample size.

(95) SCANNING ELECTRON MICROSCOPY ON THE GLOCHIDIUM AND GLOCHIDIAL ENCYSTMENT OF ANODONTA ARCHAEFORMIS ON THE HOST FISH. **Kye-Heon Jeong**, **Yong-Seok Lee** and **Yun-Bo Shim** Division of Life Sciences, College of Natural Sciences, Soonchunhyang University, P.O. Box #97 Asan, Choongnam 336-600, Korea

A scanning electron microscopic study on the glochidium and glochidial encystment of *Anodonta archaeformis* on the host fish *Carassius carassius* was conducted. The shape of the glochidium is apparently subtriangular and its average size is 270'- x 260'- x 145'-. The glochidial shell valves are of the same size, kept together by a ligament of 50.4'- in lenght and 5.5'- in width. Each of the glochidial shell valves has a long hooks studded with many spines on the superior face. A large area of at the apex of the valve surrounding the base of the hooks is provided with numerous small spines which become progressively smaller towards the periphery of the area. There are numerous niches scattered all over the surface. The glochidial shell valve is consisted of two layers. The mantle cells line the glochidial shell valves and some of hair cells are observed. A larval thread is 2.3'- in diameter. In the artificial infection of the glochidia to one of the natural hosts, *Carassius carassius*, it takes about three to four hours to encyst the glochidia with epithelial cells of the fish fins. The method of encystment is by cell migration from the neighboring epithelium.

(96) EVALUATION OF UNIONID SAMPLING TECHNIQUES IN A GULF COASTAL PLAIN STREAM **H. N. Blalock-Herod**, U.S. Geological Survey, 7920 NW 71st Street, Gainesville, FL 32653. holly_blalock-herod@usgs.gov

Several methods have been used to sample unionids, such as random hand searching, hand searching quadrats, and excavation in conjunction with sieving of quadrats. Many of these methods have been evaluated in Interior Basin streams with high unionid densities. This study was conducted in a blackwater tributary of a Gulf Coastal Plain stream with low unionid densities. I evaluated the efficiency of hand searching quadrats versus excavation and substrate sieving of the same quadrats. I also examined the influence of collector bias and water depth on unionid sampling. In this study, hand searching and excavation with sieving resulted in the same species composition. However, hand searching was biased for larger unionids. Unionid abundance, especially juvenile abundance, was underestimated when hand searching was used alone. In deeper water, hand searching alone underestimated the abundance of unionid species. The results of this study also suggest that in shallow water, collector experience does not affect efficiency; however, in the deeper water, where diving was necessary, collectors with experience in blackwater diving and sampling had greater sampling efficiency. This study supports the results and conclusions of several other studies conducted in Interior Basin rivers with high unionid densities and Atlantic Coast streams with low unionid densities. In Gulf coastal streams, monitoring projects concerned with fluctuations in unionid densities and presence or absence of juvenile unionids should use excavation and sieving of substratum within quadrats to accurately assess the mussel community. If the project objective is to identify species diversity or locate rare species within a stream reach, hand searching is an appropriate method but experienced mussel collectors may be necessary to conduct the sampling.

(97) RECOVERY OF FIVE SNAKE RIVER SNAILS IN SOUTHERN IDAHO. **G.V. Wood** and **S. D. Duke**. U.S. Fish and Wildlife Service, 1387 S. Vinnell Way, #368, Boise, ID 83709. jeri_wood@fws.gov.

Taylorconcha serpenticola and *Lanx* sp. were listed as threatened or endangered under the Endangered Species Act in 1992. Threats associated with these species included the loss and fragmentation of the free-flowing habitats in the Snake River, deteriorating water quality and competition from an exotic species, the New Zealand mudsnail (*Potamopyrgus antipodarum*). Three of the five listed snails also occur in Snake River tributary cold-water complexes that are threatened by future development and diversions. In 1995 the U.S. Fish and Wildlife Service issued a final recovery plan. Recovery objectives Five species of Snake River snails (*Pyrgulopsis idahoensis, Valvata utahensis, Physa natricina*, of the plan are to reduce and eliminate known threats and to restore and protect viable, self-reproducing colonies of the five listed species within defined geographic ranges over a 250 kilometer stretch of the Snake River. Research and monitoring efforts conducted by the Bureau of Reclamation and Idaho Power Company are increasing our understanding of the distribution of the five species; future efforts will aid in our understanding of certain limiting factors and life history traits to help further recovery of the listed species.

(98) A SIMPLE TRAP FOR COLLECTING FRESHWATER MUSSEL GLOCHIDIA DURING CAPTIVE PROPAGATION. **W. A. Lellis** and **K. M. Playfoot**. U.S. Geological Survey, Northern Appalachian Research Laboratory, RD 4, Box 63, Wellsboro, PA 16901. (570) 724-3322. lelliswm@usgs.gov

A simple trap was developed for collection of glochidia released by captive freshwater mussels maintained in glass aquaria. Each trap consists of three units: a screened PVC ring, a support panel, and an upwelling tube. The ring consists of a 6 cm length of PVC pipe with nylon mesh attached to one side with fiberglass resin. The diameter of the pipe can be varied to accommodate different material loads, and the mesh size varied to the anticipated diameter of the glochidia or conglutinate to be collected. We have found a 15 cm diameter ring with 100 µm mesh adequate for *Elliptio complanata*, and 250 µm mesh adequate for *Strophitus undulatus.* The support panel consists of a section of polystyrene egg crate diffuser panel sized to fit the aquarium. The egg crate is clipped to two sides of the aquaria with four plastic-coated wire hooks, and the ring set on top. The depth of water within the ring can be adjusted by expanding or contracting the clips. We have found 1-2 cm water depth sufficient for Atlantic slope unionids. The tube is constructed from an undergravel filter hydro lift sized to place the opening approximately 10 cm above the mussels. Water is circulated from the culture tank through the ring using an airstone placed within the tube. This system has been successfully used for several years to collect glochidia for propagation and to study the reproductive cycle of adult mussels.

