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PERFORMANCE REPORT

State: Wisconsin

Cooperators: None

Project No.: E-1-2

Study No.: 501

Project Title: Determination of Wisconsin's Endangered Species

Study Title: Distribution, Abundance, and Management of Clams in Wisconsin

Period Covered: February 1977 to February 1978

CONTENTS

ABSTRACT

A survey was set up on the Mississippi River to determine relative abundance and distribution of clams through use of the clam bar and SCUBA gear. During the first year, 885 mussels representing 18 species were taken. The threeridge (Amblema plicata) was the most abundant species. Four species were rare, denoted by the presence of few live specimens. Based on earlier survey results, the number of mussel species appears to have declined sharply from 1930 to 1965. Declining species diversity is further indicated by the present study. The average size of the threeridge has increased, indicating low recruitment of juveniles into the population. Several downstream sites in deep water along the Wisconsin and St. Croix Rivers were examined to determine distribution and density for 15 species listed as "rare" in Mathiak's (unpubl.) statewide survey of waters four feet in depth or less. One species, monkeyface (Quadrula metanerva), was found to be primrily an inhabitant of deeper water; the other 14 were not found in deeper water and are believed to be decreasing in population density and distribution within this portion of their range.

JOB 501.1: DISTRIBUTION AND ABUNDANCE OF CLAMS IN WISCONSIN

OBJECTIVE

Complete an inventory of clams on the Mississippi River, Great Lakes shorelines, and inland waters throughout the state, compile a list of endangered and threatened species, and identify critical habitat.

PROCEDURES AND FINDINGS

To accomplish this objective, two studies were supported in 1977 and 1978: (1) a survey of mussels in the Upper Mississippi River (Pools 3-8), and (2) the distribution and habitat characteristics of rare Wisconsin freshwater mussels. Reports on both of these studies are attached.

RECOMMENDATIONS

Continue the Mississippi River surveys in Pools 9-11 to complete the assessment of distribution and abundance of mussels in the Wisconsin waters of the Mississippi River. Continue studies of inland waters to refine our knowledge of those species suspected of being endangered or threatened. Activate a job to evaluate transplantation as a management technique for endangered and threatened species.

Prepared by: Ruth L. Hine

TITLE OF STUDY: Distribution and Habitat Characteristics of Endangered Wisconsin Freshwater Mussels (Bivalvia:Unionidae)

SUBMITTED BY: Dr. Edward M. Stern

Assistant Professor of Biology

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INTRODUCTION

Although several studies concerning the freshwater mussel (Unionidae) fauna of Wisconsin have been conducted since Baker (1928) published his comprehensive monograph, all of these have been limited in their coverage. In an attempt to reassess the present status of the group, Harold A. Mathiak of Horicon, Wisconsin has recently (1973-1977) systematically surveyed the major drainage systems within the State. His preliminary findings (Mathiak, pers. comm., 1977-78; 1978) indicate that of the nearly 60 forms (approximately 50 species using present concepts of a species) recorded by Baker (1928), at least 15 species may now be rare and in danger of being extirpated from Wisconsin waters. These species are listed in Table 1.

The distribution records of Baker (1928), Mathiak (pers. comm., 1978), and others indicate that all but one of the species under consideration formerly or currently occur in the Mississippi, Wisconsin, or St. Croix rivers. Most of the large river sites that Mathiak surveyed were in water less than 0.6 m deep. Because the typical habitat for several of these species includes deeper water, some of the species and forms he listed as rare might be more abundant in deeper water. Thus, utilizing SCUBA (Self Contained Underwater Breathing Apparatus) diving, several downstream sites along the Wisconsin and St. Croix rivers were examined to determine the distribution and density in deeper water for as many of the above species as was possible. Collection

TABLE 1. Species of Wisconsin freshwater mussels that are in danger of being extirpated, as determined by Mathiak (pers. comm., 1978).

