Final Report:
Mussel (Bivalvia: Unionidae) survey of the Mississippi National River and Recreation Area Corridor, 2000-01.

Prepared for:

National Park Service

Mississippi National River and Recreation Area
and
The Great Lakes Network Inventory & Monitoring Program

Prepared by:

Dan Kelner and Mike Davis, Minnesota Department of Natural Resources, Ecological Services Division

July 2002

Acknowledgments

Funding for this survey was approved and supported in part by the Minnesota Legislature, 1999 Minnesota Laws, Ch. 23, Sec. 16, Subd. 15(a), as recommended by the Legislative Commission on Minnesota Resources from the Minnesota Environment and Natural Resources Trust Fund and by the U.S. Department of Interior, National Park Service (NPS) Great Lakes Network Inventory and Monitoring Program. Mike Davis served as Project Manager for the Minnesota Department of Natural Resources (MNDNR) and assisted with the survey effort. Dan Kelner (MNDNR) served as the Field Team Supervisor and is the primary author of this report. Several individuals assisted with the field effort including; Mary Anderson, Patrick Ceas, Ryan Morgan, Brett Ostby, Scott Taylor, Ryan Taylor, Sharon Woods (Mississippi National River and Recreation Area [MNRRA]), and Shane Vatland. Jesse Kroese (MNRRA) prepared the figures for this report and he and Sharon Woods (MNRRA) assisted with database preparation. Nancy Duncan, Joan Elias, Kate Hanson, Glen Miller, and Bill Route provided critical review of earlier drafts of this report.

Citation:

Kelner, D.E. and M. Davis. 2002. Final Report: Mussel (Bivalvia: Unionidae) survey of the Mississippi National River and Recreation Area Corridor, 2000-01. Contract report to the National Park Service Mississippi National River and Recreation Area and the Great Lakes Network Inventory and Monitoring Program. Minnesota Department of Natural Resources, Division of Ecological Services, St. Paul, MN 43pp. with appendices.

Copies of this report can be obtained by contacting;

National Park Service, Mississippi National River and Recreation Area,
111 East Kellogg Blvd., St. Paul, MN. 55101-1256
voice (651)-290-3030

Executive Summary

During 2000 and 2001, we sampled 152 sites for mussels along the entire Mississippi National River and Recreation Area (MNRRA) Corridor which encompasses a 72 mile stretch of the Upper Mississippi River (UMR) (138 sites), a four mile reach of the lower Minnesota River (MNR) near its confluence with the UMR (14 sites), and the lower Rum River (RR) near its confluence with the UMR (one site). The UMR stretch extends from approximately 20 miles north of the Twin Cities, through the Twin Cities, to just below Hastings, MN. Five pools or reaches were surveyed and include from upstream to downstream; Coon Rapids Pool, St. Anthony Falls Pool, and Pools 1, 2, and Upper Pool 3. Sample methods were consistent throughout the study and consisted of timed searches and hand collection of mussels while wading, snorkeling, and diving. Quantitative samples were also collected and mussel bed boundaries mapped at five sites within the UMR. Over 12,000 live mussels representing 28 species were collected with an additional 12 species collected as empty shells. The mussel fauna of UMR Pools 1-3 appears to be recovering since its reported decimation by pollution during the first half of the 1900s. This survey provided clear evidence of recent and ongoing recruitment, and many of the individuals collected were less than 10 years old. Several state listed species were collected including two listed as endangered in Minnesota, rock pocketbook (*Arcidens confragosus)* and wartyback (*Quadrula nodulata).* Recolonization is probably due to improved water quality conditions over the past 15-20 years. Furthermore, mussels are expanding their range above St. Anthony Falls (historically a faunal barrier to upstream dispersal) as fish now circumnavigate the two navigation locks. A total of 16 live species were collected from the St. Anthony Falls Pool including 10 species previously not reported there. Zebra mussels were absent above Lock and Dam 1 and very scarce from UMR Pool 2 and Upper Pool 3 and the lower MNR. These UMR pools differ from those downstream (Pool 4 and below) where zebra mussels are extremely abundant and are decimating the native mussel communities. Ironically, this reach of the Mississippi River between the Twin Cities and Hastings, MN, once nearly a dead zone, may now be one of the last big river mussel refuges in the Midwestern United States.