(100) DEVELOPMENT AND VALIDATION OF PROCEDURES FOR MONITORING ENDOCRINE AND REPRODUCTIVE FUNCTION IN FRESHWATER MUSSELS. **T.S. Gross, C.M. Wieser, N. J. Kernaghan**, and **D.S. Ruessler.** USGS-BRD Florida Caribbean Science Center, 7920 N.W. 71st Street, Gainesville, Florida 32653-3071. Tel: 352-378-8181 Ext. 401. Fax: 352-378-4956, Tim_s_gross@usgs.gov

Considerable evidence has indicated that a wide variety of environmental stressors such as habitat degradation and environmental contaminants can adversely alter or disrupt reproductive and endocrine function in exposed wildlife populations. Most of these data have focused on effects in fish and/or other macro-faunal vertebrates. The development and validation of procedures for monitoring endocrine and reproductive function in freshwater invertebrates, such as freshwater mussels, would be critical to evaluations of reproductive health. The current study included the development and validation of procedures for monitoring endocrine function in the freshwater mussel, *Elliptio buckleyi*, as well as an evaluation of seasonal reproductive cycles. Body tissues were collected from adult mussels and extracted for endocrine analyses. Standard RIA procedures were utilized for androgen, progestin, and estrogen analyses. Sex steroid concentrations were compared to histological assessments of sex and status to validate and develop these procedures. These efforts have detected significant concentrations of estradiol, progesterone and testosterone as well as gender differences and seasonal cycles. The development of these procedures for use with freshwater mussel species will be critical to the elucidation of potential habitat and contaminant effects on reproductive function, as well as evaluations of reproductive status and function for critical populations and species.

(101) UNIONID POPULATIONS IN THE REMOTE WILDERNESS LAKES OF ISLE ROYALE NATIONAL PARK, LAKE SUPERIOR. **S.J. Nichols***, **E. Crawford**, **J. Allen, G. Black**. US Geological Survey-Great Lakes Science Center, 1451 Green Rd., Ann Arbor, MI 48105. 734-214-7218. S_Jerrine_Nichols@usgs.gov.

While Isle Royale National Park is best known for its moose and wolves, the inland lakes contain dense unionid populations that have remained relatively undisturbed by humans since the mid-1930's. In the summer of 2000, eight inland lakes were surveyed by SCUBA divers from the U.S. Geological Survey and the National Park Service to determine unionid species composition, distribution and status. Most of the lakes contain dense populations of native clams (up to 25/m^2), extensive colonies of gigantic sponges (up to 1.5 m^2), large algal clouds (1.5 m x 3 m), and leeches 0.3 m long. Only two unionid genera were found, *Lampsilis* and *Pyganadon*, represented by four "species", *L. luteola, L. radiata, P. cataracta, P. grandis. Pyganadon cataracta*/*P. grandis* hybrids also occur. The high boreal lakes in the inland part of the island are dominated by *P. cataracta*, while *P. grandis* and the *Lampsilis* spp. are present only in the lower lakes

connected to Lake Superior. Substrate composition in some lakes limits population densities of both genera, with young clams often occupying and growing in older, non-living shell. Moose feeding and stomping activities severely disturb littoral sediments in many lakes, and the impact of this continual substrate disturbance on the unionids is under investigation. While species diversity is limited, this park presents a rare opportunity to work with aquatic communities that have been protected from human activities and watershed changes over the last 60 years, and in lakes where exotic species, even the common carp, do not exist. The isolation of Isle Royale and its designation as a wilderness area makes research on aquatic systems difficult, since all sampling gear, dive equipment, etc., must be backpacked to each site over miles of primitive trails. However, this isolation will prove a key factor for ensuring the future survival of the unionids, and other unique invertebrate assemblages.

(102) HOST IDENTIFICATION FOR *STROPHITUS UNDULATUS* (BIVALVIA: UNIONIDAE) FROM THE UPPER SUSQUEHANNA RIVER BASIN, PENNSYLVANIA. **E. S. Gray, W. A. Lellis, J. C. Cole** and **C. S. Johnson**. U.S. Geological Survey, Northern Appalachian Research Laboratory, RD 4, Box 63, Wellsboro, PA 16901. (570) 724-3322. ellen_gray@nps.gov or lelliswm@usgs.gov

Hosts for *Strophitus undulatus* were identified through laboratory infestations. Mussels were collected from Pine Creek, Tioga County, Pennsylvania and held in tanks with temperature and photoperiod adjusted to natural conditions. Potential hosts were collected from areas devoid of mussels within the Susquehanna drainage and infected by submersion in aerated buckets containing freshly-released conglutinates. *Strophitus undulatus* exhibited a low degree of host specificity. Transformation occurred on 15 of 22 species examined, including Atlantic sturgeon, blacknose dace, brook trout, central stoneroller, common shiner, largemouth bass, longnose dace, rainbow trout, red-spotted newt, river chub, rock bass, slimy sculpin, tessellated darter, yellow perch, and yellow bullhead. American toad tadpoles, Atlantic salmon, banded darter, bluntnose minnow, cutlips minnow, marginated madtom, and white sucker did not act as hosts. Recovery of juveniles occurred 12-41 days post-infestation at 13-17_C, with duration of attachment declining with increasing temperature. No metamorphosis was observed without a host present.