Species:	Common name:
Family Unionidae	
Subfamily Unioninae	
Cyclonaias tuberculata (Raf., 1820)	Purple warty back
Elliptio crassidens (Lamarck, 1819)	Elephant's ear
Fusconaia ebena (Lea, 1831)	Ebony shell
Plethobasus cyphyus (Raf., 1820)	Bullhead
Quadrula metanerva (Raf., 1820)	Monkey face
Quadrula nodulata (Raf., 1820)	Warty back
Subfamily Anodontinae	
Anodonta suborbiculata Say, 1831	Heel-splitter
Arcidens confragosus (Say, 1829)	Rock pocketbook
Simpsoniconcha ambigua (Say, 1825)	
Subfamily Lampsilinae	
Actinonaias ellipsiformis (Conrad, 1836)	Ellipse
Lampsilis anodontoides (Lea, 1834)	Yellow sand shell
Lampsilis fallaciosa (Smith, 1899)	Slough sand shell
*Lampsilis higginsi (Lea, 1857)	Higgin's eye
Plagiola lineolata (Raf., 1820)	Butterfly
Villosa iris (Lea, 1829)	Rainbow shell

* Listed as an endangered species by U.S. Fish and Wildlife Service (Federal Register, 1976)

sites and locality data are presented in Fig. 1.

METHODS AND MATERIALS

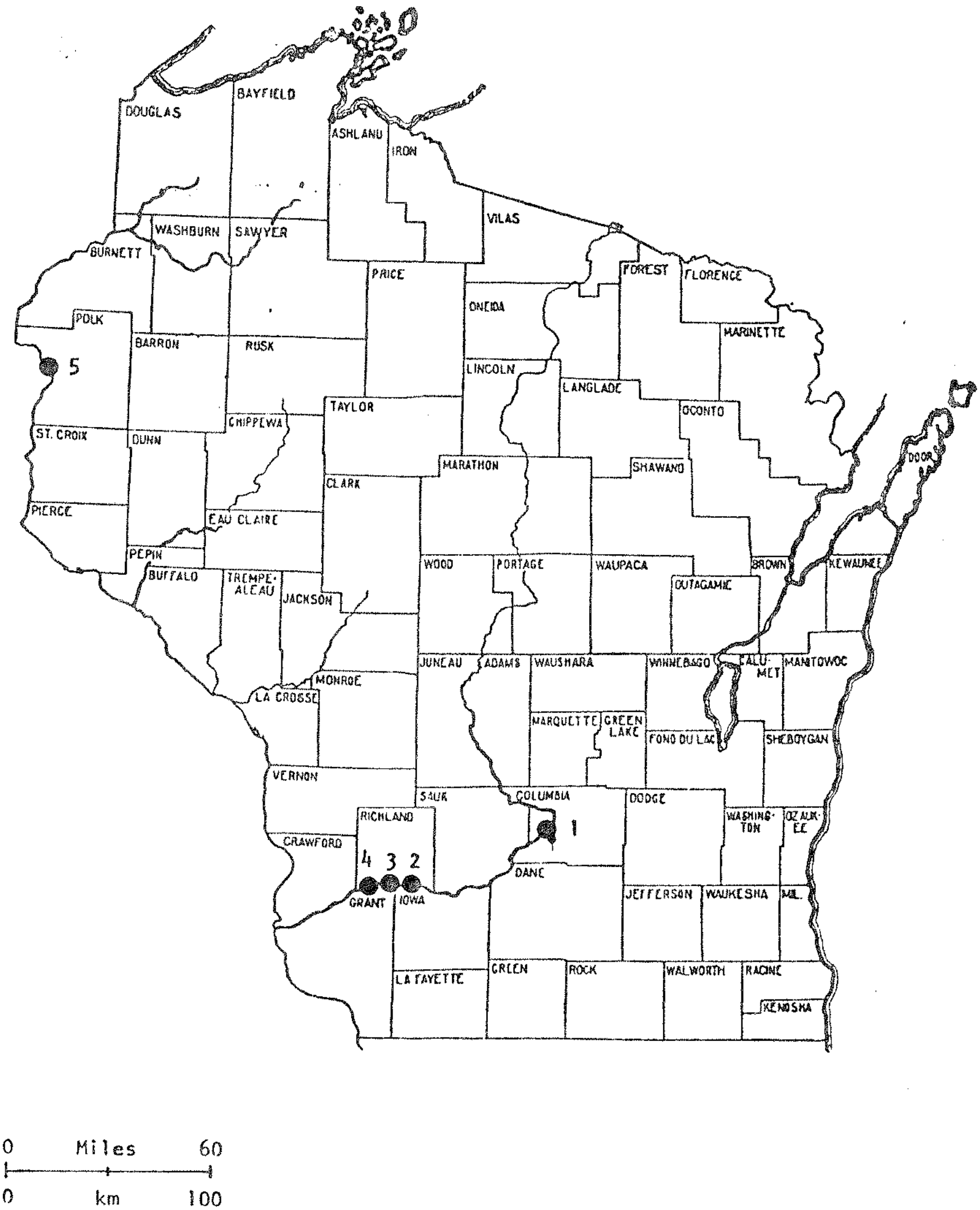
Field work was conducted during low water periods in August and September 1978. Four sites along the Wisconsin River and one on the St. Croix River were examined (Fig. 1). Although SCUBA diving has been used successfully to study lacustrine mollusks (Cvancara, 1972; Pace et al., 1975), poor visibility and currents usually limit its use in lotic habitats. However this method of collection was utilized here because it permits the acquisition of qualitative and quantitative data on the depth distribution of mussels and on habitat characteristics.

