MISCELLANEOUS PAPER EL-92-11

MUSSEL SURVEYS AT POTENTIAL MOORING SITES FOR BARGE TOWS NEAR UPPER MISSISSIPPI RIVER LOCKS AND DAMS 9 AND 10 SEPTEMBER 1990

by

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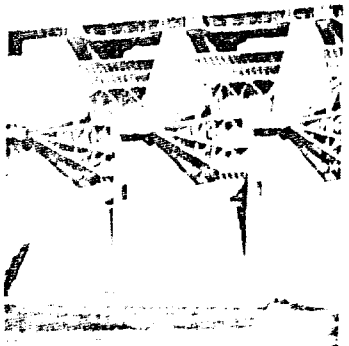

October 1992
Final Report

Prepared for US Army Engineer District, St. Paul
St. Paul, Minnesota 55101-1479

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	October 1992	Final report

4. TITLE AND SUBTITLE
Mussel Surveys at Potential Mooring Sites for Barge Tows Near Upper Mississippi River Locks and Dams 9 and 10, September 1990

5. FUNDING NUMBERS

6. AUTHOR(S)
Barry S. Payne, Andrew C. Miller

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
US Army Engineer Waterways Experiment Station
Environmental Laboratory
3909 Halls Ferry Road, Vicksburg, MS 39180-6199

8. PERFORMING ORGANIZATION REPORT NUMBER
Miscellaneous Paper EL-92-11

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
USAE District, St. Paul
St. Paul, MN 55101-1479

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

In September 1990, a survey was conducted of 10 potential mooring sites for barges along the edge of the navigation channel just above and below Locks and Dams 9 and 10. In general, conditions were too erosional just below and too depositional just above the locks and dams to support substantial populations of mussels. The only substantial community found was at a site designated as A3, at river mile 649.2 to 649.5 above Lock and Dam 9. Nineteen species of unionids were represented among 629 individuals collected at this location. A low-density assemblage (2 to 11 individuals/m^2) occurred at the upper and lower ends of Site A3. The endangered species *Lampsilis higginsii* comprised approximately 0.3 percent of the mussel community at Site A3. The estimated density of *L. higginsii* equaled 0.02 individual/m^2. This density value was slightly less than the range of densities (0.04 to 0.23 individual/m^2) that have been estimated for the least dense populations of species that have persisted in several other large-river mussel beds. Thus, the density of the *L. higginsii* population at Site A3 may be slightly less than the minimum required for a reproductively viable population.

14. SUBJECT TERMS
Endangered mussels
Mussels
Navigation effects
Upper Mississippi River

15. NUMBER OF PAGES
24

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED		

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Preface

The study reported herein was conducted by the US Army Engineer Waterways Experiment Station (WES) for the US Army Engineer District, St. Paul. Mr. Dennis Anderson, St. Paul District, monitored the study and reviewed an early draft of the report.

The report was prepared by Drs. Barry S. Payne and Andrew C. Miller of the Aquatic Habitat Group (AHG), Environmental Resources Division (ERD), Environmental Laboratory (EL). Assistance in the field was provided by Ms. Janine Harrison, a contract student employed by St. Paul District. A Corps of Engineers dive crew under the supervision of Mr. Ron Fetting performed all diving.

During preparation of this report, Mr. Edwin A. Theriot was Chief, AHG; Dr. Conrad J. Kirby was Chief, ERD; and Dr. John Harrison was Director, EL.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander and was COL Leonard G. Hassell, EN.

This report should be cited as follows:

> Payne, Barry S., and Miller, Andrew C. 1992. Mussel survey of potential barge mooring sites in the upper Mississippi River near Locks and Dams 9 and 10, September 1990. Miscellaneous Paper EL-92-11. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
feet	0.3048	meters
inches	2.54	centimeters
square feet	0.09290304	square meters

1 Introduction

Background

During the past two decades the volume of commercial barge traffic on the upper Mississippi River (UMR) has increased significantly. As a result, one or more tows often must wait for passage through the locks and dams of the navigation system. Tows often wait tied to large trees along the shore, or with the lead barge pushed against the bank. These practices injure and kill trees and disturb and erode banks. An alternative is for tows to remain under power while maintaining their position in the channel. However, since this alternative method of waiting significantly increases operating costs, the practice of tying to trees or pushing against the bank is more common.

In recent years, natural resource management agencies have become more insistent on reducing the environmental damage caused by the towing industry. Several alternative practices have been suggested to minimize damage caused by tows waiting near locks. One method acceptable to both natural resource management agencies and the barge industry involves construction of structures for temporary mooring away from the shore.

The US Army Engineer District, St. Paul, is evaluating a number of potential locations for such structures in the vicinity of Locks and Dams (L&D) 9 and 10 of the UMR Navigation System. A critical factor in evaluating potential locations for these mooring stuctures is the potential that mussels, including the Federally endangered Higgins-eye pearly mussel (*Lampsilis higginsii*) could be negatively affected. Consequently, the present study was conducted to determine the status of mussels at the proposed locations of temporary mooring structures.

Sites and Methods

On 17-19 September 1990, mussel surveys were conducted at three sites just above and two sites just below L&D 9 (Figure 1) and at two sites just above and three sites just below L&D 10 (Figure 2). The approximate

size of a mooring site is 110 by 1,200 ft[1] (i.e, the dimensions of the lock chamber). At each site, initial dives were conducted, usually in three areas, to determine the presence of mussels as well as substrate and velocity conditions. These initial searches typically involved the diver searching at least 1,000 m^2 in each area. The diver moved slowly along the bottom, felt for mussels, and assessed substrate conditions as he moved.

