A Survey of Freshwater Mussel Aggregations on the Lower Black River, Wisconsin.

By

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CONVERSION FACTORS

Multiply	By	To obtain
Foot (ft)	3.048×10^{-1}	meter
Mile (mi)	1.609×10^{0}	kilometer
Square mile (mi^2)	2.590×10^{0}	square kilometer
Cubic foot (ft^3)	2.832×10^{-2}	cubic meter
Cubic foot per second (cfs)	2.832×10^{-2}	cubic meter per second
Ton (short)	9.072×10^{-1}	megagram or metric ton

INTRODUCTION

This report summarizes the 2001 to 2002 results of a survey of freshwater mussel aggregations on the lower Black River in western Wisconsin. The purpose of this survey was to inventory and describe potential locations for introduction of the federally endangered higgins' eye freshwater mussel (*Lampsilis higginsii*). This effort was part of mussel propagation efforts related to the continued operation and maintenance of the Mississippi River System Navigation project by the U. S. Army Corps of Engineers in cooperation with the associated, multi-agency Mussel Coordination Team.

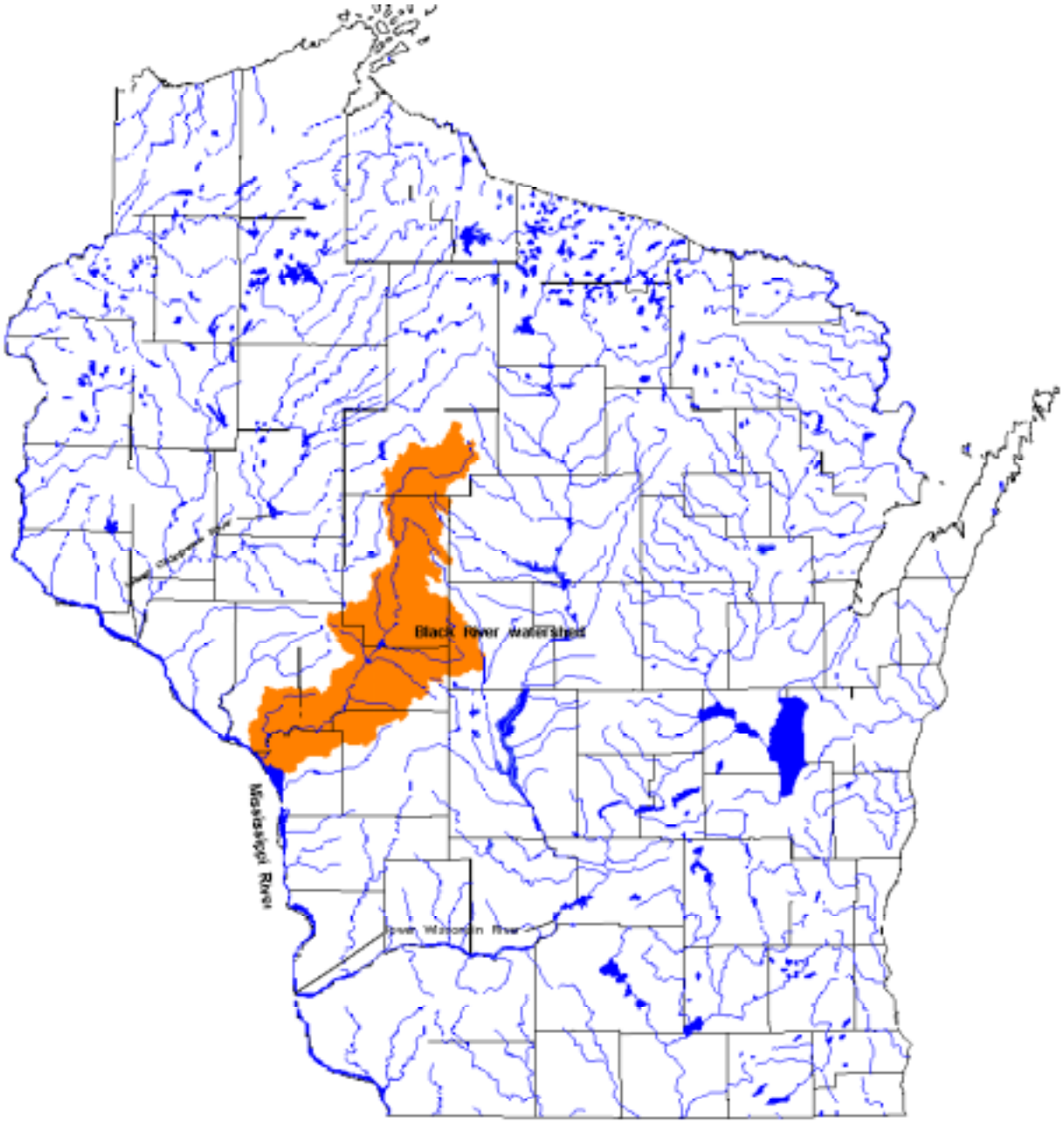
The lower Black River was chosen, along with other upper Midwestern rivers, for potential *L. higginsii* introduction or re-introduction due to its geographic location, size, mussel community composition and its relatively low risk level for zebra mussel (*Dreissena polymorpha*) colonization.

The questions we wanted answered were 1) Where are the potential mussel aggregations located? 2) Where are known mussel aggregations located? 3) What is the quality and community composition within the known mussel aggregations? 4) Which of the known mussel aggregations is of the highest quality and which ones could potentially support *L. higginsii*?

STUDY AREA

The Black River is a 198 mile-long stream located in west central Wisconsin (Figure 1). It has a drainage basin of 2574 mi^2 and empties directly into the Mississippi River near the City of La Crosse, Wisconsin. It descends from its headwaters to the dam at Black River Falls (river mile 62.4) an average of 6.6 ft/mi. Downstream of this dam, it descends towards the Mississippi River an average of approximately 1.7 ft/mi. Rock substrates, derived from Precambrian crystalline bedrock, are present from Black River Falls upstream 40 miles. Sandy substrates, derived from Cambrian sandstones, dominate the streambed from Black River Falls downstream to the confluence with the Mississippi River. These sandstones and eroded sands contribute to a large bedload in the stream. The total annual sediment load estimated from measurements taken at the at the downstream-most gage located near Galesville, Wisconsin at river mile 14.1 (USGS 05382000)

Figure 1. Black River Basin in Wisconsin.



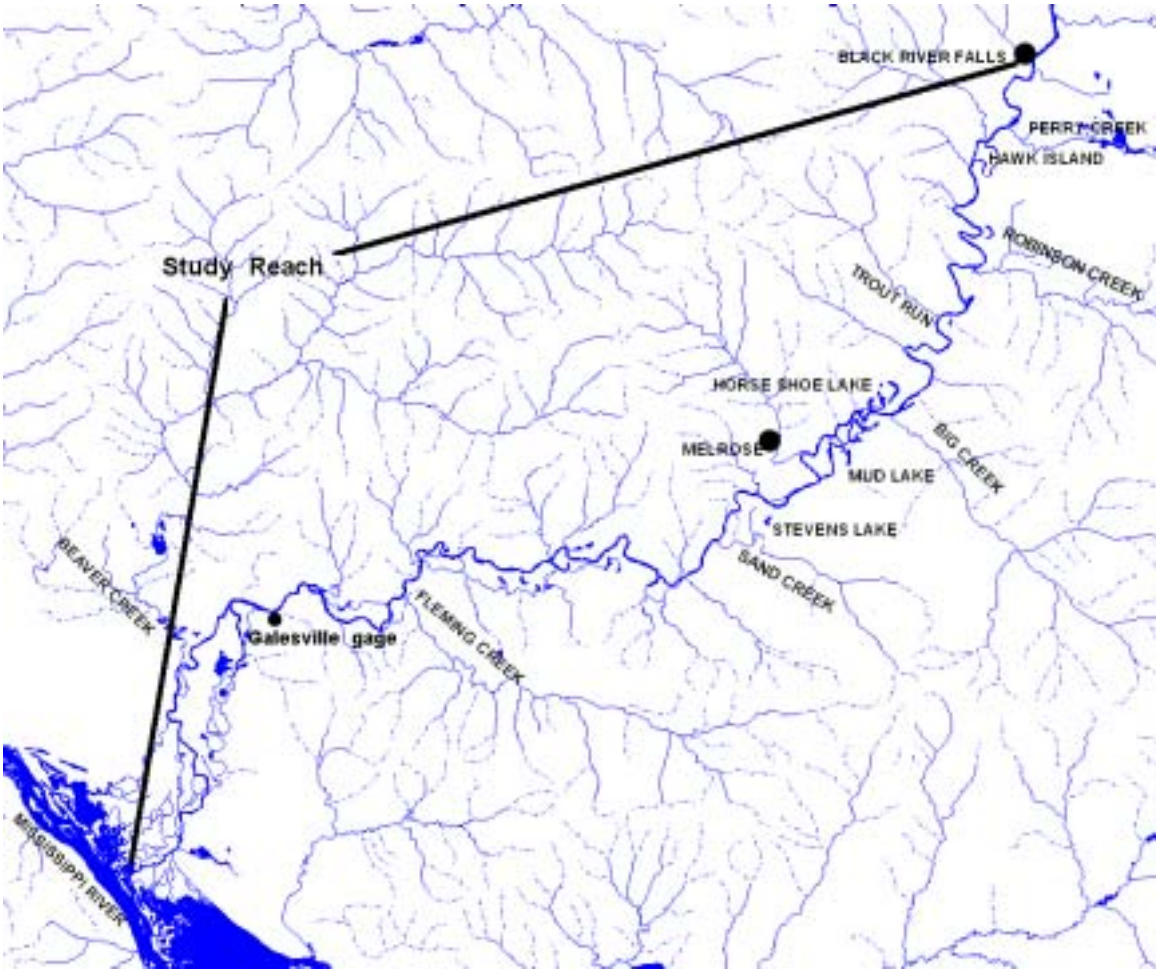
ranged from 42,300 to 471,000 tons and averaged 277,000 tons during the water years 1974-1983 (Rose, 1992).

