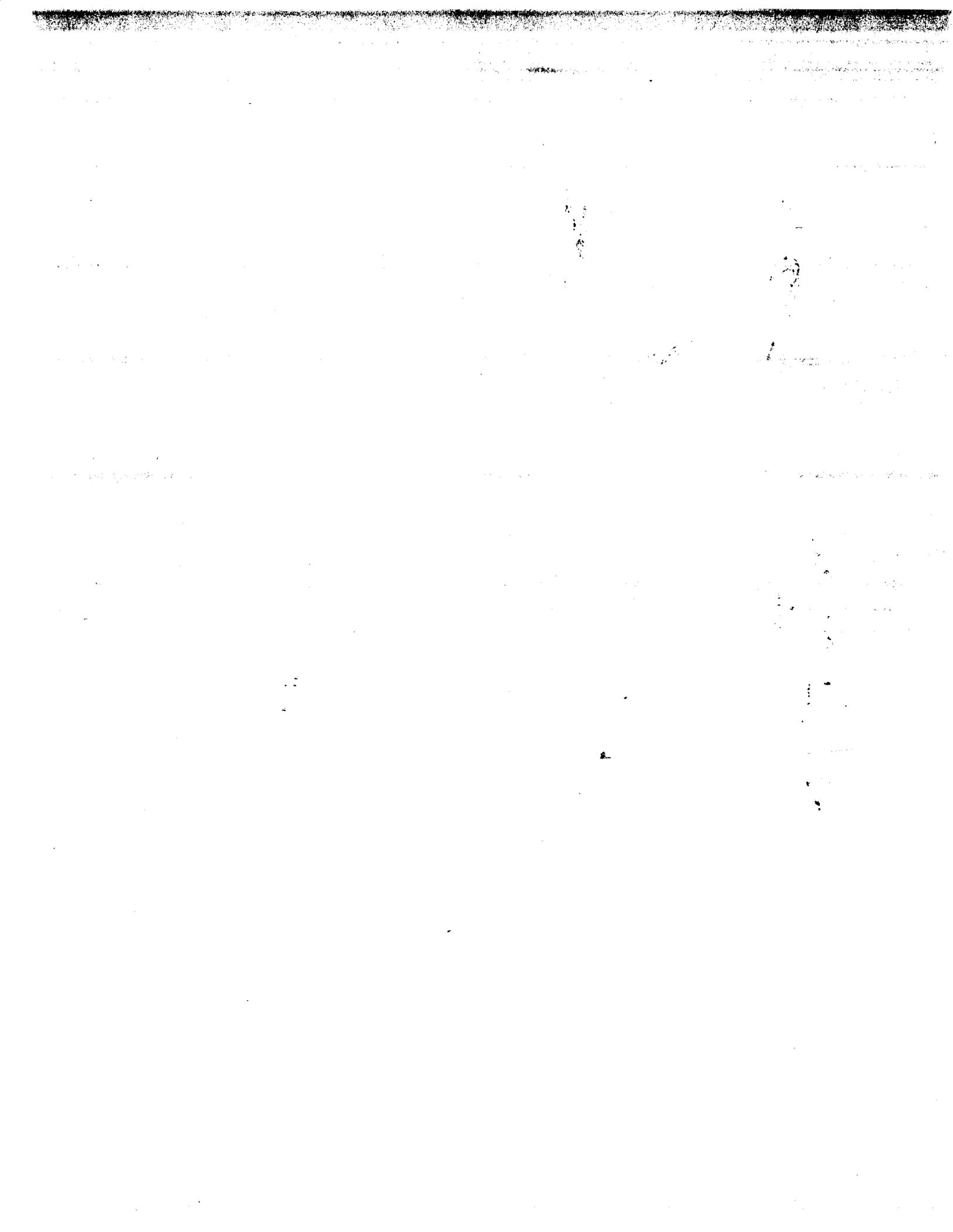


DRAFT  
BIG SUNFLOWER RIVER MAINTENANCE PROJECT

SUPPLEMENT TO APPENDIX I OF  
SUPPLEMENT NO. 2 TO THE  
FINAL ENVIRONMENTAL IMPACT STATEMENT  
FLOOD CONTROL, MISSISSIPPI RIVER AND TRIBUTARIES  
YAZOO BASIN, MISSISSIPPI

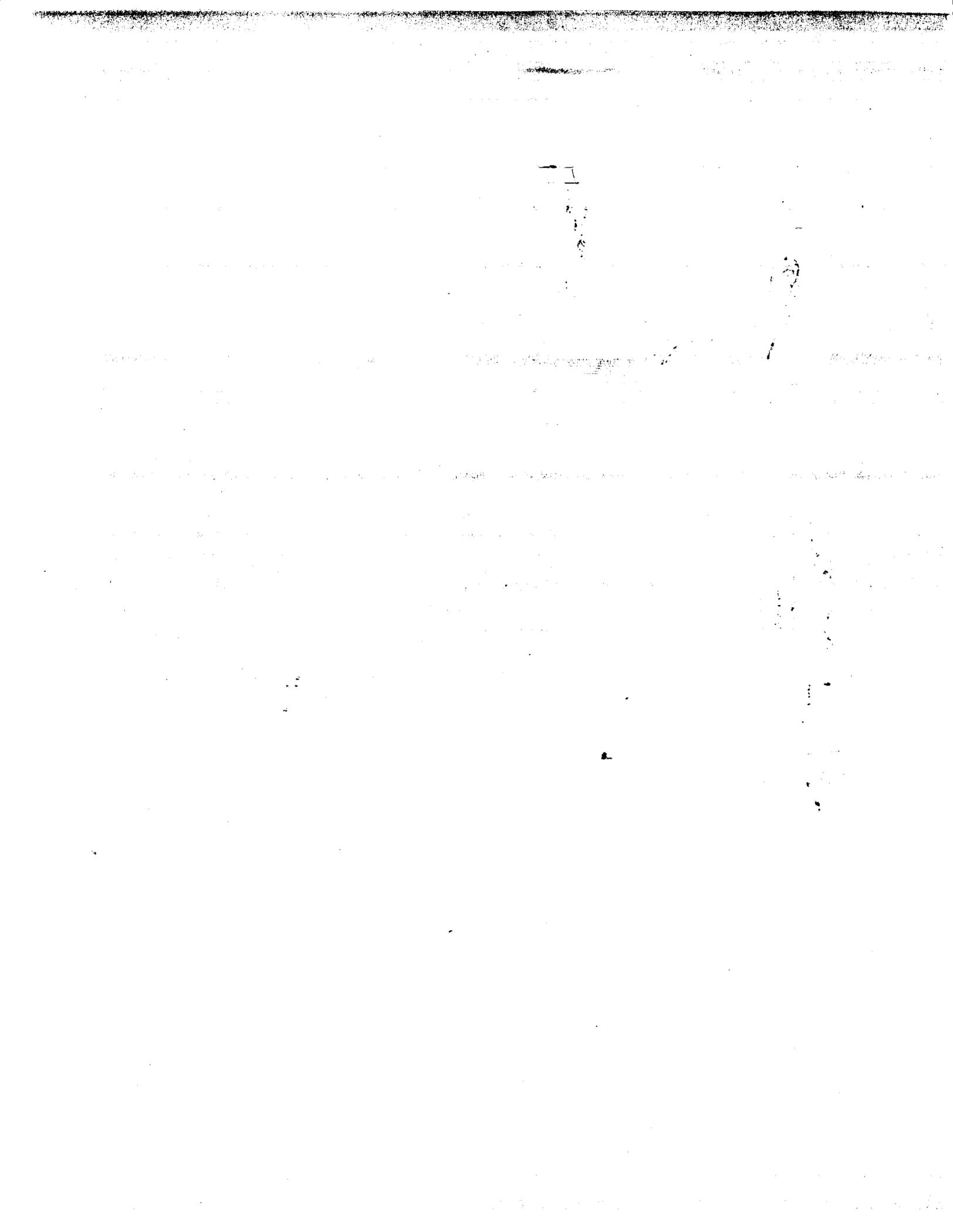
VICKSBURG DISTRICT  
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**Mussel Surveys on the Big and Little Sunflower River, 2000-2001**

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## Abstract

Surveys were conducted on the upper and middle reaches of the Big Sunflower River, 2000 and 2001, and the Little Sunflower River, 2001. Mussels were obtained using total substratum, 0.25 sq m quantitative samples as well as timed searches in which all live mussels encountered by touch were collected. Divers were used in water deeper than 1 m, and waders were used in shallow water. The purpose was to obtain information on mussels that could be used to predict impacts associated with dredging and clearing and snagging.

No federally listed endangered species were collected. However, several live individuals of the state listed sheepnose (*Plethobasus cyphus*), and the pyramid pigtoe (*Pleurobema pyramidatum*, also referred to as *P. rubrim*) were collected. The former species was only found in the upper river; the latter species was found in the upper and mid-river although it was most common in the upper river. The rabbitsfoot (*Quadrula cylindrica cylindrica*), also a state listed species, was not collected alive although several shells were collected in the upper river.

Several high-density beds of mussels were found in the upper and middle sections of the river. Outside of these beds, density in the Big Sunflower River was rarely greater than 5 individuals per square meter. The three beds in the upper river had moderate to high species richness (11-16), and moderate to high mean density (14.4 – 56.8 individuals/sq m). A bed downriver of Lock and Dam 1 had extremely low species richness (6-8) but high density (79.2- 203.2 individuals/sq m). This particular bed was dominated by *Amblema plicata* (more than 90% of the sample), which greatly reduced overall species diversity.

Densities were extremely low throughout most of the Little Sunflower River (less than 1-2 individuals/sq m), with the exception of a very narrow bed just downstream of the upper connection with the Big Sunflower River. Mean densities in the bed in the upper reach were approximately 5-15 individuals/sq m. Virtually no recent recruitment of native mussels was noted in the Little Sunflower River.

The size structure of dominant populations of mussels indicates heavy dominance of old, large mussels supported by very occasional and minor recruitment. Recent recruitment, although still minor, was substantially more evident in the upper than middle Big Sunflower River. Regardless, high longevity, slow growth, and little recruitment characterize Big Sunflower River mussel populations.

The mussel beds in the middle river would be negatively affected if dredging, or clearing and snagging, were to take place either on the bed or within 1000 ft upriver or 200 ft downriver of the mussels. Dredging, or clearing and snagging in the lower river should not have any effects on the fauna in the upper river, unless the action had a major effect on the hydraulics of the upper river. Maintenance activities should be designed to avoid the high density beds in the middle river.

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## Mussel Surveys on the Big and Little Sunflower River, 2000-2001

### Background

In September 2000, personnel of the Mississippi Museum of Natural Science, and a commercial fisherman from Indianola, MS, visited several dense and diverse mussel beds in the Big Sunflower River north of Indianola and Highway 82, central Mississippi. In addition to common species of freshwater mussels, they collected live specimens of the sheepnose (*Plethobasus cyphus*), the rabbitsfoot (*Quadrula cylindrica cylindrica*), and the pyramid pigtoe (*Pleurobema pyramidatum*, also referred to as *P. rubrim*). These species are not on the Federal list of Threatened and Endangered species, although all three are on the Mississippi State List (Endangered Species of Mississippi, Public Notice No. 3357, March 2001). The sheepnose had been considered extirpated from Mississippi and the rabbitsfoot had not been found in the Big Sunflower River although it had been collected in the nearby Big Black River. The pyramid pigtoe, although uncommon, has been collected in the Big Sunflower River during previous surveys.

There have been several published reports of mussel surveys in the Big Sunflower River since the late 1980s. Most of the sampling emphasis has been downriver of Highway 82 (Miller et al. 1992, Miller and Payne 1995). Although dense and diverse assemblages of mussels were located during these surveys, neither the rabbitsfoot or the sheepnose were found during any of the sampling.

The U.S. Army Engineer District, Vicksburg, plans to dredge and clear selected reaches of the Big Sunflower River downstream of Highway 82. In addition, they have channel maintenance actions planned for the Little Sunflower River west of Holly Bluff, MS. Clearing and snagging, as well as dredging, can negatively affect freshwater mussels and their habitat. Mussels can be killed or stranded by the dredge. Mussels can be indirectly affected if their habitat, which consists mainly of stable sand and gravel, is greatly disturbed or destroyed.

The previously described mussels were found about 10 miles upriver of the project area on the Big Sunflower River, and as much as 50 miles from the Little Sunflower River. However, District personnel would like more detailed information about distribution, abundance, and recruitment, if possible, of these three species. In addition, they would like three high density beds in the project area (located during previous surveys) checked again for these uncommon species.

In medium- to large-sized rivers, freshwater mussels (Family: Unionidae) usually reach their highest density in shallow water close to shore and outside the navigation channel. They are most common in sand/gravel substratum that is kept relatively free of silt with moderate- to high-velocity water, 0.5 to 1.5 ft/sec. Mussels are virtually non-motile, require a fish host to successfully reproduce, and feed by filtering organic matter out of the water column. Shells of many species were used to make buttons before the advent of plastics; today shells of certain species are used in the cultured pearl business. Because they are long-lived and feed on particulate matter in the water, mussel population dynamics and community composition has long been considered to be an indicator of habitat conditions. Williams (1993) listed nearly 300

species of freshwater mussels in this country; 71.7% are considered to be endangered, threatened, or of special concern.

## Purpose and Scope

The purpose is to obtain detailed information about the distribution, abundance, and recruitment of the following uncommon species of freshwater mussels in selected reaches of the Big and Little Sunflower River (*Plethobasus cyphus*, *Quadrula cylindrica cylindrica*, and *Pleurobema pyramidatum*). In addition, overall impacts of the channel maintenance actions will be assessed by a complete analysis of the entire mussel assemblage in these river reaches.

