FMCS 2007 HABITAT RESTORATION WORKSHOP ABSTRACTS (20070113)

WS 01
WHAT IS UNIONID HABITAT?
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The purpose of this workshop is to gather information on what unionid's need in their physical, chemical, and biological environment, and what techniques can be applied to restoring unionid habitat. When conditions are correct, unionids form concentrations typically known as beds. In a mussel bed, density is typically greater than the surrounding area, and several species and age classes are present. These beds tend to occur under specific hydraulic conditions. Local hydrology is a function of physiographic region, annual flow cycles, and local barriers to flow; which in turn result in substrate type, depth, and current velocity. Mussel bed limits can often be defined by changes in current velocity during high and low discharge periods, substrate stability and compaction, and depth. The Rosgen technique facilitates restoration of physical habitat. Index of hydrological alteration (IHA) examines ecologically significant components of river hydrology. Instream flow incremental methodology (IFIM) relies on a predictable relationship between amount of available habitat and stream discharge. How can these existing models and techniques be used in restoring unionid habitat? The interaction of local hydrology and unionid beds is currently being studied, particularly in large rivers. What have we learned and how can we apply the findings? Water and sediment quality are also important factors in unionid habitat. Although toxicity standards are developed for fish species, unionids seem to be considerably more sensitive to some toxicants than fish and other invertebrates. Toxicity may vary with species and life stage. Also important is the availability of fish hosts, and host habitat and behavior. Through these talks and discussion, we hope to identify research needs and develop a basis for restoring unionid habitat.

WS 02
OHIO RIVER BASIN MUSSEL HABITAT INITIATIVE (OHBMHI)
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Much like the oysters in Chesapeake Bay, freshwater mussels have historically helped keep our rivers clean by filtering and processing enormous amounts of water each and every day. In 2003, we estimated that a bed of 10,000 freshwater mussels could filter approximately 60,000 gallons of water per day, free of charge. Indeed, a typical bed of mussels may contain a much higher biomass than that of other aquatic fauna living in the same reach (Strayer et al. 1994). Thus, beds of mussels have the potential to regulate biogeochemical cycling and water quality in streams to a greater extent than any other fauna. As benthic burrowers, freshwater mussels also help to stabilize the river bottom. As chronic environmental problems are addressed and abated through conservation efforts and environmental legislation, the key to the aquatic habitat restoration puzzle will be reintroducing beds of mussels back to the system for the services they provide in maintaining aquatic ecosystem integrity. When large mussel beds have been restored, the improved water quality and increased sediment stability will provide critical habitat for a

wide array of aquatic organisms including fish. A Ohio River Basin Mussel Habitat Initiative was discussed by the Ohio River Valley Ecosystem Team in October, 2006. It was decided to move forward in establishing a new fish habitat partnership under the umbrella of the National Fish Habitat Initiative and NFH Action Plan. What sets this partnership apart from other fish habitat partnerships is the recognition of a mussel bed as habitat. Indeed the mission of the OHBMHI is to re-establish freshwater mussel beds as a key component of habitat restoration efforts aimed at providing clean water and healthy fish populations in our nation's rivers and improve the quality of life for the American people. I will provide a summary of goals and objectives for the OHBMHI action plan, and discuss actions necessary for this partnership to be given recognition by the National Fish Habitat Board.

WS 03

THE INDICATORS OF HYDROLOGIC ALTERATION (IHA): SOFTWARE FOR UNDERSTANDING HYDROLOGIC CHANGES IN ECOLOGICALLY-RELEVANT TERMS

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The Indicators of Hydrologic Alteration (IHA), a software program developed by The Nature Conservancy, provides useful information for those trying to understand the ecological implications of a particular flow pattern or water management scenario. This program has been used by more than 1,000 water resource managers, hydrologists, ecologists, researchers and policy makers from around the world. The IHA examines over 67 ecologically relevant statistics derived from daily hydrologic data. The statistics produced by the software can be used for two main purposes. First, they can be used to assess changes in natural flow regimes over time. So for example, statistics can be calculated to examine the difference in flow regimes before and after construction of a dam. Second, in conjunction with information on the relationship between the natural flow regimes and ecological processes, they can be used to set environmental flow targets and to assess how well these targets are met by a particular management scenario. Version 7 of this software program, which was recently released, includes some significant improvements over earlier versions, the most important of which are 34 new flow statistics. These new statistics quantify the frequency, magnitude, duration, timing, and rise and fall rates for five different Environmental Flow Components (EFCs) (extreme low flows, low flows, high flow pulses, small floods, and large floods). The EFC statistics are an improvement over the earlier set of flow statistics used in the IHA because they can be more readily related to ecological processes and the behavior of biota, and hence are more appropriate for setting environmental flow targets.

