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Reducing risks of maintenance dredging on freshwater mussels (Unionidae) in the Big Sunflower River, Mississippi

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Abstract

In response to proposed dredging in a 122-km reach of the Big Sunflower River, Mississippi, we studied freshwater mussels (family: Unionidae) using qualitative, semi-quantitative, and quantitative (0.25 m^2 total substratum removal) methods in 1987, 1993, 1994, 2001, 2002, and 2003. Our objectives were to identify important mussel resources, to devise methods for minimizing dredging risks, and to identify habitat improvement features. Approximately 60% of the fauna was located on two high-density shoals characterized by extreme dominance of the commercially valuable threeridge (*Amblema plicata*). Shallow nearshore and main channel areas comprised approximately 10 and 88% of the aquatic habitat in the project area; however, these areas were of less importance for mussels and supported densities of approximately 5 and 0.5 individuals/m^2, respectively. Throughout the project area the mussel fauna exhibited little or no evidence of recent recruitment, dominance of relatively few species (either *A. plicata*, or the bank climber *Plectomerus dombeyanus*), and low species diversity (H') and evenness.

No federally listed endangered or threatened mussels were found, although the pyramid pigtoe (*Pleurobema pyramidatum*), a species listed as endangered in Mississippi, was collected in and upstream of the project area. Two other state-listed species, *Plethobasus cyphyus* (sheepnose) and *Quadrula cylindrica* (rabbitsfoot), were only found on gravelly shoals upriver of the project area. Maintenance plans were redesigned to minimize environmental damage; a hydraulic cutterhead dredge will be used in most of the mainstem to reduce risk to nearshore habitats. High-density assemblages on four shoals will not be dredged and 150 and 100 m buffer zones will be left immediately up and downriver. Enhancements for aquatic biota will be created with gravel substratum and wing dams.
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Keywords: Dredging impacts; Freshwater mussels; Environmental risks; Big Sunflower River

1. Introduction

The Lower Mississippi River Delta (Delta) includes an area from just north of St. Genevieve, Missouri and Fort DeChartre, Illinois, to the mouth of the Mississippi River south of New Orleans, Louisiana. The Delta includes much of Louisiana, Arkansas, and Mississippi, as well as portions of southeast Missouri, southern Illinois, western Kentucky, and western Tennessee. The Big Sunflower River originates southwest of Memphis, Tennessee, runs south through the Delta along the lower Mississippi River to an area north of Vicksburg, Mississippi (Fig. 1). Eight counties in Mississippi border the Big Sunflower River: Bolivar, Humphreys, Issaquena, Sharkey, Sunflower, Warren, Washington, and Yazoo, which include about 12,771 km^2, or approximately 10% of the land in the state. In 2002 more than 617,000 ha in those eight counties were cultivated for corn, cotton, rice, sorghum, soybeans, and wheat. The economic significance of the Delta for Mississippi should not be underestimated. In 2002 this comparatively small parcel of rich farmland was responsible for 42% of the production of those six crops in the state.

The US Army Engineer District, Vicksburg, plans channel maintenance, to include clearing, snagging, and dredging, between river mile (RM) 6.9 and 85, as well as in three tributaries (Little Sunflower, Bogue Phalia, and Dowling Bayou). Studies conducted in 1993 revealed the presence of a high-density native mussel bed

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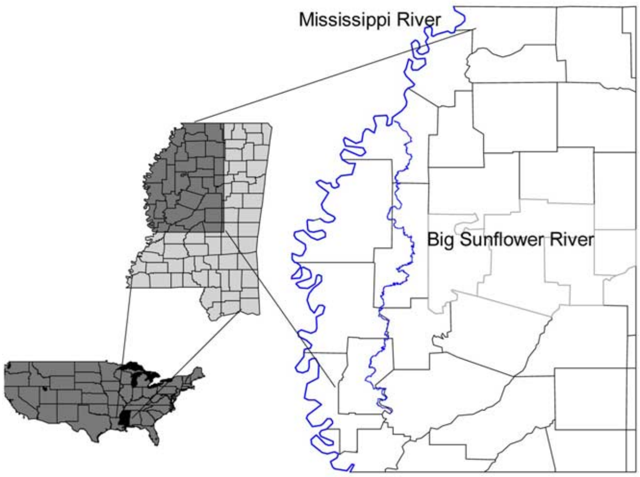

Fig. 1. The Big Sunflower River is located in Northwestern Mississippi.