(103) UNIONID FAUNA WITHIN A SELECTED REACH OF THE COOSA RIVER, ALABAMA **Jeffrey J. Herod[1], Holly N. Blalock-Herod[1], Nikki J. Kernaghan[1], D. Shane Ruessler[1], James D. Williams[1], Timothy S. Gross[1],** and **J. Malcolm Pierson**[2]. [1] U.S. Geological Survey, 7929 NW 71st Street, Gainesville, FL 32653, [2] Alabama Power Company, P.O. Box 2641, Birmingham, AL 35291. jeff_herod@usgs.gov

The unionid fauna within a 30 km reach of the old Coosa River channel between the Weiss Reservoir spillway dam and the Weiss hydropower dam, Cherokee and Etowah counties, Alabama, was examined using qualitative and quantitative techniques. Species composition was qualitatively determined at 12 locations within the river reach. At four of these sites, quantitative techniques were used to determine species composition, estimate species densities, and assess baseline population characteristics. A preliminary glycogen analysis for an endemic species, *Amblema elliottii*, was conducted at the four sites to provide a baseline health assessment. Twenty species were found in the qualitative searches, including two federally listed species: *Lampsilis altilis* and *Pleurobema decisum*. Eleven species were found in the quadrat samples: including *P. decisum*. Recent recruitment was documented for several species. Glycogen levels varied significantly among the four sites. Extent of species ranges varied within this reach of the Coosa River.

(104) STATUS OF THE SNUFFBOX, *EPIOBLASMA TRIQUETRA*, AND THE MUDPUPPY MUSSEL, *SIMPSONAIAS AMBIGUA*, IN CANADA. **Ernest T. Watson, Janice L. Metcalfe-Smith** and **Joanne Di Maio**. Environment Canada, National Water Research Institute, Burlington, ON, Canada, L7R 4A6. Janice.Smith@cciw.ca

The Committee on the Status of Endangered Wildlife in Canada began to consider molluscs for listing in 1994, and the first four species of freshwater mussels appeared on the list of Canadian Species at Risk in 1999. We have now completed assessments of the Snuffbox and Mudpuppy Mussel. In Canada, the Snuffbox previously occurred in Lake Erie, Lake St. Clair and the Ausable, Sydenham, Thames, Grand and Niagara rivers in Ontario (31 records), and the Mudpuppy Mussel was known from the Detroit and Sydenham

rivers (3 records). Both species are presumed extirpated from the zebra mussel-infested waters of the Great Lakes and their connecting channels. To determine their status in the rivers, we surveyed 65 sites in 1997-1999. For the Snuffbox, 7 live specimens, 3 fresh shells and 10 weathered shells were found at 7 sites in a 50 km reach of the East Sydenham River. Capture rates were lower than in the 1960s-70s, suggesting that abundance has declined. Seventeen shells, most of them weathered, were found at 6 sites on the Ausable and 1 site on the Thames River. For the Mudpuppy Mussel, 17 live animals, 42 fresh shells and 30 weathered shells were found at 8 sites in the same reach of the East Sydenham River. Live specimens and fresh shells were 13-49 mm long, suggesting there is ongoing recruitment. A single fresh valve was found in the Thames River. Preservation of water and habitat quality in the agriculturally-impacted Sydenham River will be critical to the continued existence of these mussels in Canada. We have recommended endangered status for both species.

(105) ENVIRONMENTAL, GEOLOGIC AND ANTHROPOGENIC DETERMINANTS OF FRESHWATER MUSSEL (BIVALVIA: UNIONIDAE) DISTRIBUTION IN AN AGRICULTURAL CATCHMENT OF SOUTHEASTERN MICHIGAN. **S.E. Kopplin**, University of Michigan School of Natural Resources and Environment, 424 N. State Street #2, Ann Arbor, MI 48104. (734) 669-9983; (734) 657-8023 skopplin@mich.edu