As of 1 June 2001, the majority of the quantitative and qualitative sampling has been complete. High water in the spring and scheduling conflicts with divers delayed some of the work; however this will be completed in early June 2001.

## Study Area

**Background.** The Big Sunflower River originates in Moon Lake, Coahoma County, and flows south through agricultural land, and enters the Yazoo River between Sharkey and Yazoo counties, Mississippi. The project area includes an upper reach near between Doddsville and Indianola, MS (Figure 1), a middle reach near Lock and Dam 1 (Figure 2), and near Anguilla, MS (Figure 3). For the purposes of this report the lower river consists of the section from the mouth to the upper end of the Holly Bluff Cutoff. The project area also includes the Little Sunflower River (Encl 4), a distributary of the lower reach of the Big Sunflower River.

Collections were made at sample sites (actually waypoints recorded with a hand-held Global Positioning System (GPS)) shown on the maps. Although searches for mussels were made at multiple locations within the project area, intensive collecting was accomplished only at specific locations noted on the maps. Every effort was made to ensure that areas likely to support mussels were thoroughly searched.

The upper Big Sunflower River, upriver of Indianola, is more erosional with less sedimentation than the middle and lower reach. In this reach there are several exposed gravel bars at low discharge that provide excellent mussel habitat. The best beds were at Waypoints 21, 27, and 26, and to a lesser extent at 22, 30, 31, and 33, see Figure 1. The middle and lower reaches of the Big Sunflower River are more depositional than the upper reaches. At low discharge there are no exposed riffles and the silt and fine-grained sediments can be up to 100 cm deep along the shoreline. The reaches that are moderately constricted, and that provide suitable mussel habitat, are located immediately downriver of Lock and Dam 1 and immediately downriver of Anguilla. The reach immediately below the upper end of the Holly Bluff Cutoff is moderately erosional with reduced sedimentation compared with other sections of the mid and lower river.

A summary of the study areas, and years they were surveyed, appear below:

<u>Study Area</u>	<u>Survey Year</u>
Big Sunflower Upriver of Highway 82	2000
Big Sunflower near Lock and Dam 1	1993, 2001
Big Sunflower near Anguilla	1993, 2001
Little Sunflower River	2001

**Study Sites.** The locations of sites surveyed in the upper Big Sunflower River in October, 2000 are listed in Table 1 and displayed in Figure 1. The location of sites surveyed in the Middle Sunflower River and the Little Sunflower River, 2001 are listed in Table 2 and depicted in Figures 2, 3, and 4.

## Methods

**Preliminary Reconnaissance.** A preliminary reconnaissance of each study reach was conducted prior to initiating intensive sampling. This was accomplished by having two individuals in a small boat traverse the area looking for live mussels, shells, or evidence of mussel beds. They searched shallow areas along the shore and exposed bars for shells and live mussels. They also obtained information on substratum conditions, and water velocity. Field notes were recorded and likely sample sites were marked with a hand-held global positioning system. More details on methods can be found in Miller et al. 1993.

**Qualitative Mussel Samples.** The majority of the qualitative samples were obtained by having 2-3 waders or a single diver in deeper water collect by hand. Each collector placed all live mussels encountered by touch in nylon bags. Divers were instructed to obtain mussels without bias toward size or type. They attempted to exclude the Asiatic clam, *Corbicula fluminea*. If *C. fluminea* was inadvertently collected, it was later eliminated.

All mussels were brought to the shore, counted, and identified. Data were recorded on standard data sheets and returned to the laboratory for analysis and plotting. Shells of voucher specimens for each species were placed in plastic zipper lock bags and labeled with high rag content paper. Mussels not needed for voucher were returned to the river. Taxonomy is consistent with Williams et al. (1993).

**Quantitative Mussel Samples.** Divers collected quantitative samples at waypoints noted in Tables 1 and 2. At each study area from 5 to 10 quantitative samples (0.25 sq m quadrats) were collected. Quadrats were positioned approximately 1 m apart in a 2 by 5 matrix. All sand, gravel, shells, and live bivalves to a depth of 10-15 cm were excavated. Material was sent to the surface in a 20 l bucket and transported to shore. Sediment was screened through a sieve series. All live mussels and *C. fluminea* removed from samples were placed in 4-l zipper lock bags. Each bivalve was then identified and total shell length (SL) measured to the nearest 0.1 mm with digital calipers.

## Results

Tables A1-A4 in Appendix A include information from the Big Sunflower River upriver of Highway 82 at Indianola, MS (Figure 1). Tables B1- B43, Appendix B, contains information from the middle reach of the Big Sunflower River (Figure 2). This includes sites immediately downriver of Lock and Dam 1, as well as sites downriver of Anguilla and immediately downriver of the upriver reach of the Holly Bluff Cutoff (Figure 3). Tables C1-C3 includes information from the Little Sunflower River, which was not studied during 1993 (see also Figure 4).

### Presence of Mussels Listed as Endangered in Mississippi

The endangered mussel species of Mississippi are listed in Public Notice No. 3357, March 2001. Three mussel species on this list (the sheepsnose (*Plethobasus cyphus*), the rabbitsfoot (*Quadrula cylindrica cylindrica*), and the pyramid pigtoe (*Pleurobema pyramidatum*, also referred to as *P. rubrim*) have been collected in the Big Sunflower River. The former two species were found in the upper Big Sunflower River north of the Highway 82 Bridge at Indianola, MS but not in the lower river. The pyramid pigtoe has been found in the upper and lower Big Sunflower River.

None of these species are common in the Big Sunflower River. A single live *P. pyramidatum* (comprising 0.35% of the fauna) was found at 19 sites in the upper Big Sunflower River, 18-19 Oct 00 (Table 2). Overall, this species comprised almost 5% of the assemblage at 7 sites (Waypoints 21, 22, 26, 29, 30, 31, and 33) intensively sampled using qualitative methods on 31 Oct – 1 Nov 00 (Table 5). This species was noted to be uncommon during the 1993 survey of the Big Sunflower River (Miller and Payne 1995). *Pleurobema pyramidatum* comprised 0.10% of the fauna at 5 high-density sites sampled using qualitative methods.

The sheepsnose (*Plethobasus cyphus*) was even less common than *Pleurobema pyramidatum* at sites surveyed in 2000 and 2001. At the same seven sites (Waypoints 21, 22, 26, 29, 30, 31, and 33) discussed earlier, this species comprised 0.24% of the assemblage. This mussel species was only found in the upper Big Sunflower River (north of the Highway 82 Bridge at Indianola) and was not seen in the Little Sunflower River. This species was not collected in 1993. In 2000, personnel of the Mississippi Museum of Natural Science found 5 live specimens at Blaine Road Bridge west of Blaine (Waypoint 30), 3 live specimens at Bill Lancaster's property (Waypoint 22), and only subfossil shells at the junction of Bright and Eastland Plantations (approximately at Waypoint 31).

No live rabbitsfoot (*Quadrula cylindrica cylindrica*) were found during this survey or during the one in 1993. However, at least 6 shells, several fresh dead, were found at Waypoint 21 in 2001. In September 2000, personnel of the Mississippi Museum of Natural Science found one dead shell at the Blaine Road Bridge west of Blaine (Waypoint 30), one live and one dead specimen at Bill Lancaster's property (Waypoint 22), and one live mussel on the river just above the junction of Bright and Eastland Plantation (approximately at Waypoint 31).

Neither the sheepsnose or the rabbitsfoot were found in the middle reach of the Big Sunflower River (immediately downriver of Lock and Dam 1, and sites near Anguilla, MS). In

addition, neither of these two species was found in the Little Sunflower River. It is very likely that the upper reach of the Big Sunflower River, which has slightly higher erosion rates and less evidence of sedimentation, provides better habitat for these two species, which are both typically found in riffles.

### **Characteristics of the mussel fauna in the upper Big Sunflower River**

Several high-density beds of mussels were located upriver of the Highway 82 Bridge at Indianola (Appendix A). Beds characterized by moderate to high density were found at Waypoints 21, 22, 26, 27, 29, 30, 31, and 33. As described above, all three of the state listed endangered species have been found in these beds. The most abundant mussel of the three is *Pleurobema pyramidatum*, followed by *Plethobasis cyphus* and then *Q. cylindrica cylindrica*.

Typically the fauna at these sites was comprised mainly of four species of mussels. In the upper river the fauna was dominated by the bank climber (*Plectomerus dombeyanus*), the bleufer (*Potamilus purpuratus*) and the threeridge (*Amblema plicata*). All of these species are common in medium-sized to large rivers in the southern United States. We found three moderate to high-density beds in the upper river at Waypoints 21, 27, and 26 (Table A2). Density at these three locations ranged from 14.4 to 56.8 individuals/ sq m (Table A2). These values are high, although overall density values are less in the upper than the middle Big Sunflower River. In addition, density throughout most of the river (outside of the mussel beds) is moderate (typically less than 5 individuals/sq m). Total mean density ranged from approximately 14 to nearly 60 individuals per square meter. Shannon's diversity index was moderately high, typically slightly above 2.00, mainly because of the even distribution of the 5 most abundant species.

It should be noted that the number of species at a site, and the distribution within the community, is typically higher at beds in the upper river, as compared with the lower river. The upper river, because of increased water velocity and less sedimentation, provides a better habitat for mussels than the lower river.

### **Characteristics of the mussel fauna in the middle reach of the Big Sunflower River**

Based upon surveys conducted in 1993, mussels in most of the river between Indianola and the Holly Bluff cutoff were scattered and not located in discrete beds. High-density assemblages of mussels exist immediately below Lock and Dam 1, near Anguilla, MS, and near the Holly Bluff Cutoff. Based upon studies conducted in June 2001, conditions have not changed much since the survey was conducted in 1993.

The fauna in the middle river is strongly dominated by the threeridge, *Amblema plicata*. Based on qualitative samples near Lock and Dam 1, this species comprised nearly 94% of the assemblage, which only consisted of 4 species total (Table B1). Overall, mussels were collected at the rate of nearly 10 individuals/min, which could be considered high. At the bed near Anguilla the fauna was strongly dominated by *A. plicata* (85%) and a total of 5 species were found. Overall, mussels were collected at the rate of nearly 10 individuals/min (Table B2). Near the Holly Bluff Cutoff, the fauna was again dominated by the threeridge (85%) and only 7 species were found in all. Collecting rate ranged from 4 to 6.8 individuals per minute (Table B3).

**Characteristics of the mussel fauna in the Little Sunflower River.** Few live mussels were found in the Little Sunflower River (Table B4). Thirty minutes of searching usually yielded few or no mussels at most sites. However, a moderately dense bed was found in the upper reach of the Little Sunflower River (Waypoints 41-42). Based upon quantitative sampling, densities were estimated to be less than 5 individuals per square meter throughout most of this section. Occasionally several higher density areas (10-20 individuals/sq m) were noted, although these were not common.

In contrast to the middle and upper Big Sunflower River, the overall collecting rate for mussels in the Little Sunflower River (Table B4) was only 0.25 individuals per minute. At moderately high density sections in the upper river (Waypoints 41-42) the collecting rate was ranged from 0.27 to 1.40 individuals/min, till much less than in the middle and upper Big Sunflower River.

As in the middle and upper reach of the Big Sunflower River, here the fauna was dominated by *A. plicata*. None of the state listed species were collected in the Little Sunflower River

## Mussel Density

Mussel density at three locations quantitatively sampled in the Big Sunflower River in June 2001 were compared to similar data collected in September 1993 (Table 3 and Appendix C). In both years two sites were sampled on the mussel bed just below Lock and Dam 1. Density in 1993 averaged 193 and 277 individuals per m<sup>2</sup>; in 2001 density averaged 79 and 203 individuals per m<sup>2</sup>. The disparity in average density noted in the two sites in 2001 was the result of patchiness in mussel distribution. The lower density site that year was located approximately 100 feet directly downstream of the higher density site. Such variation at a fine spatial scale makes temporal trends in density change especially difficult to distinguish.

Similarly, at the shoal downriver of Anguilla (above the Holly Bluff Cutoff), density at three sites in 1993 averaged 38, 47, and 62 individuals per m<sup>2</sup>. In 2001, density at four sites in the same location averaged 82, 94, 99, and 100 individuals per m<sup>2</sup>. The higher density measured in 2001 almost surely reflects spatial variation at a relatively fine scale. Although all samples in 1993 and 2001 were collected from the same river reach, probably within a 0.2-mile distance, patchiness in distribution lead to much higher density estimates in 2001 than in 1993. The similarity in age structure of mussel populations in 1993 and 2001 confirmed that recruit since 1993 cannot possible account for the density difference between years. In addition, adult mussels are relatively immobile and have almost certainly not moved into the area since 1993.

Density of mussels downriver of the Holly Bluff Cutoff was moderate in 1993 (averages among eight sites ranged from 10 to 65 individuals per m<sup>2</sup>) and moderately high in 2001 (averages at two sites equaled 56 and 78 individuals per m<sup>2</sup>). As at the other locations, it was evident that mussel density had not declined from 1993 to 2001.

## Size Demography of dominant species in the upper Big Sunflower River, November 2000

*Plectomerus dombeyanus*. This population was comprised entirely by old, large individuals in the moderate-sized sample collected in November (Figure 5). The average length was approximately 118 mm, with all mussels falling between 98 and 146 mm.

*Megalonaias nervosa*. A moderately recent recruit, measuring 61 mm long was obtained, as was a medium-sized mussel measuring 101 mm long (Figure 6). Otherwise, all mussels were old and large, ranging from 118 to 160 mm.

*Fusconaia flava*. This population was mostly comprised of old, large individuals (Figure 7). All but five individuals ranged from 58 to 87 mm. However, two very recent recruits were obtained – measuring 14 and 18 mm and probably representing 1999 or 1998 recruitment.