(family: Unionidae) immediately below an abandoned lock and dam (Miller et al., 1992). Mean total density was exceptionally high, 235 individuals/m^2, although the fauna was not species-rich and was strongly dominated by *Amblema plicata* (threeridge), a ubiquitous commercial species (Cummings and Mayer, 1992). However, the existence of the bed was notable, considering that this is a low-gradient river with extensive sedimentation, elevated temperatures, and low dissolved oxygen. This mussel assemblage, as well as the nature of the dredging project, was instrumental in having the US Fish and Wildlife Service (USFWS) list the Big Sunflower River as a Category 2 Resource. Resource Category 2 is defined to be of 'high value for evaluation species and is relatively scarce or becoming scarce on a national basis or in the ecoregion section' (Federal Register 46, No. 15, pages 7657–7659). American Rivers, an advocacy group for environmental issues, listed the Big Sunflower River as one of this Nations' 10 most endangered rivers for 2002 (American Rivers, 2002).

Numerous authors have noted the worldwide loss of aquatic ecosystems (National Research Council, 1992; Naiman et al., 1993; Little, 1973; Bohn and Kershner, 2002). Unaltered lotic systems are rare and were the archetypical habitat of most native freshwater mussels, a group with ecological, commercial, and legal significance (Williams et al., 1993). However, the alluvial Big Sunflower River, similar to many such streams in the Mississippi Delta, is slow moving and substratum consists almost entirely of silty sand, with extremely high rates of sedimentation due to extensive and intensive agricultural use in the drainage. Most of the river system is very much unlike typical molluscan habitat that as many authors (Stansbery, 1970; Fuller, 1974; Cummings and Mayer, 1992; Williams et al., 1993; Neves, 1999) have described as particularly appropriate for mussels, e.g. with firm substratum in comparatively clean, non-turbid, medium to large-sized rivers.

At the request of the Vicksburg District surveys for freshwater mussels were conducted in the Big Sunflower River in 1987, 1993, 1994, 2001, 2002, and 2003. The purpose was to obtain environmental data to satisfy requirements of the National Environmental Policy Act. Because of varying sponsor needs, sites surveyed and sampling intensity was not consistent among years, although the overall goal was to develop a data set on mussel distribution, density, community composition, and size distribution of dominant species. A more detailed discussion of findings for each study year can be found in Miller et al. (1992) and Miller and Payne (1995). The purpose of this paper is to briefly synthesize past studies, to address methods to minimize risks to the fauna, and to examine the overall value of the Big Sunflower River for mussels.

2. Study area

The Big Sunflower River originates in Moon Lake, Coahoma County, flows south through agricultural and forested land, and enters the Yazoo River between Sharkey and Yazoo Counties. There are two significant manmade features in the river. The first is the Holly Bluff Cutoff, a straight, 10.6-km reach that bypasses a 22.5-km river section. The second is abandoned Lock and Dam 1, located north of Murphy near RM 61.4. Although the lock is not functional, the dam impounds water and creates a high-velocity zone immediately downriver.

Channel maintenance is planned for selected reaches in the 122-km of the mainstem. The project starts at RM 6.9, 11.3 km upriver of its confluence with the Yazoo River, and ends at RM 85, south of Indianola. Most of the dredging in the mainstem will be done with a hydraulic cutterhead dredge with on-land disposal. A dragline, operated from land, will be used in small tributaries and at sites where it is necessary to take material from riverbanks, rather than the channel, to avoid mussels or archeological resources.

There are three types of mussel habitat in the project area: shallow, nearshore areas; the river channel; and firm, gravelly sandbars. Substratum in the nearshore habitat consists of silty sands and varied from 10 to 40 cm deep during low flow. Substratum in the erosive channel consists of coarse sand and silt. Stable, gravelly shoals provide moderate to excellent mussel habitat at two locations. The first was approximately 350 m long and was immediately downriver of the abandoned lock and dam. Flow from the dam keeps the substratum, which consists of coarse sand, some gravel and shell material, relatively free of recently settled sediments. The other mostly sediment-free reach with moderate to high densities was between RM 33 and 37 where substratum consists of firm sand and gravel from subsurface deposits (Smith, 1979).

We also collected mussels upriver of the maintenance area, between RM 85 and 150. In comparison with the downstream section, sedimentation was greatly reduced and water was shallower (usually between 0.5 and 1 m deep during low flow).