Knowledge of the current distribution and status of mussel populations is limited in many parts of the country. The goals of this study are to determine the diversity and distribution of freshwater mussels in an agricultural watershed, relate distributions to within-reach and landscape-scale variables, and examine historical changes in mussel diversity along with changes in fish distribution and land use throughout the watershed. During the summer of 2000, freshwater mussel communities and habitat parameters were surveyed at 15 sites in the upper River Raisin watershed. The River Raisin basin is a primarily agricultural catchment located in southeastern Michigan, with a small area in northern Ohio. At each of 15 sites, a 100-m reach was delineated, and timed searches for mussels using glass-bottom aquascopes were done in 10-m intervals. Mussels were identified to species, measured (length, width, height), their age approximated (by counting annuli), and then returned to the stream. In-stream and riparian habitat were quantified, as were flow, temperature and water chemistry. The number of individuals/100m reach ranged from 1-1185, only one site had no living species. Overall, 19 species were found, with extremes of one site with only one species present, to one site with 13 species present. *Lampsilis fasciola* (state threatened) and *Cyconaias tuberculata* (species of special concern in Michigan) were found at four and two sites, respectively. The relationship of mussel distribution to historical patterns and landscape variables will be assessed. Using museum records and GIS, preliminary analysis suggests that present-day distributions are different from distributions recorded in the 1920s, 1950s, and 1970s. Information from this research will aid conservation organizations, management agencies, the University of Michigan, and the public living in the River Raisin watershed by identifying areas for inspection for impacts, as well as for conservation and restoration strategies.

(106) EPILITHIC COMMUNITIES ASSOCIATED WITH TWO DIFFERENT SPECIES OF FRESHWATER MUSSEL (FAMILY UNIONIDAE), IN THE KIAMICHI RIVER OF SOUTHEASTERN OKLAHOMA. **Daniel E. Spooner,** and **Caryn C. Vaughn**. Oklahoma Biological Survey and Department of Zoology, University of Oklahoma, Norman, OK 73019. (405)-325-4034. Dspooner@ou.edu

We experimentally examined epilithic communities on two common mussel species, smooth-shelled *Actinonaias ligamentina* and rough-shelled *Amblema plicata*. Mussels from the Kiamichi River, Oklahoma, were scrubbed clear of all material. Dead shells were also cleaned and weighted with sand to create dummy mussels. Sixty cages were placed in the river each receiving one of five treatments of equal densities: live *A. ligamentina*, live *A. plicata*, *A. ligamentina* shells, *A. plicata* shells, or no mussels. Five replicates of each treatment were pulled at 1 month, 3 months and 5 months. Mussels were scrubbed and the material removed and analyzed for chlorophyll a, AFDM, algal and macroinvertebrate diversity and abundance. After one month, chlorophyll a concentrations were higher on live shells than dummy shells and highest on *A. ligamentina*. After three months, chlorophyll a concentrations were not significantly different, but algal levels were slightly higher on *A. plicata*. Differences between months probably reflect differences in flow regimes (summer drought to fall rain) and species composition over the course of the experiment. Our results indicate that unionids do influence benthic communities, but their influence is context dependent and can be overridden by physical forces.

(107) THE INTRA-SEASONAL NUTRIENT PROCESSING OF FRESHWATER MUSSELS IN A HEADWATER STREAM ECOSYSTEM. **Sara Irie**, Miami University, Pearson Hall, Oxford, OH 45056, (513) 529-3379, iries@po.muohio.edu, **Alan D. Christian**, Miami University, Pearson Hall, Oxford, OH 45056 (513) 524-3036, christad@muohio.edu, **David J. Berg**, Miami University, 1601 Peck Boulevard, Hamilton, OH 45011, (513) 529-3174, bergdj@muohio.edu.

The purpose of this study was to determine the significance of nutrient processing by freshwater mussels in a headwater stream, Big Darby Creek, OH, during the summer of 2000. Nutrient-diffusing clay pots were used to determine nutrient limitation during three sampling periods: early, mid, and late summer. Concurrent nutrient concentrations were determined on stream water and concurrent excretion experiments were performed on two species of freshwater mussels, *Elliptio dilatata* (ED) and *Lampsilis siliquoidea* (LS). Soluble P and N were measured for the water column and excretion experiments. Nutrient limitation experiments indicated that there was no nutrient limitation (N, P, N & P) across three sampling periods. Water column soluble N and P ranged from 0.66- 75.60 µM N/L (as NH_3) and 0.77-1.82 µM P/L, respectively with N:P ratios ranging from <1-52. Early ED N and P production ranged from 100.81-238.13 µM N/L/h and 0.23-1.83 µM P/L/h, respectively with N:P ratios ranging from 100-584. Early LS N and P production ranged from 152.63-330.60 µM N/L/h and 0.69-1.61 µM P/L/h, respectively with N:P ratios ranging from 136-293. Late ED N and P production ranged from 111.19-233.76 µM N/L/h and 0.54-2.32 µM P/L/h, respectively with N:P ratios ranging from 100-300. Late LS N and P production ranged from 116.70-408.021 µM N/L/h and 0.36-2.80 µM P/L/h, respectively with N:P ratios ranging from 114-463. Nutrient limitation experiments indicated that primary production was not nutrient limited, therefore mussels are providing excess N and P to the ecosystem during the summer in Big Darby Creek.