*Quadrula pustulosa*. The size structure of this population strongly resembled that of *F. flava* (Figure 8). Mostly, the population consisted of old, large individuals ranging from 55 to 70 mm. However, three recent recruits were obtained – ranging from 10 to 22 mm and probably representing recruitment from 1998 to 2000. Also, a few individuals of moderate age and length, ranging from 38 to 48 mm indicated some recruitment a few years prior to 1998.

*Fusconaia ebena*. Again, the population was comprised mostly of old, large mussels, but with some evidence of recent recruitment (Figure 9). A single individual measuring 21 mm probably represented 1998 or 1999 recruitment. In a small sample such as this one, this was clear evidence of minor recent recruitment.

*Amblema plicata plicata*. The size demography of the dominant mussel characterized the population condition most commonly encountered in the upper Big Sunflower River in November 2000 (Figure 10). Namely, the population, while heavily dominated by old, large mussels, nonetheless showed clear evidence of low levels of recruitment on occasion. The five mussels collected that were between 10 and 18 mm long represented recruitment that probably occurred in 1998 or 1999. The three individuals ranging from 38 to 42 mm long represented recruitment that probably occurred two or three years prior to 1998 or 1999. The broad “lower tail” (i.e., mussels ranging from 70 to 90 mm) of the size distribution from 70 to 122 mm indicated older recruits whose growth had not led to full size convergence with the old mussels ranging from 95 to 115 mm that comprised the large majority of the population.

## Size demography of dominant species in the middle Sunflower River, June 2001

*Amblema plicata plicata*. Size demography of the dominant mussel, *Amblema plicata plicata*, did not differ among the three locations where quantitative samples were collected – below Lock and Dam 1, above the Holly Bluff Cutoff, and below the Holly Bluff Cutoff in June 2001 (Figures 11, 12, and 13). The average length of *A. p. plicata* at each location was approximately 96 mm. All but a few individuals ranged from 80 to 110 mm, with the over half of the population ranging from 90 to 102 mm. The smallest individual at any location quantitatively sampled was 79 mm; the largest mussel was 113 mm.

*Plectomerus dombeyanus*. A composite sample of this species from all three locations quantitatively sampled is provided in Figure 14. Like *A. p. plicata*, old, large mussels represented the majority of the population. Nearly all *P. dombeyanus* ranged from 92 to 124 mm, with over half the population falling in the range of 102 to 114 mm. However, there was one very recent recruit obtained – an individual measuring only 7 mm long and almost certainly representing 2000 or 2001 recruitment. Also two moderate-sized individuals were collected; one measured 63 mm and the other 71 mm.

*Megaloniais nervosa*. A composite sample of this species from all three locations is provided in Figure 15. Only large, old mussels were obtained. The smallest individual measured 121 mm and the largest 177 mm long. The average size was approximately 136 mm. No recent recruits were found.

### Concluding Comments on Size Demography

Even small to moderate sized samples of dominant species in the upper Sunflower River in November 2000 tended to yield some evidence of recent recruitment (Figures 1-5). Nevertheless, old, large individuals heavily dominated populations.

In the middle Sunflower River in June 2001, dominance of old, large individuals was even more prominent and there only minimal evidence of recent recruitment. Size demography of assemblages of dominant species were similar among locations in the middle river. All populations were characterized by extremely minor or no recent recruitment (Figures 6-10).

Comparison are possible of the size structure of *A. p. plicata* samples from the present study, 1993, and 1987 at a gravel bar just upriver of the Holly Bluff Cutoff. In 1987, mussels 85% of the population ranged from 82 to 104 mm long, the smallest mussel collected was 74 mm, and only 5% of the population exceeded 104 mm. In 1993, 85% of the population ranged from 84 to 100 mm, the smallest mussel collected was 58 mm, and only 2% of the population exceeded 104 mm. The average mussel in 1993 was approximately 91 mm long. By 2001, there was clear evidence of growth with approximately 85% of the population ranging from 86 to 108 mm and the average individual equaling approximately 96 mm. Thus, adult growth rate has averaged approximately 5 mm over the past eight years. Slow growth and low mortality of large adult mussels combined with extremely low levels of recruitment are what characterize these populations.

Age structure is very difficult to decipher from length frequency histograms of such populations. As various individuals of different age grow to large size and old age, convergence of size and slow growth makes year classes impossible to distinguish in a length frequency histogram – the case in the Sunflower River. While it is abundantly clear that the dominant populations in the Sunflower River are based on strong recruitment that occurred long ago, it is not possible from length frequency analyses to estimate the dates of that recruitment with much certainty. In contrast, in other rivers strong or moderate recruitment cohorts typically can be distinguished over the first decade or more of life, and age, growth, and survival can be interpreted directly from length frequency histograms (Payne and Miller 2000).

Thus, this population has consistently been one heavily dominated by old, large mussels with barely any evidence of recent recruitment. In the present survey, a single recent recruit was found for four species: *Amblema plicata* (from quantitative samples in the Little Sunflower River), *Quadrula quadrula* (also from the Little Sunflower R.), *Leptodea fragilis*, and *Plectomerus dombeyanus*. These few recruits are the only individuals less than 30 mm long that have been collected in 1987, 1993, or 2001. Additionally in 2001, moderately young individuals were recovered of *Lampsilis teres*, *Quadrula nodulata*, and *Pyganodon imbecillis*. Thus, a very low level of recruitment occasionally occurs. High longevity and high adult survival rates have allowed these stocks of mussels to persist, and populations appear to be mainly based on strong recruitment that occurred many decades ago. Even extremely long-lived mussels with very low adult mortality must occasionally show some recruitment to continue to exist. Presently, the Sunflower River populations appear to be mainly relicts of successful recruitment long ago and are not being sufficiently replaced by new recruits.

In the 1993 survey it was noted that there was little to no evidence of recent recruitment in the lower Big Sunflower River. There are two possible explanations: 1) Recruitment is totally lacking in the river, or 2) Recruitment exists, but the number of new mussels is so small it is extremely difficult to find them. Data from the lower Big Sunflower or Little Sunflower River have not all been analyzed as of 1 June 00; however, it appears that conditions have not changed from the survey conducted in 1993—there is virtually no evidence of recent recruitment in either of these areas.

However, there is evidence of recent recruitment in the upper Big Sunflower River. We found small specimens of *Fusconaia flava* (Figure 7), *Quadrula pustulosa* (Figure 8), and *Fusconaia ebena* (Figure 9). Small individuals (less than 30 mm) of *Obliquaria reflexa* and *Amblema plicata* were also taken in the upper river. No evidence for recent recruitment was found for *M. nervosa* (giant washboard) or *P. dombeyanus* (Bankclimber) in the upper river.

### **A Note on the Value of the Big and Little Sunflower River for Mussels**

There is one high-density bed, and several moderately high-density mussel beds in the Big Sunflower River. Although mussels can be found virtually thorough the river, densities are typically less than 5 individuals/sq m. Overall this river system is of moderate value to mussels. There is virtually no evidence of recent recruitment in the middle river, and only a slight amount of recruitment in the upper river. The high-density sites are strongly dominated by *A. plicata*, an extremely tolerant and widespread species in the United States. The extreme dominance of *A. plicata* functions to reduce both species diversity and species richness values.

**Effects of Channel Maintenance on the Mussel Fauna.** Channel maintenance will take place in the lower river, downstream of the Highway 82 Bridge. Therefore, mussels in this upper reach should be virtually unaffected by activities in the lower reach. There is the possibility that increased conveyance in the lower river; as a result of the channel maintenance, could increase velocity and erosion in the upper reach. This could cause loss or degradation of the stable shoals and damage or stress the mussel fauna.

In the lower Sunflower River there are high concentrations of mussels immediately downriver of Lock and Dam 1, near Anguilla, and immediately up and downriver of the Holly

Bluff Cutoff. Channel maintenance activities could directly affect the mussels in the high-density beds. However, channel maintenance activities could be designed so that these beds could be avoided. Virtually anywhere in the river one can find low-density assemblages of mussels (typically less than 1/sq m) in shallow water along the shore. Dredging will be mainly restricted to the thalweg, so the majority of these mussels should be unaffected. However, it is likely that some will be directly or indirectly affected by the action of the dredge. Direct effects include either being killed by the dredge or being disposed of in an upland site. Indirect effects, which might not necessarily be lethal, include stress caused by elevated suspended sediments or burial.

The situation in the little Sunflower River is similar to that in the lower Big Sunflower River. In the majority of the river the mussels are scattered in low-density populations along the shore. However, there are high-density populations near the upper end of the little Sunflower River. If these areas were avoided by maintenance actions, then the majority of the mussels would not be damaged.

Literature Cited

Miller, A. C., B. S. Payne, and P. D. Hartfield. 1992. Characterization of a dense mussel bed in the Big Sunflower River, Mississippi. *Journal of the Mississippi Academy of Sciences* 37(3):8-11.

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 EL-95-26, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Miller, A. C., Payne, B.S., Shafer, D. S., and L. T. Neill. 1993. Techniques for monitoring bivalve communities and populations in large rivers. pp 147-158 In: Conservation and Management of Freshwater Mussels, K. S. Cummings, A.C. Buchanan, and L. M. Koch, (eds). Proceedings of a UMRCC Symposium, October 1993.

Payne, B. S., and A. C. Miller. 2001. Recruitment of *Fusconaia ebena* (Bivalvia: Unionidae) in relation to discharge of the lower Ohio River. *American Midland Naturalist* 144:328-341.

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

## Figures

Figure 1. Sample sites on the upper Big Sunflower River.

Figure 2. Sample sites on the middle Big Sunflower River immediately downriver of Lock and Dam 1. The dam is adjacent to the unnamed road to the west of the sample sites.

Figure 3. Sample sites on the Middle Big Sunflower River near Anguilla, MS.

Figure 4. Sample sites on the Little Sunflower River.

Figure 5. Length-frequency histogram for *Plectomerus dombeyanus*, upper Big Sunflower River, 1 Nov 00.

Figure 6. Length-frequency histogram for *Megalonais nervoa*, upper Big Sunflower River, 1 Nov 00.

Figure 7. Length-frequency histogram for *Fusconia flava*, upper Big Sunflower River, 1 Nov 00.

Figure 8. Length-frequency histogram for *Quadrula pustulosa*, upper Big Sunflower River, 1 Nov 00.

Figure 9. Length-frequency histogram for *Fusconaia ebena*, upper Big Sunflower River, 1 Nov 00.

Figure 10. Length-frequency histogram for *Amblema plicata*, upper Big Sunflower River, 1 Nov 00.

Figure 11. Length-frequency histogram for *Amblema plicata plicata*, below Lock and Dam 1, Big Sunflower River, 15 June 01.

Figure 12. Length-frequency histogram for *Amblema plicata plicata*, near Anguilla, upriver of the Holly Bluff Cutoff, Big Sunflower River, 15 June 01.

Figure 13. Length-frequency histogram for *Amblema plicata plicata*, downriver of the Holly Bluff Cutoff, Big Sunflower River, 15 June 01.

Figure 14. Length-frequency histogram for *Plectomerus dombeyanus*, all three locations (downriver of Lock and Dam 1, downriver of Anguilla, MS, and downriver of the Holly Bluff cutoff) combined, Big Sunflower River, 15 June 01.

Figure 15. Length-frequency histogram for *Megalonias nervosa*, all three locations (downriver of Lock and Dam 1, downriver of Anguilla, MS, and downriver of the Holly Bluff cutoff) combined, Big Sunflower River, 15 June 01.

Table 1. Survey of Big Sunflower River, 7 Oct, and 18-19 Oct, 2000.