Table of Contents

List of Figures

List of Tables

1.0 Introduction

In July 1999, the Minnesota Department of Natural Resources (MNDNR)-Division of Ecological Services began a freshwater mussel survey to determine the distribution and abundance of unionid mussels in Minnesota. During 2000, 60 sites on the Upper Mississippi River (UMR) within the Mississippi National River and Recreation Area (MNRRA) Corridor were sampled for mussels by hand while wading, snorkeling, and diving. This effort was primarily confined to UMR Pools 1, 2, and 3 and survey work within MNRRA remained incomplete. As a result MNRRA aquired funds through the National Park Service Great Lakes Network Inventory and Monitoring Program (NPS I&M) for additional survey work in 2001.

Historically, as many as 41 mussel species including three federally listed species; Higgins' eye pearly mussel (*Lampsilis higginsi*), winged mapleleaf *(Quadrula fragosa),* fat pocketbook *(Potamilus capax),* and most state listed species in Minnesota have been found within the MNRRA Corridor (Table 1-1). This constitutes nearly 90% of the mussel species found throughout the state of Minnesota (MNDNR, unpublished data) and approximately 80% of all species found throughout the entire UMR drainage (Havlik and Sauer 2000). However, the mussel fauna of the UMR above Lake Pepin was reportedly decimated by pollution during the first three-quarters of the 1900s (Fuller 1980). In the 1970s, the U.S. Army Corps of Engineers-St. Paul District conducted a mussel survey for the 9-foot navigation project and found only nine live species at one site immediately below the Ford Dam (Lock and Dam 1) and only a few scattered mussels down to Lock and Dam 3 near Red Wing, MN (Fuller 1980). No live mussels were found above the Ford Dam to just above the Falls at St. Anthony. They reported that the mussel community "….shows poor condition. It is very sparse and sporadic…. There was no evidence of recent recruitment…." and they declared "….the outlook for a mussel renaissance in this troubled reach is extremely poor…." and will remain so "…until radical improvement in water quality is accomplished…". Fortunately, there were radical improvements in water quality in the Mississippi River following a successful citizen's campaign in the late 1970s that demanded the separation of storm water and sanitary sewers and higher quality effluent from wastewater treatment facilities primarily in the Twin Cities. The MNDNR's 2000 survey effort in UMR Pools 1-3 documented a recovering mussel community which is probably due to improved water quality conditions over the past 15-20 years.

These baseline data within the MNRRA Corridor are the first step in establishing a long term monitoring program and are crucial for conservation planning of mussel species state and region wide as well as within the corridor. These data will be added to a NPS I&M database on all sensitive plant and animal species nationwide and will ultimately be used for species conservation in NPS managed units. These data will also be entered in the MNDNR's Natural Heritage and Nongame Research Program's Natural Heritage Information System. Ultimately, these data will be used for watershed

Table 1-1. Mussel species recorded[1] from the MNRRA Corridor.

Species	Common name	Status[2]
Actinonaias ligamentina	mucket	MT
Alasmidonta marginata	elktoe	MT
Amblema plicata	threeridge	
Arcidens confragosus	rock-pocketbook	ME
Cumberlandia monodonta	spectaclecase	MT
Cyclonaias tuberculata	purple wartyback	MT
Ellipsaria lineolata	butterfly	MT
Elliptio crassidens	elephant-ear	ME
Elliptio dilatata	spike	MS
Epioblasma triquetra	snuffbox	MT
Fusconaia ebena	ebonyshell	ME
Fusconaia flava	wabash pigtoe	
Lampsilis cardium	plain pocketbook	
Lampsilis higginsi	Higgins eye	ME, FE
Lampsilis siliquoidea	fat mucket	
Lampsilis teres	yellow sandshell	ME
Lasmigona complanata	white heelsplitter	
Lasmigona compressa	creek heelsplitter	MS
Lasmigona costata	fluted-shell	MS
Leptodea fragilis	fragile papershell	
Ligumia recta	black sandshell	MS
Megalonaias nervosa	washboard	MT
Obliquaria reflexa	threehorn wartyback	
Obovaria olivaria	hickorynut	MS
Plethobasus cyphyus	sheepnose	ME
Pleurobema sintoxia	round pigtoe	MT
Potamilus alatus	pink heelsplitter	
Potamilus capax	fat pocketbook	MX, FE
Potamilus ohiensis	pink papershell	
Pyganodon grandis	giant floater	
Quadrula fragosa	winger mapleleaf	ME, FE
Quadrula metanevra	monkeyface	MT
Quadrula nodulata	wartyback	ME
Quadrula pustulosa	pimpleback	
Quadrula quadrula	mapleleaf	
Strophitus undulatus	strange floater	
Toxolasma parvus	lilliput	
Tritogonia verrucosa	pistolgrip	MT
Truncilla donaciformis	fawnsfoot	
Truncilla truncata	deertoe	
Utterbackia imbecillis	paper pondshell	
Total	41	

