



DEPARTMENT OF THE ARMY
WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS
PO BOX 631
VICKSBURG, MISSISSIPPI 39180

1983

Miller
Payne
1984

REPLY TO
ATTENTION OF

WESER

SUBJECT: Transmittal of Report of Findings on a Mussel Investigation for the
Lower Ohio River Navigation Feasibility Study

Mr. Neal E. Jenkins
Chief, Planning Division
US Army Engineer District,
Louisville
PO Box 59
Louisville, KY 40201

The inclosed report of findings summarizes the results of a quantitative and
qualitative mussel survey conducted on the Ohio River near Olmsted, Illinois,
on 26-29 September 1983. Questions or comments should be directed to
Dr. Andrew Miller, FTS 542-2141.

FOR THE COMMANDER AND DIRECTOR:

1 Incl
as

F. R. BROWN
Engineer
Technical Director

An Investigation of Freshwater Mussels on the Ohio River
near Olmsted, Illinois, 26-29 September 1983

by

Andrew C. Miller and Barry S. Payne

Environmental Laboratory
U.S. Army Engineer Waterways Experiment Station

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Introduction

As part of the Lower Ohio River Navigation Feasibility Study, the Louisville District Office is considering replacement of Lock and Dam 53 and Locks and Dam 52 with a single structure near Olmsted, Illinois. The Olmsted alternative, to be located at Ohio River mile 964.4, is immediately upriver from a mussel bed located between miles 966.4 and 969.3 (Williams 1969, Williams and Schuster 1982).* Mussels have been collected from this portion of the river by Neff and Pearson (1980), as well as Williams and Schuster (1982), who indicated that a diverse population including the Federally listed Endangered orange-footed pimpleback (Plethobasus cooperianus) inhabits the bed. On 26-29 September 1983, a survey was made of a reach of the river in the immediate vicinity of the Olmsted Lock and Dam alternative. The objectives of this study were to: (1) survey the area immediately above and below the proposed damsite for common and uncommon mussels, (2) use quantitative and qualitative sampling techniques to characterize the bed downriver of the study area, and (3) search this section of the Ohio River for P. cooperianus. The results of this study will be used for preparation of a draft feasibility report and draft Environmental Impact Statement (EIS) for the Lower Ohio River Navigation Feasibility Study.

Study Area

The study area was between mile 963.5 and 966.5 on the Illinois side (Pulaski County) and mile 964 and 966 on the Kentucky side (Ballard County) of the Ohio River. Shells and live specimens were also collected from immediately below Lock and Dam 53 (mile 962.6), including the upper portion of the mussel bed.

* Williams (1969) lists the bar between 966.0 and 969.2.

Methods

Four sampling techniques were used to assess the mollusc community:

Hand-picking. Approximately 16 man-hours were spent collecting shells and live specimens from the shore and in shallow water along both sides of the river.

Brailing. A 5-ft wooden brail bar equipped with 18 chains (5 beaded hooks per chain) was used to collect mussels from the study area. A total of 21 separate brail runs were made on 26 and 27 September; 18 were from the study area and 3 were from the mussel bed. Brail runs averaged about 1000 ft in length.

Qualitative Surveys. On 28 September an experienced shell diver using breathing apparatus searched for mussels at 12 sites in the study area. At each site the diver spent about 10 min and covered from 200 to 400 ft of linear distance over which he swept his hands over an approximate 6 ft width. On 28 and 29 September the diver qualitatively surveyed the mussel bed just downriver of the proposed project.

Quantitative Survey. On 28 and 29 September the diver collected six quantitative samples (all the molluscs within the confines of a 0.25-m-sq quadrat) from each of four locations on the mussel bed.

Specimens taken by each sampling technique (i.e., brailing, quadrat samples, etc.) were placed in individual plastic bags and returned to the U.S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi, for counting and identification. Taxonomic keys of Burch (1975) and Parmalee (1967) were used for identification of Ohio River specimens. Where possible, collected material was compared with known reference material. Dr. Paul Yokley, University of North Alabama, Florence, Alabama, verified individuals that were difficult to identify. A reference collection will be retained at WES.

In the laboratory, specimens from each major taxonomic group were used to establish length-weight relationships. After determining total shell length, soft parts were removed and dried for 2 days at 75°C. This tissue dry mass (TDM), which excludes the shell and internal water, accounts for about 3 percent of the total mass of a live mussel. Length-weight regressions for each taxon were determined with an IBM 4331 computer using the Statistical Analysis System.

Results

The Study Area. Using quantitative and qualitative techniques, a total of 26 species of freshwater mussels, plus the Asian clam Corbicula, were collected along the Ohio River near Olmsted, Illinois (Table 1). Nineteen species were found by hand along the shore or in shallow water. Most of these 19 plus the remaining 7 species were obtained during the qualitative searches conducted by the diver (6 species) or from the quadrat samples (1 species). Based upon the 4-day survey, nine species were considered common, ten species uncommon, and seven were judged to be fairly common. Based upon visual analysis of rocky areas along the Illinois shore, this portion of the river could be characterized as supporting large numbers of Corbicula, Amblema plicata, Fusconaia ebena, Lampsilis teres, Megalonaias gigantea, and Potamilus alatus. Leptodea fragilis, also common in the river, was most noticeable along the Kentucky shoreline where sand and silt predominated.