If mussels were found, density estimates were made by having the diver search by feel, remove, and count all mussels within a 0.25-m^2 quadrat. Six replicate samples were taken by having the diver move the quadrat at least one body's length from the location of the preceding sample. To evaluate species richness as a function of sampling effort, incremental collections were made to allow cumulative species-to-individual curves to be plotted. Mussels initially collected from each of the six quadrats provided the first few individuals for each data pair in a cumulative species-to-individuals plot. Incremental collections were continued by having the diver return bags with approximately 10 individuals each until a total of 100 mussels were collected. Then, batches of 20 were collected until 200 individuals were obtained. Finally, batches of 50 were collected until most species present were collected. A large sample of individuals could be obtained only at Site A3 in Pool 9, although limited incremental collections were also made at Sites A4 and B1 in Pools 10 and 11, respectively.

[1] A table of factors for converting non-SI units of measurement to SI units is presented on page v.

2 Results

Sites Above L&D 9

Site A1

Three initial searches of this site led to the recovery of no live mussels. Water was 20 ft deep in the lower portion of Site A1, and the substrate was sand with a few old shells of unionids. Depth was slightly less (approximately 12 ft) in the middle and upper portions of Site A1, and the substrate was increasingly unsuitable for unionids moving upstream within this site. An 18-in.-thick layer of "muck" (a cohesive ooze of clay particles) overlaid sand in the middle portion of Site A1, and this layer increased in thickness to approximately 3 ft in the upper portion of the site.

Site A2

A total of three *Amblema plicata* were obtained in the initial dives made in the lower, middle, and upper portions of Site A2, and the substrate was unsuitable for a dense or diverse assemblage of mussels. The lower portion of Site A2 was searched near the toe of the submerged bank protection (rock) that lines portions of the outer edge of the Iowa side of the navigation channel. The depth of the channel at the toe of this bank protection was approximately 18 ft, and the substrate was a thick layer of muck over sand. The depth at the top of the bank protection was approximately 4 ft; the diver was able to stand emersed after climbing up the bank protection along the channel edge at this location. Substrate conditions along the channel edge remained the same for initial searches conducted in the middle and upper portions of Site A2. The muck layer at the upper end of Site A2 was 18 in. thick.

Site A3

This was the only site surveyed that had a substantial assemblage of mussels. The distribution of mussels within Site A3 was discontinuous, and reflected intrasite variation in substrate conditions. All mussels were collected from the lower and upper ends of the site, but no mussels were collected in the middle portion. The middle portion of Site A3 was characterized by an 8-in. to 3-ft layer of muck over the sand that was exposed only in the upper and lower ends of Site A3. The depth of each area surveyed in Site A3 ranged from 8 ft (at the upper bank of the navigation channel) to 12 ft in the channel.

A total of 19 species were obtained among 629 unionids collected from the upper and lower ends of Site A3, including one *L. higginsii* from both the upper and lower reaches (Table 1). Mussels were not dense at either location, based on six quantitative samples taken in the upper and lower portions of the site. The average density in lower Site A3 was 11 individuals/m^2; the average density in upper Site A3 was 2 individuals/m^2. A total of nearly three diving hours was required to obtain 629 mussels from the two areas combined. The cumulative number of species obtained was a linear function of the logarithm of the cumulative number of individuals collected (Figures 3-5), as is typical of species richness-to-sampling effort relationships for a diverse community (Magurran 1988).

Shells (but no live individuals) were collected of two species, *Leptodea fragilis* and *Strophitus undulatus*, in addition to the 19 species for which live specimens were obtained. The community composition was similar in the upper and lower reaches of Site A3. *Amblema plicata* comprised 34.8 percent of the total community. *Quadrula nodulata* (17.7), *Q. quadrula* (15.7), and *Megalonaias gigantea* (12.1 percent) were moderately abundant. These four most abundant species alone accounted for 80.3 percent of all mussels collected. Species abundance as a function of dominance rank followed a geometric series (i.e., a straight line on a plot of log abundance on dominance rank; Figure 6), as is typical of a local assemblage of a diverse community (McNaughton and Wolf 1973).

Lampsilis higginsii represented 0.32 percent of the total community. This percent abundance for *L. higginsii* was multiplied by the average density of mussels in the lower and upper portions of Site A3 to provide estimates of the average density of the endangered species at each location. Thus computed, the estimated density of *L. higginsii* equaled 0.035 and 0.006 individual/m^2 in lower and upper Site A3, respectively.

Populations of all four of the most abundant species at Site A3 consisted of a relatively equal proportion of young and small to old and large individuals, indicating sustained recruitment of mussels despite the relatively low density of individuals. A model of length-to-age relationship, based on measurements of shell length at each successive shell annulus, was developed for *Q. nodulata*, a Wisconsin state-endangered species (Figure 7). This model was made possible by both the wide size range of

individuals collected and the distinct shell annuli of this species. The growth model indicates longevity of slightly greater than 10 years for this intermediate-sized unionid species. This species appears to attain 5-mm shell length (SL) in the first partial season of growth after summer recruitment. The annual increment of SL increase is approximately 8 mm in the next full season of growth, 6 mm in the second full season of growth, and approximately 4 to 5 mm for the next 7 years such that an average SL of 51 mm is attained by mussels upon entering their tenth overwintering period. The largest *Q. nodulata* collected at Site A3 was 57 mm SL and had 11 annuli; the oldest mussel collected from this population had 12 shell annuli and measured 52 mm in SL.

