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A Habitat Improvement Plan for the Big Sunflower River, Mississippi

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Introduction

State and Federal conservation agencies recently expressed concern that proposed maintenance dredging in the Big Sunflower River, Mississippi, by the U.S. Army Engineer District, Vicksburg, could adversely affect freshwater mussels (Family: Unionidae). Freshwater mussels are bivalve molluscs that filter-feed particulate organic matter from the water and live partially buried in firm gravelly sand substratum. Thick-shelled species are collected from medium-sized to large rivers and their shells used in the cultured pearl trade (Williams et al. 1992). Concern over dredging was partially due to high densities of commercially valuable species in some reaches of the river.

The Vicksburg District assemble a multidisciplinary team to develop a habitat improvement plan for the Big Sunflower River that offset some of the habitat losses caused by dredging. Although small streams are often restored, man-made habitat improvements to larger rivers are uncommon, possibly because of costs and potential for interference with navigation (Gore and Shields 1995). A successful restoration project of narrow scope was completed in 1984 in the Tombigbee River (Miller et al. 1988). Two riffles 46 m long and 24 m wide were created by capping sand fill with 2- to 80-mm diameter coarse sand and gravel. In the case of the Big Sunflower River the team was asked to consider fairly large-scale modifications over much of the area to be dredged. The intent was to modify water velocity and substratum conditions in selected reaches to maintain the existing mussel species and to improve species diversity and recruitment levels above those measured in an earlier survey (Miller and Payne 1995).

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Study Area

The Big Sunflower River originates near Moon Lake, Coahoma County, flows south through agricultural land, and enters the Yazoo River between Sharkey and Yazoo counties (Figure 1). The gradient is low, with steep, poorly vegetated and often eroding banks. Water velocity at low flow is typically less than 15 cm/sec. With the exception of isolated gravelly sand bars in the mid reach, substratum throughout consists mainly of fine-grained silt and sand.

The most recent channel modifications were completed in the 1960s which included channel clearing (76.4 km), cleanout (34.6 km), enlargement (69.4 km), cut-offs aggregating 25.7 km, and construction of a weir at the lower end of the Holly Bluff Cutoff to control low water level. Following recent flooding it was determined that channel hydraulic conveyance had deteriorated since earlier modifications. The District proposes to hydraulically dredge sediments from much of the river channel to improve flood conveyance and reduce local flooding.

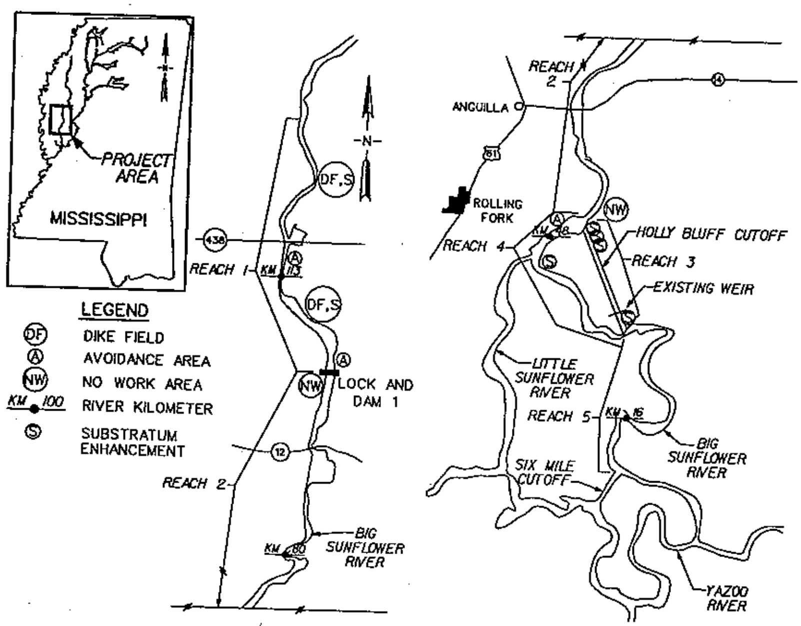

Figure 1. Map of the study reaches.

Freshwater Mussels in the Big Sunflower River

At a mussel bed immediately downriver of abandoned Lock and Dam 1, total mean density (individuals/m^2) and biomass (g/m^2) was 235.0 $\pm$16.0 (standard error of the mean) and 52,250.1 $\pm$3,284.8, respectively. Approximately 90% of the fauna consisted of the commercially valuable threeridge mussel *Amblema plicata plicata* that would sell for an estimated $2.20/kg ($1/lb) live weight. Regardless of localized high densities, there was virtually no recent recruitment (evidence of recent successful reproduction as noted by presence of individuals less than 30-mm total shell length), the total number of species collected was 12, and diversity (a measure of total species present and their evenness of distribution) was 0.49. In contrast, at a bed in the lower Tennessee River downriver of Kentucky Dam, 30% of the *A. p. plicata* were less than 30 mm, 23 species were identified, and species diversity ranged from 1.54 to 1.87. Mean density at 6 sites (10 samples were collected at each) ranged from 9.2 to 128.0 individuals/m^2 (Miller et al. 1992).

Poor recruitment and low species richness and diversity in the Big Sunflower River are likely the result of stress from high sedimentation, reduced dissolved oxygen, and high water temperatures during low flow in the summer. Habitat could be improved by increasing water velocity and substratum stability, and increasing fish habitat, since immature mussels must develop on the skin or gills of a host fish.