The following species were collected from the study area using the brail bar: Amblema plicata, Elliptio crassidens, Fusconaia ebena, Lampsilis teres, Obliquaria reflexa, Quadrula nodulata, Q. pustulosa, and Q. quadrula (Figure 1, Table 2). Of the brail samples, 17 yielded no live mussels; all specimens were collected at sites 1, 12, 13, and 16 on the Illinois side of the river. Species found with the brail were also obtained by the diver or by hand collecting.

In the qualitative survey, the diver searched for mussels in the study area at 12 sites, most of which corresponded to areas previously brailed (Figure 2, Table 3). In several cases he reported observing fresh brail tracks as he worked. At 10 of the 12 sites the diver found from one to nine live mussels. The diver collected a total of 29 specimens representing 9 taxa while

spending about 2 hr on the bottom. During his searches of the study area he did not obtain any species not found by hand collecting along the shore.

In approximately 2 hr the diver collected five times as many mussels and three more species than were taken by working the brail for 4 hrs. The diver found species that were not taken by brail (Leptodea fragilis, P. alatus, Megalonaias gigantea, and Ellipsaria lineolata) but were collected by hand along the shore or in shallow water. Based upon time expended and areas searched, mussel density in the study area was considerably less than $1/m^2$.

The river channel in the study area consisted of clay with patches of sand mixed with detritus, gravel, and Corbicula. On the Illinois side of the river, banks were narrow, steep, and rocky. Water along the shore was 10 or more feet deep and the bottom was composed of soft mud mixed with twigs, partially decomposed leaves, and occasionally small amounts of sand. At the upper end of the study area (off the Illinois bank about 2000 ft downstream of Lock and Dam 53) there was a gravel bar that contained many shells but no live mussels.* On the Kentucky side of the river, the bottom was shallow and made up of sand or clay overlaid with silt. The shore was flat and sandy. The only shells commonly collected by hand on this side of the river were L. fragilis and P. alatus. On the Illinois side of the river, shells and live specimens of many species including Quadrula sp., M. gigantea, F. ebena, as well as Corbicula, were abundant.

The Mussel Bed. A qualitative survey of mussels on the gravel bar was made by the diver on 28-29 September 1983 (Figure 3, Table 4). For the first sample the diver concentrated on large, common organisms, many with commercial value. For samples II through IV the diver was instructed to retrieve unusual or uncommon mussels. Specific attention was given to pustulate individuals; the endangered P. cooperianus superficially resembles the very common Q. pustulosa. Three specimens of P. cooperianus were obtained in the last sample. They were located on the gravel bar several hundred feet from shore and below the study area (Figure 3).

* The lack of live mussels at this site was noted but not fully investigated.

Based upon the quantitative sampling conducted by the diver (Appendix A) the gravel bar was numerically dominated by Corbicula. Total numbers of the Asian clam ranged from 556 to 2628/m² ($\bar{X} = 1475$). Total unionids, which included all species, ranged from 28 to 124/m² ($\bar{X} = 66$). Numerically, F. ebena ($\bar{X} = 46/m^2$) and Truncilla donaciformis ($\bar{X} = 12/m^2$) dominated the unionids. The remaining unionid species were taken in less than half of the 24 quadrats, and two species, Q. metanevra and Q. nodulata, were taken in only a single quadrat. Juveniles clearly outnumbered adults on the gravel bar; evidence of recruitment was found for 12 species.

TDM for Corbicula ($\bar{X} = 128.2$) was approximately three times that of the total unionids ($\bar{X} = 39.7$). Because of their large size and high numbers, F. ebena ($\bar{X} = 27.4$) represented the majority, about 70 percent, of the unionid biomass. Although numerically dominant, T. donaciformis, because of its small size, represented only about 1 percent ($\bar{X} = 0.44 \text{ g/m}^2$) of the unionid biomass.

Unionid species diversity (Shannon-Weaver index) ranged from 0.64 to 2.19 in the quadrat samples taken from the mussel bed. Species diversity (usually including all taxa collected) can range from 0.0 to more than 5; values greater than 3 are usually found in structurally diverse oligotrophic systems. These comparatively low values are the result of: (1) considering only unionids, and (2) dominance of two of the species in the majority of the samples. Species evenness or equitability (Lloyd and Ghelardi 1964), the ratio between observed and theoretical maximum diversity, can vary from 0.0 to 1.0. At the gravel bar in the Ohio River, values ranged from 0.33 to 0.88 ($\bar{X} = 0.69$). Species richness (number of species present) and evidence of recruitment provide the best indicator of high quality unionid habitat. Species richness ranged from 2 to 7 in the quadrat samples with total richness for the bar equaling 26.