The mean daily flow is 1788 cubic feet per second (cfs) for the 1931-2003 period of record. The maximum and minimum flows recorded are 62,000 and 180 cfs, respectively.

METHODS AND MATERIALS

We conducted this mussel aggregation survey on the lower 62.4 miles of the Black River from the dam at the City of Black River Falls downstream to its confluence with the Mississippi River (Figure 2). We began by first reviewing all mussel information previously collected from this reach. Based on previous mussel-related work on the lower Black River and other similar rivers in the upper Midwest, we assumed that nearly all mussel aggregations were associated with gravel or rock bars and that very few mussels are found in shifting sand, which is the dominant substrate type in this reach.

Figure 2. Reach of Black River Studied in 2001 and 2002.



Then, during the summers of 2001 and 2002, we reconnoitered the river using an outboard engine-powered canoe and airboat to locate and map gravel and rock bars as

well as visible mussel aggregations. We located and mapped these either visually or using a 10 ft-long pole that was probed into the substrate. Bars and aggregations were recorded using a Lowrance Globalnav ® 212 Geographic Positioning System receiver as well as United States Geological Survey 7.5 Minute Series Topographic maps and aerial photographs from various sources. Approximate widths, lengths and general substrate characteristics were taken at each bar and mussel aggregation.

Bars and preliminarily identified mussel aggregations found during the reconnaissance survey were prioritized for future detailed examination based on the potential for a mussel aggregation. The potential existence of a mussel aggregation was based on the size of the bar, its' substrate characteristics and presence or absence of mussels or mussel shells.

Detailed examinations included sampling mussels using SCUBA divers. Two divers both visually and tactilely characterized substrates in a portion of, or throughout the entire previously identified bar or aggregation. Most locations examined were sampled for at least 5 minutes during which we collected all living and dead mussels encountered. We defined a mussel aggregation as a location where we found at least five living mussels in one hour of collecting. All mussels encountered both living and dead, were brought to the surface, identified and counted. We did not measure mussel population density, but at most locations examined, we visually estimated this density.

RESULTS AND DISCUSSION

Previous Mussel Work

A number of surveys limited in scope and extent have been done on the lower Black River, but no comprehensive survey has ever been done. During 1976, Mathiak (1979) examined 5 locations and found about 27 individuals representing 8 species (Table 1). From 1981-1997, various collectors, including Heath (Unpub), Wisconsin Department of Natural Resources (Unpub.) and Havlik (Ohio State University Museum of Biological Diversity collections) recorded 200 living individuals representing 15 species and 3 additional species represented by dead individuals. No living or dead *L. higginsii* were recorded from any of these investigations.

Table 1. List of Freshwater Mussel Species Found in the Lower Black River, Wisconsin.

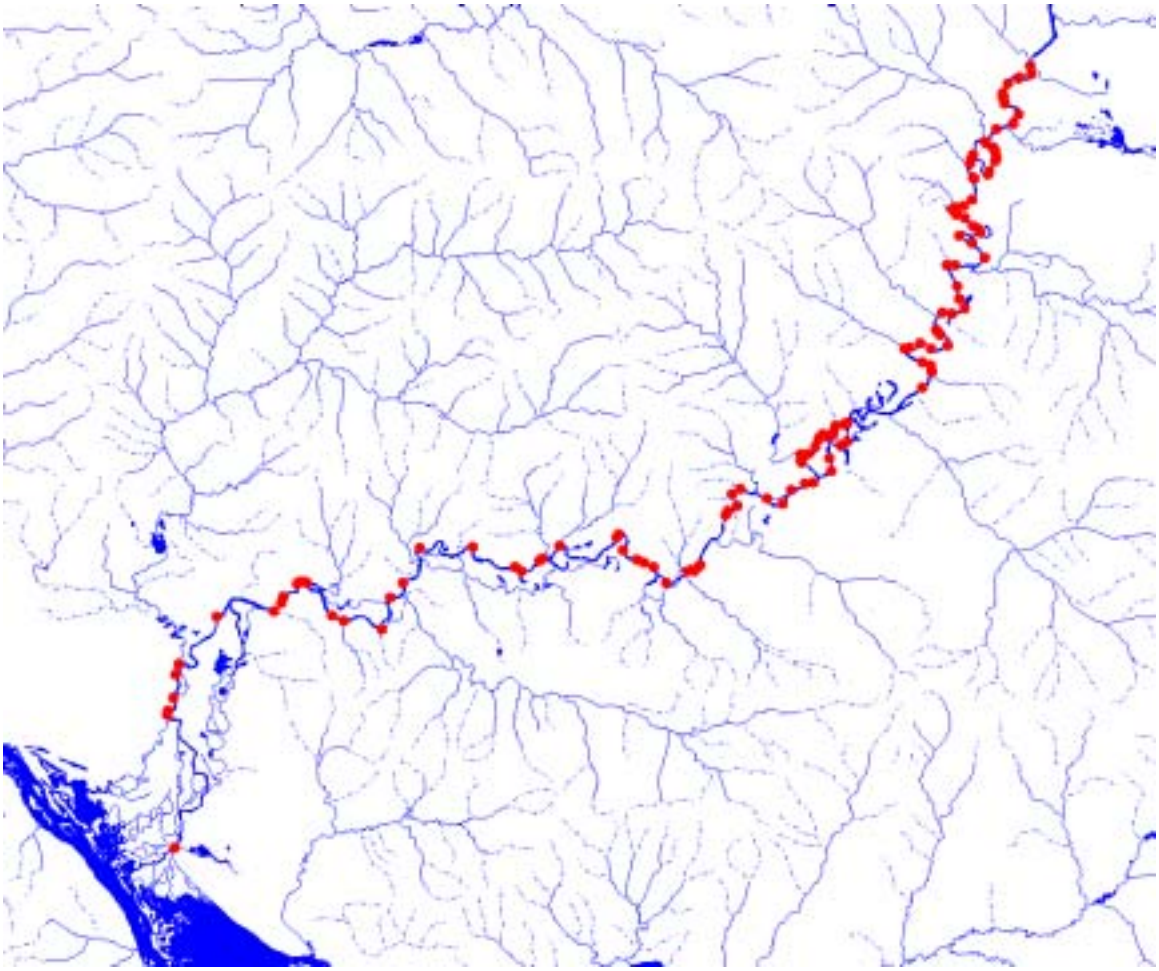
TAXON	Mathiak 1976	Misc. 1981-1996	This Study 2001-2002
Actinonaias ligamentina carinata		L	L
Alasmidonta marginata		L	L
Amblema plicata plicata		L	L
Anodonta grandis form corpulenta	L	L	L
Anodonta suborbiculata			D
Ellipsaria lineolata			L
Fusconaia flava	L	L	L
Lampsilis siliquoidea	L	L	L
Lampsilis cardium	L	L	L
Lasmigona complanata complanata	L	L	L
Lasmigona compressa			L
Lasmigona costata		D	L
Leptodea fragilis	L	L	L
Ligumia recta		L	L
Pleurobema sintoxia		L	L
Potamilus alatus	L	L	L
Quadrula metanevra		D	
Quadrula pustulosa pustulosa		D	L
Quadrula quadrula			L
Simpsonaias ambigua			L
Strophitus undulatus undulatus		L	L
Toxolasma parvus			L
Tritogonia verrucosa	L	L	L
Truncilla donaciformis			L
Truncilla truncata		L	L
TOTAL INDIVIDUALS	27	200	1536
TOTAL SPECIES REPRSENTED LIVING	8	15	23
ADDITIONAL SPECIES REPRESENTED DEAD	0	3	1