Sites Just Below L&D 9

Site B2a

Six searches were conducted at this site. Nearshore (50 to 150 ft from shore) and farshore (200 to 300 ft from shore) dives were conducted at both lower and upper-to-middle portions of Site B2. Substrate was sand at all areas searched, and only three mussels were found (two *Amblema plicata* and a single *Potamilus alatus*). Depth was difficult to estimate even with a heavily weighted line because of the high current velocity below the lock and dam. Estimated depth was at least 13 ft at Site B2a; current velocity was at least 2.5 fps.

Site B2b

Conditions at this site were the same as found at Site B2a. The bottom was uniformly sandy, and current velocity was at least 2.5 fps. No mussels were found at either lower or upper Site B2b. The relatively scouring conditions discovered at Sites B2a and B2b during this survey in relatively low stage and discharge conditions of late summer clearly indicate that high spring flows are sufficent to thoroughly scour the sand bottom in this area below the lock and dam, preventing this area from providing suitable habitat for a substantial community of unionids.

Sites Just Above L&D 10

Site A1

Initial searches were made of the lower, middle, and upper portions of this site. These searches were conducted from the edge toward the center of the navigation channel in water ranging in depth from 13 to 15 ft. A

single clam was found during the search of the lower portion of the site, two individuals were obtained in the middle portion of the site, and five mussels were obtained in the upper portion of the site. Six species were represented among the total of eight mussels collected: *A. plicata*, *Truncilla truncata*, *Obliquaria reflexa*, *Lampsilis ventricosa*, *Obovaria olivaria*, and *Ligumia recta*. Water current was swift (at least 2 fps), and substrate was sand throughout the site.

The paucity of mussels discovered during initial searches clearly indicated that mussel density was so low in this location (i.e., a total area of approximately 3,000 sq ft was searched and yielded only eight mussels) that more extensive sampling was not warranted.

Site A4

Three initial searches were conducted at this site. Both a shallow and deep portion of the upper end of the site were searched, and a single site along the channel margin was investigated in the lower half of the site. The water depth at the search area in the upper portion of the site ranged from 5 to 18 ft, and substrate was sand. Six quantitative samples were taken upon discovery of scattered mussels in the shallow upper portion of Site A4; mussel density at that location equaled 0.5 individual/m^2. Density of mussels was even less in the deeper area searched in the upper portion of the site. A sparse assemblage of mussels was also discovered in the lower portion of the site, and six quantitative samples led to a density estimate of 4 individuals/m^2.

Both density estimates (i.e., at the upper and lower portions of the site) represented patches of the highest density of mussels found in Site A4. A total of 20 diving minutes was required to obtain 22 mussels in addition to the five obtained by quantitative sampling in lower Site A4; during a total of 30 diving minutes, only 29 mussels were recovered in addition to the three obtained by quantitative sampling at upper Site A4. The distribution of individuals among species represented in the total of 59 mussels obtained at Site A4 is shown in Table 2. The paucity of mussels in Site A4 indicated that more extensive sampling of this site was not warranted.

Sites Just Below L&D 10

Site B1

Four searches were made at approximately equal intervals from the lower and upper ends of Site B1. Substrate was well-washed sand, and current velocity was high (at least 2.5 fps). In general, the entirety of Site B1 was too scoured to support mussels. A total of only 83 mussels could be collected in approximately 2 hr of diving at Site B1; 36 of these

were mussels that came from a single patch of mud and those that had collected in the bottom of a 1-m-diam depression found in the sand at upper Site B1. No other high-density patches of mussels were located at this or other portions of Site B1. The distribution of individuals among species obtained at Site B1 is shown in Table 3. Although a few mussels are scattered through Site Bl, the generally scoured nature of this site does not allow for establishment of a substantial mussel community.

Site B2

Site B2 was even more unsuitable for mussels than Site B1, with the water flow being uniform (>15 ft just 50 ft from the shoreline) and swift (approximately 3 fps). Substrate was either sand or hardpan clay (presumably indicating erosion of overlying sand by swift currents). Three mussels were obtained during approximately 1 hr of diving at three areas at Site B2. Two *A. plicata* and a single *L. fragilis* were obtained.

Site B3

As at Site B2, swift currents (>3 fps) cut a deep channel even a few feet from the shoreline in this location. A dive in lower Site B3 had to be aborted. The current velocity was too swift for a heavily weighted diver to reach the bottom before risking entanglement in the stern anchorline that was approximately 70 ft downstream of the bow site of diver entry into the water. A second dive was attempted in upper Site B2, in an area where current velocity was as low as anywhere in this site but still at least 2.5 fps. During a 15-min dive at this location, the diver recovered three mussels (one each of *A. plicata*, *Q. nodulata*, and *L. ventricosa*). All three mussels were found in velocity refuges formed just downstream of large submerged tree stumps and root wads that littered the bottom in this area. Except for these refuges, bottom velocity was too swift to allow suitable stable substrate for mussels. The substrate was well-washed sand or hard clay.