Plethobasus cooperianus. This species closely resembles Q. pustulosa, except that Q. pustulosa is smaller and has fewer and relatively larger tubercles which tend to be laterally rather than radially expanded. In Q. pustulosa, young specimens have prominent, broad green rays while in P. cooperianus the rays are obscure or narrow. In addition, all demibranchs are marsupial in Quadrula, while only the outer demibranchs are marsupial in

Plethobasus. Externally, Plethobasus resembles Cyclonaias tuberculata, except that Cyclonaias tuberculata is more quadrate and its nacre is purple. The major distinguishing feature of P. cooperianus is the soft parts which are pale to bright orange. These can be observed by gently prying the valves of a living specimen apart.

Plethobasus cooperianus is a large-river species which usually is found in sand and gravel substrate. It is uncommon and occurs as a minor element in diverse mussel populations. Its host fish is unknown.

The historical range of P. cooperianus included the Ohio River from western Pennsylvania to southern Indiana; the Wabash River below Mount Carmel, Illinois; the Cumberland River from Cumberland County, Kentucky, to the vicinity of Nashville, Tennessee; the lower Clinch River in Anderson County, Tennessee; and the Tennessee River from near Knoxville, Tennessee, to Kentucky Lake, Benton County, Tennessee. It has also been recorded from the Caney Fork, Holston, and French Rivers in Tennessee and from the Green and Rough Rivers in Kentucky. At present, P. cooperianus is restricted to the Ohio and Lower Wabash Rivers where it is uncommon, and in the lower Tennessee River in Alabama and western Tennessee where it is also uncommon. All specimens collected alive in recent decades are old adults and, presumably because of habitat alteration, the species may no longer be reproducing. Plethobasus cooperianus collected during this survey were not aged; however, they were adult sized. (The above information on P. cooperianus was taken from Clarke and Fuller 1983.)

Discussion

The gravel bar, located on the Illinois side of the river between miles 966.4 and 969.3, provided high quality sand/gravel substrate for maintenance of a diverse mollusc community. Outside the confines of the gravel bar, the substrate consisted of clay, sand, or silt which was not suitable for most bivalves, and species diversity and density were low. Suitable substrate for molluscs was found on the Illinois side of the river in the upper portion of the study area; however, no live unionids were collected at that site.

The dominant unionid on the gravel bar, F. ebena, is commonly found in sand and gravel substrates in large rivers (Parmalee 1967, Starrett 1971). The second most abundant unionid on the gravel bar, T. donaciformis, has been taken from mud, sand, and gravel substrate in large and small rivers and lakes. While Corbicula far outnumbered unionids on the bar, mean densities of 1474/m² should not be considered unusually high. Corbicula have been found in densities greater than 15,000/m² in the Arkansas River (Kraemer 1979). The other unionids commonly found on the gravel bar (Quadrula sp., M. gigantea, C. tuberculata, and E. lineolata) are thick-shelled individuals typically found in gravel substrate in large rivers. An exception to this is L. fragilis which is usually found in sand or mud bottom in slack-water habitats. It is significant that only juveniles of this species were collected at the gravel bar. Evidently the gravel substrate is not suitable to enable this species to reach maturity.

From the results of this survey it is not possible to estimate densities of the Endangered species P. cooperianus. Williams and Schuster (1982) collected one specimen in this stretch of the river in their survey, but it was not reported in an earlier study (Williams 1969). Mr. J. Latentresse, president of the American Shell Company in Camden, Tennessee (Personal Communication), reported that this species has been found recently in this stretch of the Ohio River. Its appearance in a diverse mussel bed in the Ohio River is in agreement with information on the species provided by Clarke and Fuller (1983).

Summary

On 26-29 September 1983, a survey for mussels was conducted on a stretch of the Ohio River immediately below Lock and Dam 53. The purpose of this work was to characterize the existing mussel fauna, and search for the Federally listed Endangered P. cooperianus. The center portion of the study area, mile 964.4, is the site of the proposed Olmsted Lock and Dam, which would replace Lock and Dam 53 in Locks and Dam 52. The Louisville District will use the results of this work for a draft feasibility report and a draft EIS for the Lower Ohio River Navigation Feasibility Study.

Using a combination of quantitative and qualitative techniques, 26 species of unionids, plus the Asian clam Corbicula, were collected from the study area and a gravel bar immediately downriver. Because of poor substrate, most of the study area supported a low density and diversity of unionids. A second gravel bar, located on the Illinois side of the river in the upper portion of the study area and fairly close to the Lock and Dam, was also searched for mussels. No live unionids were found, although many shells of common species were collected. It is not known why live mussels are no longer found on this gravel bar. The main gravel bar, located between miles 966.4 and 969.3 on the Illinois side of the river and about 2 miles from the Lock and Dam, supported a dense, diverse mussel fauna. On the mussel bed Corbicula ($1475/m^2$) clearly outnumbered unionids ($66/m^2$). Two unionids were dominant, F. ebena ($46/m^2$), and T. donaciformis ($12/m^2$). Three specimens of P. cooperianus were found on the gravel bar downriver of the study area.