<u>WayPoint</u>	<u>GPS Latitude (N)</u>	<u>GPS Longitude (W)</u>	<u>Date</u>	<u>Notes</u>	<u>Live Mussels Collected per minute</u>	<u>Number of Species</u>
1	33.491081	90.593294	18-Oct-00	Few dead shells	0.00	0
2	33.491274	90.591170	18-Oct-00	Few dead shells, exposed shoal	0.00	0
3	33.485797	90.591229	18-Oct-00	Depth shallow to > 1.0 m	0.10	1
4	33.481886	90.586959	18-Oct-00	Sandy shoal	0.00	0
5	33.467960	90.565313	18-Oct-00	Mouth of Quiver River	0.00	0
6	33.462719	90.562164	18-Oct-00	Dense assemblage of mussels, no shoal	2.60	11
7	33.452688	90.575817	18-Oct-00	Exposed shoal on RDB	1.60	7
8	33.429267	90.586208	18-Oct-00	Flat, muddy area along LDB	2.20	6
9	33.412085	90.610004	18-Oct-00	Flat, muddy area along LDB	1.50	3
10	33.418152	90.635512	18-Oct-00	Shallow, muddy area, LDB	2.20	7
11	33.395315	90.702240	18-Oct-00	Shallow, muddy area, LDB	0.60	3
12	33.544210	90.544199	19-Oct-00	Shallow riffle, shells and no live mussels	0.00	0
13	33.540267	90.539907	19-Oct-00	Shallow run along RDB	0.00	0
14	33.539892	90.542557	19-Oct-00	Sandy area along RDB, no shells	0.00	0
15	33.538020	90.547884	19-Oct-00	Shoal along RDB	0.90	5
16	33.531180	90.552621	19-Oct-00	Flat, muddy area along RDB	0.85	6
17	33.536877	90.555620	19-Oct-00	Shoal along the LDB	0.05	1
18	33.533449	90.557320	19-Oct-00	Boat launch area, did not collect	ND	ND
19	33.532677	90.555620	19-Oct-00	Flat, muddy area	0.80	7
20	33.525891	90.582860	19-Oct-00	Flat, muddy area	0.35	2
21	33.519046	90.601013	19-Oct-00	Exposed shoal, very high quality bed	ND	ND
22	33.516321	90.608744	19-Oct-00	B. Lancaster's property, high quality	ND	ND



23	33.514631	90.611243	19-Oct-00	bed	ND
24	33.512807	90.612306	19-Oct-00	Many exposed shells, did not stop	ND
25	33.511198	90.614097	19-Oct-00	Many exposed shells, did not stop	ND
26	33.505350	90.621017	19-Oct-00	Exposed shoal, very high quality bed	ND
27	33.516358	90.608422	7-Oct-00	B. Lancaster's property, high quality bed	ND
28	33.503736	90.611758	7-Oct-00	Boat launch area, did not collect	ND
<b>Qualitative Samples - 31 Oct and 1 Nov, 2000</b>					
29	33.514861	90.601233	31-Oct-00	Identified by B. Lancaster	
30	33.600864	90.537590	1-Nov-00	Bridge west of Blaine, MS	
31	33.628571	90.546801	1-Nov-00	Shell pile north of Blaine	
32	33.578848	90.549885	1-Nov-00	No mussels	
33	33.564461	90.545374	1-Nov-00	High density site	
21	33.519046	90.601013	1-Nov-00	High density site	
22	33.516321	90.608744	1-Nov-00	High density site	
26	33.505350	90.621017	1-Nov-00	High density site	
<b>Quantitative Samples - 31 Oct and 1 Nov, 2000</b>					
21	33.519046	90.601013	31-Oct-00	Two sets of 10 quantitative samples	
27	33.516321	90.608744	31-Oct-00	Two sets of 10 quantitative samples	
26	33.505350	90.621017	1-Nov-00	Two sets of 10 quantitative samples	



**Table 2. Waypoints at sites on the lower Big Sunflower River and Little Sunflower River, June 2001.**

Waypoint	Latitude	Longitude	Location	Quantitative Samples	Qualitative Samples
34	33.171582	90.684119	Lock & Dam 1	10	20
35	33.171769	90.684135	Lock & Dam 1		1
36	33.172123	90.684119	Lock & Dam 1		1
37	33.172601	90.683352	Lock & Dam 1		1
38	32.939034	90.77158	Anguilla	10	
39	32.938771	90.771259	Anguilla		5
40	32.912786	90.754565	Near HBC	5	5
41	32.848054	90.835921	Little Sunflower		1
42	32.848552	90.835503	Little Sunflower		1
43	32.849143	90.835106	Little Sunflower	5	
44	32.806474	90.837643	Little Sunflower		2
45	32.763548	90.825981	Little Sunflower		2
46	32.689229	90.774547	Little Sunflower		2
47	32.692587	90.815982	Little Sunflower		2

**Table 3.**  
**Comparison of density and standard error of the mean (SE) for three locations on the Big Sunflower River, MS**

Location	Site	1993 Survey		Waypoint	2001 Survey	
		Mean	SE		Mean	SE
Lock & Dam 1	1	277.2	24.2	34	203.2	25.2
	2	192.8	10.2	34	79.2	16.5
Shoal downriver of Anguilla	12	46.8	6.7	38	100	12.1
	13	38.4	7.6	38	99.2	6.9
	14	62	7.1	39	82.4	6.8
				39	93.6	10.2
Downriver of the Holly Bluff Cutoff	3	10	7	40	56	7.2
	4	35.6	8.9	40	78.4	8.1
	5	64.8	9.2			
	6	34.8	4.6			
	7	24	4.5			
	15	15.6	3			
	16	33.6	3			
	17	10.4	2.1			

# Big Sunflower River

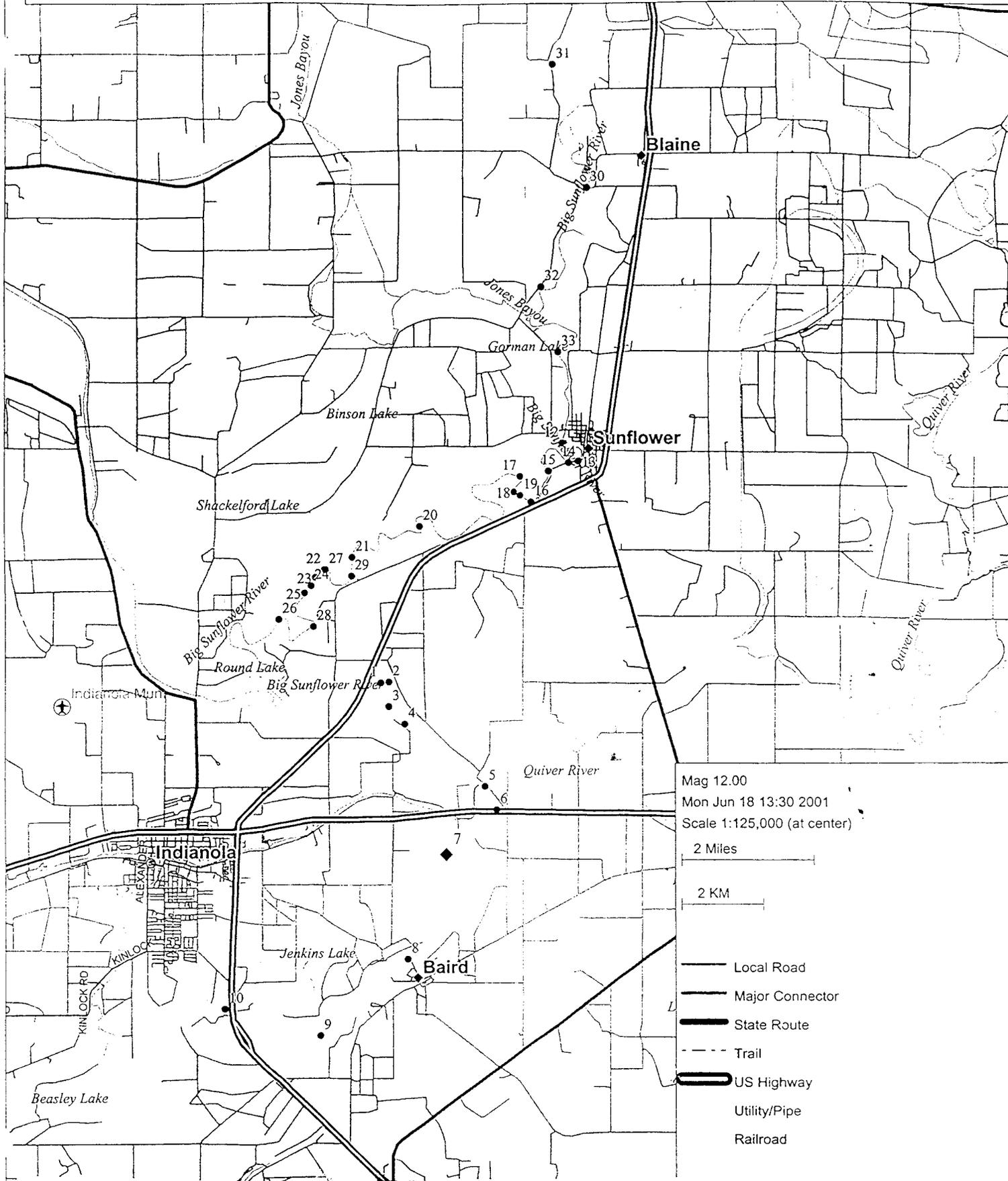


Figure 1. Sample sites on the upper Big Sunflower River.

# Big Sunflower River

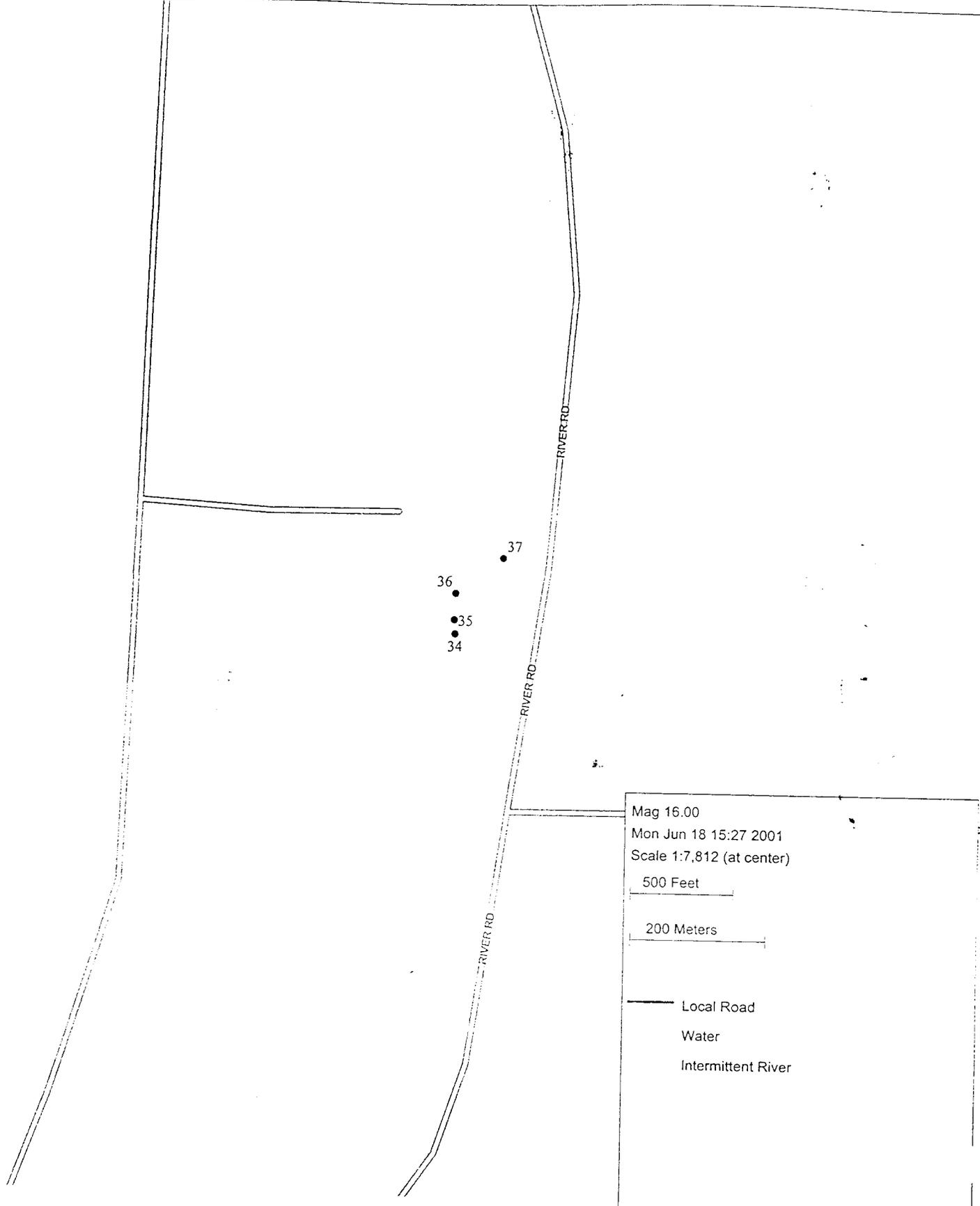


Figure 2. Sample sites on the middle Big Sunflower River immediately downriver of Lock and Dam 1. The dam is adjacent to the unnamed road to the west of the sample sites.

# Big Sunflower River

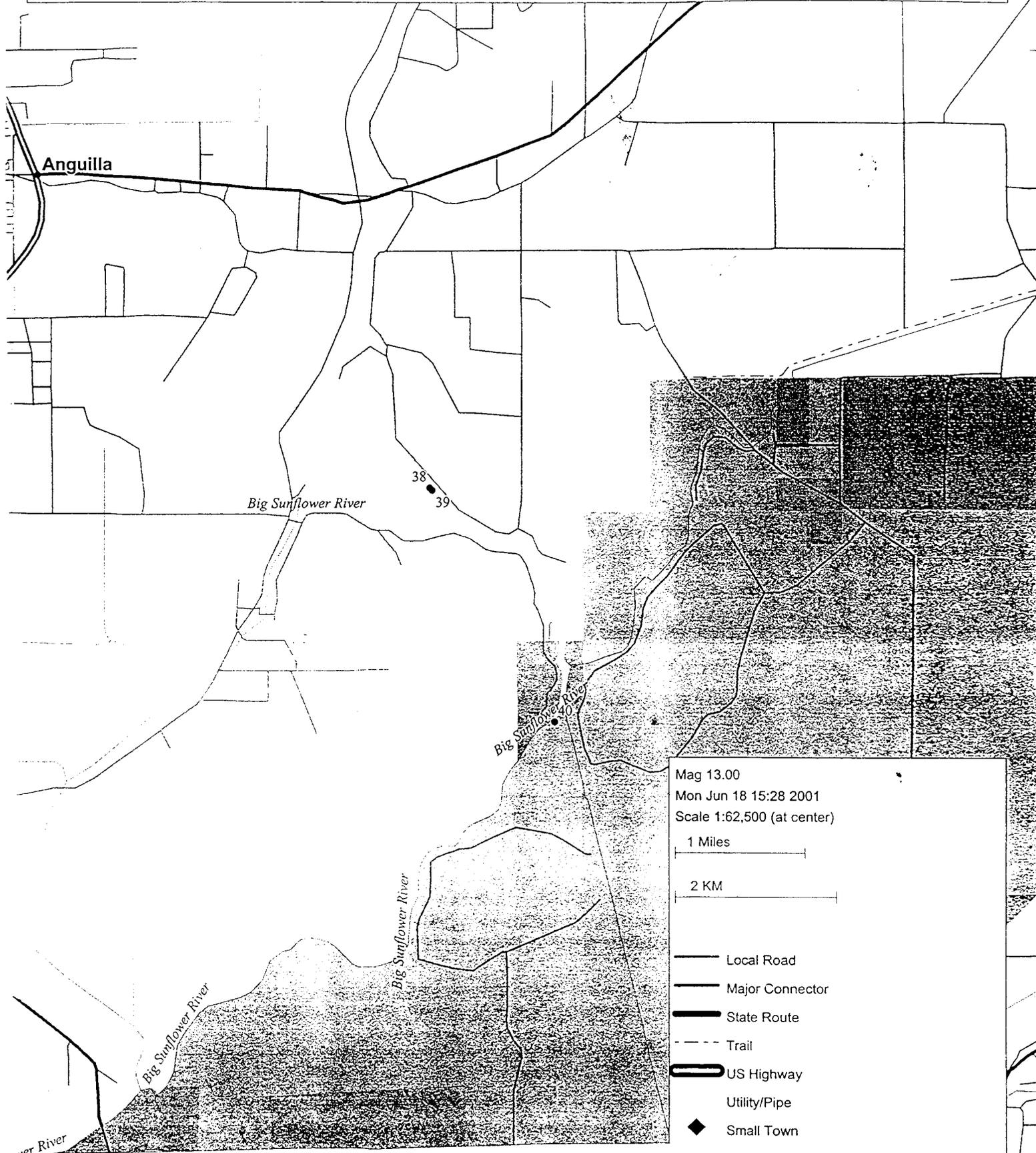


Figure 3. Sample sites on the Middle Big Sunflower River near Anguilla, MS.