A total of 14 transects, each measuring 2 m by 20 m, were examined during 26 hours of underwater time. The transect lines were constructed of nylon rope 6 mm in diameter and weighted at 5 m intervals with 2 kg lead weights. Plastic milk cartons were attached at 10 m intervals to serve as buoys and the entire transect was anchored in place with stakes. While initially the transects were oriented perpendicular to the shore, the current proved too strong and subsequent transects were oriented parallel with the current. At each site, transects were established at several depths with maximum depths of 2.5 m and 3.5 m in the Wisconsin and St. Croix rivers, respectively. All mussels collected within each 40 m^2 transect were placed in bags and transported back to the laboratory for identification. Densities were determined at random using a 0.25 m^2 wire frame. A number of physico-chemical parameters were measured using Hach colorimetric and titrametric procedures. Observations were made at each transect of the bottom type using the following classification

FIGURE 1. Localities on the Wisconsin and St. Croix rivers from which freshwater mussels were collected.

Locality no.:

1. Wisconsin, Columbia County, Wisconsin River, County Park at Dekorra, T. 11 N, R. 9 E, Sec. 5.
2. Wisconsin, Richland County, Wisconsin River, junction Wisconsin Highways 60 & 00, T. 8 N, R. 1 E, Sec. 5.
3. Wisconsin, Richland County, Wisconsin River, junction Wisconsin Highways 60 & E at public landing, T. 9 N, R. 1 W, Sec. 33.
4. Wisconsin, Richland County, Wisconsin River, junction Wisconsin Highways 60 & TX at wayside, T. 9 N, R. 2 W, Sec. 35.
5. Wisconsin, Polk County, St. Croix River, T. 35 N, R. 19 W, Sec. 9.


DOUGLAS
BAYFIELD
ASHLAND
IRON
VILAS
WASHBURN
SAWYER
BURNETT
PRICE
FOREST
FLORENCE
ONEIDA
POLK
BARRON
RUSK
MARINETTE
LINCOLN
LANGLADE
5
TAYLOR
OCONTO
CHIPPEWA
ST. CROIX
DUNN
MARATHON
SHAWANO
DOOR
CLARK
PIERCE
EAU CLAIRE
PEPIN
WOOD
PORTAGE
WAUPACA
BROWN
KEWAUNEE
BUFFALO
TREMPE-ALEAU
JACKSON
OUTAGAMIE
JUNEAU
ADAMS
WAUSHARA
WINNEBAGO
CALU-MET
MANITOWOC
MONROE
LA CROSSE
MARQUETTE
GREEN LAKE
FOND DU LAC
SHEBOYGAN
VERNON
SAUK
COLUMBIA
DODGE
RICHLAND
1
WASHING-TON
OZAUK-EE
CRAWFORD
4 3 2
DANE
GRANT
IOWA
JEFFERSON
WAUKESHA
MIL.
LA FAYETTE
GREEN
ROCK
WALWORTH
RACINE
KENOSHA
0 Miles 60
0 km 100

for particle size: silt 0.004 - 0.062 mm; sand 0.062 - 2.0 mm; gravel 2.0 - 64.0 mm; and boulder ≫ 64.0 mm.

RESULTS AND DISCUSSION

The results of this study are summarized in Tables 2 - 6. All species collected at each transect are included as well as data on bottom type, depth, and density. In most cases, the depths recorded are maximum river depths because the transects were set up in or adjacent to the main channel. While the Mathiak data are not quantitative in terms of surface area examined and collection methods varied, his species lists are included because they represent baseline data on what species presently occur at each site down to a depth of 0.6 m. The data obtained revealed several important trends and the following points pertain to all of the species collected.