Acknowledgements

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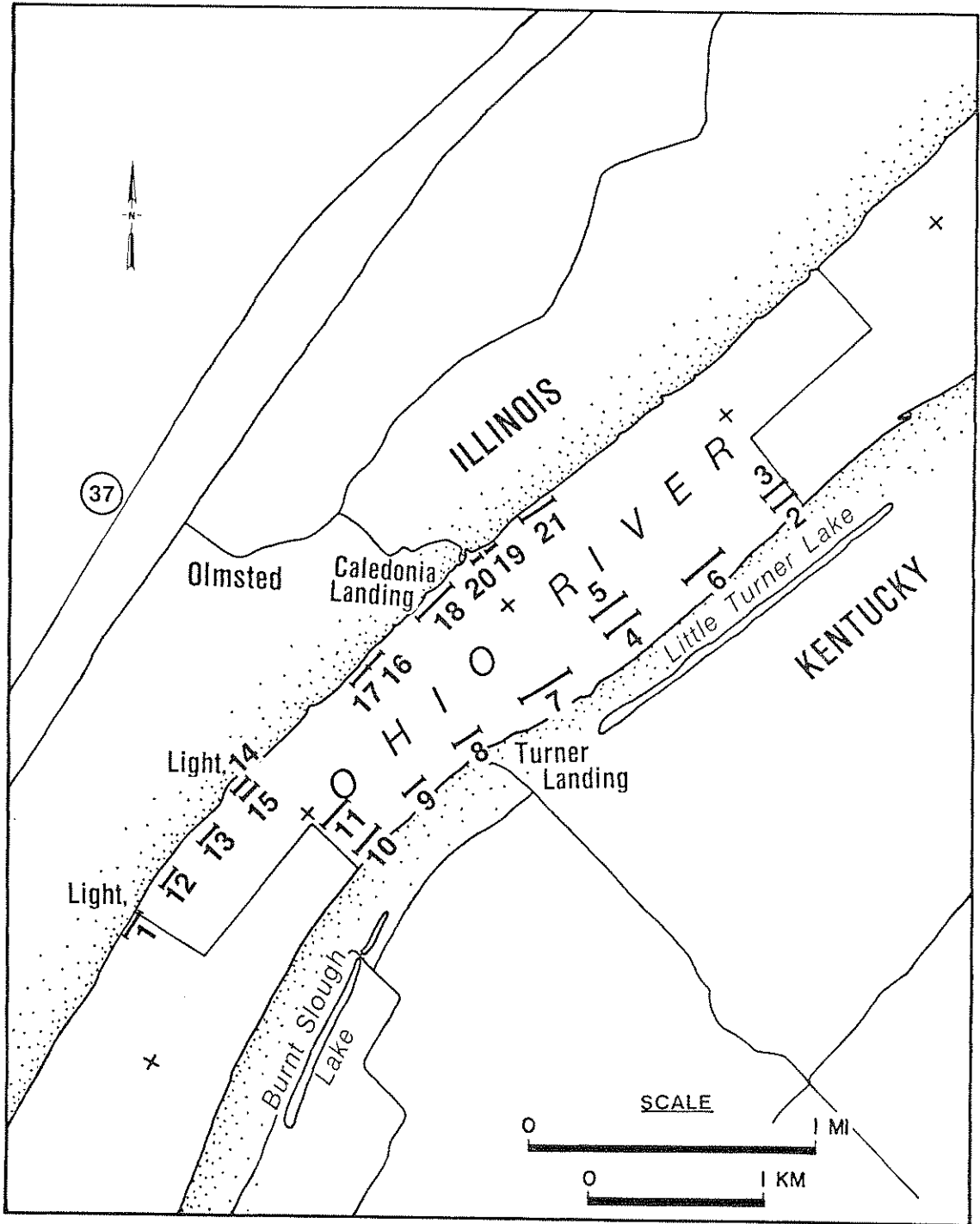


Figure 1. Sites brailed on the Ohio River near Olmsted, Illinois, 26-27 September 1983.