Proposed Habitat Improvement Features

The improvement plan depended on the proper placement of a series of features to modify habitat. Dikes will be used to increase water velocity in selected reaches where sedimentation rates were high. The dikes would be placed in a field of three, constructed of riprap, and would reach halfway across the channel (Figure 2). The field was restricted to one bank, since most riverine mussels are found between the thalweg and the shore. The banks opposite the dike field would be protected from erosion

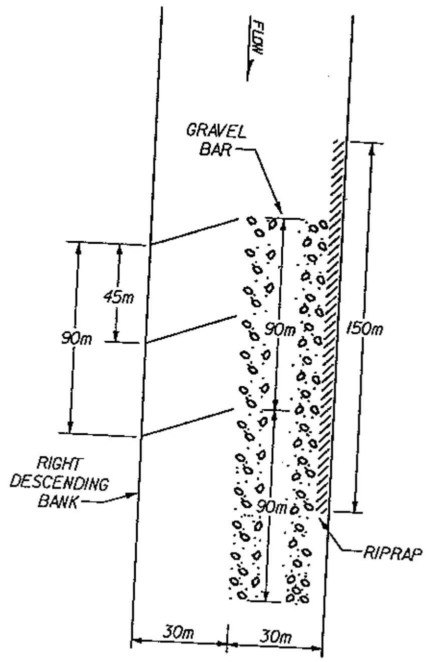

Figure 2.
Design of dike field with associated gravel substratum and bank protection.

with riprap and an underlying gravel filter. If needed, flood-tolerant trees (green ash, baldcypress, and Nutall oak) would be used to reduce erosion in adjacent areas. Mussel habitat would be improved by placing gravel on existing sand, mud, or clay substratum opposite and a short distance downriver of the dike field. Increased velocity (at least 40-50 cm/sec) resulting from the dikes should keep gravel sediment-free. There is a lack of natural cover that provides hiding places and food for fish. Artificial cover can be made from PVC pipe, automobile tires, logs, or brush.

Description of the Habitat Improvement Plan

The river was divided into five reaches based upon sedimentation rates, hydraulic features, and existing mussel resources. The team prepared 5 alternative plans which differed in the number of features and total cost. The District accepted the fifth plan which is described in the following paragraphs:

Two 3-dike fields with added gravel substratum, bank protection, and fish attractors will be placed in Reach 1. This reach extends approximately 35 km upriver of abandoned Lock and Dam 1 (Figure 1). Substratum consist of fine sands and silt, and the morphology is conducive to placement of physical structures to modify velocity.

Reach 2 extends from Lock and Dam 1 downriver to the upper end of the Holly Bluff Cutoff. Some sections are free of excessive sedimentation and have firmly packed sand or gravelly sand. Since there are some locally dense mussel beds in this reach, no major habitat features, with the exception of fish attractors, were considered.

The third reach includes the Holly Bluff Cutoff, a 11.9-km man-made channel. A weir is located near the downriver end that maintains flow in the excluded channel. Mussel populations are less than $1.0/m^2$ in the clay and shifting sand. Because of the hydraulic design of the cutoff, it is not possible to alter flow with dikes or weirs. Narrow strips (60 m long by 7.6 m) of gravel will be placed along one shore upstream of the existing weir, and two strips of gravel will be placed 60 and 240 m downriver of the weir.

Reach 4 consists of 24 km excluded by the Holly Bluff Cutoff. Water velocity is moderate to high in the upper section in which there is a bed where densities at 8 sites (10 samples taken at each) ranged from 10.0 ± 7.0 to 64.8 ± 9.2 individuals $/m^2$. Because flow is affected by the Holly Bluff Cutoff, dikes were not considered. Fish attractors will be put in the upper section.

Reach 5 includes 26 km of the most downriver section of the maintenance project where mussel densities are less than $1/m^2$. Fish attractors will be placed at two locations.

The estimated cost of the improvement plan is $249,808. The plan includes 2 three-dike fields, 54 fish attractors, 152.4 m of bank stabilization at 2 locations, and 670 linear m of gravel at 7 locations. In addition to the above features, the District identified two no-work reaches where there will be no dredging because of high

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References

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density mussel populations. Three avoidance areas were identified where dredging will be restricted to one bank to reduce impacts to mussels.

Physical and biological effects of the features will be monitored for a minimum of 10 years. Habitat features will be inspected by divers. Sedimentation rates, water velocity, and water quality variables important to mussels (temperature, dissolved oxygen, turbidity, and total suspended solids) will be monitored regularly. Mussel recruitment rates, richness, diversity, and density will be measured annually.

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References

Gore, J. A., and Shields, F. D. 1995. Can large rivers be restored? BioScience 45(3):142-152.

Miller, A. C., Killgore, K. J., King, R. H., and Mallory, J. 1988. Aquatic habitat development on the Tombigbee River. pp 77-89 In: Inland Waterways, Proceedings of a National Workshop on the Beneficial Uses of Dredged Material. Technical Report D-88-8, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Miller, A. C., Payne, B. S., and Tippit, R. 1992. Characterization of a freshwater mussel (Unionidae) community immediately downriver of Kentucky Lock and Dam in the Tennessee River. Transactions of the Kentucky Academy of Sciences 53(3-4):154-161.

Miller, A. C., and Payne, B. S. 1995. An analysis of freshwater mussels (Unionidae) in the Big Sunflower River, Mississippi, for the Big Sunflower River Maintenance Project: 1993 studies. Technical Report, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Williams, J. D., Warren, M. L., Cummings, K. S., Harris, J. L., and Neves, R. J. 1992. Conservation status of freshwater mussels of the United States and Canada. Fisheries 18(9):6-22.