The three most common species, in order of decreasing abundance, were Q. pustulosa, A. plicata, and T. verrucosa. During the diving, visibility on the bottom varied from a maximum of 2 m in the St. Croix River (at a depth of 3.5 m) to a minimum of 0.25 m at one site on the Wisconsin River (at a depth of 1.5 m). Zero visibility forced the cancellation of one afternoon dive at Locality 3. Despite these fluctuations, the greater densities found during this study at each locality partially reflect the obvious advantage of visually sighting the mussels buried in the bottom vs brailing as in the Mathiak study. The value of SCUBA is also reflected in the greater diversity obtained at most sites (Tables 2, 4, and 6) and in the addition of the species Q. quadrula. This species was last reported in the Wisconsin River system by Baker (1928) and never subsequently collected by other investigators prior to this study.

TABLE 2. Habitat characteristics of and freshwater mussels collected from Locality 1 on the Wisconsin River by Mathiak and during this study. Locality identified in Fig. 1.

Species collected:	Mathiak (<0.6 m)	Transcect no.: 3 Depth: (1.7-2.0 m) Bottom type: s-g-b
Family Unionidae		
Subfamily Unioninae		
Amblema plicata s.l.	4	28
Elliptio dilatatus		3
Fusconaia flava s.l.	8	26
Plethobasus cyphyus	3	1*
Quadrula metanerva		3*
Quadrula pustulosa	27	38
Tritogonia verrucosa		2
Subfamily Anodontinae		
Anodonta grandis s.l.	5	
Anodonta imbecillis	1	
Strophitus undulatus		1
Subfamily Lampsilinae		
Actinonaias carinata		6
Carunculina parva	4	
Lampsilis radiata	4	5
Lampsilis ventricosa	4	46
Leptodea fragilis	1	8
Ligumia recta		15
Obovaria olivaria		12
Proptera alata	1	4
Proptera laevissima		1
Total no. individuals:	62	199
Mean density:		$5/m^2$
Maximum density:		$4/0.25\ m^2$

*=subfossil shells
s=sand; g=gravel; b=boulder

TABLE 3. Habitat characteristics of and freshwater mussels collected from Locality 2 on the Wisconsin River by Mathiak and during this study. Locality identified in Fig. 1.

Species collected:	Mathiak (<0.6 m)	Transect no.: 2	3	4
		Depth: (1.3-1.7 m)	(1.3-1.7 m)	(1.7-2.0 m)
		Bottom type: s-g-b	s-g-b	s-g-b
Family Unionidae				
Subfamily Unioninae				
Amblema plicata s.l.	6	28	33	18
Elliptio dilatatus	17	7	8	12
Fusconaia flava s.l.	20	12	14	15
Plethobasus cyphyus	4		1	
Pleurobema coccineum	1	1	1	
Quadrula metanerva	6	11	40	12
Quadrula pustulosa	18	16	26	38
Tritogonia verrucosa	11	20	43	60
Subfamily Anodontinae				
Alasmidonta marginata	11	4	5	2
Anodonta grandis s.l.	3	1		1
Arcidens confragosus	1	1*		1*
Strophitus undulatus	6	3	1	
Subfamily Lampsilinae				
Carunculina parva	1			
Lampsilis higginsi	2			
Lampsilis ventricosa	6	12	15	18
Leptodea fragilis	5		4	2
Ligumia recta	6	1	29	22
Obliquaria reflexa	3	2	2	2
Obovaria olivaria	13	2	17	5
Proptera alata	4	1	1	4
Proptera laevissima	1	1		2
Truncilla donaciformis	2	1		
Truncilla truncata			4	3
Total no. individuals:	147	124	244	217
Mean density:		$3.1/m^2$	$6.1/m^2$	$5.4/m^2$
Maximum density:			$15/0.25m^2$	

*=subfossil shells
s=sand; g=gravel; b=boulder

TABLE 4. Habitat characteristics of and freshwater mussels collected from Locality 3 on the Wisconsin River by Mathiak and during this study. Locality identified in Fig. 1.