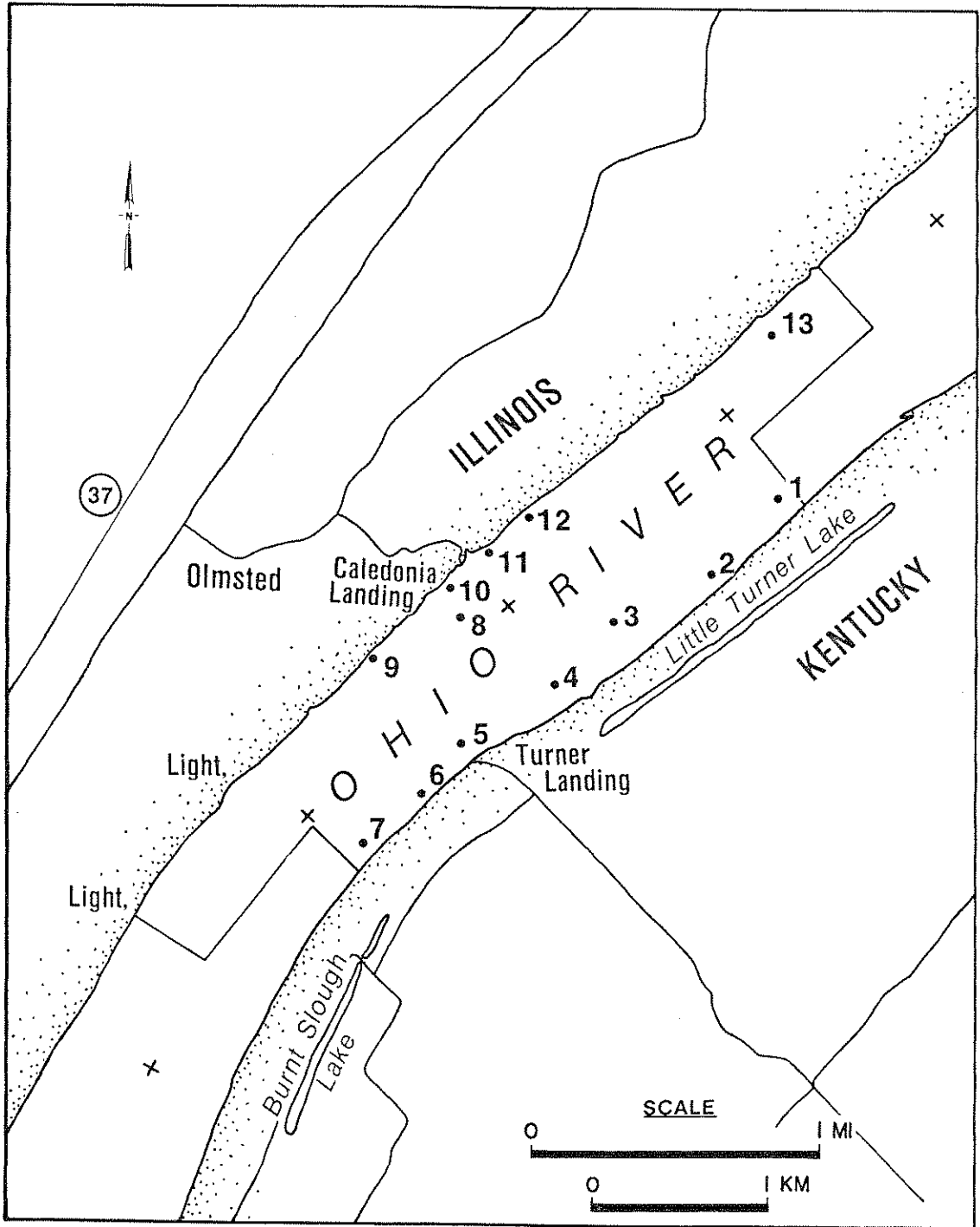


Figure 2. Sites surveyed by a diver on the Ohio River near Olmsted, Illinois, 28 September 1983.