Reconnaissance Survey of Gravel and Rock Bars

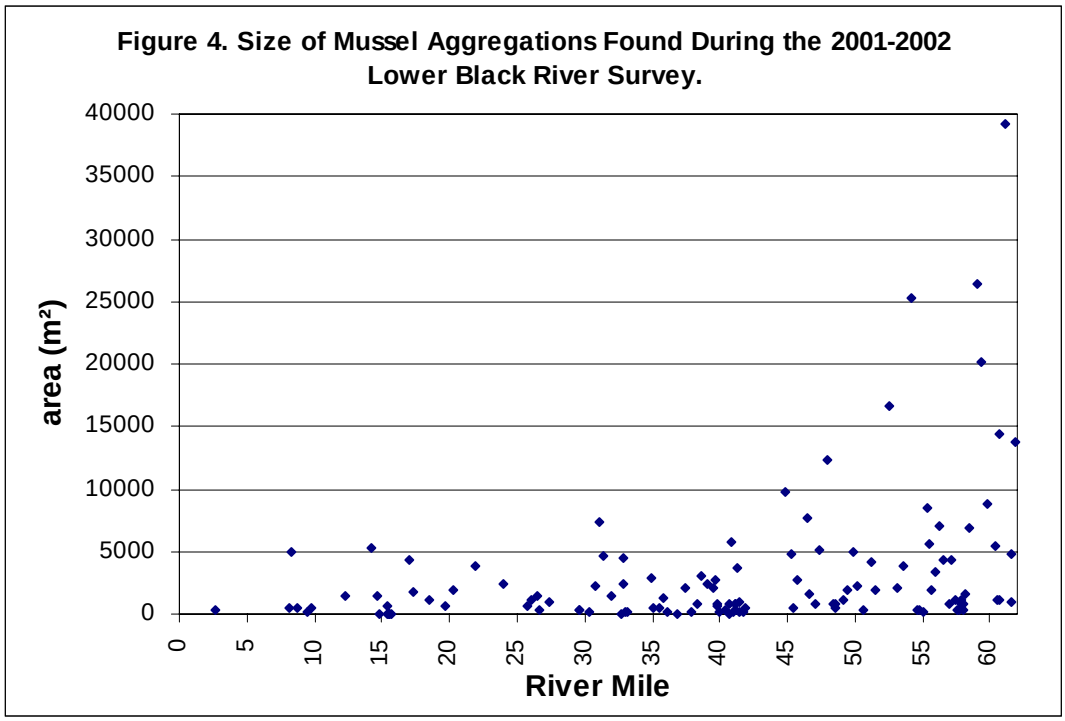
A total of 125 gravel bars, rock bars or mussel aggregations were found during the reconnaissance survey. These locations are shown in Figure 3. Over half of these 125 bars were located in the upstream one-third of the study reach. This is consistent with the geology of the lower Black River. There are decreasing remnants of the crystalline

bedrock and increasing volumes of unconsolidated sand the farther one is downstream from Black River Falls.

Figure 3. Location of 125 Gravel Bars and Rock Bars Found During the 2001-2002 Lower Black River Reconnaissance Survey.



Not only were most bars located in the upstream reach, total area of bars was distributed differently from upstream to downstream. The upstream one-third of the study reach accounted for 77.7% of the total bar surface area of 39.38 ha. The average size of bars increased from downstream to upstream. Near the mouth, the average bar size was close to 1500m², at river mile 30 the average size was about 1100m² while near Black River Falls at mile 62, the mean size was about 11000m² (Figure 4). The total surface area of bars (38.38 ha) covered 4% of the total instream surface area of 962.7 ha.



A total of 71 of the 125 bars were examined in detail. Of the priority 1 locations, 19 of the 20 were examined in detail. A total of 40 of the 50 priority 2 and 12 of the 55 priority 3 locations were examined (Table 2).

Mussel Aggregations

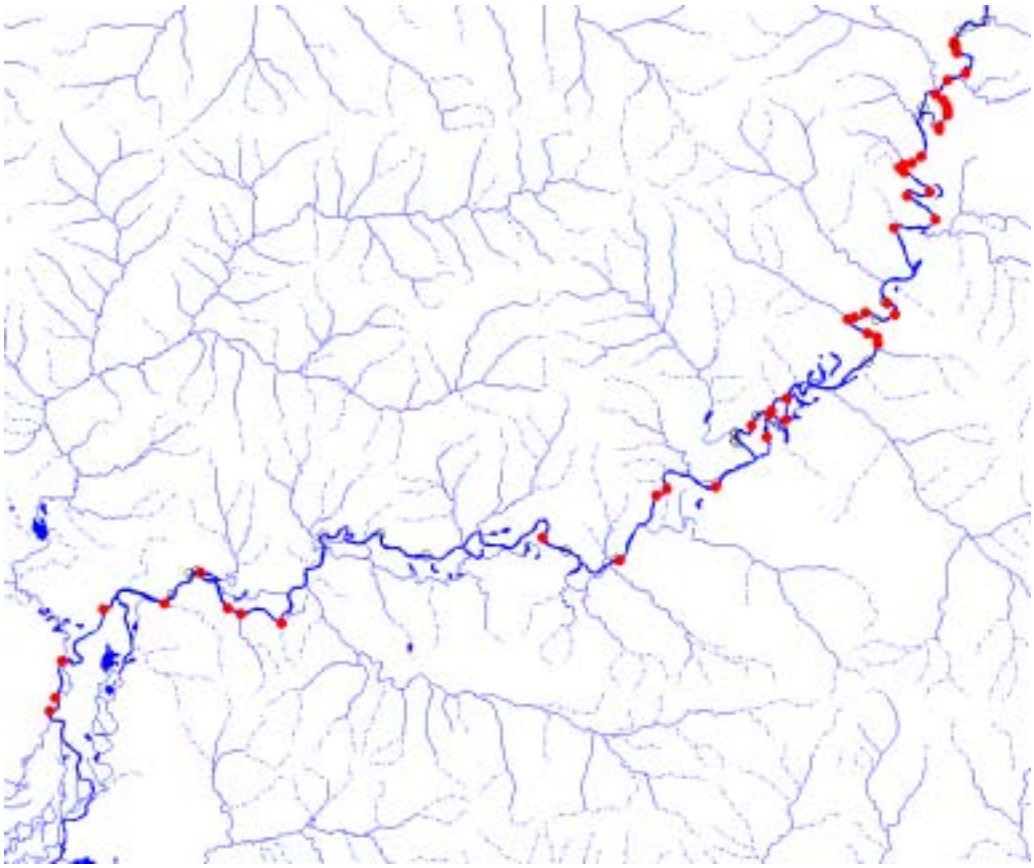
Of the 71 bars that were examined in detail, 49 (69%) were mussel aggregations based primarily on finding an average of greater than five mussels per hour of searching (Table 2).