Species collected:	Mathiak (<0.6 m)	Transect no.: / Depth: / Bottom type:	1 (1.3-1.7 m) s-g-b	2 (1.7-2.0 m) s-g-b
Family Unionidae				
Subfamily Unioninae				
Amblema plicata s.l.			4	1
Elliptio dilatatus	11		20	4
Fusconaia flava s.l.	3		14	1
Plethobasus cyphyus				1*
Pleurobema coccineum			1	
Quadrula metanerva	1		9	2
Quadrula pustulosa	3		12	7
Tritogonia verrucosa	6		10	
Subfamily Anodontinae				
Alasmidonta marginata			1	
Andodonta grandis s.l.	1			
Strophitus undulatus			1	1
Subfamily Lampsilinae				
Lampsilis fallaciosa	1			
Lampsilis radiata			1	
Lampsilis ventricosa	5		6	1
Leptodea fragilis	2		1	
Ligumia recta			9	
Obliquaria reflexa			3	
Obovaria olivaria			1	5
Proptera laevissima	1			
Truncilla donaciformis			2	
Total no. individuals:	34		95	23
Mean density:			2.4/m^2	0.6/m^2
Maximum density:			4/0.25m^2	

*=subfossil shell
s=sand; g=gravel; b=boulder

TABLE 5. Habitat characteristics of and freshwater mussels collected from Locality 4 on the Wisconsin River by Mathiak and during this study. Locality identified in Fig. 1.

Species collected:	Mathiak ($\leq$0.6 m)	Transect no.: 1	2	3
		Depth: (1.0-1.3 m)	(1.3-1.7 m)	(1.3-1.7 m)
		Bottom type: s-g-b	s-g-b	s-g-b
Family Unionidae				
Subfamily Unioninae				
Amblema plicata s.l.	6	2	11	5
Elliptio dilatatus	18	3	6	8
Fusconaia flava s.l.	7	5	10	11
Plethobasus cyphyus			1	
Pleurobema coccineum	1			
Quadrula metanerva	2	8	12	23
Quadrula pustulosa	6	11	18	19
Quadrula quadrula			1	
Tritogonia verruscosa	12	5	4	12
Subfamily Anodontinae				
Alasmidonta marginata	5			2
Anodonta grandis s.l.	2			
Arcidens confragosus	1			1
Lasmigona complanata	1			
Lasmigona compressa	1			
Strophitus undulatus	2	1		4
Subfamily Lampsilinae				
Actinonaias carinata	1			
Lampsilis radiata		1		
Lampsilis ventricosa	3	5	9	11
Leptodea fragilis	5	1	3	4
Ligumia recta	8	2	2	9
Obliquaria reflexa	1	4	7	9
Obovaria olivaria	2	5	10	16
Proptera alata	1			
Truncilla donaciformis	2	1		2
Truncilla truncata	1		2	1
Total no. individuals:	88	54	96	137
Mean density:		1.4/m^2	2.4/m^2	3.4/m^2
Maximum density:				12/0.25 m^2

s=sand; g=gravel; b=boulder

TABLE 6. Habitat characteristics of and freshwater mussels collected from Locality 5 on the St. Croix River by Mathiak and during this study. Locality identified in Fig. 1.

Species collected:	Mathiak (< 0.6 m)	Transect no.: Depth: Bottom type:	1 (1.0-1.3 m) sand	2 (2.7-3.3 m) s-g-b
Family Unionidae				
Subfamily Unioninae				
Amblema plicata s.l.			4	31
Cyclonaias tuberculata	21			1
Elliptio dilatatus	8		2	25
Fusconaia flava s.l.	1		1	6
Quadrula pustulosa	29			3
Subfamily Anodontinae				
Anodonta grandis s.l.			4	
Anodonta imbecillis			1	
Lasmigona costata				8
Subfamily Lampsilinae				
Actinonaias carinata	2		3	21
Lampsilis radiata			18	21
Lampsilis ventricosa	5		1	
Ligumia recta				2
Obovaria olivaria	2			1
Proptera alata				3
Total no. individuals:	68		34	122
Mean density:			$0.9/m^2$	$3.1/m^2$
Maximum density:				$5/0.25m^2$