3. Methods

A reconnaissance to search for beds was made during a low-water period in 1993 and again in 2003. For all study years, quantitative (total substratum removal from 0.25 m^2 aluminum quadrats), semi-quantitative (search by feel in 0.25 m^2 aluminum quadrats), and qualitative (timed searches) were used to collect mussels. More than 800 0.25 m^2 quadrat samples (quantitative and semi-quantitative combined), and over 50 h were expended collecting mussels using timed searches. Sampling design was based on the recognition that considerable effort can be required to find very uncommon species while collecting by hand (Kovalak et al., 1986; Metcalfe-Smith et al., 2000), and that large numbers of samples are required to adequately estimate population densities (Strayer and Smith, 2003). Results reported herein are based almost exclusively on the quantitative sampling.

A six-person dive crew with surface supplied-air and communications equipment was used in water greater than 1.0 m deep; waders were used in shallow water. All underwater work was done by feel, since visibility was usually less than 20 cm. Sediments from the quantitative samples were washed through three nested screens (minimum mesh size = 6.35 mm) and all live mussels were removed and measured to the nearest 0.1 mm with digital or dial calipers. Mussels collected using semi-quantitative or qualitative methods were identified, but not measured. The latter two methods can be biased toward larger mussels, especially in gravelly substratum, although in silty sand such as in the Big Sunflower River, there is probably not much difference in size distribution among the three collection methods. After processing, all mussels were returned to the river unharmed. Nomenclature is consistent with Williams et al. (1993).

The Vicksburg District divided the project area into eight reaches and estimated average channel width in each. Available habitat was estimated in each reach based on the District's data and field measurements. A Global Positioning System (GPS) was used to mark sites. The GPS was linked to a Fujitsu Computer with Version 6.1 of the GeoLink GPS/GIS mapping system. All coordinates were UTM, NAD 83, Zone 15.

4. Characterization of mussel resources

Results of extensive sampling illustrate the comparatively high value of the stable shoals, and lower value of channel and nearshore areas, for mussels. Based on more than 200 quadrat samples from nearshore areas, total density

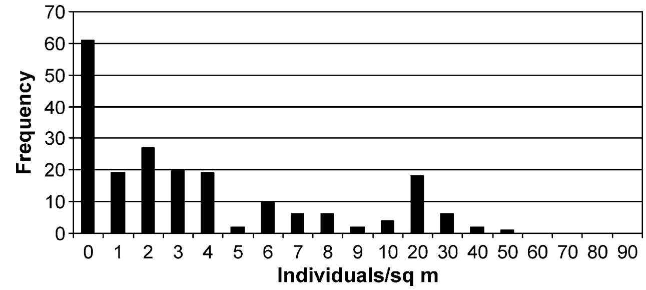

Fig. 2. Frequency of density estimates for all mussel species in shallow (<1.0 m) nearshore habitats, Big Sunflower River, 1994 data.

ranged from 0 (most frequent at 30%) to as high as 50 individuals/m^2 (Fig. 2). Nearly 87% of nearshore samples yielded density of 10 individuals/m^2 or less. The main channel was less appropriate for mussels than the nearshore areas. More than 75% of these samples had no live mussels present and the maximum density was 5 individuals/m^2 in one sample (Fig. 3). Quantitative samples taken from the shoals ranged between 0 (7%) and 390 individuals/m^2 (one sample). Density in the majority of these samples ranged between 10 and approximately 100 individuals/m^2 (Fig. 4).

Eight mussel beds were identified in the project area that ranged in size from approximately 1200 to 17,500 m^2 (Table 1). Four were on firm gravel substratum, one was in a constricted area adjacent to the upstream end of the cutoff and downriver of the gravely reach, and one was downriver of the abandoned lock and dam. Two small beds, several kilometers downriver of the lock and dam, were in naturally constricted areas. Overall mean density at these shoals, based on multiple samples and years, was estimated between 204 individuals/m^2 (at RM 61.6 below the abandoned lock and dam) and approximately five individuals/m^2 at low-density beds (Table 1). Total surface area of the eight beds was approximately 60,000 m^2 or approximately 2% of the total aquatic habitat in the project area. The beds that supported the largest number of mussels, both because of size and density, were located at RM 61.6 and 34.5 and supported nearly 60% of the fauna in the project area.