(108) RECOVERY OF THE UPPER ILLINOIS RIVER MUSSEL (BIVALVIA: UNIONIDAE) FAUNA FOLLOWING CATASTROPHIC DISTURBANCE. **Bernard E. Sietman**[1], **Scott D. Whitney**[2], **Daniel E. Kelner**[3], **K. Douglas Blodgett**[4], **Heidi L. Dunn**[5]. [1]Illinois Natural History Survey, 607 E. Peabody Dr., Champaign, IL 61820, [2]U.S. Army Corps of Engineers, Clock Tower Building, Rock Island, IL 61204, [3]Minnesota Department of Natural Resources, 500 Lafayette Rd., St. Paul, MN 55155, [4]The Nature Conservancy, 220 West Main, Havana, IL 62644, [5]Ecological Specialists, Inc., 114 Algana Ct., St. Peters, MO 63376. bsietman@inhs.uiuc.edu

Freshwater mussels were extirpated from the upper Illinois River in the early 1900s after completion of the Sanitary and Ship Canal which diverted Chicago's sewage and other pollutants into the river. During surveys in 1994, 1995, and 1999, we collected 326 individuals of 17 species between river miles 232.0 and 271.2, the reach of river where mussels were extirpated. These are the first documented collections of live mussels from the upper Illinois River in nearly a century, and include six species, *Actinonaias ligamentina*, *Alasmidonta marginata*, *Lampsilis cardium*, *Lasmigona costata*, *Pleurobema sintoxia*, and *Strophitus undulatus*, thought to have been extirpated from the entire Illinois River mainstem, and one species, *Anodonta suborbiculata*, that has recently expanded its range into the upper river. Age structure of the community suggests these mussels began recolonizing in the early 1980s, which coincides with improvements in water quality and an increase in fish species richness. We hypothesize that upper Illinois River tributaries and lower reaches of the Illinois River harbored source populations for the recolonizing mussels. Although the present community is only half as species rich as the historic fauna, these data show that given adequate time and improved conditions, some mussel communities may recover from a devastating disturbance.

(109) ACCUMULATION OF POLYCYCLIC AROMATIC HYDROCARBONS BY UNIONID MUSSELS: COMPARISON TO SEDIMENT AND A PASSIVE SAMPLING DEVICE. **W. A. Watson, W. G. Cope, P. R. Lazaro,** and **D. Shea**. North Carolina State University, Department of Environmental and Molecular Toxicology, Box 7633, Raleigh, NC 27695-7633. (919) 515-5296.
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One of the most important classes of contaminants in urban aquatic environments is polycyclic aromatic hydrocarbons (PAHs). Assessing ecological and human-health risks associated with PAH contamination requires an adequate measure of exposure. Exposure to PAHs is often measured directly in water, sediment and biota; both indigenous and transplanted mussels are used widely as sentinels of aquatic contamination. More recently, passive sampling devices (PSDs) such as semi-permeable membrane devices have been used as an indirect measure of contaminant exposure. Unionid mussels are long-lived (30-60 yr), widely distributed freshwater mussels that are closely associated with aquatic sediments and readily accumulate PAHs. However, little is known about the uptake, elimination, distribution, or accumulation of PAHs in unionid mussels. We transplanted mussels (*Elliptio spp*.) to an urban creek in Gaston County, North Carolina and compared the accumulation of 48 PAHs in mussels, sediment and a PSD consisting of strips of polyethylene (PE). Concentrations of total PAHs ranged from 437-3397 ng/g for mussels, 342-357 ng/g for sediment, 185-194 ng/L for water and 6835-14120 ng for PE strips. Mussels over-predicted the lower molecular weight (petroleum related) PAHs in water compared to sediment, whereas mussels under-predicted the higher molecular weight (combustion related) PAHs in water compared to sediment. This suggests that unionids are accumulating the various PAHs through differing routes of exposure (e.g., uptake of the lower molecular weight PAHs from the water via the gills and the higher molecular weight PAHs from the sediment via the gut) and/or that the higher molecular weight, combustion-related PAHs are less bioavailable to the mussels.

(110) AN EVALUATION OF THE POTENTIAL EFFECTS OF PAPERMILL EFFLUENTS ON FRESHWATER MUSSELS IN RICE CREEK. **Kernaghan, N.J**.*, **Ruessler, D.S**., **Wieser, C**., **Holm, S**., and **Gross T.S**., USGS/BRD/FCSC, 7920 N.W. 71st Street, Gainesville, Florida 32653-3071. Tel: 352-378-8181 Ext. 401. Fax: 352-378-4956. E-mail: nikki_kernaghan@usgs.gov

Adult *Elliptio buckleyi* and *Elliptio icterina,* were exposed to papermill effluent in both a flow-through system and in cages in Rice Creek. In both studies, mussles were exposed in the water column and on the sediment. At test termination sub-lethal effects of exposure to papermill effluent on freshwater mussels were analyzed by several endpoints including; body condition index, glycogen concentrations, sex steriod concentrations, and tissue histopath. No significant differences were observed between mussels exposed to sediments and those exposed to the water column. However, mussels exposed to the 40% and 80% concentrations were determined to have significantly reduced body condition indices and sex steroid concentrations. Furthermore, mussels exposed at 40% and 80% effluent exhibited altered reproductive status and no individuals were observed to be gravid. At test termination, sub-samples of mussels from each treatment group were placed in clean pond environments for three weeks. These mussels were then examined and it was determined that those from the 40% and 80% treatment groups had become gravid. The effect on reproductive status would therefore appear to be reversible, and normal reproductive function may resume when removed from the effluent. These data suggest that freshwater mussels may be a useful indicator of ecosystem health and quality.