WS 04

MODELING UNIONID HABITAT IN A LARGE RIVER: APPROACHES AND CRITICAL DATA NEEDS.

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Large floodplain rivers are fundamentally different from smaller systems in their lateral complexity and hydrology. However, conditions that constitute unionid mussel habitat in large rivers are poorly understood, greatly limiting our understanding of the effects of anthropogenic alterations and evaluation of the potential effects of management actions (e.g., water level drawdown, island construction). We modeled the abundance and spatial distribution of mussels in the Upper Mississippi River (UMR) using physical and hydraulic variables. Analyses of data from mussel beds at small (0.4 km) to large (38 km) spatial scales indicated that computed hydraulic variables (e.g., shear stress, Froude number) were more predictive than measured physical variables (e.g., depth, velocity, substrate type). Classification tree models of mussel presence, which had a prediction success of ~74%, were largely driven by shear stress and substrate stability, but interactions with physical variables (e.g., slope) were important. Moreover, discharge-specific models suggested that episodic events such as droughts and floods were more important in structuring mussel distributions than conditions during average flows. Geospatial models predicted few mussels in poorly connected backwater areas (e.g., floodplain lakes) and the navigation channel, whereas main channel border areas with high geomorphic complexity (e.g., river bends, islands, side channel entrances) and small side channels were typically favorable to mussels. In addition to suitable habitat, individual-based models indicated that patterns in juvenile settlement, which depend on hydrodynamic conditions after excystment, might be important for predicting locations of mussel beds. Overall, our studies indicate a complex interaction of biotic and abiotic factors acting at various spatial scales, but that certain hydraulic variables can improve our ability to predict their spatial distribution in large rivers. Our research suggests that the interaction of geomorphology and discharge produces a template of hydrophysical conditions in the UMR that could be manipulated by managers to benefit mussel communities.

WS 05

ECOHYDRAULICS AND FRESHWATER MUSSEL AGGREGATE LOCATIONS IN LARGER RIVER SYSTEMS: EMPIRICAL EVIDENCE OF THE REFUGIA CONCEPT AND PROMISING RESEARCH AREAS.

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Freshwater mussel habitat requirements continue to confound researchers and resource managers, partially due to their highly complex life history and the variability of the habitats in which they are found. Attempts have been made to quantify habitat characteristics at the micro-habitat scale with varying degrees of success largely due to the dynamic behavior of habitat characteristics. Efforts to quantify macro-habitat have been more successful at correlating habitat features and mussel bed locations and/or abundances. Until recently, relatively little research has been attempted to assess mussel habitat at the reach scale in larger river systems. The objective of this case study is to explain hydraulic conditions that shape mussel habitats in a large, Delta river in eastern Arkansas. The original purpose of this research was to compare the flow regime between existing high density mussel beds to those that historically had high densities, but don't at this time, to determine if geomorphologic conditions are influencing lower White River mussel assemblages. The findings of this particular study, when compared to previously described meander hydraulics, may provide widely applicable insight to the fundamental habitat characteristics of large river mussel aggregations. Analysis of field data identified lateral and longitudinal differences in the energy regime within a reach. Mean velocity, bed velocity, Froude number, and stream power were all significantly lower ($p<0.10$) in the vicinity of mussel beds than in other areas of meander. The only energy regime differences between present and historic mussel beds were those of shear stress and stream power being higher at historic mussel beds. Lateral and longitudinal differences in the sediment regime, primarily bedload transport, were identified in meanders; an expected outcome as the sediment regime is highly influenced by the energy regime. Mussel bed locations in the lower White River show clear signs of velocity and sediment refugia, which may be rationalized by the core and secondary flow conditions previously described for river meanders. Core and secondary flow pathways largely influence the sediment transport pathways in a meander. However, the core and secondary pathways are likely not static within the channel, rather they may expand, contract, and shift around the channel with changing stage. It is plausible that the conditions created by these pathways act as the keystone physical habitat characteristics of freshwater mussels. However, a better understanding of the factors influencing pathway location, dimension, and intensity are needed along with a much clearer depiction of their relationship to sediment transport. Other promising areas of exploration include planometry of meanders as development stage may better identify viable mussel habitat at the meso-scale. Further, how the respective pathways are influenced by stage levels, ranging from extreme drought to extreme flooding, may provide further insight to habitat viability.