# Little Sunflower River



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Mag 12.00

Mon Jun 18 15:31 2001

Scale 1:125,000 (at center)

2 Miles

2 KM

- |   |  |
|---|--|
|  Local Road        |  Water              |
|  Major Connector   |  National Park      |
|  Major Forest Road |  State Park/Forest  |
|  State Route       |  Woodland           |
|  Trail             |  River/Canal        |
|  US Highway        |  Intermittent River |
|  Utility/Pipe      |  |
|  Small Town        |  |

Figure 4. Sample sites on the Little Sunflower River.

Upper Big Sunflower River, 1 Nov 00  
*Plectomerus dombeyanus*

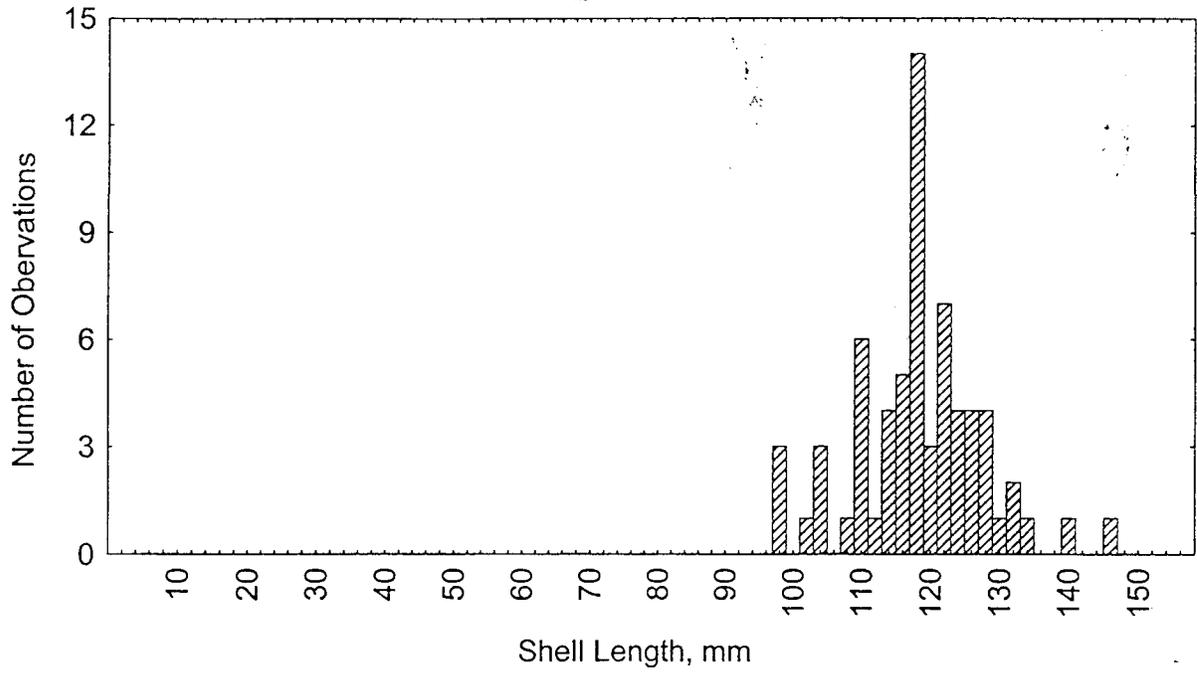


Figure 5. Length-frequency histogram for *Plectomerus dombeyanus*, upper Big Sunflower River, 1 Nov 00.

Upper Big Sunflower River, 1 Nov 00

 *Megalonais nervosa*

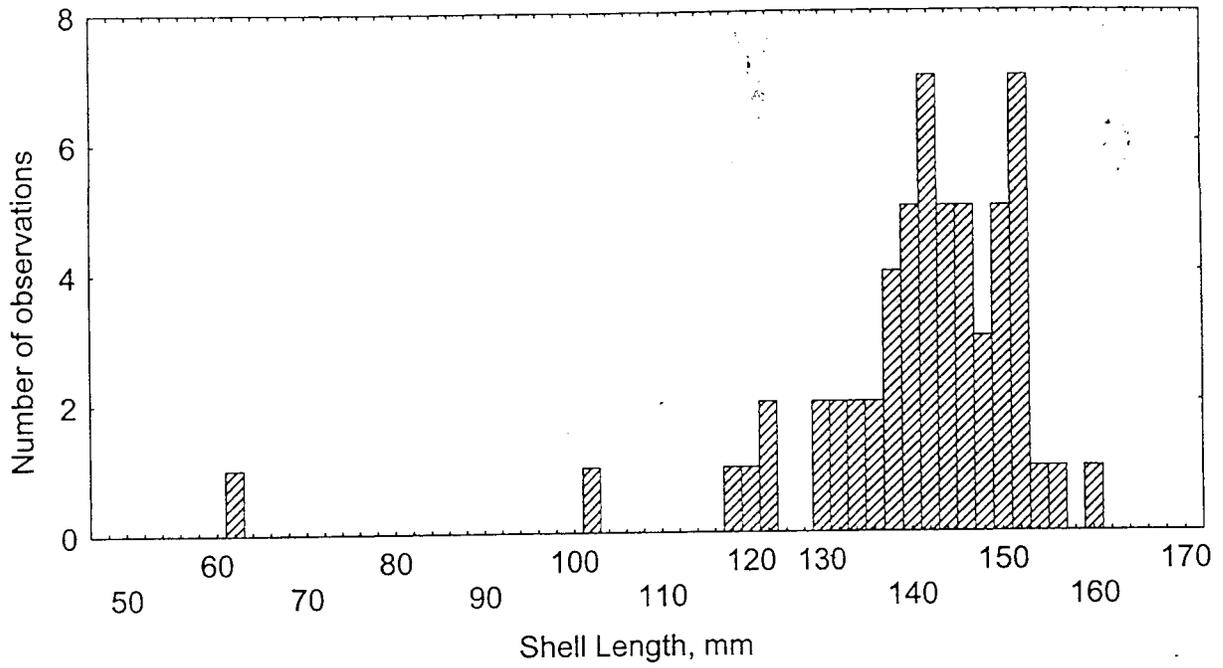


Figure 6. Length-frequency histogram for *Megalonais nervosa*, upper Big Sunflower River, 1 Nov 00.

Upper Big Sunflower River, 1 Nov 00  
*Fusconia flava*

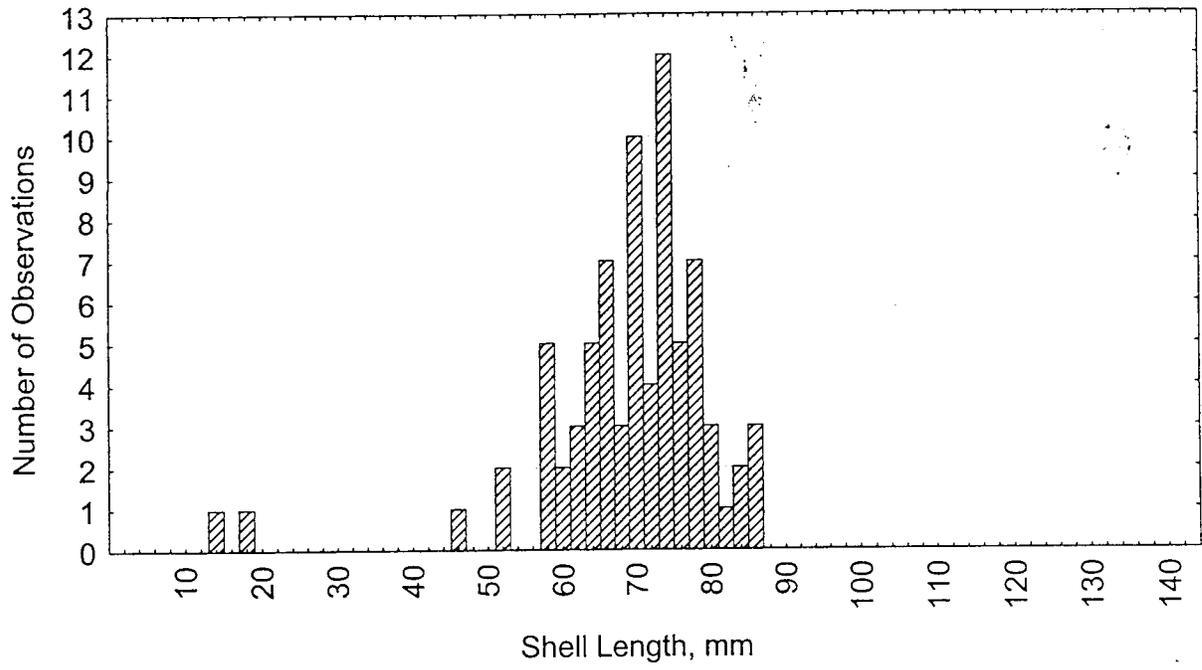


Figure 7. Length-frequency histogram for *Fusconia flava*, upper Big Sunflower River, 1 Nov 00.

Upper Big Sunflower River, 1 Nov 00  
*Quadrula pustulosa*

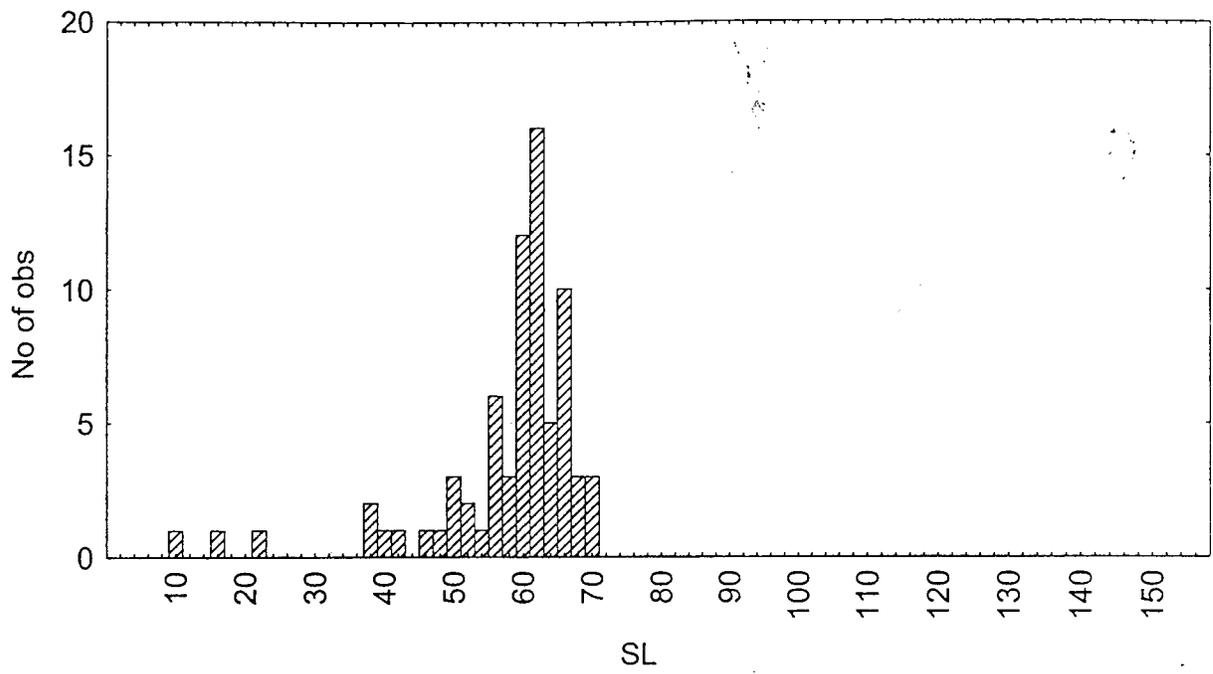


Figure 8. Length-frequency histogram for *Quadrula pustulosa*, upper Big Sunflower River, 1 Nov 00.