The distribution of mussel aggregations had a similar spatial pattern as gravel bars. A total of 60.3% of the aggregations were in the upstream one-third of the study reach. The upstream one-third of the study reach accounted for 84% of the total mussel aggregation surface area of 22.7 ha^2. The average size of aggregations generally increased from downstream to upstream. Near the mouth, the average bar size was 2226m^2, at river mile 30 the average size was about 1537m^2 while near Black River Falls at mile 62, the mean size was about 12299m^2.

Table 2. List of Gravel and Rock Bars, Rivermile, Survey Priority, Detailed Examination Status, Bed Status, Catch Per Hour and Total Surface Area. Lower Black River, 2001-2002.

MAP_CODE	RIVERMI	PRIORITY	EXAMINED	BED	CPH	AREA (m²)
CG	2.66	3	n			373
CF2	8.11	3	n			404
CF1	8.24	3	y	y	62.61	4938
CE	8.75	2	y	y	12.86	558
CD2	9.49	3	n			184
CD1	9.80	3	y	y	88.24	457
CC	12.29	1	y	y	39.72	1440
CB	14.20	2	y	y	48.00	5283
CA2	14.58	3	y	n	5.45	1414
CA1	14.76	3	n			71
BZ6	15.37	2	y	n		710
BZ5	15.44	2	n			51
BZ4	15.50	2	n			64
BZ3	15.55	2	y	n	2.40	69
BZ2	15.61	2	n			40
BZ1	15.64	2	y	y	24.00	35
BY	16.99	1	y	y	11.20	4297
BX	17.37	1	y	y	90.40	1699
BW	18.48	1	y	y	6.67	1157
BV	19.62	3	n			638
BU	20.34	3	n			1988
BT	21.85	2	y	n		3791
BS	23.99	3	y	n		2322
BR	25.76	3	y	n		607
BQ	25.98	3	n			1112
BP2	26.52	3	n			1435
BP1	26.66	3	n			244
BO	27.37	3	n			938
BN2	29.55	3	n			352
BN1	29.64	3	n			297
BM	30.30	2	y	y	8.57	162
BL	30.82	3	n			2208
BK2	31.07	2	y	n	5.00	7311
BK1	31.37	3	n			4624
BJ	32.00	3	n			1515
BI	32.74	3	n			35
CT	32.91	3	y	y	16.55	2461
BH	32.92	2	y	n	0.00	4475
BG2	33.06	3	n			165
BG1	33.14	3	n			174
BF	34.96	3	n			2841
BE	35.08	2	y	y	13.33	496
CW	35.47	2	y	y		490
BD2	35.80	3	n			1304
BD1	36.09	3	n			108
BC	36.91	3	n			46
BB	37.40	1	y	y	112.26	2005
BA	37.87	3	n			86
AZ	38.31	2	n			754
AY	38.60	3	n			3012
CR	39.11	3	n			2326
AX	39.50	2	y	n		2146
AW	39.59	2	y	n	0.00	2728
CQ	39.74	2	y	y	38.18	610
AV	39.76	2	y	n	0.00	860
AU	40.02	3	n			82
AT	40.42	2	y	y	14.91	363
AS3	40.64	3	n			48
AS2	40.71	2	y	n		724
AS1	40.85	3	n			5718
AR2	40.99	2	n			162
AR1	41.10	2	y	y	7.14	773
CU	41.15	2	y	n		873
CV	41.16	2	y	y	5.00	298
AQ	41.27	2	y	y	20.40	3750
AP	41.45	3	n			960
AO3	41.50	2	n			142
AO2	41.75	2	n			206
AO1	41.82	3	y	y	25.38	508
AN	44.78	2	y	n		9789
AM	45.32	2	y	y	7.50	4765
AL	45.49	3	n	y		511
AK	45.77	3	y	y		2711
AJ	46.45	3	y	y	14.12	7739
AI	46.67	2	y	y	40.00	1571
AH	47.05	2	y	y	41.74	827
AG	47.40	2	y	n	10.00	5143
AF	47.92	2	y	y	31.76	12508
AE3	48.46	2	y	y	3.25	805
AE2	48.54	2	y	n	0.00	821
AE1	48.57	2	n			526
AD	49.14	3	n			1088
AC	49.37	3	n			1885
AB	49.85	3	n			4983
AA	50.18	3	n			2283
Z	50.57	3	n			276
Y	51.27	2	y	y	12.44	4217
X	51.53	3	n			1919
W	52.50	1	y	y	0.00	16619
V	53.10	2	n			2143
CP	53.50	2	y	y		3806
U	54.21	1	y	y	46.00	25266
T2	54.60	3	n			364
T1	54.72	3	n			349
S	55.08	3	n			163
R2	55.38	2	y	y	27.50	8555
R1	55.50	2	y	y	12.31	5601
Q	55.70	2	y	y	30.00	1914
P	55.90	2	y	y	120.00	3355
O	56.19	2	y	y	66.32	7110
L	56.48	3	y	n	2.00	4398
N	57.02	3	n			736
M	57.17	3	n			4295
CI	57.42	1	y	y	44.00	1067
CJ	57.52	1	y	y	22.50	363
K	57.64	3	n			349
J	57.80	3	y	n	3.33	1199
CK	57.92	1	y	y	8.18	453
CL	57.93	1	y	y	60.00	775
CM	58.01	1	y	y	154.67	878
CN	58.07	1	y			367
CO	58.09	3	y	y	19.33	1548
I	58.45	2	y	y	9.43	6827
H2	58.97	2	y	y	7.59	26426
H1	59.38	2	y	y		20157
G	59.84	2	n			8812
F3	60.30	1	y	y	55.38	5396
F2	60.58	2	y	n		1112
F1	60.62	1	y	y	42.00	1094
E2	60.72	1	y	y	10.71	14347
E1	61.08	1	y	n	1.58	39221
C	61.49	1	y	n	0.00	4759
D	61.49	1	n			997
B	61.90	1	y	n	24.00	13708
A	62.17	3	n			638

Figure 6. Location of Mussel Aggregations Found During the 2001-2002 Lower Black River. ●= Known Mussel Aggregation Locations. O = Examined & Not an Aggregation.



In locations determined to be aggregations, the mean catch of living mussels per hour (CPH) was 34.8 (maximum = 154.7, minimum = 0.0). This is probably quite low compared to other local large rivers. Locations of aggregations are given in Figure 6.

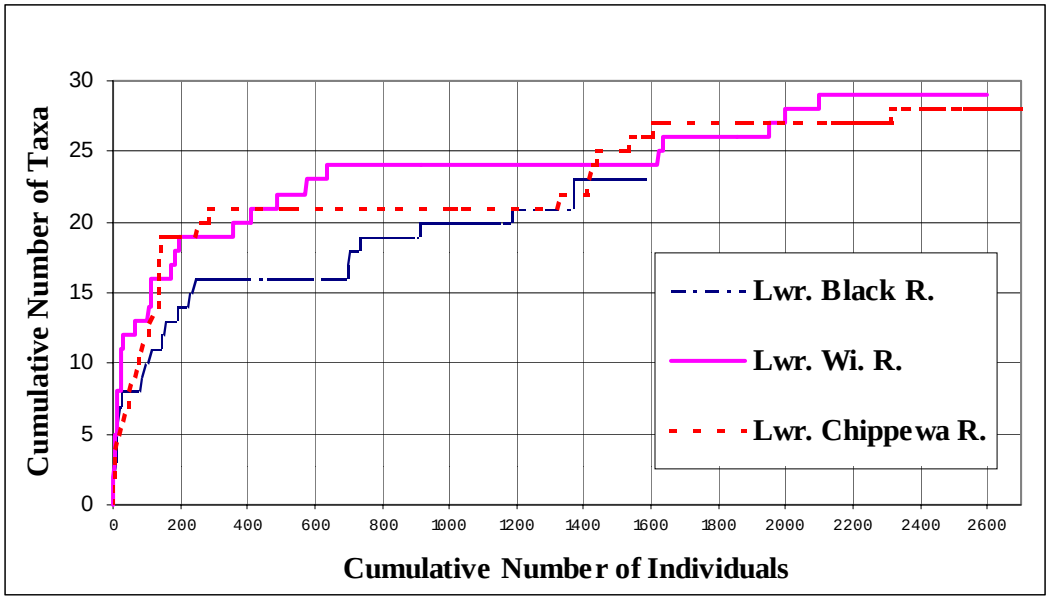
Although there were more and larger bars in the upstream part of the study reach, the CPH for all bars (including mussel aggregations and non-aggregations) was similar throughout the study reach. There was not an upstream-downstream trend observed for CPH. The mean CPH for all bars was 27.8 (maximum = 154.7, minimum = 0.0) (Table 2). Also, there was no upstream-downstream trend in CPH apparent for bars that were aggregations and bars that were not. This suggests that there was no general longitudinal pattern of mussel density throughout the study reach within bars and aggregations.