3 Discussion

Mussels were essentially absent from all sites surveyed just downstream of the locks and dams. Marginal assemblages were present in some locations just upstream. The paucity of mussels near the locks and dams is not surprising given the harsh erosional and depositional conditions typically encountered just above and below these structures, respectively. The only location with a substantial assemblage of mussels was Site A3 in Pool 9. Nineteen species, including *Lampsilis higginsii*, were represented among 629 individuals collected at this site. Mussels were found only in the upper and lower reaches of Site A3, and the middle reach was overlain by deep muck that was found throughout most of the area above L&D 9. The density of mussels in upper and lower Site A3 was low and ranged from 2 to 11 individuals/m^2.

The minimum required density for a viable population of a freshwater mussel is difficult to determine; however, a limited empirical basis exists for approximation of this important quantity. Several extensive quantitative surveys have recently been made of riverine mussel beds (Miller and Payne 1988, 1991a,b,c; Payne and Miller 1989; Way, Miller, and Payne 1990; unpublished data of our laboratory) which allow approximation of density of the rarest species present. Cumulative species-to-individual curves were plotted to determine that virtually all species present were collected, and historic information was available for most sites that indicated persistence of the rarest species in the local fauna. Based on quantitative sampling, the percentage abundances of locally rare species were estimated. In addition, quantitative estimates were made of total density of mussels at these same locations. Multiplication of this density and the percentage abundance of the rarest species provides an estimate of the density of the rarest species (Table 4). It is reasonable to assume that these density estimates for the least common species approximate the minimum density required for viable populations.

These estimates of minimum population density range from 0.04 to 0.23 individual/m^2. For the sake of visualization, a regular distribution of individuals can be assumed, such that 0.04 individual/m^2 corresponds to mussels spaced at 5-m intervals. The upper limit of 0.23 individual/m^2 corresponds to one mussel every 2 m. Intermussel distances of 2 to 5 m

are intuitively reasonable as an estimate of maximum spacing for sufficient fertilization of females by males releasing sperm into river currents.

The estimated density of *L. higginsii* at Site A3 in Pool 9 was slightly less than the lower limit of this density range. Averaged for the upper and lower sites, *L. higginsii* occurred at a density of approximately 0.01 individual/m^2 (corresponding to individuals spaced at 10-m intervals if their distribution were regular). The percentage abundance of *L. higginsii* was 0.16 among Site A3 mussels, and the density of all mussels was approximately 6.5 individuals/m^2. Compared to major mussel beds that have been surveyed in the upper Mississippi River, the assemblage of unionids at Site A3 in Pool 9 was best characterized as isolated patches of relatively low density. The low relative abundance of *L. higginsii* within this marginal community, combined with estimates of minimum population densities summarized in Table 4, suggests that density of the Higginsii mussel is just less than a minimum that can be tentatively proposed as necessary for effective reproduction.

In comparison, *L. higginsii* comprises approximately 0.15 percent of a mussel density of approximately 90 individuals/m^2 in the upper Mississippi River near Prairie du Chien (Miller and Payne 1991a). Thus, the estimated density of *L. higginsii* at Prairie du Chien is 0.14 individual/m^2 (Miller and Payne 1991a), corresponding to the approximate upper end of the estimated range for the minimum density of a reproductively viable population. The east channel at Prairie du Chien supports the most dense known assemblage of *L. higginsii* in the upper Mississippi River, and gravid females have been collected at that site. Furthermore, the mussel bed containing *L. higginsii* in the east channel near Prairie du Chien covers a tremendously larger area than the isolated patches of mussels found in upper and lower Site A3. The degree of isolation of *L. higginsii* in Site A3 in Pool 9 is sufficient that the reproductive species' value may be diminished and is certainly low in comparison to the Pool 10 population in the east channel near Prairie du Chien.