[1]This study, Fuller 1980

[2]MS=Minnesota species of special concern, MT=Minnesota threatened, ME=Minnesota endangered, MX=extirpated from Minnesota, FE=federally endangered

management planning by minimizing impacts to mussel species from sources such as water resource development projects and in assigning legal state and federal mussel conservation status.

The MNDNR, under contract with NPS, completed sampling for this survey in the summer of 2001. This report summarizes the results of this mussel survey (2001) as well as previous MNDNR work within the MNRRA Corridor (2000).

L. higginsi.

Q. fragosa (photo courtesy Kevin S. Cummings INHS).

In April 2000, the U.S. Fish and Wildlife Service (USFWS) issued a jeopardy opinion to the U.S. Army Corps of Engineers (USACE) on the federally endangered *L. higginsi* in the Upper Mississippi River system. The USFWS determined the major adverse effect to the continued existence of *L. higginsi* is the upriver transport of nonindigenous zebra mussels *(Dreissena polymorpha)* by commercial and recreational vessels. The USFWS biological opinion listed a Reasonable and Prudent Alternative (RPA) believed necessary to avoid jeopardy for *L. higginsi*. An RPA was for the Corps to develop an *L. higginsi* Relocation Action Plan and a monitoring program for *L. higginsi* and other mussels. As a result *L. higginsi* along with other species listed for protection in Minnesota were relocated from zebra mussel infested waters in Pools 11 and 14 of the Mississippi River to areas within the MNRRA Corridor in 2000 and 2001. These relocation areas were selected based on the results of this survey effort. This report will present total number of mussels and species relocated and their location. Our data should be considered for future monitoring activities.

2.0 Methods

2.1 Study Area

The MNRRA Corridor includes 72 miles (115.9 km) of the Upper Mississippi River (UMR) and four miles (6.4 km) of the lower Minnesota River (MNR) and encompasses approximately 54,000 acres (22,000 ha) of public and private land and water in five Minnesota counties (Figure 2-1). The MNRRA Corridor boundary is somewhat irregular and is roughly defined as the area existing from "bluff to bluff" on each side of the UMR. Lower portions of tributaries of the UMR that fall within this boundary are included in the corridor. The upstream and downstream boundary of the UMR portion of the corridor extends from approximately 20 miles (32 km) north of the Twin Cities near the cities of Dayton and Ramsey, MN (River mile [RM] 879), through the Twin Cities to the Goodhue-Dakota county line just south of Hastings, MN (approximate mid-point of UMR Pool 3 at RM 807). Four pools or reaches and an upper portion of a fifth pool fall within this stretch and include from upstream to downstream; Coon Rapids Pool (CR) (above Coon Rapids Dam), St. Anthony Falls Pool (SAF) (above St. Anthony Falls), and Pools 1, 2, and upper 3. We define a pool as a segment of the river separated by locks and dams. Pool 2 comprises nearly half of the study area (32 miles, 51.5km) and consists of three distinct reaches that differ in habitat and mussel species composition and relative abundance. Therefore, for a more accurate interpretation of the results we have sub-divided Pool 2 into three distinct reaches; Upper Pool 2 (Lock and Dam 1 to the confluence with the Minnesota River), Middle Pool 2 (Minnesota River to the I-494 Bridge at RM 832.5), and Lower Pool 2 (I-494 to Lock and Dam 3) (see Figure 2-1). The lower MNR reach extends from the I-494 Bridge in Bloomington, MN to its confluence with the UMR at Upper Pool 2 in the Twin Cities. Another reach within the MNRRA Corridor included in the study was the lower Rum River (RR) near its confluence with the UMR at Anoka, MN (see Figure 2-1).