Species Richness

During this survey, a total of 23 species were represented among 1536 living individuals (Table 1). One additional species was represented by a dead individual only (*Anodonta suborbiculata*). We found every species that has been recorded from the river prior to 2001 except for a subfossil empty shell of *Quadrula metanevra* found by Heath (Unpub.) during 1991. No specimens of *L. higginsii* were found.

Species richness for the lower Black River was slightly lower than other large Mississippi River tributaries in Wisconsin. The lower Wisconsin River (see Figure 1), which contains *L. higginsii*, has about 29 species while the lower Chippewa River has 28 (Figure 5). However, for similar sample sizes (about 1600 individuals), species richness

Figure 5. Species Richness for Lower Black, Wisconsin and Chippewa Rivers.



was about the same among the three rivers. The lower Black River contained 23 species, while the lower Chippewa had 26 and the lower Wisconsin River 24. Additional sampling on the lower Black River may provide a very small number of additional species

We analyzed species associates of *L. higginsii* over a broad geographic scale in the upper Midwest. Several mussels were associated with this species in particular river reaches and some were weakly associated or mutually exclusive. Results of this analysis are given in Table 3.

Table 3. Species Associates of Lampsilis higginsii.

Strongly Associated	Moderately Associated	Weakly or Never Associated
Arcidens confragosus	*Tritogonia verrusoca*	*Alasmidonta viridis*
Ellipsaria lineolata.	*Obovaria olivaria*	*Anodonta cataracta*
Elliptio crassidens crassiden	*Truncilla truncata*	*Anodontoides ferusscianus*
Fusconaia ebena		*Lasmigona compressa (occasionally found with L.h.)*
Lampsilis teres form anodontoides		*Lasmigona costata (occasionally found with L.h.)*
Lampsilis teres form teres		*Venustaconcha e. ellipsiformis (rarely found with L.h.)*
Megalonaias nervosa		*Villosa i. iris*
Potamilus ohiensis		
Quadrula metanevra		
Quadrula nodulata		
Truncilla donaciformis		

A total of 11 taxa are strongly associated with *L. higginsii*. Of these, only two taxa (*E. lineolata* and *T. donaciformis*) were present on the lower Black River. On the lower Wisconsin River and the Mississippi River, where *L. higginsii* is present, 9 of these 11 and all 11 associates are present, respectively. A total of 2 of the 3 moderate associates are present in the lower Black River while all 3 are present in the lower Wisconsin River and Mississippi River. Of the weakly associated or mutually exclusive taxa, 2 of the 7 are present in the lower Black River while three are present in the lower Wisconsin River and none in the Mississippi River. This comparison suggests that the lower Black River may not contain a mussel community that is associated with the presence of *L. higginsii*.

Relative Abundance and Species Distribution Patterns

The fauna was dominated by the lithophilic *Simpsonaias ambigua* which accounted for 17% of the sample (Table 5). It was followed by *Lampsilis cardium* and *Tritogonia verrucosa*. Only single specimens each were found of *Ellipsaria lineolata, Truncilla donaciformis, Lasmigona compressa, Quadrula p. pustulosa* and *Q. quadrula.* All but 7 of the 23 species were found throughout the study reach.

Three of the twenty-three species found were seen predominately in the upstream half of the study reach and were very rare or absent from the downstream half. These were *Lasmigona costata, Alasmidonta marginata, Strophitus u. undulatus,*

Four species were found only in the downstream half. These were *Truncilla donaciformis, Toxolasma parvus, Quadrula quadrula* and *Ellipsaria lineolata.*

Table 5. Number of Living and Dead Mussels Found, Relative Abundance, Lower Black River, 2001-2002.

OBS	TAXON	LIVING	DEAD	RANK	% REL. ABUNDANCE
1	*Actinonaias ligamentina carinata*	20	19	12	1.3
2	*Alasmidonta marginata*	15	4	13	1.0
3	*Amblema plicata plicata*	2	3	18	0.1
4	*Anodonta grandis form corpulenta*	119	58	7	7.7
5	*Anodonta suborbiculata*	0	1		0.0
6	*Ellipsaria lineolata*	1	0	19	0.1
7	*Fusconaia flava*	121	363	6	7.9
9	*Lampsilis cardium*	170	188	2	11.1
8	*Lampsilis siliquoidea*	101	111	9	6.6
10	*Lasmigona complanata complanata*	158	47	4	10.3
11	*Lasmigona compressa*	1	2	19	0.1
12	*Lasmigona costata*	13	7	14	0.8
13	*Leptodea fragilis*	143	101	5	9.3
14	*Ligumia recta*	70	40	10	4.6
15	*Pleurobema sintoxia*	107	133	8	7.0
16	*Potamilus alatus*	46	10	11	3.0
17	*Quadrula pustulosa pustulosa*	1	1	19	0.1
18	*Quadrula quadrula*	1	0	19	0.1
19	*Simpsonaias ambigua*	260	29	1	16.9
20	*Strophitus undulatus undulatus*	7	7	16	0.5
21	*Toxolasma parvus*	4	1	17	0.3
22	*Tritogonia verrucosa*	167	29	3	10.9
23	*Truncilla donaciformis*	1	0	19	0.1
24	*Truncilla truncata*	8	9	15	0.5
25	*unidentified*	0	1		0.0
	TOTAL	**1536**	**1164**		**100.0**

Suggested Locations for Introduction of *L. higginsii*

We did a rank analysis of locations that *L. higginsii* could be introduced. Mussel aggregations were ranked based on a measure of population density (CPH) and the spatial size of the aggregation. This ranking was dependent upon the following assumptions.

We assumed that *L. higginsii* is most likely to be found in locations with relatively high population densities. Also, locations with relatively high population densities would have a greater chance for a successful introduction and habitation and provide for instream mussel reproduction. Past work on various rivers has suggested that sometimes *L. higginsii* is associated with relatively high total mussel population densities. (Baker, et al. 1994; Miller, and Payne. 1997).

A second assumption was that introductions at locations where the size of the aggregation was relatively large would be more successful than locations that were

smaller. Larger aggregations may have more long term stability, a factor that is probably very important in a stream like the Black River which is dominated by shifting, sandy substrates and large fluctuations in water elevations and discharge. Also, due to the broadcast nature of some introduction methods, for example the release of free-ranging fish infested with glochidia or the use of inoculated host fish confined in open-bottomed cages, the chances of newly dropped juvenile mussels settling on suitable substrate would be greater in a larger aggregation.

The rank analysis is given in Table 4. We did not include species richness in the ranking because of highly variable and often small sample sizes which can influence richness values. The mussel aggregations with the highest combined ranking of CPH and surface area were locations “U”, “O”, “F3”, “CF1”, “P”, “CB” and “AF”. All 7 of these aggregations ranked in the top 20 of CPH or surface area.

Location “U” is a 1023 m-long aggregation located on the left descending bank at river mile 54.2 (Figure 7). It has a surface area of 25266 m² and a width of 8 to 63 m. The substrate here was primarily rubble, followed in composition by gravel and coarse sand. The current during normal low discharges was slow and the maximum depth was 1.3m. We found a total of 13 mussel species here among a total of 46 individuals collected. We found no locations that could be protective of caged fish inoculated with mussel glochidia during high discharges. This suggests that there is some risk of cage disturbance and dislodgment here if mussel introductions or reintroduction were attempted here.

Location “O” is a 245 m-long aggregation located on the left descending bank at river mile 56.19 (Figure 8). It has a surface area of 7110 m² and a width of 14 to 22 m. The substrate here was primarily rubble and gravel. We found a total of 11 mussel species here among a total of 21 individuals collected. We found no locations that could be protective of caged fish inoculated with mussel glochidia during high discharges.