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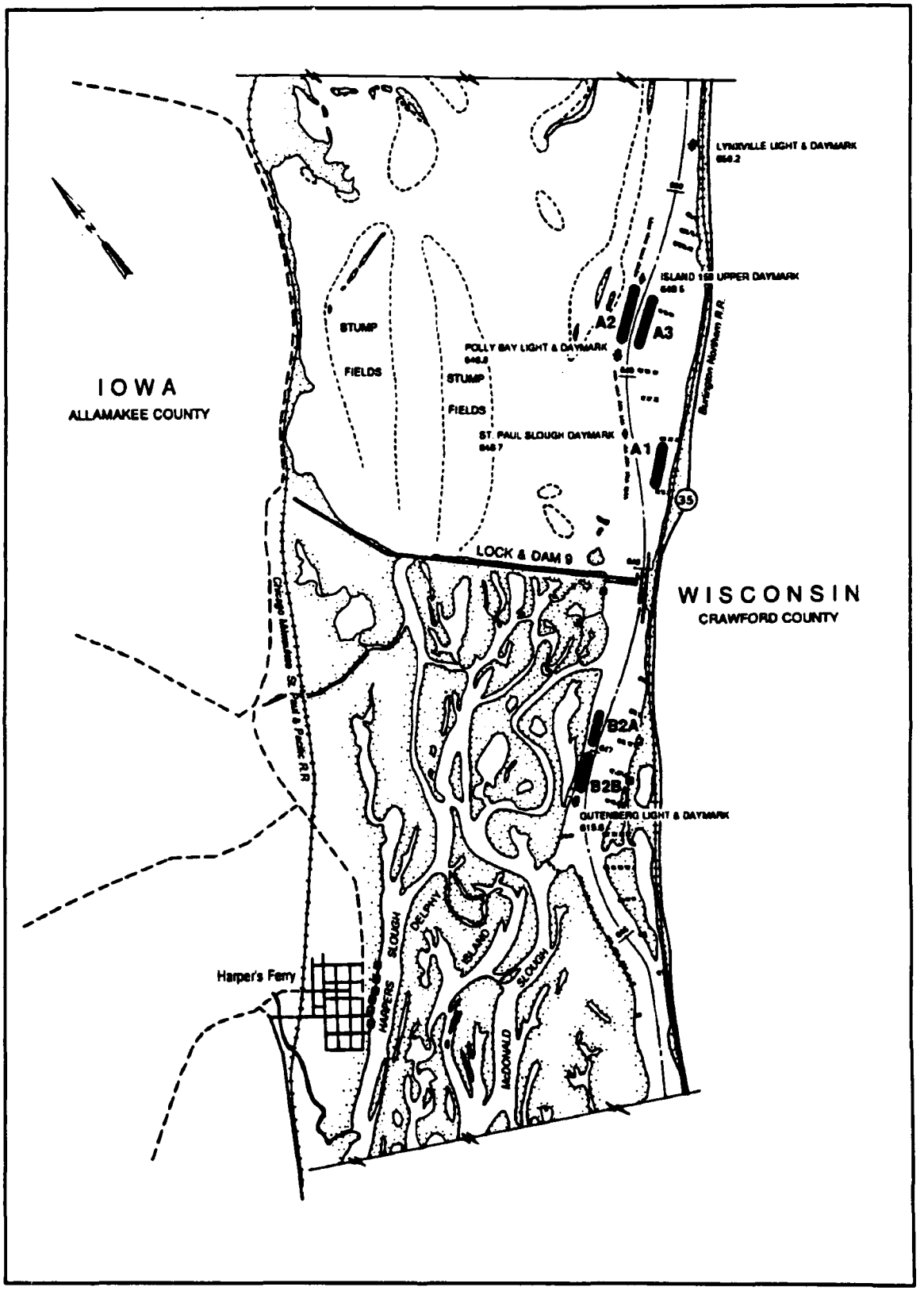