Although the shoal immediately downstream of the abandoned lock and dam supported a high-density assemblage, the number of species present in that collection was

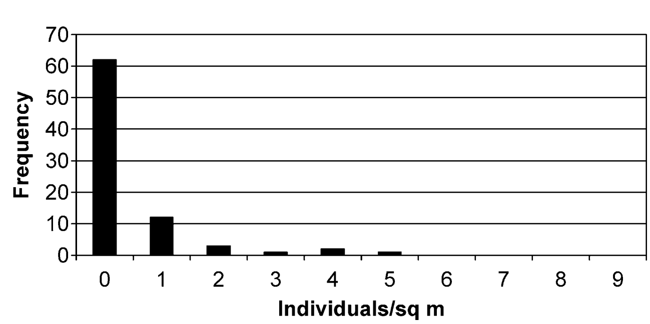

Fig. 3. Frequency of density estimates for all mussel species in the main channel of the Big Sunflower River, 2003 data.

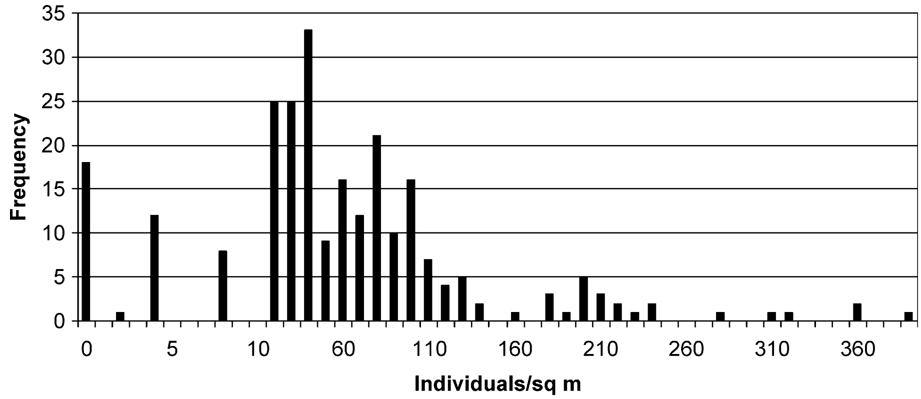

Fig. 4. Frequency of density estimates for all mussel species on gravel shoals, Big Sunflower River, 1987, 1993, 1994, 2001, 2002, and 2003 data.

only 12. Ninety percent of the fauna was *A. plicata* and the next two most abundant species were *Quadrula pustulosa* (pimpleback) and *Plectomerus dombeyanus* (bankclimber) together comprised 3.5% of the assemblage. The remaining nine species each comprised no more than 1% of the collection; this high dominance of a single species caused Shannon's Diversity Index (H') to be low—in 1993 it was only 0.49. A commercial sheller judged these *A. plicata* to be of moderate to high value (J. Alley, personal communication). In comparison with other rivers in the central United States, the specimens taken at this site were comparatively small, although the periostracum was intact and the nacre solid with few discolorations.

The shoal at RM 34.5 is in the center of the gravelly reach and was approximately 17,000 m^2. In surveys conducted in 1987, 1993, and 2003, total mean densities were less (approximately 70 individuals/m^2) than they were at the bed near Lock and Dam 1. This assemblage was not as strongly dominated by *A. plicata* as the previous site (Table 2). In 1993 *A. plicata* comprised 78% and *P. dombeyanus* comprised 9% of the fauna. The periostracum of *A. plicata* was eroded and these were of less commercial value than those immediately downriver of Lock and Dam 1. Length-frequency histograms in 1987, 1993, and 2001 illustrate the relative lack of juveniles in the *A. plicata* and *P. dombeyanus* populations (Fig. 5).

Results from the two high-density shoals can be compared with other habitats on the Big Sunflower River (Table 2). A shoal in a constricted reach immediately downriver of the gravelly area (RM 33.2) had a lower percentage of *A. plicata* (63%) and a higher percentage of *P. dombeyanus*, 17.8%. More even distribution of species caused a higher H', 1.19.

The fauna along the shore throughout the project area was dominated (57%) by *P. dombeyanus*. This species, known as the bankclimber, tends to be most common in shallow, nearshore areas. Again, a more even distribution of species within the assemblage, due in part from sampling multiple sites over more than 100 km of riverbank, yielded a moderately high diversity index of 1.47. Several species were uncommon in the collection and were restricted to nearshore habitats: *Lampsilis hydiana*, *Uniomerus declivus*, *Uniomerus tetralasmus*, and *Toxolasma texasensis*. The low-density main channel fauna was co-dominated by *A. plicata* and *Q. nodulata* (wartyback) with less than 2% *P. dombeyanus* and had an H' equal to 1.77 (Table 2).