Upper Big Sunflower River, 1 Nov 00  
*Fusconia ebena*

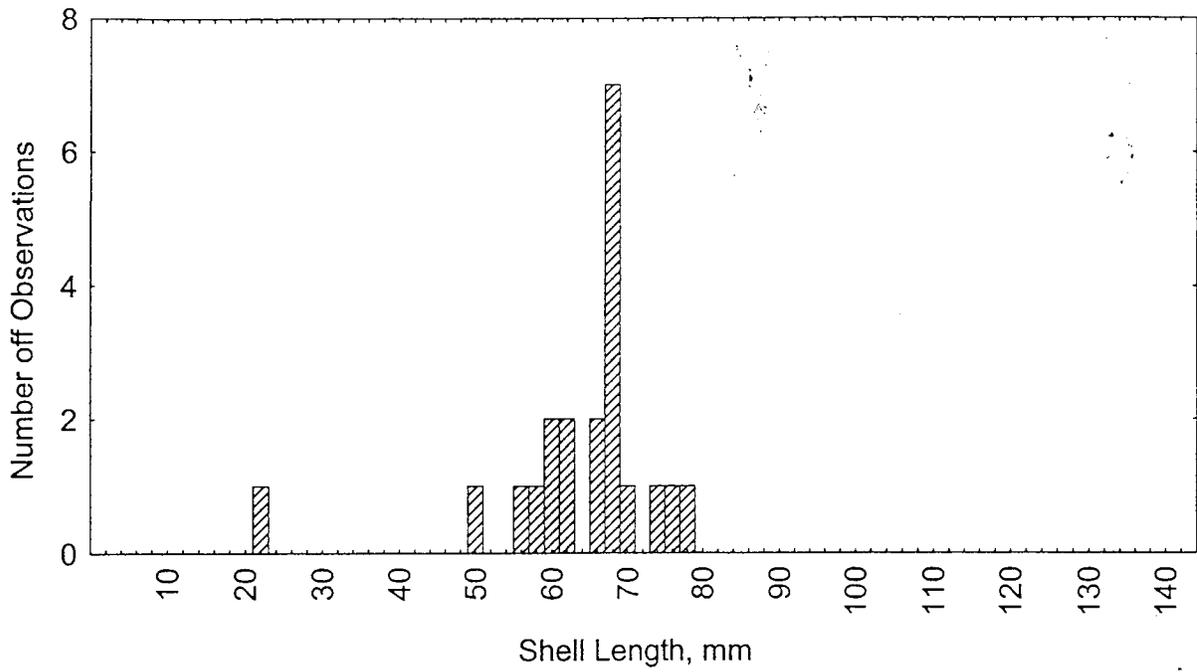


Figure 9. Length-frequency histogram for *Fusconia ebena*, upper Big Sunflower River, 1 Nov 00.

Upper Big Sunflower River, 1 Nov 00  
*Amblema plicata*

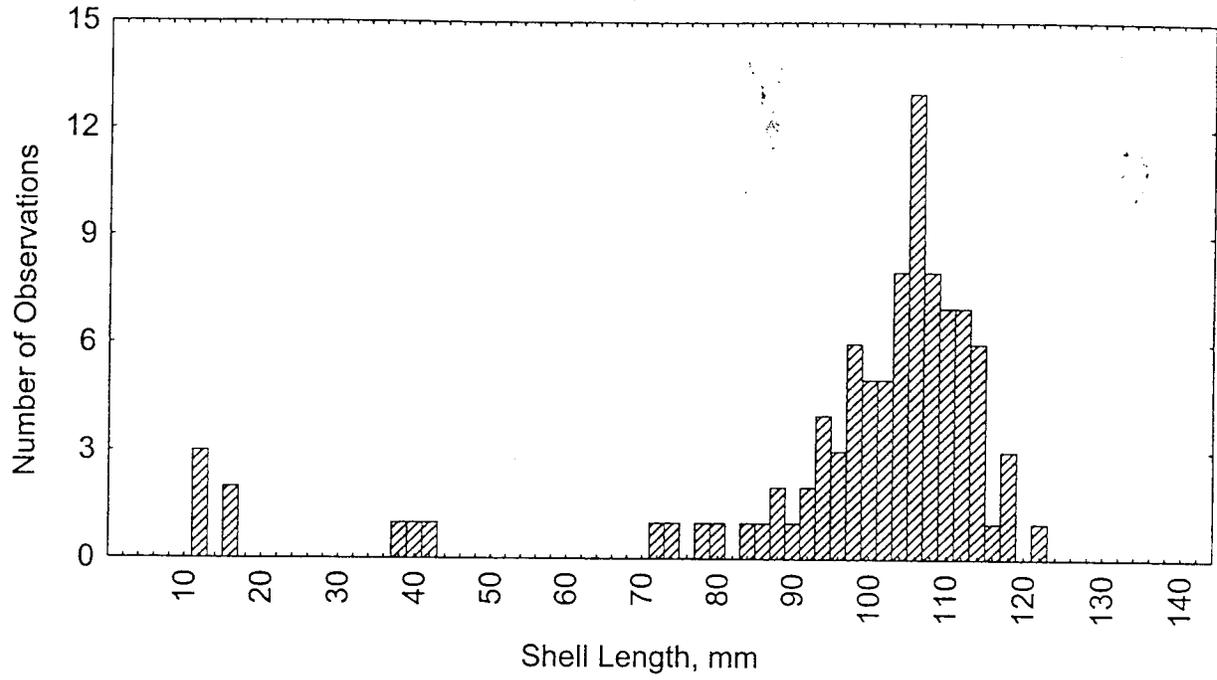


Figure 10. Length-frequency histogram for *Amblema plicata*, upper Big Sunflower River, 1 Nov 00.

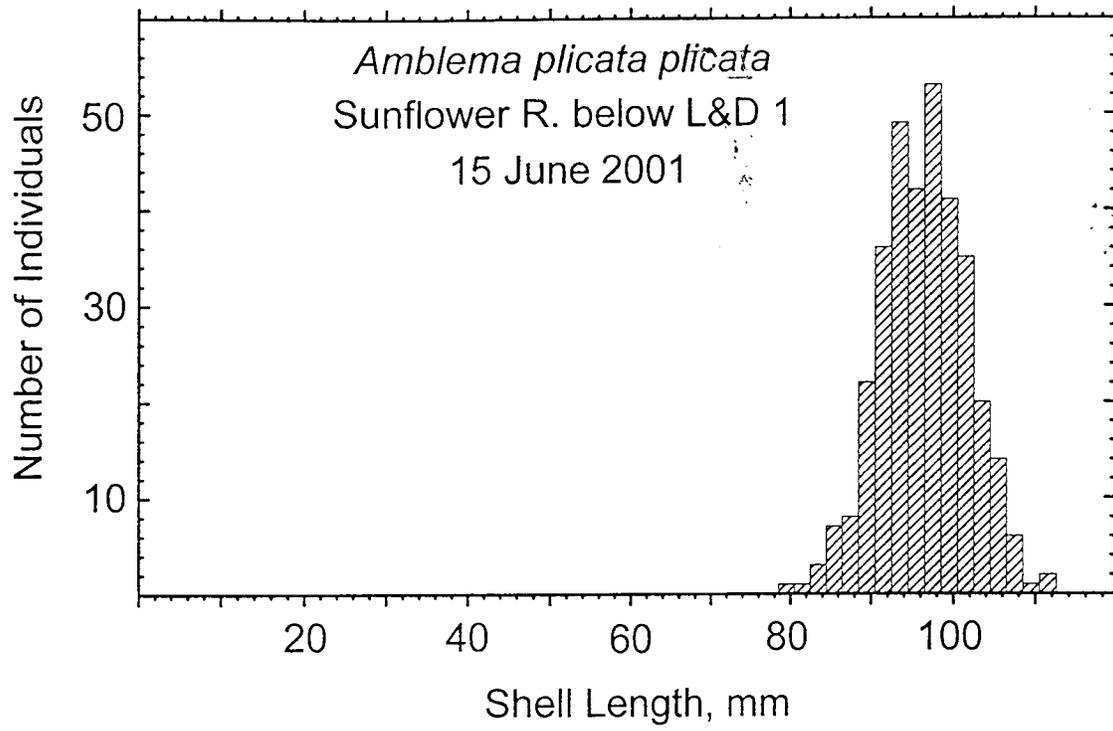


Figure 11. Length-frequency histogram for *Amblema plicata plicata*, below Lock and Dam 1, Big Sunflower River, 15 June 01.

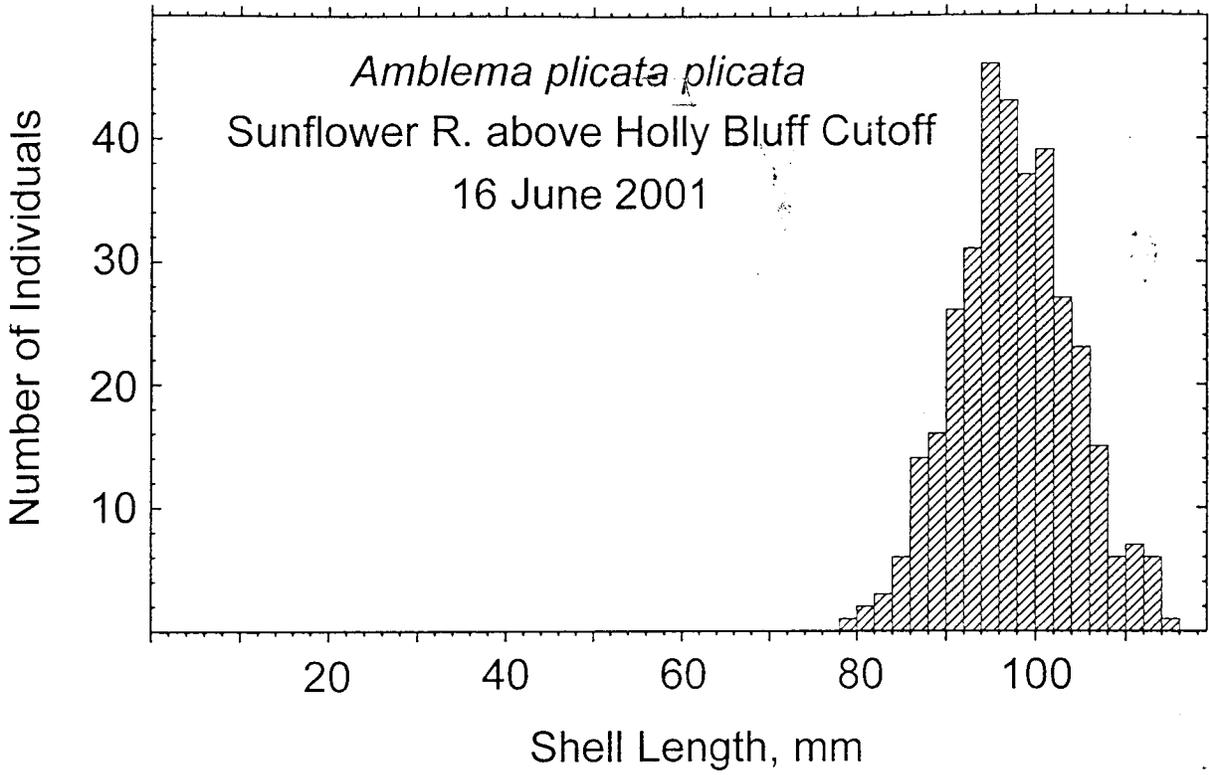


Figure 12. Length-frequency histogram for *Amblema plicata plicata*, near Anguilla, upriver of the Holly Bluff Cutoff, Big Sunflower River, 15 June 01.

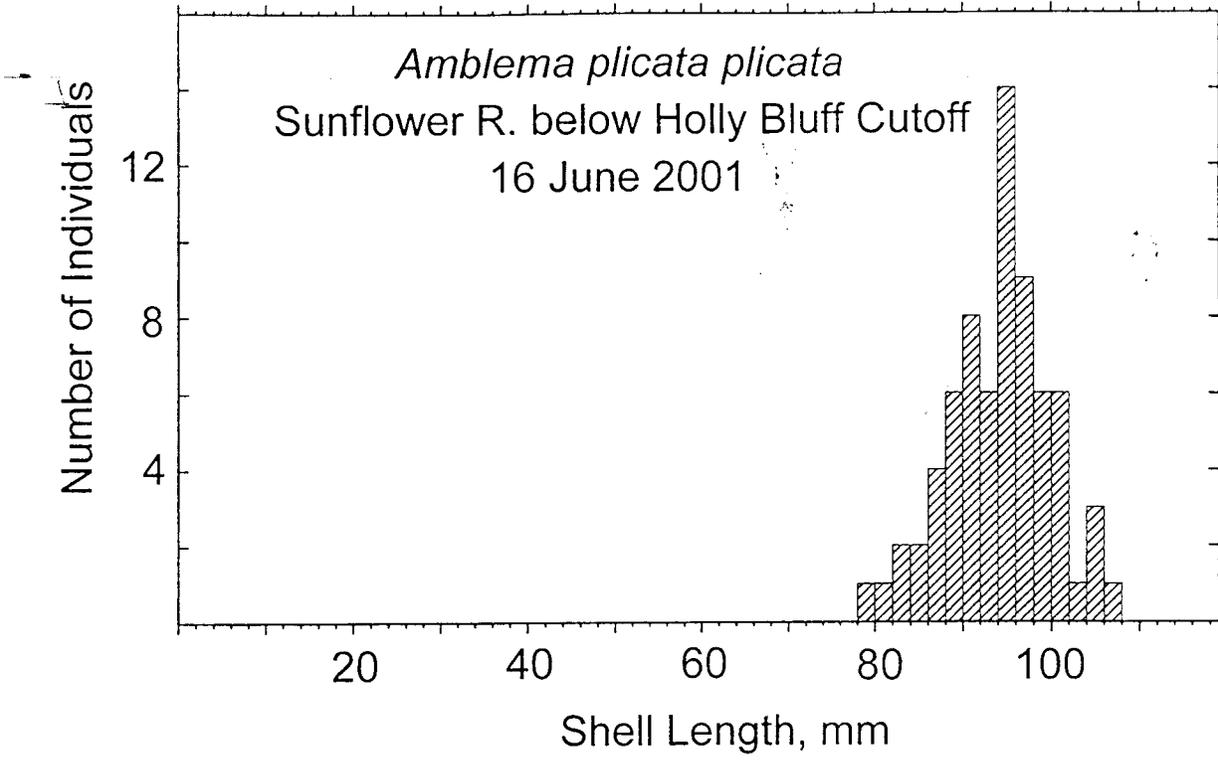


Figure 13. Length-frequency histogram for *Amblema plicata plicata*, downriver of the Holly Bluff Cutoff, Big Sunflower River, 15 June 01.