Location F3 is a 936 m-long aggregation located on the right descending bank at river mile 60.3 (Figure 9). It has a surface area of 5396 m² and a width of 4 to 9 m. The substrate here was primarily rubble and gravel. We found a total of 7 mussel species here among a total of 24 individuals collected. We found no locations that could be protective of caged fish inoculated with mussel glochidia during high discharges.

Location “CF1” is a 279 m-long aggregation located on the right descending bank

Table 4. Ranking of Lower Black River Mussel Aggregations based on Catch per Hours and Total Surface Area.

AGGREGA-TION CODE	RIVER MILE	CPH	AREA (m²)	CPH RANK	AREA RANK	CPH & AREA RANK	RICHNESS	NUMBER LIVING (N)
U	54.2	46.00	25265.508	11	2	1	13	46
O	56.2	66.32	7109.619	6	9	2	11	21
F3	60.3	55.38	5395.501	9	12	3	7	24
CF1	8.2	62.61	4938.225	7	14	3	12	139
P	55.9	120.00	3354.992	2	20	4	6	24
CB	14.2	48.00	5283.068	10	13	5	10	48
AF	47.9	31.76	12508.029	18	6	6	2	9
BB	37.4	112.26	2004.693	3	23	7	9	116
R2	55.4	27.50	8555.125	20	7	8	6	11
BX	17.4	90.40	1699.165	4	25	9	16	339
CM	58.0	154.67	877.528	1	32	10	16	232
AJ	46.5	14.12	7739.354	28	8	11	4	4
E2	60.72	10.71	14346.869	34	5	12	7	25
H2	59.0	7.59	26425.905	39	1	13	6	10
H1	59.38	8.46	20156.597	37	3	13	7	22
AI	46.7	40.00	1570.738	15	26	14	9	14
R1	55.5	12.31	5600.93	32	11	15	7	8
AQ	41.3	20.40	3750.023	24	19	15	6	17
Q	55.7	30.00	1913.993	19	24	15	1	3
F1	60.62	42.00	1093.553	13	30	15	7	24
CI	57.4	44.00	1066.913	12	31	15	6	11
CL	57.9	60.00	774.651	8	35	15	8	15
CC	12.3	39.72	1439.772	16	28	16	5	47
I	58.5	9.43	6827.026	35	10	17	7	11
AH	47.1	41.74	826.691	14	33	18	7	16
Y	51.3	12.44	4216.653	31	17	19	10	36
CT	32.9	16.55	2461.022	26	22	19	2	8
CD1	9.8	88.24	457.265	5	43	19	10	75
BY	17.0	11.20	4297.121	33	16	20		
W	52.5	0.00	16618.98	46	4	21	2	2
CO	58.1	19.33	1548.022	25	27	22		
CQ	39.7	38.18	610.112	17	37	23	4	7
AM	45.3	7.50	4765.071	40	15	24	1	1
AO1	41.8	25.38	508.036	21	40	25	6	14
CP	53.5	0.28	3806.106	45	18	26	11	53
CE	8.8	12.86	557.903	30	38	27	2	3
CJ	57.5	22.50	362.841	23	46	28	1	3
BE	35.1	13.33	495.936	29	41	29	3	6
BW	18.5	6.67	1156.776	42	29	30	3	6
BZ1	15.6	24.00	35.185	22	49	30	1	6
AT	40.4	14.91	363.006	27	45	31	7	41
AR1	41.1	7.14	773.485	41	36	32	7	20
AE3	48.5	3.25	805.216	44	34	33	7	13
CK	57.9	8.18	452.64	38	44	34	3	3
BM	30.3	8.57	161.984	36	48	35	3	5
CV	41.2	5.00	297.827	43	47	36	4	4
AK	45.8		2711.262		21		3	3
AL	45.5		511.291		39			
CW	35.5		490.445		42			

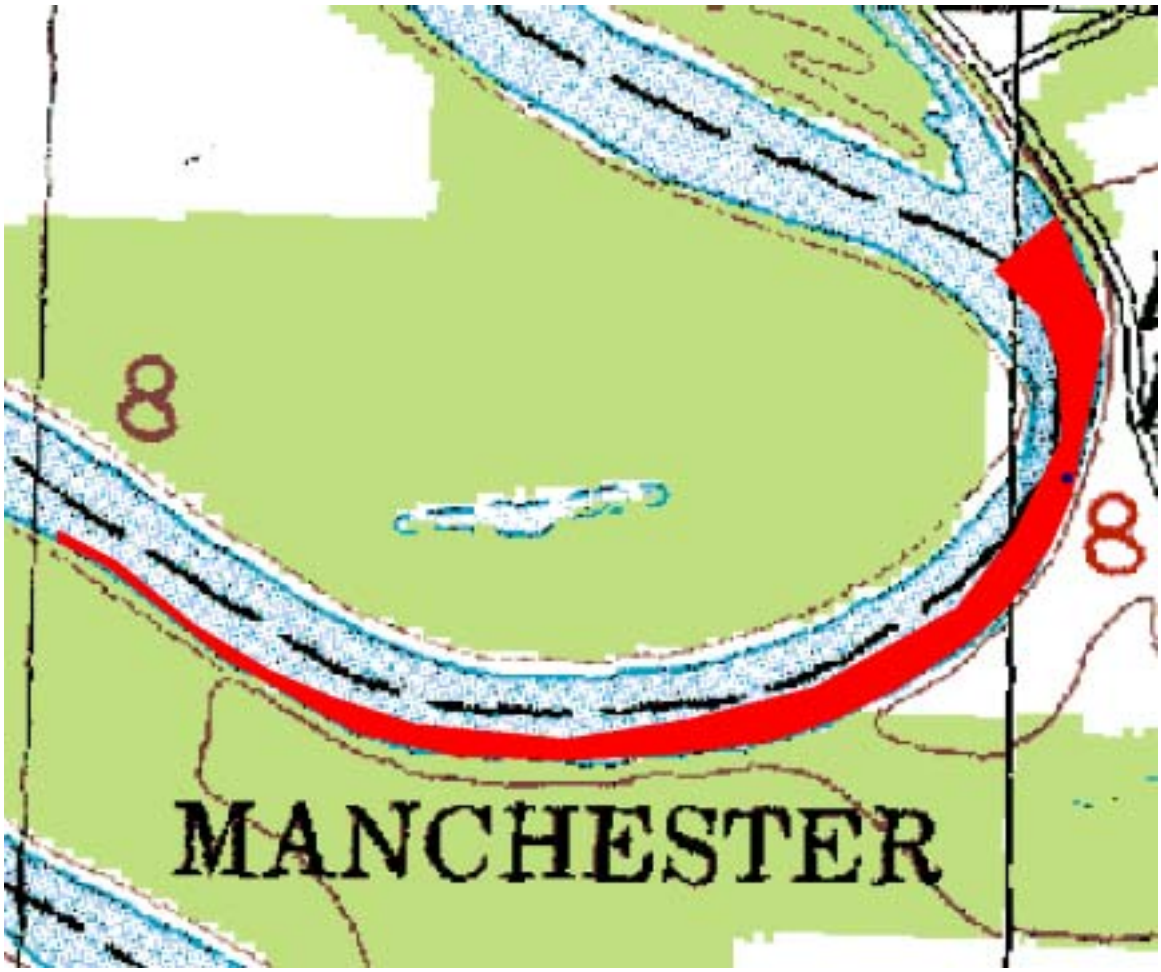
at river mile 8.24 (Figure 10). It has a surface area of 4938 m² and a width of 2 to 27 m. The substrate here was primarily gravel followed by rubble and coarse sand. We found a total of 12 mussel species here among a total of 139 individuals collected. We found no locations that could be protective of caged fish inoculated with mussel glochidia during high discharges.

Location "P" is a 173 m-long aggregation located on the left descending bank at river mile 55.9 (Figure 11). It has a surface area of 3355 m² and a width of 17 to 21 m. The substrate here was primarily gravel and rubble. We found a total of 6 mussel species here among a total of 24 individuals collected. We found no locations that could be protective of caged fish inoculated with mussel glochidia during high discharges.