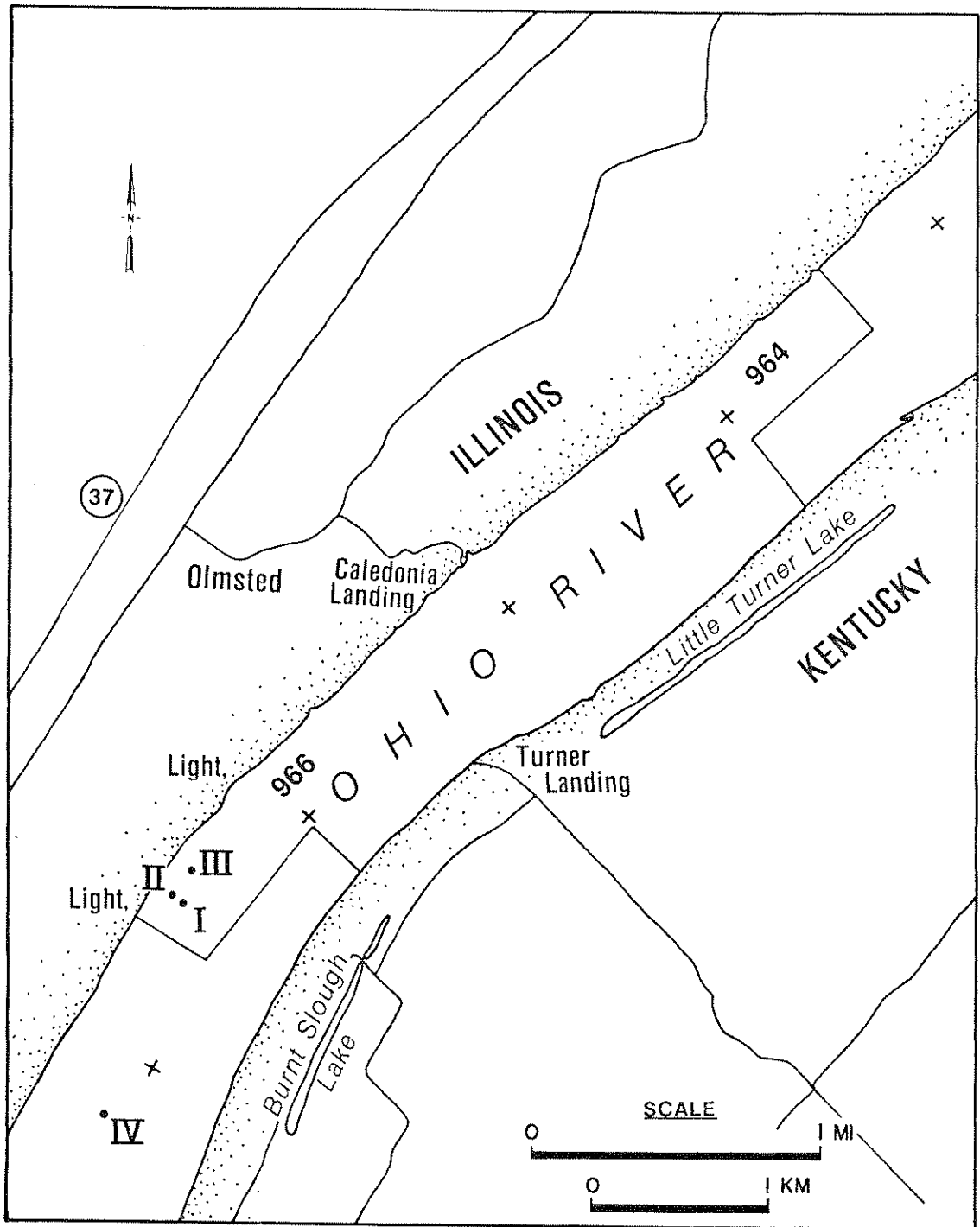


Figure 3. Sites surveyed for mussels by the diver on the Ohio River near Olmsted, Illinois, 28-29 September 1983.

Table 1

Mollusc Species Collected at Ohio River Mile 962.6 to 969.0

Pulaski Co., Ill. and Ballard Co., Ky., 26-29 Sept 83

Scientific Name	Common Name	*Presence	**Collection Technique
Family Unionidae			
<u>Actinonaias ligamentina</u>	Mucket	UC	D
<u>Anblema plicata</u>	Three Ridge	C	D, HP, B, Q
<u>Cyclonaias tuberculata</u>	Purple Warty-Back	UC	D, HP, Q
<u>Ellipsaria lineolata</u>	Butterfly	FC	D, HP, Q
<u>Elliptio crassidens</u>	Elephant Ear	FC	D, HP, B
<u>Elliptio dilatatus</u>	Spike	UC	HP
<u>Fusconaia ebena</u>	Ebony Shell	C	D, HP, B, Q
<u>Lampsilis ovata</u>	Pocketbook	UC	HP
<u>Lampsilis teres</u>	Yellow Sand Shell	C	D, HP, B
<u>Lasnigona complanata</u>	White Heel-Splitter	UC	HP
<u>Leptodea fragilis</u>	Fragile Paper Shell	C	D, HP, Q
<u>Ligumia recta</u>	Black Sand Shell	C	D, HP
<u>Megalonaias gigantea</u>	Washboard	C	D, HP, Q
<u>Obliquaria reflexa</u>	Three Horned Warty-Back	FC	D, HP, B
<u>Obovaria olivaria</u>	Hickory Nut	UC	D
<u>Plethobasus cooperianus</u> [#]	Orange-Footed Pimpleback	UC	D
<u>Plethobasus cyphus</u>	Bullhead	UC	D
<u>Pleurobema cordatum</u>	Pig-Toe	C	D, HP
<u>Potamilis alatus</u>	Pink Heel-Splitter	C	D, HP
<u>Quadrula metanevra</u>	Monkey-Face	FC	D, HP, Q
<u>Quadrula nodulata</u>	Warty-Back	FC	D, HP, Q, B
<u>Quadrula pustulosa</u>	Pimple-Back	FC	D, HP, B, Q
<u>Quadrula quadrula</u>	Maple Leaf	FC	D, HP, Q
<u>Tritogonia verrucosa</u>	Pistol Grip	UC	D, Q
<u>Truncilla truncata</u>	Deer-Toe	UC	D
<u>Truncilla donaciformis</u>	Fawn's Foot	C	Q
Family Corbiculidae			
<u>Corbicula fluminea</u>	Asiatic Clam	C	D, HP, Q, B

* Presence, based on the present study

UC - Uncommon, < 6 collected

FC - Fairly common, 6-20 collected

C - Common, >21 collected

** Collection Technique

D - Diver qualitative samples

HP - Hand picked from shore and shallow (<50 cm) water

B - Brail includes WES brail plus professional shell collector

Q - Quadrat sample (0.25 m²) made by diver, total N = 24

Listed as Endangered by the US Fish and Wildlife Service. This species was found outside of the study area; see Figure 3 and Table 4.