Figure 1. Locations of potential mooring sites in the vicinity of L&D 9

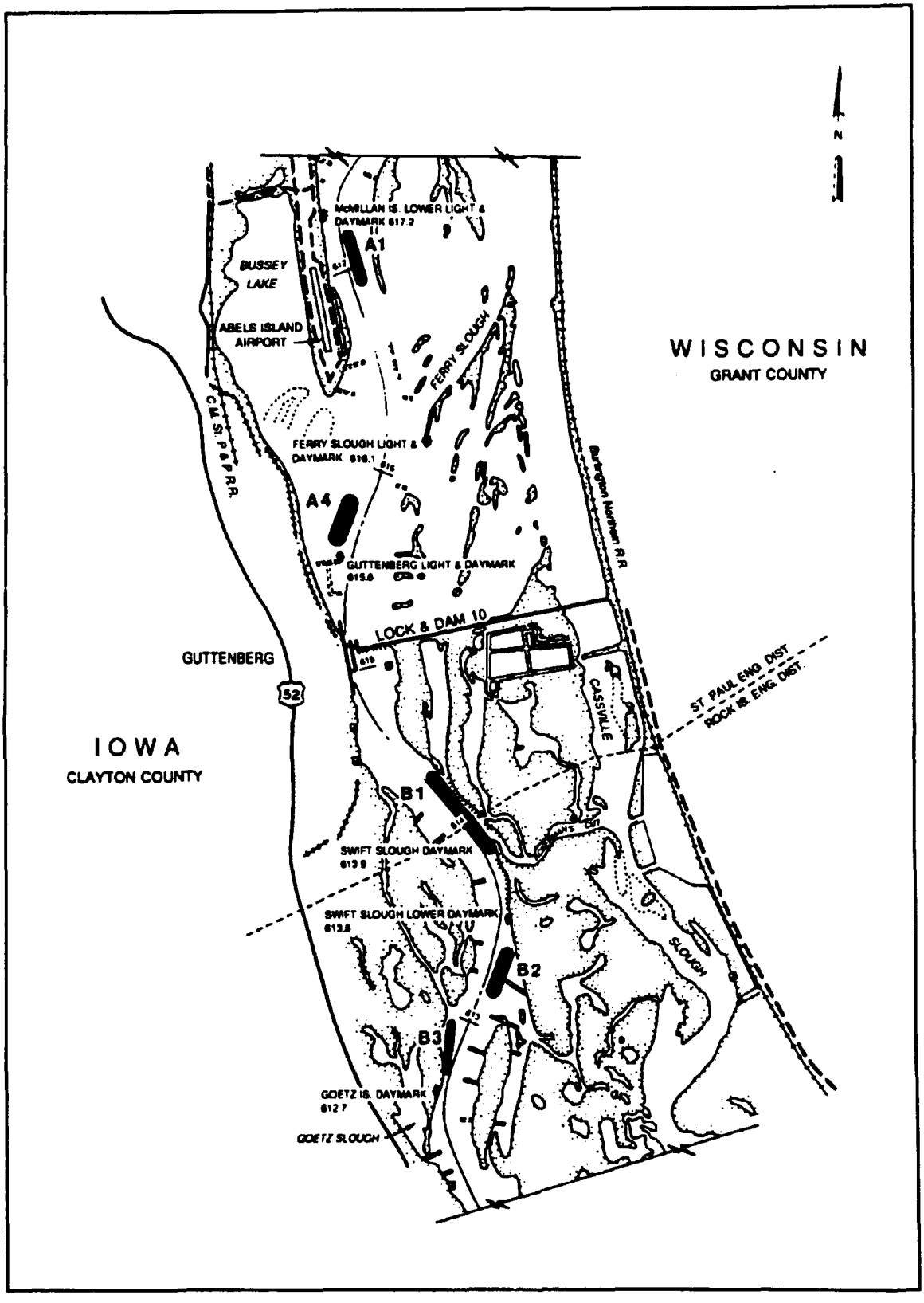

Figure 2. Locations of potential mooring sites in the vicinity of L&D 10

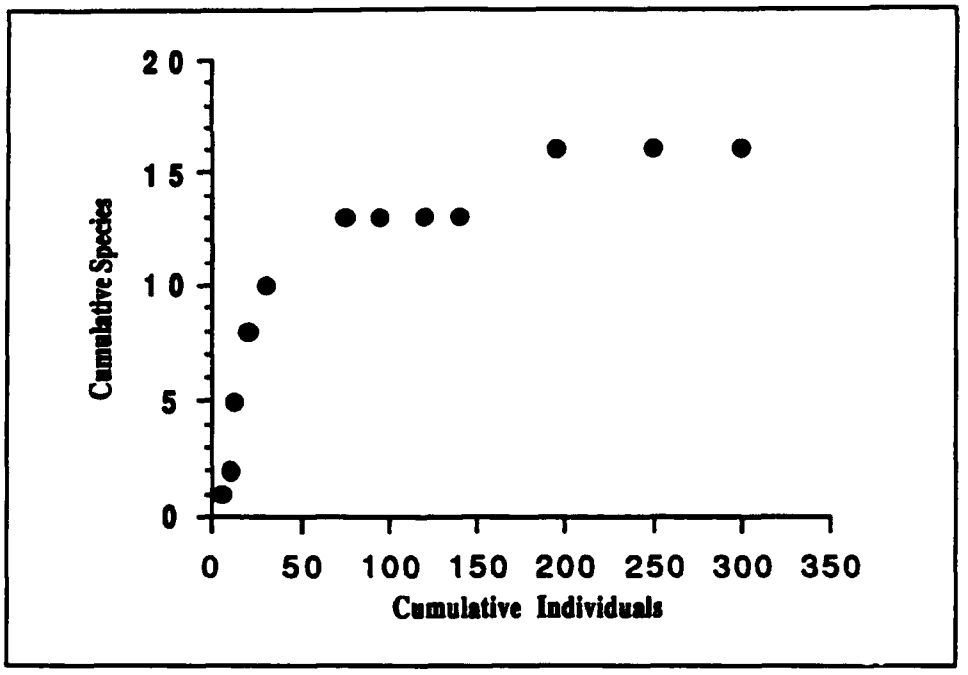

Figure 3. Cumulative species as a function of cumulative individuals collected at lower Site A3, Pool 9

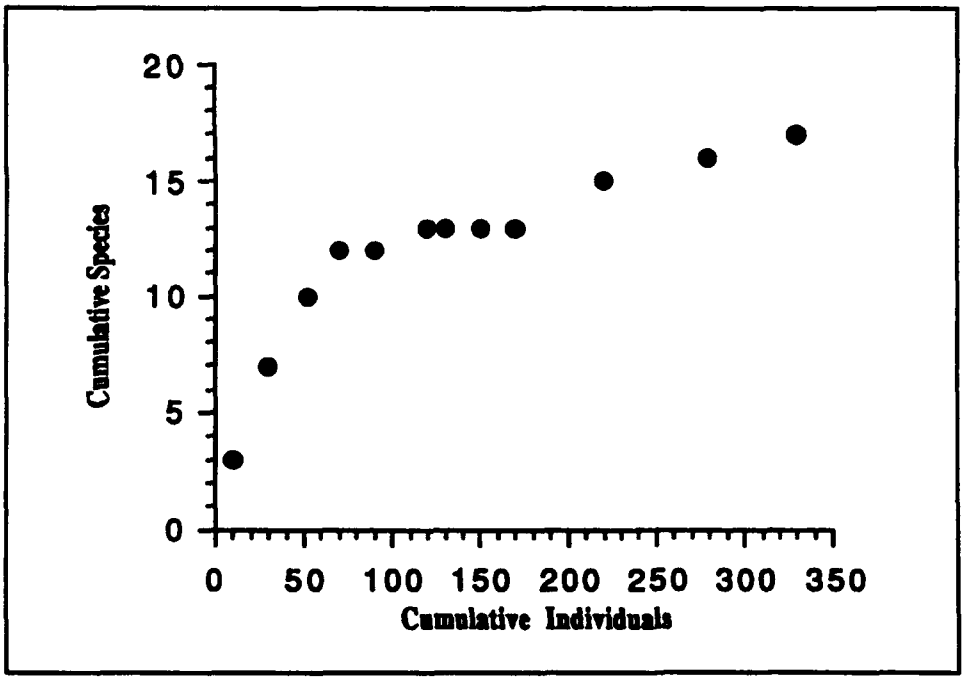

Figure 4. Cumulative species as a function of cumulative individuals collected at upper Site A3, Pool 9