s=sand; g=gravel; b=boulder

Because in the Wisconsin and St. Croix river systems seasonal fluctuations in water level can be substantial, depth determinations are not absolute. All collection depths represent low water levels and depending upon the locality high water levels may be an additional 1 to 2 m. Depth is a factor in governing the horizontal distribution of mussels primarily because it is a reflection of gradations in current velocity and bottom type. The current at all sites was moderately swift with an average velocity of 0.6 m/sec (1.4 mph). At no site were mussels located uniformly across the river bed. Although at all localities the river bed was a minimum of 100 m wide, mussels were found only from adjacent to the shore out to a maximum distance of about 25 m. This pattern of distribution became apparent in the initial transects that were perpendicular to the shore. Mussels were most abundant in those transects that included a bottom with a mixture of particle sizes from sand to boulder and least abundant or absent entirely in a shifting sand bottom. The latter is the predominate substrate at all sites. Those species that were most abundant in and are characteristic of predominately sand and mud substrates include seveal species in the genera Lampsilis and Anodonta. Thus, in the lower Wisconsin and St. Croix rivers where mussel densities are still high in some areas (up to 15/0.25 m^2), although depth is a factor, the nature of the bottom is of more importance. The same phenomenum has been demonstrated by Coker et al. (1922) in the Mississippi River. The result is that these small, isolated, more favorable habitats serve as refugia for the remaining populations and, as such, are more precarious.

Examination of live material in the laboratory revealed the presence of a number of gravid females representing eight species. The total number of individuals of each species and the degree of development of the larvae within the marsupia (eggs vs glochidia) are noted in Table 7. All of the species

TABLE 7. Species of gravid female freshwater mussels collected in the Wisconsin and St. Croix rivers.

Species:	No. of individuals	Larval development	
		Eggs	Glochidia
Family Unionidae			
Subfamily Anodontinae			
Alasmidonta marginata	2		X
Lasmigona costata	2		X
Subfamily Lampsilinae			
Actinonaias carinata	6		X
Lampsilis radiata	1		X
Lampsilis ventricosa	3		X
Ligumia recta	3		X
Obovaria olivaria	2	X	
Proptera alata	2	X	

are bradytictic - i.e. winter breeders that retain their glochidial larvae in their gills throughout the year except in the Nearctic summer. The glochidia of each species have previously been illustrated by Surber (1912, 1915) and Baker (1928) and Fuller (1974) has recently summrized all known host fishes.

At each locality, a number of physico-chemical parameters were measured and the results are presented in Table 8. Because these data represent only a single test at each locality, for purposes of valid comparison water quality data prepared by the U.S. Geological Survey (1978) for the water year 1977 are also included. All of the parameters measured were within acceptable levels. The most current data on those physico-chemical parameters that affect the physiological ecology of freshwater mussels are discussed by Fuller (1974).

With specific regard to those species that were the primary focus of the study (Table 1), the following results were obtained. With one exception, the species under consideration were not found in greater abundance in deeper water. The major exception in Q. metanerva. A comparison of the population densities in shallow water (<0.6 m) as reported by Mathiak vs those in this study clearly indicates that Q. metanerva is a deep water, large river species. Adult mussels were typically most abundant at or near the maximum river depths at each site (Tables 3 and 5) in a mixed sand - gravel substrate in a current. Quadrula metanerva exhibits this type of distribution throughout most of its range.

Of the remaining rare species collected, none were abundant in deeper water. Mathiak collected C. tuberculata at several sites along the St. Croix River in shallow water where it is still common (Table 6). These may represent the last

TABLE 8. Physico-chemical data for several localities on the Wisconsin and St. Croix rivers. Localities 1-5 are identified in Fig. 1. Localities 6 and 7 are on the Wisconsin River at Muscoda and on the St. Croix River at St. Croix Falls, respectively. Data for localities 6 and 7 are from the U.S. Geological Survey (1978) and are mean values representing measurements for the water year October 1976 to September 1977.

Locality No.	pH	Temperature °C	Turbidity (FTU)	Dissolved Oxygen (mg/l)	Total Hardness (mg/l $CaCO_3$	Total Alkalinity (mg/l $CaCO_3$)
1. Wisconsin River	6.7	23	9	11.0	55	30
2. Wisconsin River	6.8	23	26	9.5	70	20
3. Wisconsin River	6.6	24	20	11.0	95	30
4. Wisconsin River	6.8	26	25	12.0	90	20
5. St. Croix River	6.6	19	30	10.0	50	20
6. Wisconsin River	7.9	18.5	7	9.4	128	102
7. St. Croix River	7.5	18	3	8.9	88	82