Location "CB" is a 1286 m-long aggregation containing two disjunct segments located on the left descending bank at river mile 14.2 (Figure 12). It has a surface area of 5283 m² and a width of 3 to 6.5 m. The substrate in the downstream segment, outside of Council Bay, was dominated by equal amounts for boulder and rubble followed by coarse sand. The segment within Council Bay was dominated by fine sand followed by muck and silt. Maximum depth throughout this aggregation was 1 m. There was no perceivable current within Council Bay and a moderate current in portions outside of the bay. We found a total of 10 mussel species here among a total of 48 individuals collected. Council Bay provided an evidently excellent location that could be protective of caged fish inoculated with mussel glochidia during high discharges. Although this bay would not provide suitable habitat for adult *L. higginsii* due to its silty substrate and lack of current, mussels could be reared here until they attained suitable size for outplanting at a more riverine location.

Location "AF" 610 is a 600m-long aggregation located on the left descending bank at river mile 47.9 (Figure 13). It has a surface area of 12508 m² and a width of 45 to 11 m. The substrate here was primarily bedrock in the upstream half with gravel and rubble from shore out 5m. The lower half is a mix of bedrock and gravel and rubble. We found a total of 2 mussel species here among a total of 9 individuals collected. An additional 5 species were found dead along the shoreline. We found no locations that could be protective of caged fish inoculated with mussel glochidia during high discharges.

Figure7. Map of Mussel Aggregation "U".

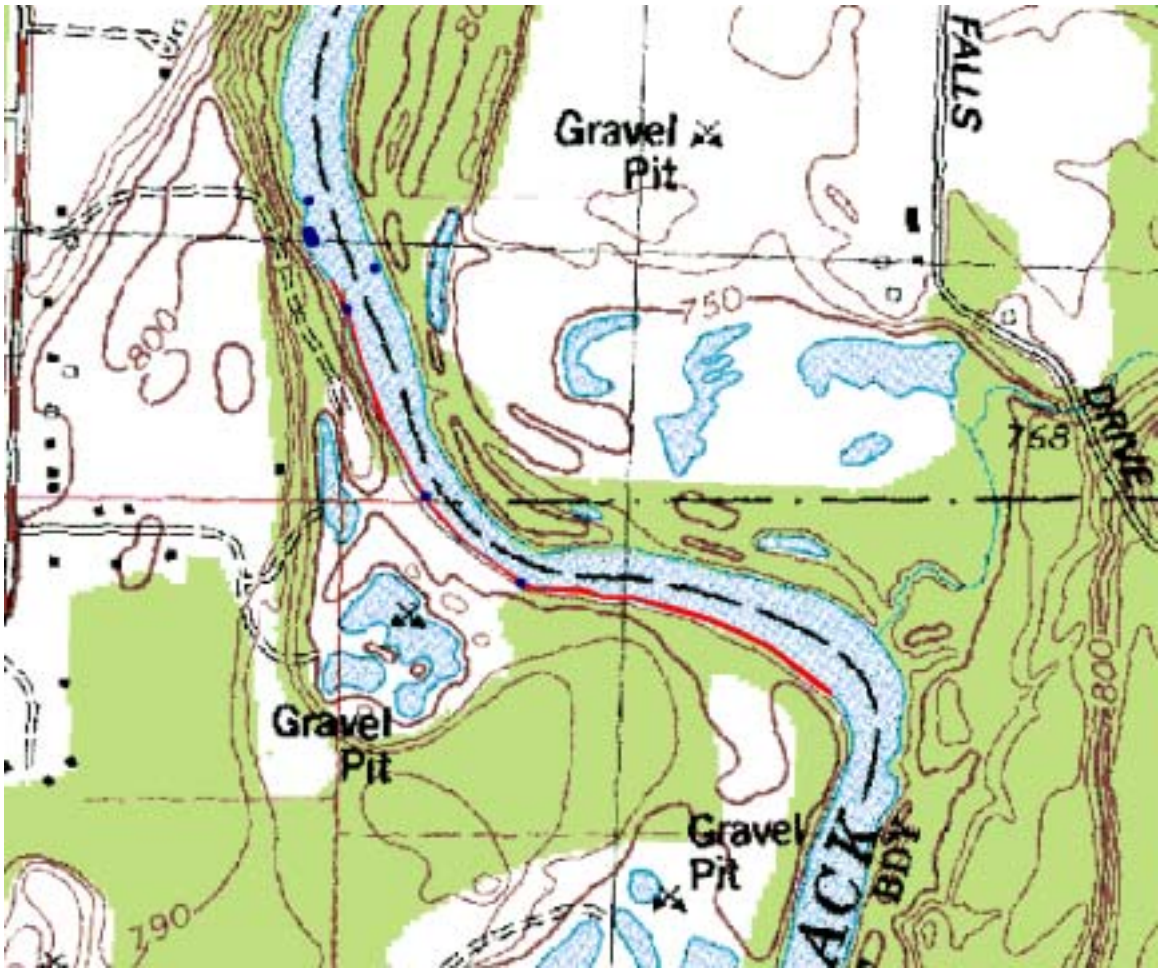


MUSSEL AGGREGATION “U”	
Latitude/Longitude	44° 13’ 23.5”N, 90° 52’ 28.4”W
Public Land Survey	Twp. 20N, Rng. 4W, Sec. 8 SE ¼, Jackson County, Wisconsin.
River Mile	52.4
Visually Est. Density	2/m²
Rank	1

Figure 8. Map of Mussel Aggregation "O".

MUSSEL AGGREGATION "O"	
Latitude/Longitude	44° 14' 12.5"N, 90° 52' 46.1"W
Public Land Survey	Twp. 20N, Rng. 4W, Sec. 5 SE ¼, Jackson County, Wisconsin.
River Mile	56.19
Visually Est. Density	1.5/m²
Rank	2

Figure 9. Map of Mussel Aggregation "F3".



MUSSEL AGGREGATION "F3"	
Latitude/Longitude	44° 16' 38.0"N, 90° 51' 38.2"W
Public Land Survey	Twp. 21N, Rng. 4W, Sec. 22 SW ¼, Twp. 21N, Rng. 4W, Sec. 27 NW ¼, Jackson County, Wisconsin.
River Mile	60.3
Visually Est. Density	1/m²
Rank	3

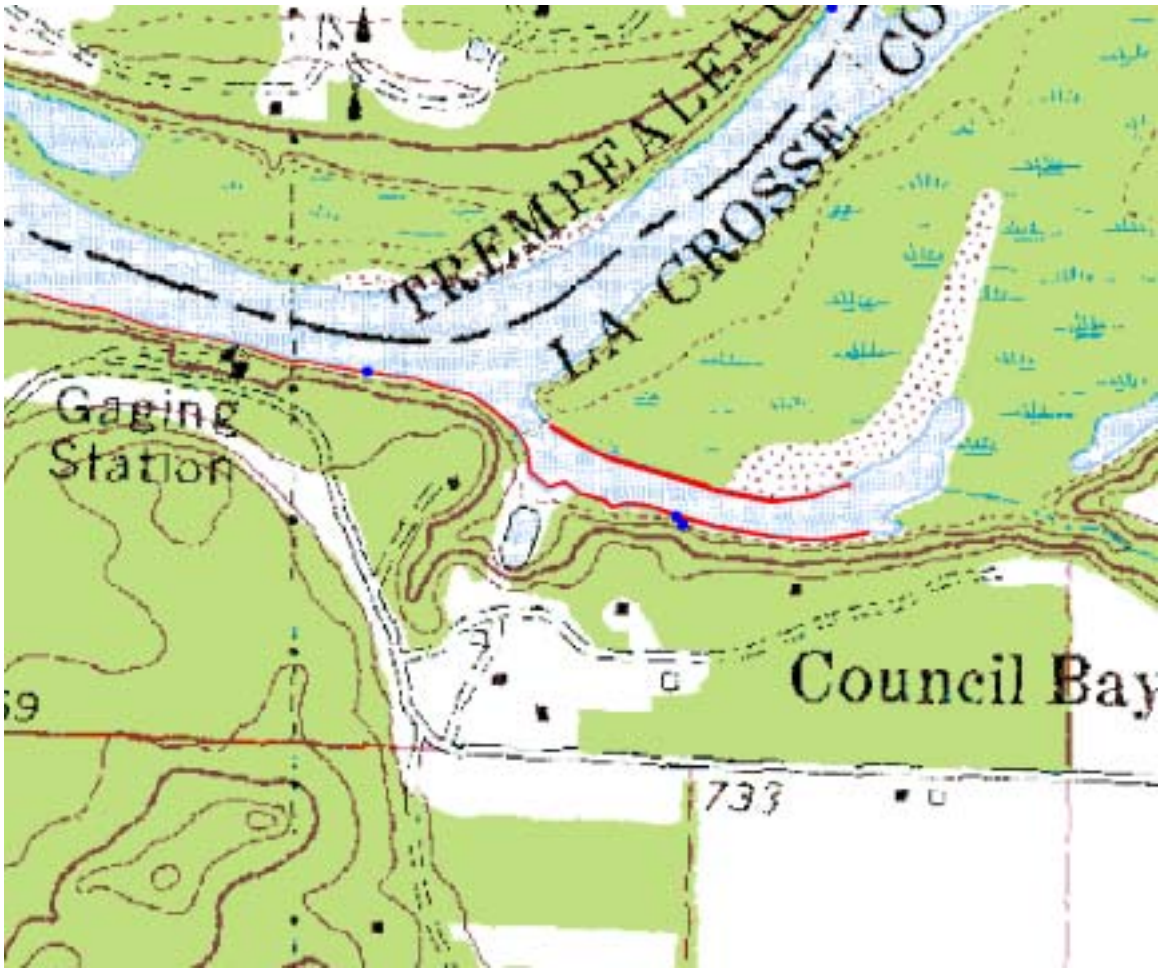
Figure 10. Map of Mussel Aggregation "CF1".