(111) TWO-YEAR RESULTS OF A MUSSEL (BIVALVIA: UNIONIDAE) SURVEY OF MINNESOTA. **Daniel E. Kelner[1], Rick A. Hart[2] & Mike Davis[3]**. Minnesota Department of Natural Resources, Division of Ecological Services, [1]500 Lafayette Rd., St. Paul, MN 55155, [2]1601 Minnesota Dr., Brainerd, MN 56401 & [3]1801 South Oak St., Lake City, MN 55981. 651-282-2509.
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We have initiated the first ever statewide freshwater mussel survey in Minnesota. A qualitative sample approach with timed visual and tactile searches was used. During 1999 and 2000, we spent over 1,000 hours searching for mussels at 686 sites in 25 rivers, 64 tributaries, and 7 lakes. To date, mussel surveys in two drainage basins of the Mississippi River; the Missouri and St. Croix, are complete. Surveys have been

nearly completed in the Lower Mississippi River and Lake Superior Basins, and partially completed in the Minnesota, Red, and Upper Mississippi (above St. Anthony Falls at Minneapolis) River Basins, and Pools 1, 2, and 3 of the Mississippi River. Survey work in the southern one-third of the state shows that most streams no longer support their historic complement of mussel species. This loss of species is probably due to poor water quality and habitat degradation. In contrast, tributaries of the St. Croix River support healthy mussel communities of up to 25 live species, indicating sustained quality of the system. The high quality habitats in the St. Croix River Basin are probably the result of less intensive agricultural and urban developments than are found in other drainage basins. The mussel fauna in Pools 1, 2, and 3 of the Mississippi River, once decimated by pollution, appears to be re-establishing itself following improved water quality conditions over the past 15 years**.** Twenty-seven mussel species, most of which were represented by young individuals, were found inhabiting this reach of the Mississippi River. While species richness in the Lake Superior Basin was comparatively low, mussels were abundant and we believe this system's historical complement of species remain intact.

(112) A TECHNIQUE FOR ISOLATION OF BACTERIA FROM FRESHWATER BIVALVES. **Clifford E. Starliper**. USGS, National Fish Health Research Laboratory, 1700 Leetown Road, Kearneysville, WV 25430. (304) 724-4433 cliff_starliper@usgs.gov

One tool in the conservation of freshwater bivalves is a relocation program. Native bivalves are taken from their environment, for example, prior to an advancing infestation with zebra mussels, and then are placed on facilities free of their natural predators. Bivalves are to be maintained and perhaps, propagated, but with the goal of reintroduction at an appropriate future date. Selected safe refuges to maintain bivalves include hatcheries that intensively rear fishes, particularly salmonids e.g. trout. With relocation and subsequent co-culture of fish and bivalves, concerns arose regarding the potential for transmission of pathogens. Studies were initiated to address these concerns. Techniques for isolation of bacteria from fish are well established and widely employed, but information on culture of bacteria from freshwater bivalves is sparse. This study describes a technique to reliably isolate aerobic and facultative anaerobic bacteria from bivalves. Fluid (inside valves and outside soft tissues) and soft tissues (portioned as "gut" and "OT") were collected, weighed, homogenized in peptone-yeast extract, diluted and plated onto primary bacterial isolation media. Soft tissues were surface disinfected with sodium hypochlorite so only the bacteria inside the tissues were isolated. The dilution series employed was effective for isolating bacterial colonies. Bivalves collected from the Ohio River were studied. Total bacterial counts consistently ranged between 1×10^5 and 1×10^6 cfu/g of soft tissue and were dominated by non-fermenters and motile *Aeromonas* spp. Following a relocation, the total counts remained stable, however, the flora profile changed within 24 h.

(113) BASELINE GLYCOGEN LEVELS FOR *ELLIPTIO MCMICHAELI* (CLENCH AND TURNER, 1956); SEASONALITY BETWEEN TWO SITES IN THE CHOCTAWHATCHEE RIVER WATERSHED AND LABORATORY HOLDING**.** **Jeffrey J. Herod, Holly N. Blalock-Herod, D. Shane Ruessler,** and **James D. Williams.** U.S. Geological Survey, Florida Caribbean Science Center, 7920 NW 71st Street, Gainesville, FL 32653;(jeff_herod@usgs.gov)

Describing *Elliptio mcmichaeli* population dynamics at two sites within the Choctawhatchee River Watershed includes demographical data for shell parameters, weights of soft tissue, and seasonality of glycogen. A total of 120 *Elliptio mcmichaeli*, 20 each from the Choctawhatchee River proper and the Pea River for the spring, fall, and holding experiment, were used in glycogen analysis to examine variations within and between populations, and over time. Mussels used in the glycogen analysis were measured and weighed. The fall field and captive samples were compared for both the Choctawhatchee and Pea rivers. Comparison of field and captive samples for the Choctawhatchee River reveal shell length was not significantly different, but the glycogen levels were significantly different. Comparison of field and captive samples for the Pea River found shell length was not significantly different, but the glycogen levels were significantly different. Glycogen concentrations after laboratory holding for 5 months were not significantly different between the two populations. These data are being included into the long-term study involving comparative analysis of *Elliptio mcmichaeli* from two river systems.

(114) LONG-TERM DYNAMICS OF MUSSEL POPULATIONS IN THE ST. CROIX RIVER. **Daniel Hornbach, Mark Hove, Sonya Clarkson, Liz Gilles, Ian Harmon, Erik Nelson, Kelly Paulson, Cristina Salazar, Emily Peters,** and **Jessica Lynch**, Department of Biology, Macalester College, 1600 Grand Avenue, St. Paul, MN 55105; Hove@Macalester.edu.