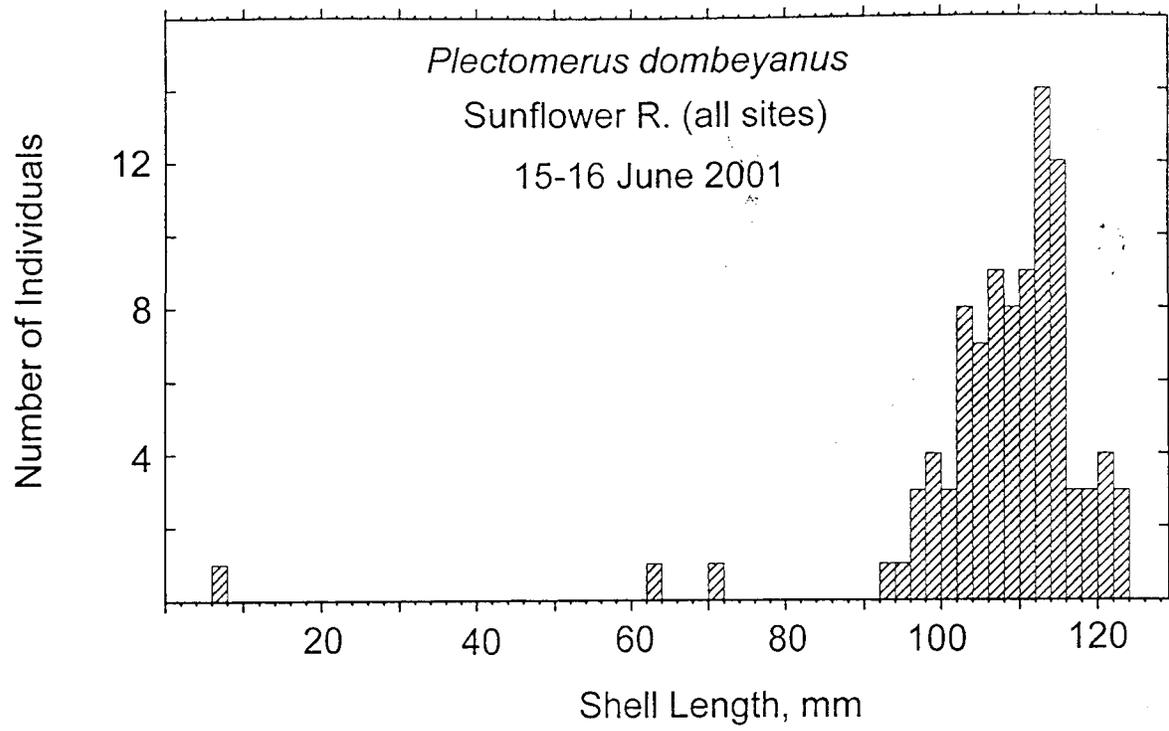


Figure 14. Length-frequency histogram for *Plectomerus dombeyanus*, all three locations (downriver of Lock and Dam 1, downriver of Anguilla, MS, and downriver of the Holly Bluff cutoff) combined, Big Sunflower River, 15 June 01.

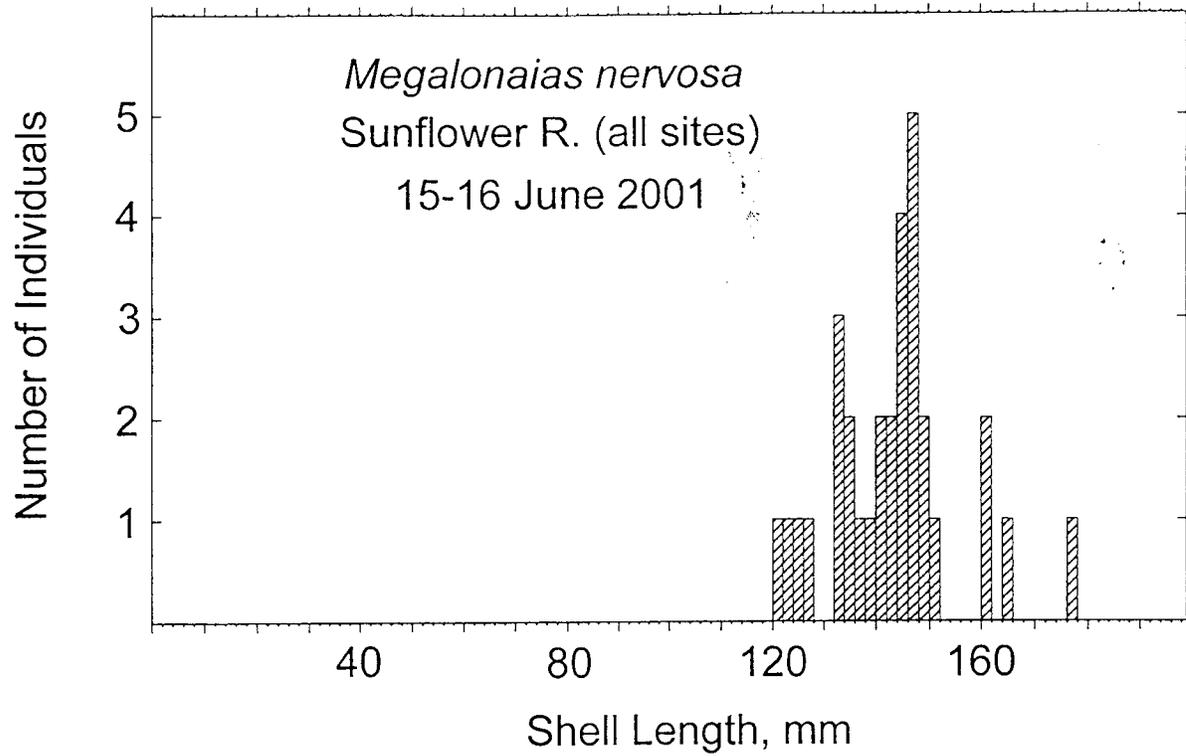


Figure 15. Length-frequency histogram for *Megaloniaias nervosa*, all three locations (downriver of Lock and Dam 1, downriver of Anguilla, MS, and downriver of the Holly Bluff cutoff) combined, Big Sunflower River, 15 June 01.



**Appendix A**

**Results of Qualitative and Quantitative Sampling on the  
upper Big Sunflower River, 2001**

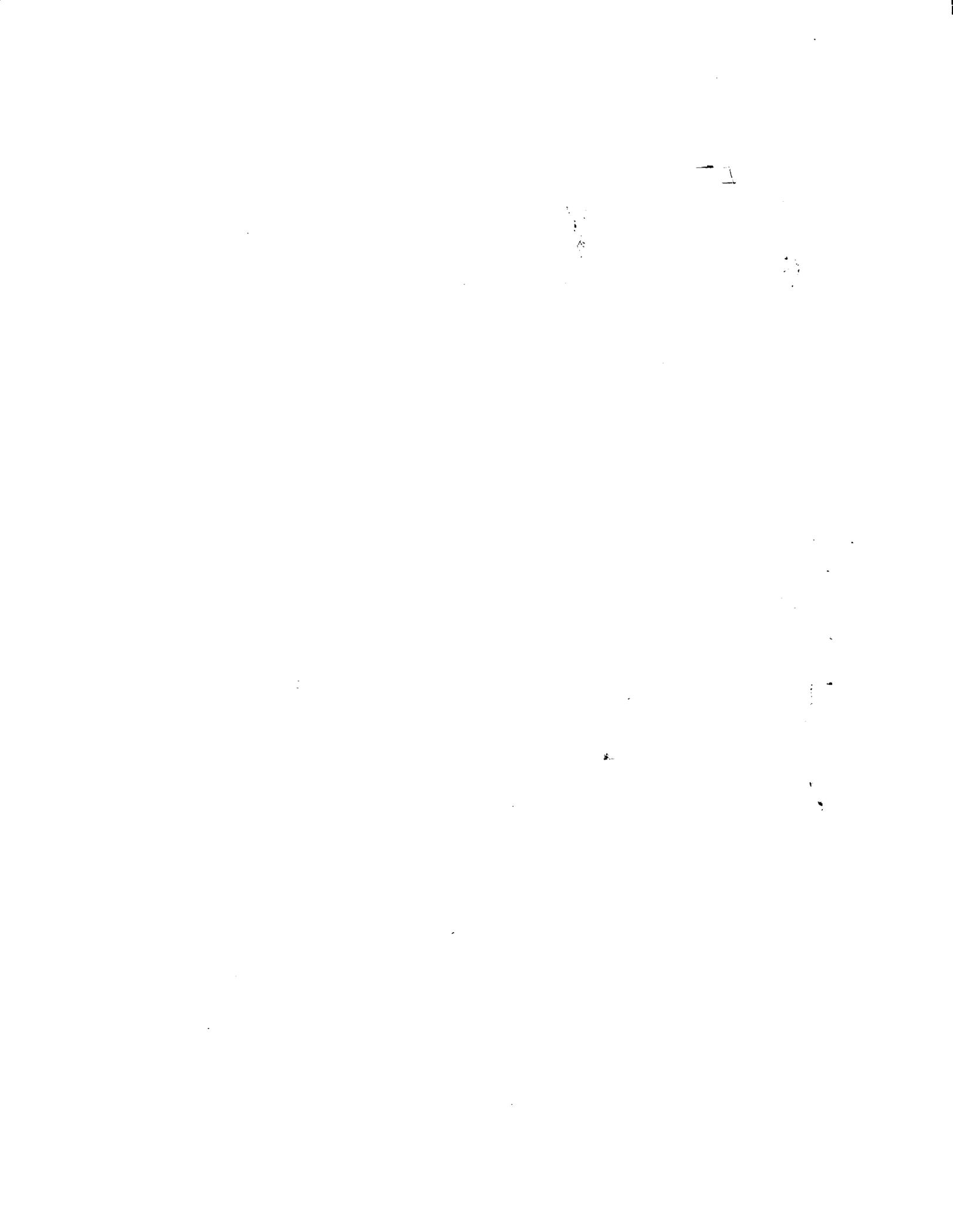


Table A1. Summary data from qualitative collections for Freshwater Mussels at 19 sites along the Big Sunflower River, MS, 18-19 Oct 00.

Species	Total Mussels	%	Total Sites	%
<i>P. dombeyanus</i>	129	45.42	9	47.37
<i>P. purpuratus</i>	50	17.61	8	42.11
<i>A. plicata</i>	42	14.79	8	42.11
<i>L. teres</i>	15	5.28	6	31.58
<i>L. fragilis</i>	15	5.28	6	31.58
<i>M. nervosa</i>	6	2.11	3	15.79
<i>P. ohiensis</i>	6	2.11	4	21.05
<i>Q. pustulosa</i>	5	1.76	3	15.79
<i>Q. nodulata</i>	4	1.41	3	15.79
<i>O. reflexa</i>	3	1.06	2	10.53
<i>P. grandis</i>	3	1.06	2	10.53
<i>T. truncata</i>	2	0.70	1	5.26
<i>A. confragosus</i>	1	0.35	1	5.26
<i>G. rotundata</i>	1	0.35	1	5.26
<i>P. pyramidatum</i>	1	0.35	1	5.26
<i>U. imbecillis</i>	1	0.35	1	5.26
Total time	320			
Total individuals	284			
Total species	16			
Ind/min	0.89			
Total sites sampled	19			

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Table A2. Percent Abundance Data, and Other Summary Statistics, from Quantitative Samples Collected at Three Locations in the upper Big Sunflower River, Mississippi, 31 Oct - 1 Nov, 2000. At each location 10 samples were collected at each of two subsites.