2.2 Sampling

The mussel survey was conducted during the Summer/Fall of 2000 and 2001 using two sampling techniques. First, we used a qualitative sampling design, consisting of timed visual and tactile searches at multiple sites throughout the corridor, in order to rapidly determine; 1) species richness and relative abundance, 2) overall abundance, 3) distribution of species, 4) rare species presence, 5) present vs. historic mussel fauna, 6) some limited age demographics; and to 7) locate species rich and high density areas (mussel beds). Because qualitative samples can be somewhat biased toward larger and more conspicuous individuals and species, we also conducted more labor-intensive quantitative sampling at a subset of sites (mussel beds) qualitatively sampled. Quantitative sampling consisted of collecting $0.25m^2$ total substrate samples within a mussel bed to determine density, relative abundance, and population demographics (size/age class) (Miller and Payne 1988). Mussel bed boundaries were also mapped during this effort. Ultimately, these quantitative data, in conjunction with qualitative data, can be used as a benchmark to establish trends within the mussel community for subsequent long term monitoring. Zebra mussel (*Dreissena polymorpha*) density was determined from quantitative samples and zebra mussels

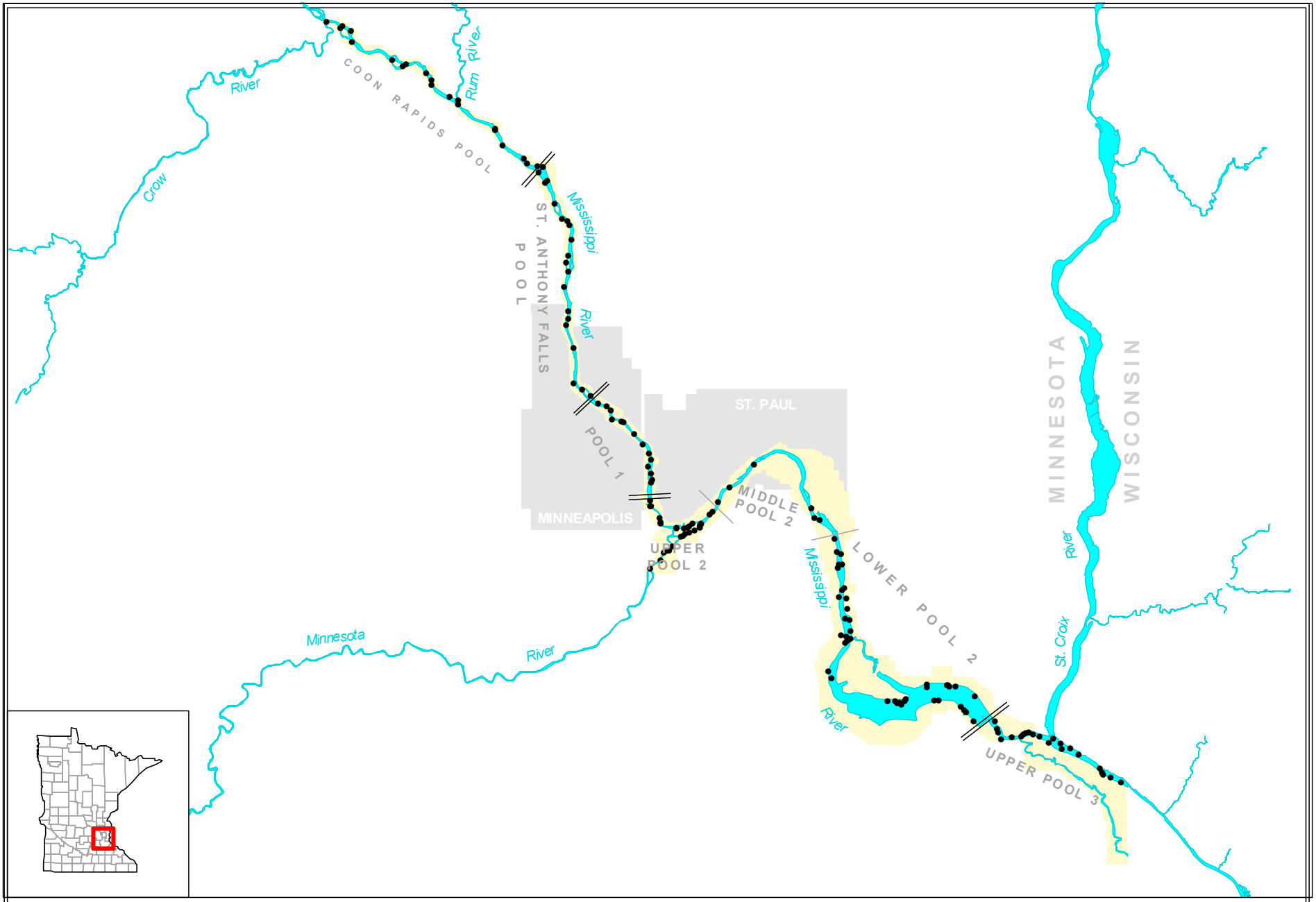


Figure 2-1. The MNNRA Corridor and sites sampled for mussels, 2000-01.

attached to native mussels collected were counted and destroyed.