In the summer of 2000 we quantitatively assessed 4 mussel communities in the St. Croix River. We had sampled these populations at least once before: 1992 at Bayport, 1993 at Osceola, 1995 at Lakeland and 1992, 1995 and 1998 at Interstate Park. Population density was greatest at Interstate Park (average 29-39 mussels/m2), followed by Lakeland (14-18 mussels/m2), Bayport (5-10 mussels/m2) and Osceola (7-9 mussels/m2). Twenty-eight mussel species were found at Interstate Park, with 25, 24 and 16 species at Lakeland, Osceola and Bayport, respectively. The endangered *Lampsilis higginsii* was found at all locations except Bayport and the endangered *Quadrula fragosa* was observed at Interstate Park. The Lakeland location had the highest species diversity (H'=2.0) followed by Osceola (H'=1.88), Interstate Park (H'= 1.87) and Bayport (H'=1.44). Lakeland had 5 dominant species while Bayport and Osceola had 2 dominant species and Interstate Park only had 1 dominant species. Zebra mussels were found at Lakeland. At all 4 locations mussel density was lower in 2000 compared to earlier periods. The most dramatic decline, 51% was at Bayport; other populations declined 22-26%. None of the changes were statistically significant. However, juvenile mussel density (mussels < 30mm), at all locations except Osceola showed a significant decline over the period. Two possible reasons for the decline in juvenile density could be high juvenile mortality, or lack of recruitment. Shell-length frequency diagrams for dominant species show a general lack of recruitment during this time period. Since mussels require approximately 6 years to mature, long periods of low recruitment may be possible. An increase in fine sediments was noted at all locations. Previous studies found neither increased sedimentation nor lack or recruitment above the dam at St. Croix Falls. This suggests that increased sedimentation below the dam may be influencing mussel recruitment or juvenile mussel survival.

(115) FECUNDITY VARIABLES OF SIX SPECIES OF FRESHWATER MUSSELS. **J. Leann Staton[1], Wendell R. Haag[1,2], Melvin L. Warren, Jr.[1], and Gary L. Miller[2].** [1] USDA Forest Service, Center for Bottomland Hardwoods Research, 1000 Front Street, Oxford, MS 38655 and [2] Department of Biology, University of Mississippi, Oxford, MS 38655. whaag@fs.fed.us

We investigated fecundity variables of six species of freshwater mussels from the Sipsey River, AL, Buttahatchee River, MS, and Little Tallahatchie River, MS. Species investigated were *Elliptio arca*, *Lampsilis ornata*, *Medionidus acutissimus*, *Obliquaria reflexa*, *Quadrula asperata*, and *Quadrula pustulosa*. Annual fecundity differed widely among species. Mean annual fecundities (± SE) were 119,243 (±8,661, n = 27) for *E. arca* (Sipsey River), 386,826 (±28,989, n = 19) for *L. ornata* (Sipsey River), 19,667 (±7,458, n = 4) for *M. acutissimus* (Sipsey River), 58,924 (+31,151, n = 4) for *O. reflexa* (Little Tallahatchie River), 10,949 (±760, n = 74) for *Q. asperata* (Buttahatchee and Sipsey rivers), and 26,527 (±2,678, n = 30) for *Q. pustulosa* (Little Tallahatchie River). Fecundity increased with shell length for all species, but slopes of regressions of fecundity on length differed among genera. Fecundity/length relationships were similar for both species of *Quadrula*. No intraspecific differences in annual fecundity or slopes of fecundity/length relationships were observed among five populations of *Q. asperata* in the Sipsey and Buttahatchee rivers or between two populations of *E. arca* in the Sipsey River. Approximate size at first reproduction was 50 mm for E. arca, 65 mm for *L. ornata*, 19 mm for *M. acutissimus*, 22 mm for *O. reflexa*, and 25 mm for *Q. asperata* and *Q. pustulosa*. Our results suggest that life history strategies differ substantially among mussel genera and fecundity traits have likely evolved in concert with differences in host-fish use, host attraction strategy, longevity, and growth rate.

(116) EXPERIENCES OF AN INTER-INSTITUTIONAL TEAM TO CONSERVE MUSSELS IN THE ST. CROIX RIVER. **Richard Baker**, Minnesota Department of Natural Resources, 500 Lafayette Road, St. Paul, MN USA 55155; richard.baker@dnr.state.mn.us.
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Over the last four years representatives from private, state, and federal institutions have been coordinating efforts to conserve the mussel fauna of the St. Croix River. This river supports most of the mussel species that previously occurred in the upper Mississippi River. Consequently the St. Croix River is one of the most important rivers in the region for conservation efforts of the Mississippian fauna. Some of the activities the team has worked on include coordinated studies on mussel relocation, and effects of sedimentary ammonia on mussels, presentations of research results at the St. Croix River Research Rendezvous, endangered species recovery plans, large scale zebra mussel reconnaissance, draft mussel community recovery plan, nutrient monitoring, and streamlined permitting program. Challenges the team faced include temporary loss of team coordinator, team participation of key parties, and meeting logistics to maximize member participation. Practices that have been particularly effective for this group include selecting one agency to coordinate meeting logistics, broad participation to facilitate decision making, and patient and regular communication in support of team activities.