WS 06

INSTREAM FLOW REQUIREMENTS OF MUSSELS

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The Instream Flow Incremental Methodology (IFIM) relies on a continuous, predictable relationship between the amount of useable habitat (a surrogate for population parameters) and stream discharge. Establishing such relationships for target fish species has been conducive to instream flow negotiations. In the past, flow requirements of mussels received far less attention than fish did. The now well-known plight of mussels, the proliferation of water development schemes, and the relicensing of hydroelectric dams have brought a greater focus on the need to set flow regimes conducive to sustaining or enhancing mussel populations. Despite recent advances in determining relationships between complex hydraulic variables and mussel populations, our understanding of the relationships between discharge and various life stages of mussels is rudimentary. Determining these relationships is difficult because mussels can tolerate for short periods dewatering and flood events. Questions regarding instream flow needs for mussels are often framed within the context of minima, but higher discharges also can profoundly affect mussel populations. Historically, recruitment of most species below the Green River Dam has been limited. Since 1999, the annual discharge regime of the Green River has varied considerably as a result of a 2-yr-long drought, followed by average and above average rainfall years. This unique set of circumstances has allowed an examination of the relationship between discharge and mussel recruitment over a 6-yr period. Although recruitment of most, if not all, species occurred when the discharge regime approached monthly predam, median flows, recruitment of some species also occurred at higher discharges. The variation in recruitment among species seems related to the temporal variation in gametogenesis, spawning, brooding, larval release, host species and the parasitic period.

WS 07

ROSGEN STREAM RESTORATION TECHNIQUES AND MUSSEL HABITAT

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We have long attempted to control streams through widening, dredging, and channelizing and further degraded them by cutting the riparian zone and compacting the landscape. Unnatural engineered streams typically become unstable and tend to lose their ecological function. Changes in the watershed land use can also destabilize a stream by increasing sediment loads and flows. We again try to control them through armoring the banks with such things as gabions and rip-rap. Dave Rosgen developed techniques that approach stream restoration through natural channel design that restores a streams dimension, pattern, and profile based upon the morphology of a natural, stable river as a reference. Rosgen, an avid fisherman, often refers in his classes to the fish habitat benefits resulting from his techniques. When one thinks of Rosgen techniques, they think of the structures he uses. These structures are only about 10 percent of the process. They are used to fix and maintain the other 90 percent by restoring the dimension, pattern, and profile. Can these same methods be used to restore mussel habitat? Rosgen methods are used to establish a stable stream. A stable stream is morphologically defined as the ability of the stream to maintain, over time, its dimension, pattern, and profile in such a manner that it is neither aggrading or degrading and is able to transport without adverse consequence the flows and detritus of its watershed. So if what mussels need is naturally stable substrate, then the answer is yes. Failed stream restoration projects do occur but are often the result of individuals that are not fully trained in the process or have tried to shortcut the process and do not design the project to handle sediment transport and other key factors.

WS 08

WATER QUALITY AND STREAM RESTORATION EFFORTS: IMPLICATIONS FOR FRESHWATER MUSSELS

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The integrity of many stream communities, including those of freshwater mussels, has been shown to decline in response to anthropogenic activities causing changes to the stability of physical habitat and trophic structure. With the rise in urban, industrial, and agriculturally-influenced stressors, mechanisms affect stream ecosystems both internally (i.e., point source pollution, channelization, dewooding) and externally (land-use change). In urban areas, the increase in magnitude and frequency of large storm events often results in increased bank scouring, altered physical habitats, and degraded water quality. In agricultural watersheds, livestock access results in trampled stream banks and erosion-related processes results in a cover of fine sediments over coarse bed material. Increased nutrient loads from agricultural activities trigger overgrowth of algae and macrophytes within the stream channel. Stream corridors may also suffer from removal of riparian vegetation, disrupted sediment transport, removal of meandering pattern through channelization, and imbalance of energy resources as a result of