Table 1
Estimates have been made of mussel density and size of available habitat at multiple locations in the mainstem Big Sunflower River

RM	Area		Mussels			
	m^2	%	No./m^2	SD	Number	%
34.5	17,485	0.56	69.4	32.4	1,213,459	15.35
61.6	17,421	0.56	203.7	82.7	3,548,658	44.88
33.6	13,609	0.44	35.8	31.9	487,202	6.16
33.2	1779	0.06	28.7	24.6	51,057	0.65
54.0	1788	0.06	5	nd	8940	0.11
36.7	1391	0.04	5	nd	6955	0.09
35.2	4956	0.16	5	nd	24,780	0.31
60.7	1238	0.04	5	nd	6190	0.08
Nearshore	326,432	10.48	4.50	6.80	1,468,944	18.58
Channel	2,728,341	87.60	0.40	0.96	1,091,337	13.80
Total	3,114,440				7,907,522	

Summary information for beds at miles 33.2, 54.0, 36.7, and 60.7 were made in 2003 only. Information for beds at RM 61.6 and 33.6 came from all study years. Information for nearshore habitats was obtained in 1993 and for the channel was obtained in 2003. The bed at RM 34.5 was studied in 1987, 1993, 1994, 2001, and 2003 (nd, not determined because of low sample size).

Table 2
Percent abundance of freshwater mussels at selected locations in the Big Sunflower River, Mississippi, based on studies collected in 1993, 2000, and 2003

Species	River mile					
	61.6	34.5	33.2	62–85	6.9–85	85–150
Amblema plicata	90.94	77.72	63.25	21.31	36.55	19.88
Plectomerus dombeyanus	3.49	8.70	17.81	57.00	1.21	13.87
Quadrula pustulosa	3.49	3.80	9.62	1.97	5.62	15.12
Quadrula nodulata	0.43	0.27	0.10	0.31	31.73	1.25
Megalonaias nervosa	0.17	1.90	1.94	3.57	5.22	12.01
Fusconaia flava	0.09	0.54	1.13	1.43	1.61	15.94
Quadrula quadrula	0.43	3.26	4.50	0.34	8.43	1.86
Obliquaria reflexa	1.36	2.45	0.61	0.24	2.41	3.11
Leptodea fragilis	0.00	0.82	0.10	0.54	2.41	1.45
Lampsilis teres	0.00	0.00	0.00	4.86	0.00	0.21
Pyganodon grandis	0.00	0.00	0.10	2.82	2.41	0.00
Fusconaia ebena	0.09	0.00	0.10	0.00	0.00	4.34
Pleurobema pyramidatum	0.17	0.27	0.10	0.03	0.00	3.93
Potamilus purpuratus	0.17	0.00	0.20	2.01	0.80	0.82
Glebula rotundata	0.00	0.00	0.00	2.45	0.40	0.00
Truncilla truncata	0.09	0.00	0.00	0.00	0.00	2.48
Truncilla donaciformis	0.00	0.00	0.00	0.00	0.00	1.86
Ellipsaria lineolata	0.00	0.27	0.00	0.00	0.00	1.25
Actinonaias confragosus	0.00	0.00	0.31	0.54	0.40	0.00
Potamilus ohiensis	0.00	0.00	0.00	0.17	0.40	0.00
Tritogonia verrucosa	0.00	0.00	0.10	0.00	0.00	0.41
Anodonta suborbiculata	0.00	0.00	0.00	0.00	0.40	0.00
Utterbackia imbecillis	0.00	0.00	0.00	0.03	0.00	0.00
Toxolasma texasensis	0.00	0.00	0.00	0.24	0.00	0.00
Plethobasus cyphyus	0.00	0.00	0.00	0.00	0.00	0.21
Lampsilis hydiana	0.00	0.00	0.00	0.07	0.00	0.00
Uniomerus declivus	0.00	0.00	0.00	0.03	0.00	0.00
Uniomerus tetralasmus	0.00	0.00	0.00	0.03	0.00	0.00
Shannon's diversity, H'	0.49	0.93	1.19	1.47	1.77	2.30
Total individuals	1175	368	977	2939	249	483
Total species	12	11	15	21	15	18
Study year	1993	1993	1993	1993	2003	2000
Collection type	QT	QT	QL	QT, QL	QL	QT
Habitat	Shoal	Shoal	Shoal	Shore	Channel	Shoal

QT, quantitative samples; QL, qualitative samples. The project area is between RM 6.9 and 85; mussels collected upriver of RM 85 are outside the project area (column 7).