MUSSEL AGGREGATION "CF1"	
Latitude/Longitude	44° 1' 2.6"N, 91° 10' 39.8"W
Public Land Survey	Twp. 18N, Rng. 8W, Sec. 21 SW ¼, Trempealeau County, Wisconsin.
River Mile	8.24
Visually Est. Density	5/m²
Rank	3

Figure 11. Map of Mussel Aggregation "P".

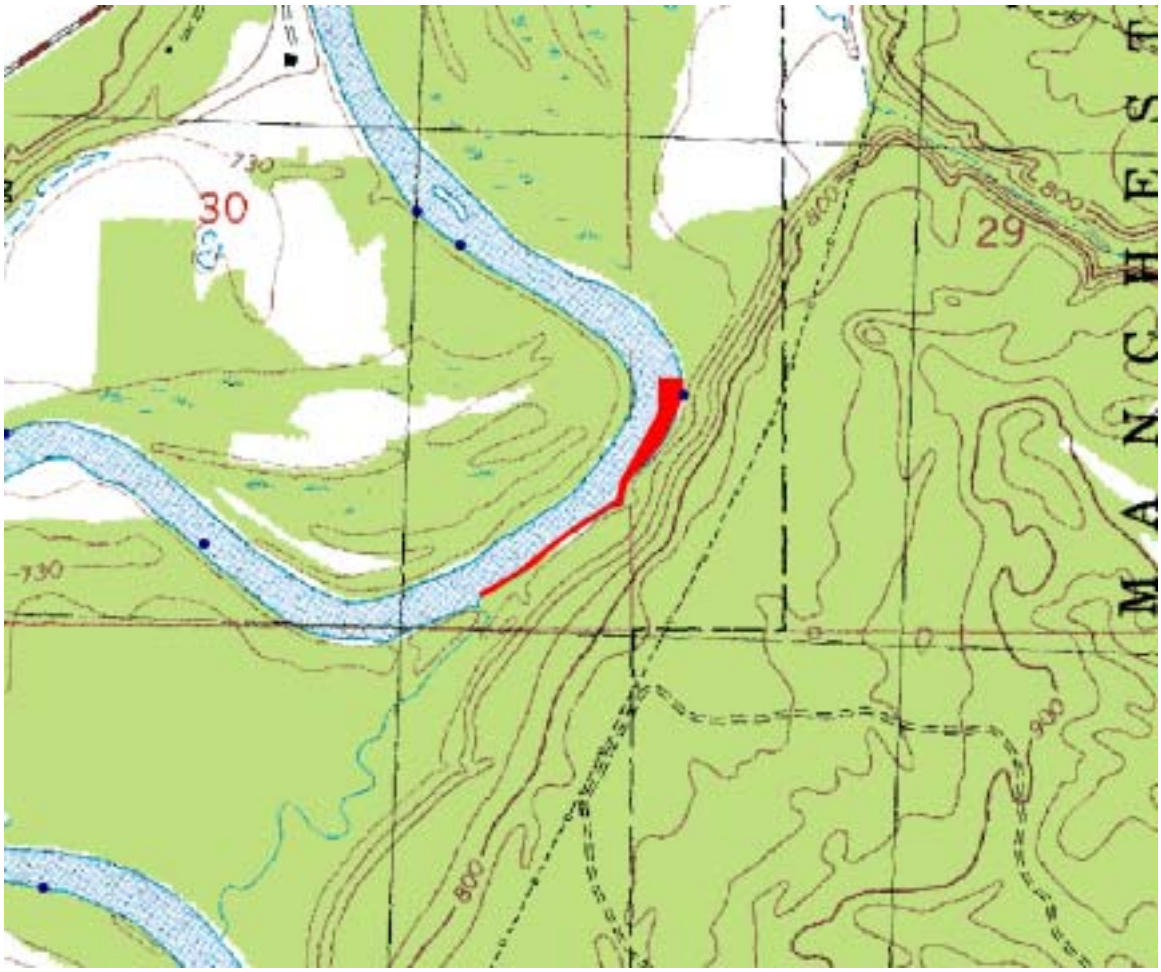
MUSSEL AGGREGATION "P"	
Latitude/Longitude	44° 14' 3.3"N, 90° 53' 3.6"W
Public Land Survey	Twp. 20N, Rng. 4W, Sec. 5 SW ¼, Jackson County, Wisconsin.
River Mile	55.9
Visually Est. Density	
Rank	4

Figure 12. Map of Mussel Aggregation "CB".



MUSSEL AGGREGATION "CB"	
Latitude/Longitude	44° 3' 35.3"N, 90° 17' 00.8"W
Public Land Survey	Twp. 18N, Rng. 8W, Sec. 1, La Crosse County, Wisconsin.
River Mile	14.2
Visually Est. Density	0.05/m²
Rank	5

Figure 13. Map of Mussel Aggregation "AF".



MUSSEL AGGREGATION “AF”	
Latitude/Longitude	44° 10’ 31.4”N, 90° 53’ 34.7”W
Public Land Survey	Twp. 20N, Rng. 4W, Sec. 29 SW ¼, Twp. 20N, Rng. 4W, Sec. 30 SE ¼, Jackson County, Wisconsin.
River Mile	47.92
Visually Est. Density	
Rank	6

CONCLUSIONS AND RECOMMENDATIONS

1) A total of 125 gravel and rock bars were identified during a census of the lower 62.4 miles of the Black River, Wisconsin. The total surface area of bars (38.38 ha) covered 4% of the total instream surface area of 962.7 ha. The majority of gravel bars and the greatest proportion of bar surface area were located in the upstream one-third of the study reach.

2) Of the 71 bars that were examined in detail, 49 (69%) were mussel aggregations as defined here (>5 mussels/hour). The majority of mussel aggregations and the greatest proportion of aggregations surface area were located in the upstream one-third of the study reach.

3) A total of 23 species were represented among 1536 living individuals. One additional species was represented by a dead individual only. Black River species richness was somewhat lower than other large tributary stream to the Mississippi River in Wisconsin. More sampling may provide additional species.

4) The lower Black River may not contain a mussel community that is associated with the presence of *L. higginsii*. Only two of the taxa strongly associated with *L. higginsii* were found. This compares with the lower Wisconsin River, where *L. higginsii* is present, which has 9. A total of 2 moderate associates are present in the lower Black River while 3 are present in the lower Wisconsin River.

5) Of the 49 mussel aggregations, we recommended 5 based on CPH and total surface area as locations where *L. higginsii* introductions may be most successful. However, given the relatively low density of mussels, absence of *L. higginsii*, low numbers of associates, limited cage placement options, more suitable tributary and Mississippi River mainstem locations; other waterbodies may have a higher suitability for

introductions. However, the lower Black River may be suitable for a juvenile rearing waterbody for latter outplanting.

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