2.2.1 Qualitative Sampling (timed searches)

Sites to be sampled were typically identified by consulting a navigation chart and by conducting reconnaissance searches by brailing and/or bank searches. We initially identified areas from the navigation chart that we expected to harbor mussels based on our experience in other reaches of the Mississippi River and mussel habitat preference. These areas were normally along either bank (outside or inside descending), in side channels, in eddies, in-between wing dams, or in other similar habitat. We usually avoided the main channel, eroded or unstable banks, and areas with considerable human disturbance (i.e., barge fleeting/loading facilities, marinas, effluent discharges, trash, etc..). We then conducted reconnaissance searches to better locate sites for our timed searches. Reconnaissance included bank searches for empty shells, locating habitat that appeared favorable (i.e., stable and sufficient flow or wave action to maintain a relatively silt free but stable substrate) and the use of a depth finder to determine bottom contour and depth. During 2000, we also conducted five-minute brail runs. The brail consisted of an eight foot wooden bar with several crowfoot shaped hooks attached to each of 20 x 12 inch long chains. The bar was dragged along the river bottom, downstream, and parallel to the bank. Mussels were captured when they clamped down on the hooks. However, we abandoned this method in 2001 and had equal success in identifying sites to sample from our initial reconnaissance searches. Sites were numbered from upstream to downstream and were continuous throughout the Mississippi River irrespective of reach. The Minnesota and Rum rivers were numbered similarly, starting with Site 1 at the most upstream site.

At each site, two or three divers hand collected all live and dead mussels by crawling along the river bottom, continually sweeping their hands back and forth sifting through the substrate, while looking and feeling for mussels. One-person hour/site was targeted as the search time and sites were typically spaced no more than one mile (1.6 km) apart. Divers typically searched all microhabitats at a particular site with the intent of locating high mussel densities and collecting as many live mussels as possible, thus maximizing the chance of collecting all species present. All mussels collected were placed in mesh bags, brought to the surface, identified to species, counted, and aged by an external annuli count (Neves and Moyer 1988). To compensate for the error associated with aging, mussels were placed in one of three age classes; 1-5, 6-10, and >10 years old. Within each age class, minimum and maximum length were determined for each species (maximum shell length, anterior-posterior axis). We collected at least one live and one empty shell of each species from each river and pool and deposited them at the University of Minnesota's James Ford Bell Museum of Natural History Mollusk Collection. All others were returned to the approximate location where collected. These specimens have been identified in the NPS I&M database. For each site, time spent searching and general habitat conditions (i.e., min. max. depth, substrate [silt/sand/gravel/cobble/boulder], and general riparian zone comments) were recorded. Catch per unit effort (CPUE) was calculated as the number of individuals collected divided by the time

spent searching for mussels (live mussels/hour). One centrally located GPS coordinate was recorded for each site to mark the site's general location.

2.2.2 Quantitative Sampling

Sites sampled by timed searches that harbored a species rich and/or dense mussel community, or that contained rare species, were chosen as areas to be quantitatively sampled. Quantitative samples were collected in 2001 at five sites, all within the UMR proper. These areas are referred to as Beds 1-5 and as with qualitative sites, are organized from upstream to downstream. Beds 1 and 2 were at the head of the SAF Pool and correspond to qualitative Sites 22 and 29, respectively. Beds 3 and 4 were in Upper Pool 2 and correspond to Sites 58 and 66, respectively. Bed 5 was in Lower Pool 2 and corresponds to Site 97.

At each site, prior to quantitative sampling, divers delineated the approximate boundaries of the bed. Divers traversed the river bottom to estimate mussel density, placing anchored buoys along the perimeter of the bed to aid the surface crew in mapping the beds' boundaries. This also facilitated the placement of individual quadrats within the bed so that the sampling effort was distributed throughout the bed.