There was a notable lack of juveniles in all samples. Although high unionid density attests to successful reproduction in the past, we have found very few mussels less than 30 mm total shell length, which indicates that recent recruitment is low or sporadic.

There are no threatened and endangered mussels in the Big Sunflower, although three are on the Mississippi State List (Endangered Species of Mississippi, Public Notice No. 3357, March 2001). *Plethobasus cyphyus* (sheepnose) and *Quadrula cylindrica* (rabbitsfoot, only found via qualitative sampling) were only in the upriver reach, whereas a third species *Pleurobema pyramidatum* (pyramid pigtoe) was found in the lower and the upper reach. A shoal upstream of the project area, where two state-listed species were collected, had higher species diversity (2.30) and richness than shoals in the project area. Dominance was shared by five species and *A. plicata* was not the most abundant species (Table 2).

The total amount of bank and channel habitats (exclusive of the shoals) in the project area was estimated at 326,000 and 2,728,000 m^2, respectively (Table 1). These comparatively low value areas, with estimated mean unionid densities of 4.7 and 0.3 individuals/m^2, account for nearly 98% of the available habitat, but support only about 32% of the mussels in the project area.

5. Protective measures and enhancement features

Two strategies will be used to protect mussel resources in the Big Sunflower River. The first will be to remove sediments using a hydraulic cutterhead dredge to the extent possible. This would reduce risks to mussels inhabiting shallow water along the shore. Conversely, a dragline removes material from bank to bank, and would damage nearshore habitats. In addition, four of the most valuable beds, located at RM 34.5, 61.6, 33.6, and 33.2, will not be dredged. A no-dredging zone, extending 150 m up- and 100 m downriver of each, will reduce potential effects of sediment resuspension and settling. A dragline will be used,