Locality No.	Carbon Dioxide (mg/l)	Sulfate (mg/l)	Chloride (mg/l)	Silica (mg/l SiO_2)	Secchi Disc (cm)
1. Wisconsin River	2.0	--	12.5	3.0	--
2. Wisconsin River	2.0	7.0	12.5	2.6	51
3. Wisconsin River	3.0	--	10.0	4.0	30
4. Wisconsin River	2.0	3.0	15.0	2.8	45
5. St. Croix River	2.0	2.0	5.0	1.7	90
6. Wisconsin River	4.7	19.6	13.6	4.5	--
7. St. Croix River	6.7	6.3	3.2	11.6	--

significant populations within the State. Although Barnes (1823) cited the Wisconsin River as the type locality for verrucosus (=tuberculata), none were collected by Baker (1928) nor in this study. Cyclonaias tuberculata has also been extirpated from the Mississippi River at Prairie du Chien (Havlick and Stansbery, 1977), where it was last collected by Ellis in 1930 (van der Schalie, 1950).

Elliptio crassidens is a large river species last recorded in Wisconsin waters by Baker (1928). Baker (1928) considered the species to be confined to the Mississippi River, from which it too has now been extirpated (Havlick and Stansbery, 1977), although he suspected that it also inhabited the lower part of the Wisconsin River. However, no live or subfossil specimens were collected by Mathiak or during this study.

Baker (1928) reported F. ebena as rare in both the Mississippi and Wisconsin rivers, the latter from which it has not been collected since. Williams (1978) recently collected two individuals from the St. Croix River near Hudson, Wisconsin and Havlick and Stansbery (1977) reported it from the Mississippi River at Prairie du Chien.

Plethobasus cyphyus has been extirpated from the Mississippi River at Prairie du Chien (Havlick and Stansbery, 1977) where it was last collected by Shimek (1921). Baker (1928) reported it from Lake Pepin to the north. Several live specimens were collected by Mathiak and during this study in the Wisconsin River. However, because a number of subfossil shells were also collected, the speices is probable disappearing from Wisconsin waters. Where collected live, P. cyphyus has been found in equal densities in both shallow and deeper water in sand - gravel bottoms in a rapid current.

Quadrula nodulata was recorded by Baker (1928) only from the Mississippi

River near Prairie du Chien, where it still occurs (Havlick and Stansbery, 1977). Although Mathiak collected one specimen in the Wisconsin River 7 km from its junction with the Mississippi River, it probably ascends no further upstream and it was not found during this study.

The distribution of A. suborbiculata covers the southern portion of the Mississippi River system, from Nebraska, Iowa, and Illinois south into Louisiana. This speices had never been reported in Wisconsin waters prior to its recent discovery in the Mississippi River near La Crosse (Havlick, 1978). This record probably represents an accidental introduction.

Arcidens confragosus was reported only from the Mississippi River by Baker (1928), where it still occurs (Havlick and Stansbery, 1977). Mathiak collected live specimens in the Wisconsin River and several additional live and subfossil specimens were collected during this study. Throughout most of its range, it is most abundant in a mud bottom in sluggish water at shallow depths (<1 m), but in the Wisconsin River it was collected from a sand - gravel bottom in a moderate current. An emphasis on collecting in the former habitat might reveal A. confragosus in larger numbers.

Baker (1928) collected several shells, but no living specimens, of S. ambigua on a gravel bar in 0.3 m of water in the Wisconsin River. Only a single specimen wss collected by Ellis in 1930 in the Mississippi River at Prairie du Chien (van der Schalie, 1950). Although Mathiak recently collected a live individual in the Wolf River system, S. ambigua was probably never common and it was not encountered during this study. Simpsoniconcha ambigua has an unique glochidial host, the mudpuppy Necturus maculosus. An examination of those sites at which its amphibian host is known to occur might help to clarify the distribution of this unionid. Stansbery (1970, 1971) has noted that *S. ambigua* may be endangered throughout its entire range. Its distribution is sporadic and, when encountered, it is seldom abundant.

While there are records of its occurance in the region of Lake Pepin (Grier and Mueller, 1923), *Actinonaias* (=*Ligumia* of Baker) *ellipsiformis* has not been found in the Mississippi River proper (van der Schalie, 1963; Havlick and Stansbery, 1977). It occurs primarily in the southeastern part of State where it is confined almost entirely to small rivers and creeks. Thus it was not found in this survey in the Wisconsin and St. Croix rivers.