Table 2

Results of Brail Surveys at Ohio River, Mile 963.5 to 966.5, Pulaski Co., Ill.
and Ballard Co., Ky., 26-27 Sept 83

Collection No.	River Side	Distance		Water Depth (ft)	Substrate Type	Species	Shell Length (cm)	Total Wet Weight (gm)
		From Bank (ft)	Length (ft)					
1	Ill	35	500	6	Gravel, Sand	<u>Fusconaia ebena</u>	-	-
2	Ky	300	500	3	Mud, Detritus	<u>Obliquaria reflexa</u>	-	-
3	Ky	600	500	15	Sand, Overlaid with Silt	<u>Elliptio crassidens</u>	-	-
4	Ky	600	950	15	Sand, Overlaid with Silt	<u>Corbicula</u>	-	-
5	Ky	1,000	950	20	Clay, Detritus	None	-	-
6	Ky	400-450	1,000	4-5	Silt, Detritus	None	-	-
7	Ky	500	1,050	6-7	Sand, 10% Silt	None	-	-
8	Ky	400	800	20	Coarse and Fine Sand, Detritus	None	-	-
9	Ky	300	460	24	Hard Clay	None	-	-
10	Ky	250	750	16	Mud, Detritus	None	-	-
11	Channel	1,000*	50	≥24	Sand, Gravel <u>Corbicula</u>	None	-	-

(Continued)

* Distance from Ky. shore.

Table 2 (Concluded)

Collection No.	River Side	Distance		Length (ft)	Water Depth (ft)	Substrate	Type	Species	Shell Length (cm)	Total Wet Weight (gm)
		From Bank (ft)								
12	III	110	340	6	Gravel, Sand	<u>F. ebena</u>	7.8	73		
						<u>F. ebena</u>	7.8	83		
						<u>Quadrula quadrula</u>	5.3	82		
						<u>Corbicula</u>	-	-		
						<u>Quadrula pustulosa</u>	8.1	31		
13	III	110	320	6	Gravel, Sand	<u>Amblyma plicata</u>	9.7	95		
						<u>Quadrula nodulata</u>	4.9	51		
						<u>Q. pustulosa</u>	1.9	7		
14	III	110	300	7	Mud	None	-	-		
15	III	280	300	21	Mud	None	-	-		
16	III	280	300	> 24	Mud	<u>Lampsilis teres</u>	14.2	390		
						(9) <u>Corbicula</u>	-	-		
17	III	75	500	15	Mud	None	-	-		
18	III	60	850	4-15	Clay, Twigs	None	-	-		
19	III	60	150	15	Gravel, <u>Corbicula</u>	None	-	-		
20	III	85	220	22	Mud	None	-	-		
21	III	100	850	16	Mud	None	-	-		

Table 3

Results of Qualitative Diver Surveys at Ohio River Mile 963.5 to 966.5
Pulaski Co., Ill. and Ballard Co., Ky., 28 Sept 1983

Collection No.	River Side	Distance From Bank (ft)	Water Depth (ft)	Substrate Type	Species	Shell Length (cm)	Total Wet Weight (gm)
1*	Ky	280-600	8	6" to 12" of sediment on sand	None	-	-
2	Ky	375	4.5-6.0 (12" visibility)	Sand, Pea Gravel	<u>Leptodea fragilis</u>	10.1	93
3	Ky	800	7	Sand, Mixed with Mud	<u>Quadrula nodulata</u>	4.1	34
4	Ky	500	15	Sand	<u>Q. nodulata</u>	3.1	18
5	Ky	400	17	Sand, some clay	<u>Ellipsaria lineolata</u>	3.7	22
6	Ky	250	18	Sand, Clay, Detritus	<u>Q. nodulata</u>	3.3	18
7	Ky	260	17	Sand, Clay, Detritus	<u>Q. nodulata</u>	4.0	31
8	ILL	800	20	Firm Clay, Sand	<u>L. fragilis</u>	10.2	75
9	ILL	280	>24	Mud	<u>Q. nodulata</u>	5.8	74
					None	-	-
					<u>Potamilis alatas</u>	14.3	313
					"	11.4	180
					"	13.3	222
					"	13.4	261

(Continued)

* Total time in water, 15 min.