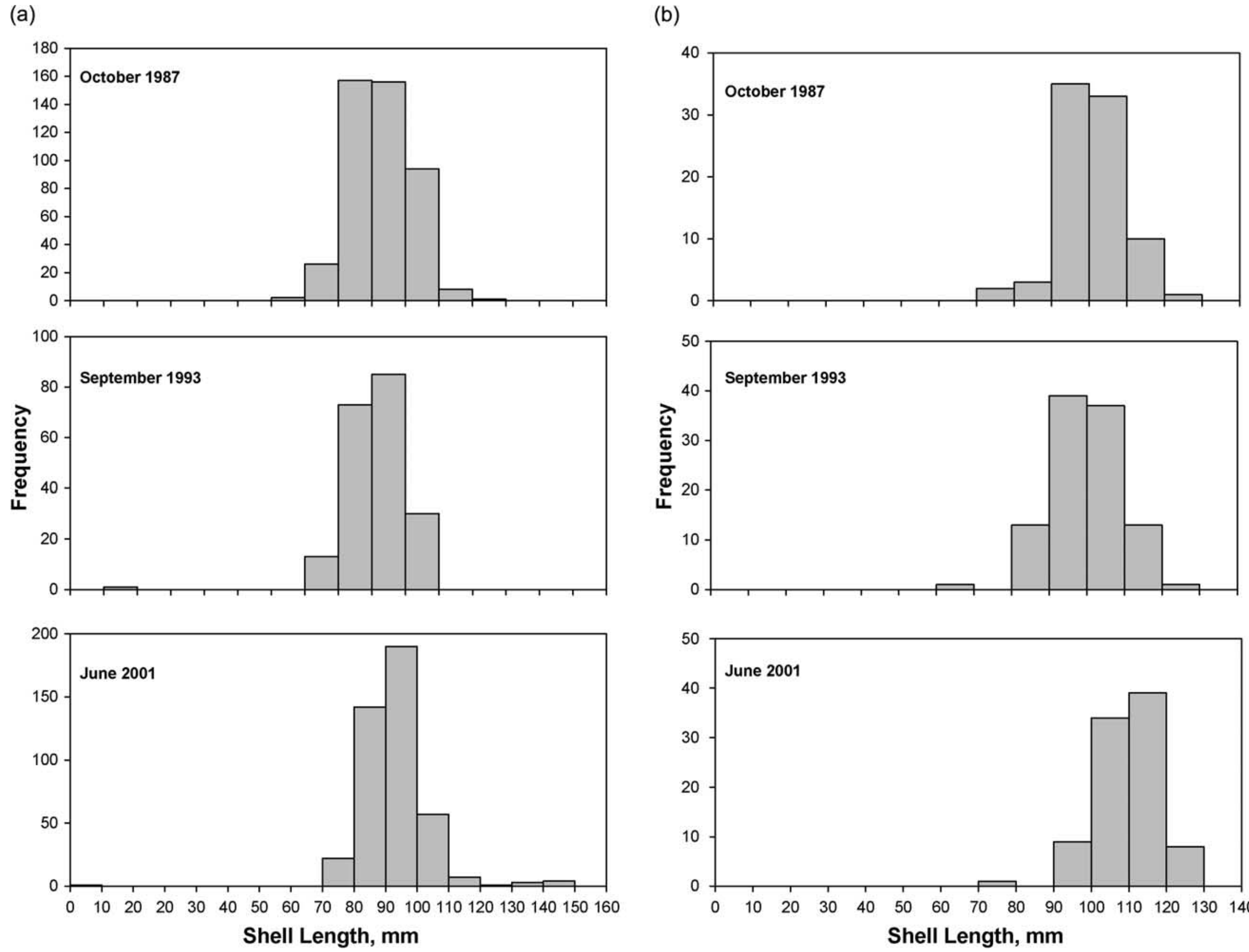

Fig. 5. (a) Size distribution of *Amblema plicata* at a gravel shoal in the Big Sunflower River, mile 34.5. (b) Size distribution of *Plectomerus dombeyanus* at a gravel shoal in the Big Sunflower River, mile 34.5.

and sediment removal will be restricted to the opposite shore at the other four, lesser-valued beds. Some species restricted to shallow near shore areas (*U. declivus*, *U. tetralasmus*, *T. texasensis*, and *L. hydiana*) should not be directly impacted by this dredging. However another uncommon species in this collection (*A. suborbiculata*) which was only collected in the main channel would be negatively affected.

In response to environmental concerns, the Vicksburg District assembled a multidisciplinary team to investigate methods of improving habitat for mussels and other aquatic organisms (Miller et al., 1995). Since team members recognized the value of stable gravel substratum with adequate flow, they decided such conditions should be created at sites with comparatively poor habitat. In selected reaches three wing dams would be placed along one bank to create moderate to high-velocity flow (Fig. 6). The opposite bank would be stabilized with riprap, and 2–8 cm diameter gravel would be placed in the high-velocity zone. In adjacent areas logs, brush, or other materials would be used to create sources of cover and food for fishes and invertebrates. The number of enhancement areas to be built has not been determined.

6. Conclusions and implications

Although the mussel bed located immediately downriver of Lock and Dam 1 supported a high-density fauna, the assemblage was characterized by reduced species richness and diversity (H'), and virtually no evidence of recent recruitment. Regardless, this high-density shoal caught the attention of the public and conservation groups. The USFWS rated the Big Sunflower River as a Category 2 Resource out of four possible categories (Table 3). Considering that channel modifications in large and small streams has been a consistent theme in the 19th and 20th centuries, the gravel shoals immediately downstream of Lock and Dam 1, and the river reach between RM 33 and 37, are appropriately rated as Resource Category 2. However, the majority of mussel habitat in the project area, with substratum consisting of silty sand and supporting moderate to low-density populations of fairly common species, would not qualify as Resource Category 2. In contrast, the fauna upstream of the project area is more diverse, species rich, and exclusively supports two state-listed endangered species. To a large extent the Big Sunflower River mussel

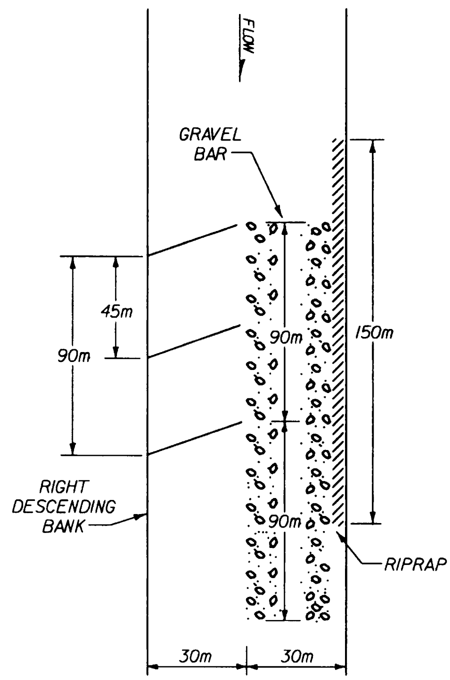

Fig. 6. Design plan for a habitat enhancement feature.

fauna is not much different from that in other flowing water systems in the central and southeastern United States (upper Mississippi, lower Ohio, Tennessee, Wabash, as well as a host of smaller streams in Tennessee, Alabama, Mississippi, Kentucky, Pennsylvania, and Ohio), in which the greatest abundance and richness is concentrated in moderately depositional zones (see citations in Fuller, 1974; Cummings and Mayer, 1992; Williams et al., 1993; Parmalee and Bogan, 1998).