The taxonomic status of the next two mussels has not been decided to the satisfaction of all workers and this has contributed to the problem of defining their distribution. The following treatments appear in the literature: *L. anodontoides* and *L. fallaciosa* have been recognized as separate species; *fallaciosa* has been treated as a subspecies or ecophenotypic variant of *anodontoides*; and recently several authors have begun to use Rafinesque's name *teres* for *anodontoides*, believing that it has priority. For the sake of conformity, Baker's (1928) treatment will be followed. Both species have been recorded at several sites in the Mississippi River by numerous authors. *Fallaciosa*, as an inhabitant of muddy sloughs and pondlike areas of the river where there is little current, is the predominant form in Lake Pepin. Because the lower Wisconsin River is not impounded, this type of habitat is not typical and the slough sand shell is scarce. Mathiak collected only a single specimen and none were collected in this study. The absence of *anodontoides* in the Wisconsin River puzzled Baker (1928) because the river seemed "ecologically well suited for the species". Several live specimens have subsequently been collected by Mathiak. Despite its apparent ability to adjust to a variety of habitats from mud to sand to gravel bottoms, in either swift or slow current, and at varying depths (Baker, 1928; Murray and Leonard, 1962; Parmalee, 1967), only one live individual was collected in this study from a sand bottom in 0.25 m of water.

The fact that L. higginsi has been placed on the federal rare and endangered species list partially attests to its present status throughout its entire range. Lampsilis higginsi has been recently reported from a number of additional sites along the upper Mississippi River and Mathiak collected two specimens in the lower Wisconsin River. However, little is known about its distribution and biology other than that it is a large river, deep water form. It was not collected during this study.

As is the case with many of the previous species, P. lineolata is largely confined to the Mississippi River (Baker, 1928; Havlick and Stansbery, 1977). Although Baker (1928) believed it may ascend the Wisconsin River, there are no records to substantiate this.

Like A. ellipsiformis, V. iris is primarily restricted to southeastern Wisconsin where it is found in small streams. Baker (1928) noted that it lives below riffles in a sand or mud bottom in shallow (<1 m) water.

CONCLUSIONS

The results of a recent survey (Mathiak, pers. comm., 1977-78) have indicated that of the approximately 60 forms of freshwater mussels that Baker (1928) reported from Wisconsin drainages, 15 species (Table 1) may be rare and in danger of being extirpated from Wisconsin waters. The results obtained in this study, in conjunction with all available literature records, are summarized below.

At present, Q. metanerva is abundant at several localities in the Wisconsin

River. Its previous status is due to the fact that it is primarily an inhabitant of deeper water and not readily accessible.

The remaining 14 species are decreasing in population density and distribution within this portion of their range. Baker (1928) in his monograph indicated at that time that several of the species were rare in Wisconsin drainages, including E. crassidens, F. ebena, Q. nodulata, S. ambigua, A. ellipsiformis, L. higginsi, and V. iris. That these species, although scarce, are still found today some 70 years later, is encouraging. Five species, C. tuberculata, A. confragosus, L. anodontoides, L. fallaciosa, and P. lineolata, were never widely distributed throughout the State, but were and are still represented by several viable populations. Anodonta suborbiculata, despite extensive collecting, was not reported in Wisconsin waters prior to 1978 and this record may represent a recent accidental introduction. Baker (1928) noted that P. cyphyus was common in certain parts of the Mississippi and Wisconsin rivers. Although it was collected during this study, it was rare, and Havlick and Stansbery (1977) reported only subfossil shells from Prairie du Chien.

The scarcity of some of the above species may simply reflect the fact that the Wisconsin drainages represent the periphery of their distributional range. However, for several of these species, their decline is attributable to man's activities, including changes in water quality, elimination of host fishes, commerical over exploitation, and the creation of large impoundments that profoundly and permanently alter habitats.

Finally, this study has demonstrated the value of SCUBA diving in riverine habitats. Although it is not practical on a large scale, it permits the collection of quantitative data on the depth distribution of frehswater mussels as well as in situ habitat observations.

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ACKNOWLEDGEMENTS

I wish to thank a number of individuals for their assistance in the field, including Pam Gomez, Dave Timm, Dr. William LeGrande, and especially Rick Rothman, who accompanied me on all of the dives. I am also most grateful to Mr. Harold A. Mathiak for all of the unpublished data that he supplied. Finally, I wish to thank Dr. Ruth L. Hine, the Wisconsin Department of Natural Resources, and the Endangered Species Project (E-1) for financial support provided.