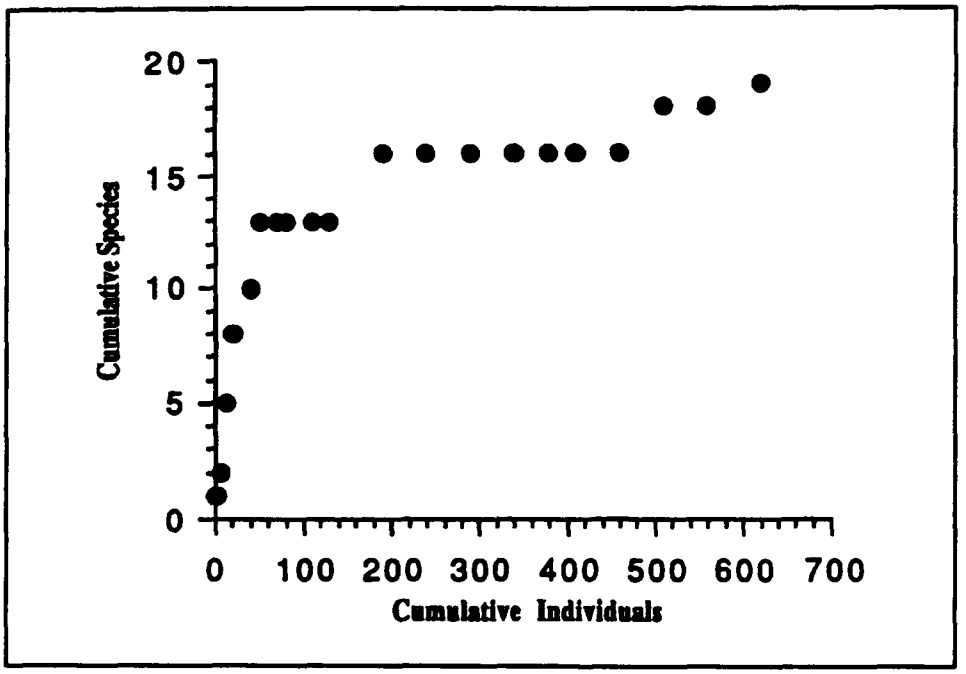

Figure 5. Cumulative species as a function of cumulative individuals collected at Site A3, Pool 9

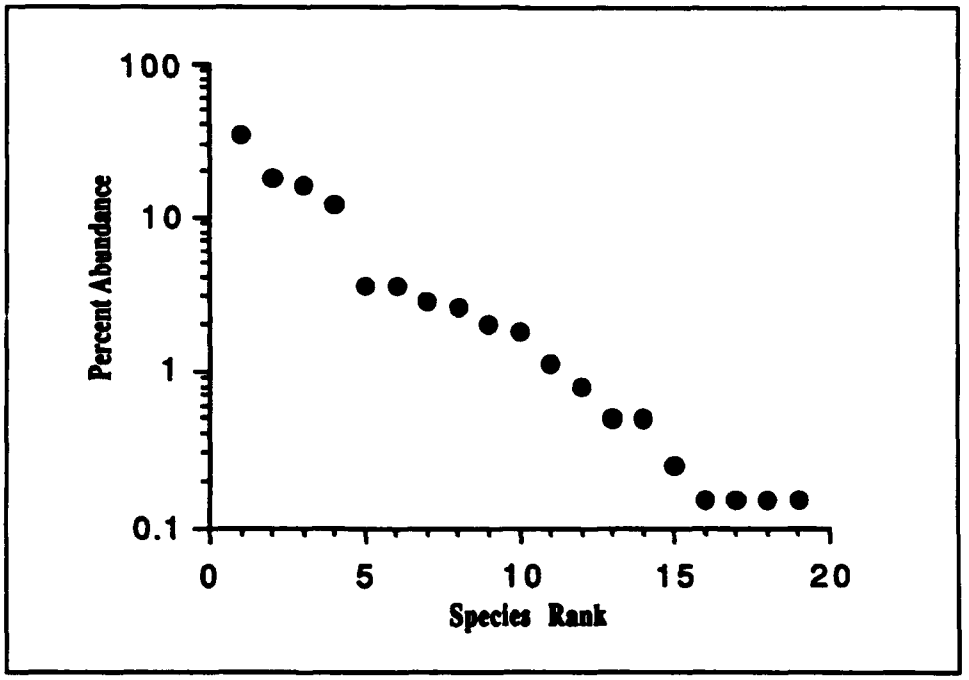

Figure 6. Log (base 10) percentage abundance on species rank for mussels at Site A3, Pool 9