Species	Waypoint Number						Total
	21		27		26		
	1	2	1	2	1	2	
<i>A. plicata</i>	27.78	21.11	10.20	12.16	20.75	21.83	19.32
<i>F. flava</i>	16.67	13.33	8.16	25.68	23.58	7.75	15.49
<i>Q. pustulosa</i>	13.89	18.89	18.37	14.86	8.49	15.49	14.69
<i>P. dombeyanus</i>	8.33	16.67	12.24	6.76	17.92	13.38	13.48
<i>M. nervosa</i>	8.33	5.56	16.33	14.86	9.43	14.79	11.67
<i>F. ebena</i>	2.78	1.11	2.04	1.35	5.66	7.75	4.23
<i>P. pyramidatum</i>	2.78	8.89	14.29	1.35	0.00	1.41	3.82
<i>O. reflexa</i>	0.00	3.33	0.00	1.35	4.72	4.23	3.02
<i>C. fluminea</i>	2.78	2.22	0.00	1.35	5.66	2.82	2.82
<i>T. truncata</i>	2.78	0.00	2.04	5.41	0.94	3.52	2.41
<i>Q. Quadrula</i>	11.11	0.00	2.04	2.70	0.94	0.70	1.81
<i>T. donaciformis</i>	0.00	2.22	4.08	2.70	0.00	2.11	1.81
<i>L. fragilis</i>	0.00	2.22	0.00	2.70	0.94	1.41	1.41
<i>E. lineolata</i>	0.00	1.11	2.04	2.70	0.00	1.41	1.21
<i>Q. nodulata</i>	2.78	2.22	2.04	0.00	0.94	0.70	1.21
<i>P. purpuratus</i>	0.00	0.00	4.08	2.70	0.00	0.00	0.80
<i>T. verrucosa</i>	0.00	0.00	2.04	1.35	0.00	0.00	0.40
<i>L. teres</i>	0.00	1.11	0.00	0.00	0.00	0.00	0.20
<i>P. cyphus</i>	0.00	0.00	0.00	0.00	0.00	0.70	0.20
Total species	11	14	14	16	12	16	19
Total individuals	36	90	49	74	106	142	497
Density, /m <sup>2</sup>	14.40	36.00	19.60	29.60	42.40	56.80	33.13
Standard deviation	2.67	5.69	5.15	2.95	5.81	4.13	5.65
% Ind < 30 mm	2.85	1.13	10.20	13.69	3.00	6.52	6.00
% Species < 30 mm	10.00	7.69	28.57	26.67	18.18	33.33	55.55
Species diversity (H')	2.08	2.19	2.32	2.29	2.05	2.29	2.36
Evenness	0.87	0.83	0.88	0.83	0.83	0.83	0.80
Menhenick's Index	1.83	1.48	2.00	1.86	1.17	1.34	0.85
No. of samples	10	10	10	10	10	10	60

Table A3. Frequency of Occurrence Data from Quantitative Samples Collected at Three Locations in the upper Big Sunflower River, Mississippi, 31 Oct - 1 Nov, 2000. At each location 10 samples were collected at each of two subsites.

Species	Waypoint Number						Total
	21		27		26		
	1	2	1	2	1	2	
<i>A. plicata</i>	50.0	80.0	30.0	50.0	80.0	100.0	65.0
<i>F. flava</i>	60.0	60.0	40.0	70.0	80.0	70.0	63.3
<i>Q. pustulosa</i>	50.0	80.0	60.0	70.0	60.0	90.0	68.3
<i>P. dombeyanus</i>	20.0	70.0	20.0	40.0	60.0	100.0	51.7
<i>M. nervosa</i>	30.0	50.0	20.0	60.0	60.0	90.0	51.7
<i>F. ebena</i>	10.0	10.0	10.0	10.0	30.0	60.0	21.7
<i>P. pyramidatum</i>	10.0	30.0	30.0	10.0	0.0	20.0	16.7
<i>O. reflexa</i>	0.0	20.0	0.0	10.0	50.0	50.0	21.7
<i>C. fluminea</i>	10.0	10.0	0.0	10.0	40.0	20.0	15.0
<i>T. truncata</i>	10.0	0.0	10.0	30.0	10.0	20.0	13.3
<i>Q. quadrula</i>	30.0	0.0	10.0	20.0	10.0	10.0	13.3
<i>T. donaciformis</i>	0.0	20.0	20.0	20.0	0.0	20.0	13.3
<i>L. fragilis</i>	0.0	20.0	0.0	20.0	10.0	20.0	11.7
<i>E. lineolata</i>	0.0	10.0	10.0	20.0	0.0	20.0	10.0
<i>Q. nodulata</i>	10.0	10.0	10.0	0.0	10.0	10.0	8.3
<i>P. purpuratus</i>	0.0	0.0	20.0	20.0	0.0	0.0	6.7
<i>T. verrucosa</i>	0.0	0.0	10.0	10.0	0.0	0.0	3.3
<i>L. teres</i>	0.0	10.0	0.0	0.0	0.0	0.0	1.7
<i>P. cyphus</i>	0.0	0.0	0.0	0.0	0.0	10.0	0.0
<b>Total samples</b>	<b>10</b>	<b>10</b>	<b>10</b>	<b>10</b>	<b>10</b>	<b>10</b>	<b>60</b>

**Table A4. Summary Information from Qualitative Sampling for Freshwater Mussels at Seven Locations in the upper Big Sunflower River, Mississippi, 31 Oct and 1 Nov, 2000.**

Species	Waypoint							Percent Abund	Freq Ocurr
	29	21	22	26	30	31	33		
<i>A. plicata</i>	33.19	21.45	18.03	27.67	15.68	10.26	6.21	21.31	90.0
<i>M. nervosa</i>	23.11	18.23	20.49	27.18	14.83	13.68	31.07	21.21	94.0
<i>P. dombeyanus</i>	15.13	15.55	9.49	9.22	25.42	20.51	54.24	17.95	88.0
<i>F. flava</i>	14.92	12.06	22.39	8.25	26.69	30.77	1.13	16.67	90.0
<i>Q. pustulosa</i>	0.63	13.40	9.30	13.11	6.36	4.27	5.08	7.48	80.0
<i>P. pyramidatum</i>	6.93	8.04	6.83	0.49	0.00	0.85	0.00	4.78	44.0
<i>F. ebena</i>	0.21	0.00	6.45	7.28	0.85	1.71	0.00	2.56	34.0
<i>P. purpuratus</i>	2.10	2.95	1.71	2.91	2.12	4.27	0.00	2.18	54.0
<i>Q. quadrula</i>	2.10	2.41	1.33	0.97	3.39	2.56	0.00	1.85	44.0
<i>L. fragilis</i>	1.05	1.88	1.33	0.00	2.54	0.00	0.00	1.18	34.0
<i>O. reflexa</i>	0.21	1.34	0.76	0.97	1.27	2.56	1.13	0.95	30.0
<i>Q. nodulata</i>	0.42	1.07	0.00	0.49	0.00	2.56	0.00	0.47	12.0
<i>T. truncata</i>	0.00	1.34	0.00	0.49	0.42	0.00	0.00	0.33	10.0
<i>P. cyphus</i>	0.00	0.00	0.00	0.49	0.42	2.56	0.00	0.24	8.0
<i>T. texasensis</i>	0.00	0.00	0.76	0.00	0.00	0.00	0.00	0.19	8.0
<i>U. imbecillis</i>	0.00	0.00	0.76	0.00	0.00	0.00	0.00	0.19	6.0
<i>E. lineolata</i>	0.00	0.27	0.19	0.49	0.00	0.00	0.00	0.14	6.0
<i>L. teres</i>	0.00	0.00	0.19	0.00	0.00	0.00	0.56	0.09	4.0
<i>A. confragosus</i>	0.00	0.00	0.00	0.00	0.00	0.85	0.00	0.05	2.0
<i>C. fluminea</i>	0.00	0.00	0.00	0.00	0.00	0.85	0.00	0.05	2.0
<i>L. hydiana</i>	0.00	0.00	0.00	0.00	0.00	0.85	0.00	0.05	2.0
<i>P. ohiensis</i>	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.05	2.0
<i>P. grandis</i>	0.00	0.00	0.00	0.00	0.00	0.85	0.00	0.05	2.0
Total time	40	120	76	30	50	70	20	406	
Total individuals	476	373	527	206	236	117	177	2112	
Total species	12	13	15	14	12	16	8	23	
Ind/min	11.90	3.11	6.93	6.87	4.72	1.67	8.85	5.20	
Total samples	8	8	8	6	9	7	4	50	



**Appendix B**

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**Results of Qualitative Sampling on the middle  
Big Sunflower River, MS, June 2001**

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**Table B1. Results of 20 qualitative samples for mussels immediately below Lock and Dam 1, Big Sunflower River, Waypoint 34.**

Species	Sample Number																				Total	%
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
<i>A. plicata</i>	26	17	16	17	16	15	19	13	17	19	18							20	25	18	360	93.99
<i>P. dombeyanus</i>				1														1		1	13	3.39
<i>Q. pustulosa</i>					1		4	1													9	2.35
<i>F. flava</i>						2															1	0.26
<b>Total</b>																						
Individuals	26	17	16	18	17	21	21	14	17	21	22											
Total Time	2	2	2	2	2	2	2	2	2	2	2											
Total Species	1	1	1	2	2	3	3	2	1	3	3											
Ind/min	13	8.5	8	9	8.5	10.5	10.5	7	8.5	10.5	11											
<b>Species</b>																						
<i>A. plicata</i>	18	17	14	14	14	17	20															
<i>P. dombeyanus</i>		1				1																
<i>Q. pustulosa</i>		1				1																
<i>F. flava</i>																						
Total individuals	18	19	14	24	14	19	20															
Total time	2	2	2	2	2	2	2															
Total species	1	3	1	1	1	3	1															
Ind/min	9	9.5	7	12	7	9.5	10															



**Table B2. Results of timed searches by divers at a mussel bed located near Anguilla, MS, Waypoint 39, Waypoint 40.**

Species	Sample Number					Total	%
	1	2	3	4	5		
<i>A. plicata</i>	23	19	12	22	12	88	85.44
<i>P. dombeyanus</i>	1	3	3	1	3	11	10.68
<i>Q. pustulosa</i>	1	1				2	1.94
<i>F. ebena</i>			1			1	0.97
<i>F. flava</i>				1		1	0.97
Total Individuals	25	23	16	24	15	103	100
Total Time	2	2	2	2	2	10.00	
Total Species	3	3	3	3	2	5	
Ind/min	12.5	11.5	8	12	7.5	10.3	



**Table B3. Results of timed searches by divers at a mussel bed immediately downriver of the upper end of the Holly Bluff Cutoff, 16 June 01, Waypoint 40.**

Species	Sample Number					Total	%
	1	2	3	4	5		
A. plicata	30	28	32	31	33	154	85.08
Q. pustulosa		2	1	1	5	9	4.97
M. nervosa	2		1	2		5	2.76
F. flava		2		2		4	2.21
P. dombeyanus	1		1	2		4	2.21
Q. nodulata	1	1		1	1	4	2.21
O. reflexa				1		1	0.55
Total Individuals	34	33	35	40	39	181	14.92
Total Time	5	5	10	10	10	40	
Total Species	4	4	4	7	3	7	
Ind/min	6.8	6.6	3.5	4	3.9	4.5	

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Table B4. Results of timed searches by divers along the Little Sunflower River, 17 June 01.

Species	Waypoint Number										Total Individuals	%
	41	42	43	44	45	46	47					
<i>A. plicata</i>	12	13	1								26	65.00
<i>Q. quadrula</i>	2	4	1								7	17.50
<i>L. fragilis</i>		1	1								2	5.00
<i>A. suborbiculata</i>					1						1	2.50
<i>E. dilatata</i>					1						1	2.50
<i>P. grandis</i>		1									1	2.50
<i>P. purpuratus</i>		1									1	2.50
<i>Q. nodulata</i>				1							1	2.50
Total Individuals	14	20	4	0	2	0	0	0	0	0	40	100
Total Time	10	15	15	30	30	30	30	30	30	30	160	
Total Species	2	5	4	0	2	0	0	0	0	0		
Ind/min	1.40	1.33	0.27	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.25	

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**Appendix C**

**Results of Quantitative Sampling along the  
Middle Big Sunflower River, MS**

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**Table C1. Results of Quantitative sampling immediately downriver of Lock and Dam 1, June 01, Waypont 34**

Species	Set # 1		Set # 2		Grand Total	
	Number	%	Number	%	Number	Percent
A. plicata	247	97.24	94	94.95	341	96.60
L. teres	1	0.39			1	0.28
L. fragilis			1	1.01	1	0.28
P. dombeyanus			4	4.04	4	1.13
M. nervosa	1	0.39			1	0.28
Q. nodulata	2	0.79			2	0.57
Q. pustulosa	2	0.79			2	0.57
U. imbecillus	1	0.39			1	0.28
Total individuals	254		99		353	
Total species	6		3		8	



**Table C2. Percent abundance of mussels collected using quantitative methods at Waypoints 38 (Samples 1 and 2) and 39 (Samples 3 and 4) at a mussel bed near Anguilla, MS.**

Species	Sample Number				Total
	1	2	3	4	
<i>A. plicata</i>	81.60	72.58	63.11	84.62	75.91
<i>P. dombeyanus</i>	13.60	20.16	33.01	6.84	17.91
<i>M. nervosa</i>	1.60	3.23	2.91	1.71	2.35
<i>Q. pustulosa</i>	1.60	1.61	0.00	2.56	1.49
<i>O. reflexa</i>	1.60	0.81	0.00	0.00	0.64
<i>L. fragilis</i>	0.00	0.81	0.00	0.85	0.43
<i>Q. nodulata</i>	0.00	0.81	0.00	0.00	0.21
<i>T. truncata</i>	0.00	0.00	0.97	0.85	0.43
<i>F. ebena</i>	0.00	0.00	0.00	0.85	0.21
<i>F. flava</i>	0.00	0.00	0.00	0.85	0.21
<i>L. teres</i>	0.00	0.00	0.00	0.85	0.21
Total individuals	125	124	103	117	469
Total species	5	7	4	9	11

**Table C3. Results of two sets of Quantitative samples (n = 5 for each) at a site immediately upriver of the Holly Bluff Cutoff, Waypoint 40, 16 June 2001.**

Species	Set #1		Set #2		Grand	
	Number	%	Number	%	Total	%
A. plicata	51	70.83	20	71.43	71	72.45
M. nervosa	12	16.67			12	12.24
P. dombeyanus	5	6.94	2	7.14	7	7.14
Q. pustulosa			3	10.71	3	3.06
C. fluminea	1	1.39	1	3.57	2	2.04
Q. nodulata			2	7.14	2	2.04
P. grandis	1	1.39			1	1.02
Total individuals	70		28		98	
Total species	5		5		7	