Since 1983 we have conducted numerous mussel surveys in medium-sized to large rivers and have found only one other site with mean densities greater than several hundred individuals/m^2 (Miller and Payne, 1988, 1994, 1998a,b). That site was immediately downriver of a wing dam in the upper Mississippi River and was also dominated by *A. plicata*; total mean density was 333/m^2. Typically, mean densities on stable shoals in medium-sized to large rivers in the southeast are between 50 and 100 individuals/m^2. Extremely low values are not uncommon; in the Green River, Kentucky, there are viable beds with densities less than 5 individuals/m^2 (Miller et al., 1994).

Table 3
Resource categories established by the USFWS (Federal Register 46, No. 15, pages 7657–7659)

Category	Resource value	Basis
1	High, unique and irreplaceable	National or ecoregion section
2	High, relatively scarce or becoming scarce	National or ecoregion section
3	High to medium, relatively abundant	National
4	Medium to low	None

Commercial shellers will often collect in areas with densities equal to one individual per square meter (J. Alley, personal communication).

The lack of recent mussel recruitment in this river is perplexing, especially since extremely high densities exist in two reaches, and moderate-to low-density assemblages are found virtually everywhere. It is likely that this is the result of stressful conditions for juveniles caused by high sedimentation and low dissolved oxygen. By contrast, in a 1983 survey of a historically prominent bed in the lower Ohio River more than 50% of the dominant *Fusconaia ebena* were recent recruits (Payne and Miller, 1989, 2001). In studies conducted in the upper Mississippi River prior to zebra mussel (*Dreissena polymorpha*) infestations, 25–50% of the mussels present were usually less than 30 mm in total shell length (Miller, unpublished information).

The question of what constitutes a molluscan resource worthy of protection deserves consideration and discussion. Recent authors (Bogan, 1993; Williams et al., 1993; Neves, 1999) argue the importance of species richness, and are rightfully critical of anthropogenic activities that cause extirpation and extinction. However, since the inception of the environmental movement of the 1960s, the value of high species diversity and presence of taxa sensitive to stress, a major feature of the Rapid Assessment Protocols (Barbour et al., 1999), has been an important driving force in most aquatic studies. How is it then that the entire Big Sunflower River, which is literally the antithesis of high quality mussel habitat with its extensive sedimentation, merits the distinction of a Category 2 Resource? There is no doubt that our finding in 1993 of the bed that supported extremely high density (at one site mean density was 235 individuals/m^2) was part of the reason. Sapolsky and Ehrlich (2003) argue that humans appear to be innately attracted to the biggest version of everything (as well as the smallest, first, last, only, etc.). Although an outlier, this extremely dense shoal is notable, however this assemblage was strongly dominated by an extremely common, obviously tolerant bivalve (*A. plicata*) that inhabits large and small rivers, oxbows, ponds, and lakes (Cummings and Mayer, 1992).

Aquatic biologists, whether or not they work for governments, have a right if not an obligation to criticize civil works projects that negatively affect aquatic habitats and their biota. However, criticism levied on behalf of scientific, ecological concerns should be objectively directed at issues. With respect to dredging alluvial rivers in the southeast, the cost and financial benefits, as well as short- and long-term risks to the biota are equally important and should be considered. Indeed, a variety of decision-making methods, becoming more common in business and governments (Clemen and Reilly, 2001; Saaty, 2001), represent an alternative to simple advocacy. Regardless, it should still be possible to successfully argue against a project, without portraying a particularly aquatic resource as more valuable, interesting or unusual, or scarce than it actually is. A similar obligation of objectivity should be met with respect to economic and engineering justifications of projects.

The relatively few planned habitat enhancement features will not have major, system-wide effects. Once in place, they will likely support a high-density, low diversity fauna like other shoals in this river. They were not envisioned as compensation for the dredging; the value of converting a few short reaches of silty sand and low velocity water to gravelly sand with higher velocity in a moderately long river such as this cannot be reasonably quantified. Theses features are open to criticism for being insufficient or even self-serving. Regardless, they were designed with the recognition that stable gravelly shoals with consistent flow are important features for unionids.

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