(117) COMPARING EFFICIENCY OF STRATEGIES TO PROCESS FRESHWATER MUSSELS IN DEEP WATER SURVEYS. **J. E. Swift, D. R. Smith, C. D. Snyder, D. P. Lemarié,** and **R. F. Villella**. USGS – Biological Resources Division, 1700 Leetown Road, Kearneysville, WV 25430

Cost is critical in the design and implementation of surveys for endangered freshwater mussels because of the large sample size required for reliable estimates of population parameters. Concern over cost is compounded when sampling in deep-water where SCUBA must be used. We compared cost (i.e., time) to process (i.e., identify and measure) mussels in deep water under 2 scenarios: 1) mussels processed underwater and 2) mussels brought to the surface and then processed. The trials took place on the Allegheny River at East Brady, PA on September 25, 2000 where depth averaged 4 m and visibility ranged from 1 to 2 m. Two divers excavated quadrats every 10 m along 50 m transects oriented roughly parallel to the thalweg. Transect deployment and mussel processing took 19 min less (90% CI: 1 – 37 min) when mussels were processed underwater. Underwater processing reduced cost by over 33%. We conclude that where visibility allows, survey cost would be reduced substantially by having trained divers process mussels underwater.

(118) HOST IDENTIFICATION FOR *ELLIPTIO COMPLANATA* (BIVALVIA: UNIONIDAE) FROM THE UPPER SUSQUEHANNA RIVER BASIN, PENNSYLVANIA. **W. A. Lellis**, **E. S. Gray, J. C. Cole, B. S. White and J. S. Hotter**. U.S. Geological Survey, Northern Appalachian Research Laboratory, RD 4, Box 63, Wellsboro, PA 16901. (570) 724-3322. lelliswm@usgs.gov

Hosts for *Elliptio complanata* were identified through laboratory infestations. Mussels were collected from Pine Creek, Tioga County, Pennsylvania and held in tanks with temperature and photoperiod adjusted to natural conditions. Potential hosts were collected from areas devoid of mussels within the Susquehanna drainage or cultured in the laboratory from egg or fry. Infestation was accomplished by exposing potential hosts to freshly-released glochidia in aerated aquaria for 24 hours. *Elliptio complanata* metamorphosed on American eel, brook trout, lake trout, and mottled sculpin. Juveniles were recovered 18-48 days post-infection at 17-19_C. Glochidia that incubated on hosts for longer periods appeared larger and more developed than those released after a shorter incubation period. No metamorphosis was observed in the absence of a host nor on American toad tadpoles, Atlantic sturgeon, blacknose dace, bluntnose minnow, central stoneroller, common shiner, cutlips minnow, fallfish, longnose dace, marginated madtom, red-spotted newt, river chub, rock bass, shield darter, smallmouth bass, spottail shiner, tessellated darter, or white sucker.

(119) SELECTIVE FEEDING ON ALGAE BY THE RAINBOW MUSSEL (*VILLOSA IRIS*). **Beck, Kevin M. and Richard J. Neves**.. Virginia Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife, Virginia Polytechnic Institute and State University, Blacksburg, Virginia. 540-231-5703. kbeck@vt.edu.

Feeding selectivity of the rainbow mussel (*Villosa iris*) was examined for three age groups (2-3 days old, 50-53 days old, and > 3 years old). The mussels were fed a tri-algal diet consisting equally of *Scenedesmus*, *Nannochloropsis*, and *Selenastrum*. Manual cell counts using a hemacytometer and a bright view phase microscope were conducted to obtain the relative abundance of each algal species over time. After 5 hours, the change in relative abundance for each species was used to record selective feeding behavior. Regardless of age, the mussels positively selected for *Nannochloropsis* (p=0.026, 0.012, and 0.003 for 2-3 days old, 50-53 days old, and > 3 years old, respectfully), and negatively selected for *Scenedesmus* (p=0.01, 0.012, and 0.004). There was a significant difference between the change in relative abundance of *Scenedesmus* and the other two algae species, suggesting that the rainbow mussels preferred *Nannochloropsis* and *Selenastrum* over *Scenedesmus*. Because *Scenedesmus* is considerably larger (> 4x) than the other two species, selectivity presumably is an indication of particle size preference or efficiency.

(120) THE RIVER MANAGEMENT SOCIETY AS A PARTNER IN THE STEWARDSHIP OF MOLLUSK CONSERVATION. **Byron N. Karns**. P.O. Box 401, Taylors Falls, MN 55084 717-483-3284x616. Byron_Karns@nps.gov or prairie@cornernet.com

Mollusk conservation is inseparable from the proper conservation of the habitat in which they live. Freshwater mussels are considered one of the most imperiled groups of fauna in North America (Nature Conservancy, 1997) and essentially are river animals. The greatest abundance and most outstanding diversity occur in larger, more pristine river systems likely to be under some sort of active management. As such, the free exchange of knowledge between those managing habitat and those concerned with the species contained within is crucial. The River Management Society (RMS) is a non-profit organization involved with “the protection and sound management of North America’s river resources” (RMS, 2000). The purpose of the organization is to facilitate positive management actions and policy goals towards rivers and provide instruction and discussion within and among interested parties. To share information and provide contact between the FMCS and RMS, a poster/display of the RMS function and accomplishments will be presented to symposium participants.