urban and agricultural development. The practice of stream restoration has attempted to mitigate for increases in both internal and external stresses through hardening measures such as bank protection, grade controls, flow deflection/concentration, and bank stabilization. Such activities have characterized the science of stream restoration, formally defined as the various techniques used to replicate the hydrological, morphological, and ecological features that have been lost in a stream due to urbanization, farming, or other disturbance. However, most of the restoration design approaches focus more on morphologic elements, and less on comprehensive ecological, hydrological features, and water chemistry of a stream system. This approach has resulted in manipulation and restoration of channel geometry and form, but neglected restoration of overall ecological function and resolution of watershed influences on the hydrologic regime. The hypothesis that stream restoration will result in improved water quality is equivocal and thus the implications for restoration of fish, mussel, and other aquatic biota must be examined, preferably at intervals before and after the effort is undertaken. Several water and sediment quality characteristics like turbidity and ammonia, among others are important factors that must be considered when restoration efforts are conducted, especially when restoration of the mussel fauna is an objective.

WS 09
HABITAT REQUIREMENTS FOR HOST FISH OF FRESHWATER MUSSELS
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Major movement (i.e., >10 m) of unionids typically occurs in one of three early life stages: passive movement of glochidial larvae, parasitic stage of larvae on a host fish, and juvenile movement in sediment. Quality habitats are essential for supporting freshwater fish species and therefore unionids. Recent data suggests that abundance and location of host fish are valuable predictors of mussel populations. In natural settings, abiotic predictors of fish communities may be similar to predictors of mussel populations (e.g., flow conditions, water temperature regimes, substrate type, turbidity, depth, nutrient levels). Yet, some predictor variables, such as cover and accessibility to migration routes, may be relatively unique to fish communities. Habitat quality affects the health of individual fishes and fish communities and changes in habitat often result in changes in fish species composition. In a reach of the Upper Mississippi River, we show that host fish communities differ from other fish communities because the spatial distribution of hosts is important to the condition of mussel communities. About 73% of host fish have a home range of <400 m, suggesting considerable potential movement of unionids during encystment. Knowledge of host fish movement can be used to determine critical host fish species in specific river reaches, what habitats are necessary for host fish, and whether there are natural host limitations.

WS 10

FRESHWATER MUSSEL RECOVERY IN THE DUCK RIVER, TENNESSEE FOLLOWING HYDROLOGICAL IMPROVEMENTS MADE FOR INCREASED MINIMUM FLOWS AND OXYGEN CONCENTRATIONS FROM WATER RELEASES AT TENNESEE VALLEY AUTHORITY (TVA) NORMANDY DAM RESERVOIR

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Many thousands of miles of riverine habitat and their aquatic biological communities are inundated and destroyed by reservoir impoundments constructed for flood control, water supply, navigation, and hydro-electric power production. Water released downstream from reservoir impoundments continues to directly and indirectly affect the survival of riverine fishes and mollusk communities for many miles downstream as a result of abnormal peaking flows during power production or extreme low flows (non-peaking), low oxygen concentrations, and altered thermal temperatures from deep storage reservoirs that stratify. Recent technological advances developed by TVA within the last 15 years have established minimum flows and oxygen aeration systems below 16 reservoir storage impoundments. In 1991, TVA initiated hydrological improvements at Normandy Dam for increasing minimum flows and oxygen aeration. Normandy Dam produces no hydro-electric power but provides flood control and water supply for industry and water municipalities downriver. The mussel fauna in the Duck River was extensively surveyed in 1979, 1988, and 2001-2002 and currently contains 55 extant species including 3 federally protected. Of particular note in the 2001-2002 sampling are significant gains in mussel densities and species richness at 17 sites that were compared to 1979 and 1988 upper river surveys. Substantial juvenile mussel recruitment was observed including range extensions and significant higher numbers for three federally listed species *Epioblasma cf. capsaeformis*, *Lemiox rimosus*, and *Quadrula intermedia*. Improvements in minimum flows and increased oxygen concentrations correlate with mussel recovery in the Duck River. This technology is available and applicable for improving and restoring aquatic communities downstream from most reservoir storage impoundments worldwide.