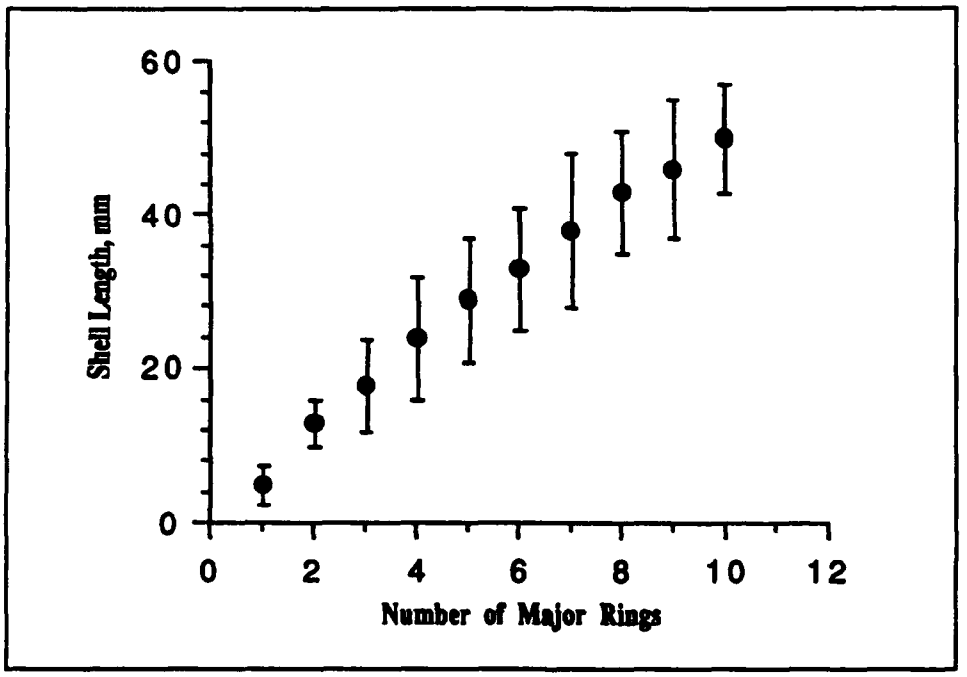

Figure 7. Age-to-length relationship for *Quadrula nodulata* from Site A3, Pool 9. Closed circles and error bars represent the mean ±2 standard deviations

Table 1
Distribution of Individuals Among Species of Mussels Collected at Site A3, Pool 9

Species	Number of Individuals		
	Lower A3	Upper A3	Total
Amblema plicata	109	110	219
Anodonta grandis	8	15	23
Arcidens confragosus		1	1
Elliptio dilitata	1		1
Ellipsaria lineolata		1	1
Fusconaia flava	10	7	17
Lampsilis higginsii	1	1	2
Lampsilis radiata		1	1
Lampsilis ventricosa	11	12	23
Ligumia recta	5		5
Megalonaias gigantea	42	34	76
Obliquaria reflexa	8	7	15
Obovaria olivaria	1	2	3
Potamilus alatus	2	5	7
Potamilus laevissima	1	2	3
Quadrula nodulata	52	59	111
Quadrula pustulosa	4	8	12
Quadrula quadrula	40	59	99
Truncilla truncata	5	5	10
Total number of individuals	300	329	629
Total number of species	16	17	19
Average density (individuals/m^2)	11	2	6.5

Table 2
Distribution of Individuals Among Species of Mussels Collected at Site A4, Pool10

Species	Number of Individuals
Amblema plicata	34
Anodonta grandis	3
Lampsilis ventricosa	3
Obliquaria reflexa	2
Obovaria olivaria	9
Potamilus laevissima	1
Quadrula nodulata	1
Quadrula pustulosa	4
Quadrula quadrula	1
Truncilla truncata	1
Total number of individuals	59
Total number of species	10

Table 3
Distribution of Individuals Among Species of Mussels Collected at Site B1, Pool 11

Species	Number of Individuals
Amblema plicata	46
Anodonta grandis	2
Lampsilis ventricosa	1
Obliquaria reflexa	1
Obovaria olivaria	19
Potamilus alatus	1
Potamilus laevissima	1
Quadrula nodulata	1
Quadrula pustulosa	8
Quadrula quadrula	2
Truncilla truncata	1
Total number of individuals	83
Total number of species	11

Table 4
Estimates of Density of Rarest Species Present in Several Riverine Mussel Beds

Bed Density (River Mile)	Number of Species	Mussel Density (Ind./m^2)	Percent Abundance	Rarest Species (Ind./m^2)
Lower Tennessee River below Kentucky L&D				
RM 21.6	23	63	0.070	0.044
RM 19.0	24	121	0.052	0.062
Big Black River in Mississippi	15	102	0.11	0.11
Ohio River				
RM 967	21	93	0.25	0.23
RM 445	20	46	0.36	0.17
Upper Mississippi River				
RM 635	30	90	0.08	0.07
RM 505	19	70	0.19	0.13
RM 299	18	116	0.12	0.14

Waterways Experiment Station Cataloging-In-Publication Data

Payne, Barry S.
Mussel surveys at potential mooring sites for barge tows near upper Mississippi River locks and dams 9 and 10, September 1990 / by Barry S. Payne, Andrew C. Miller ; prepared for US Army Engineer District, St. Paul.
24 p. : ill. ; 28 cm. — (Miscellaneous paper ; EL-92-11)
Includes bibliographical references.
1. Freshwater mussels — Mississippi River — Effect of sediment on. 2. Inland navigation — Environmental aspects. 3. Lampsilis — Effect of habitat modification on. 4. Barges — Environmental aspects. I. Miller, Andrew C. II. United States. Army. Corps of Engineers. St. Paul District. III. U.S. Army Engineer Waterways Experiment Station. IV. Title. V. Series: Miscellaneous paper (U.S. Army Engineer Waterways Experiment Station) ; EL-92-11.
TA7 W34m no.EL-92-11