Table 3 (Concluded)

Collection No.	River Side	Distance		Water Depth (ft)	Substrate Type	Species	Shell Length (cm)	Total Wet Weight (gm)
		From Bank (ft)						
9 (Cont.)	III	280		> 24	Mud	<u>Potamilis alatas</u>	10.8.	145
						"	10.9	97
						"	11.1	147
						"	10.2	99
						"	9.8	82
10**	III	75		4-15	Mud	<u>P. alatas</u>	12.1	196
						"	12.7	204
						"	11.2	110
11	III	60		15	Mud	<u>Amblema plicata</u>	11.0	328
						<u>Megalonias gigantea</u>	13.1	388
						<u>Amblema plicata</u>	9.4	140
						<u>Fusconaiia ebena</u>	7.3	143
						<u>P. alatas</u>	13.4	228
12	III	85		22	Clay, Twigs	<u>P. alatas</u>	14.2	297
						"	12.5	220
						"	11.7	183
						<u>Lampsilis teres</u>	10.0	143

** Total time in water, 8 min.

Table 4

Results of Qualitative Diver Surveys at a Gravel Bar at Ohio River
Between Miles 966 and 968 (see Figure 3), Pulaski Co., Ill., 28-29 Sept. 83

I. 28 Sept. 83, Total Time = 10 min.	
<u>Species</u>	<u>Number</u>
<u>Potamilis alatas</u>	14
<u>Lampsilis teres</u>	1
<u>Megaloniaias gigantea</u>	2
<u>Quadrula quadrula</u>	2
<u>Fusconaia ebena</u>	22
<u>Ligumia recta</u>	4
<u>Amblyma costata</u>	3
<u>Pleurobema cordatum</u>	1

II. 29 Sept. 83, Total Time = 30 min.	
<u>Species</u>	<u>Number</u>
<u>Elliptio crassidens</u>	2
<u>Tritogonia verrucosa</u>	1
<u>Quadrula quadrula</u>	7
<u>Fusconaia ebena</u>	4
<u>Pleurobema cordatum</u>	1
<u>Ligumia recta</u>	1
<u>Quadrula pustulosa</u>	3

III. 29 Sept. 83, Total Time = 30 min.	
<u>Species</u>	<u>Number</u>
<u>Quadrula metanevra</u>	1
<u>Tritogonia verrucosa</u>	1
<u>Quadrula pustulosa</u>	2
<u>Plethobasis cooperianus</u>	1
<u>Elliptio crassidens</u>	5
<u>Ellipsaria lineolata</u>	1
<u>Pleurobema cordatum</u>	7
<u>Fusconaia ebena</u>	1

(Continued)

Table 4 (Concluded)

IV. 29 Sept. 83, Total Time = 30 min.

<u>Species</u>	<u>Number</u>
<u>Quadrula metanevra</u>	11
<u>Obovria olivaria</u>	1
<u>Plethobasis cyphus</u>	1
<u>Quadrula nodulata</u>	1
<u>Elliptio crassidens</u>	1
<u>Pleurobema cordatum</u>	1
<u>Fusconaia ebena</u>	1
<u>Cyclonaias tuberculata</u>	1
<u>Plethobasus cooperianus</u>	2
<u>Quadrula pustulosa</u>	2
<u>Actinonaias ligamentina</u>	1

APPENDIX A: EXPLANATION OF VARIABLES USED FOR ANALYSIS OF MOLLUSC
DATA COLLECTED FROM A GRAVEL BAR ON THE OHIO RIVER NEAR
OLMSTED, ILLINOIS

- BUOY - A total of six quadrat samples were collected from each of four buoys.
- QUADRAT - A total of 24 quadrat samples (0.25 m^2) were collected by the diver.
- CORBIC1 - *Corbicula*/m²
- CORBIC2 - *Corbicula*, tissue dry mass (TDM)/m²
- NUMUNIO - Total unionid species/quadrat
- DIVERS - Shannon-Weaver diversity index
- EQUIT - Equitability index, or ratio of observed to theoretical maximum diversity
- UNIONID1 - Total unionids/m²
- UNIONID2 - Tissue Dry Mass for all unionids/m²
- EBENA1 - Fusconaia ebena/m²
- EBENA2 - F. ebena, TDM/m²
- DONACIF1 - Truncilla donaciformis/m²
- DONACIF2 - T. donaciformis, TDM/m²
- FRAGIL1 - Leptodea fragilis/m²
- FRAGIL2 - L. fragilis, TDM/m²

REFLEXA1 - Obliquaria reflexa/m²
REFLEXA2 - O. reflexa, TDM/m²
PUSTUL1 - Quadrula pustulosa/m²
PUSTUL2 - Q. pustulosa, TDM/m²
PLICATA1 - Amblema plicata/m²
PLICATA2 - A. plicata, TDM/m²
ELIPSARI - Elipsaria lineolata/m²
ELIPSAR2 - E. lineolata, TDM/m²
VERUCOS1 - Tritogonia verrucosa/m²
VERUCOS2 - T. verrucosa, TDM/m²
QQUADRU1 - Q. quadrula/m²
QQUADRU2 - Q. quadrula, TDM/m²
QMETANI - Q. metanevra/m²
QMETAN2 - Q. metanevra, TDM/m²
QNODUL1 - Q. nodulata/m²
QNODUL2 - Q. nodulata, TDM/m²
MGIGANT1 - Megalonaias gigantea/m²
MGIGANT2 - M. gigantea, TDM/m²