A diver collected total substrate samples from each site using a $0.25m^2$ metal frame quadrat with a mesh bag consisting of ¼ inch mesh (6 mm) attached, to receive the collected sample. The number of samples per site ranged from 25 to 40 depending on the size of the bed. Quadrat placement was not random, rather we attempted to distribute the samples throughout the entire bed. Each sample was brought to the surface, fine substrates rinsed through the bag, and all mussels removed. All live native mussels were identified, aged, length measured, number of attached zebra mussels recorded, and then returned to the approximate location where collected. GPS coordinates were recorded along the perimeter of each mussel bed to approximate the area and location of the bed. One-way ANOVA followed by Tukey's multiple comparison test followed by Bonferroni correction was used to compare mussel density among beds.

Diver with a full bag of mussels from a timed search (left).

Working up mussels (right).

3.0 Results

A total of 152 sites (60 and 92 during 2000 and 2001, respectively) were sampled within the MNNRA Corridor via timed dive searches (qualitative) (see Figure 2-1). During 2001, five of these sites were also sampled quantitatively. Overall, 12,290 live mussels representing 28 species were found and an additional 12 species were found as empty shells (Table 3-1). Below are results for qualitative samples, first summarized collectively then organized by reach, followed by quantitative samples organized by site (bed).

3.1 Qualitative Sampling (timed searches)

During qualitative sampling a total of 11,932 live mussels were found including all live (28) and dead (12) species recorded in the study (i.e., no additional species collected in quantitative samples) (see Table 3-1). Sample sites were distributed fairly evenly throughout the study area (see Figure 2-1) and average time spent searching for mussels was slightly greater than one-person hour/site but varied (mean 64.3 person minutes/site ± 34.0 stdev [range 5 to 200]). Overall, average CPUE was 71.4 live mussels/hr, but was highly variable throughout the study (± 93.9 stdev, range 0 to 504 mussels/hr).

Although no federally endangered species were found live, old shells of the federally endangered *L. higginsi* and *Q. fragosa* were collected, an indication of their former presence in the area. Twelve mussel species listed for protection in Minnesota were collected live. These included two listed as endangered, the rock pocketbook (*Arcidens confragosus)* and wartyback (*Quadrula nodulata*) (see Table 3-1). Overall, the mussel fauna within the MNRRA Corridor was dominated (in descending order) by; three-horned wartyback (*Obliquaria reflexa*), threeridge (*Amblema plicata*), deertoe (*Truncilla truncata*), and mapleleaf (*Quadrula quadrula*) (see Table 3-1). However, as with CPUE, individual species occurrence and relative abundance were highly variable among pools and rivers and even among sites within pools. For individual species distributions throughout the MNRRA Corridor see maps in Appendix I and for species, number of individuals collected, and CPUE for each site see tables in Appendix II. For UTM coordinates (NAD 1983) for each site sampled see Appendix III.

The mussel fauna within all reaches of the MNRRA corridor was relatively young indicating that recent reproduction and recruitment of young individuals has occurred throughout the corridor and that until recently, mussels were uncommon. Most species were dominated by young individuals (<11 and <6 years old) (Figure 3-1). However, a few older relict populations consisting of only a few individuals were also present indicating that some species apparently have been present for a long time and have not recently reproduced.

Table 3-1. Overall mussel species richness and relative abundance within the MNRRA Corridor, 2000-01.

		Qualitative		Quantitative		Total	
Species	Status[1]	No.	%	No.	%	No.	%
Actinonaias ligamentina	MT	6	0.1			6	<0.1
Alasmidonta marginata	MT	3	<0.1			3	<0.1
Amblema plicata		1,899	15.9	94	26.3	1,993	16.2
Arcidens confragosus	ME	30	0.3			30	0.2
Cumberlandia monodonta	MT	D				D	
Cyclonaias tuberculata	MT	D				D	
Ellipsaria lineolata	MT	1	<0.1			1	<0.1
Elliptio crassidens	ME	D				D	
Elliptio dilatata	MS	14	0.1			14	0.1
Epioblasma triquetra	MT	D				D	
Fusconaia ebena	ME	D				D	
Fusconaia flava		927	7.8	24	6.7	951	7.7
Lampsilis cardium		751	6.3	5	1.4	756	6.2
Lampsilis higginsi	ME, FE	D				D	
Lampsilis siliquoidea		203	1.7	D		203	1.7
Lampsilis teres	ME	D				D	
Lasmigona complanata		23	0.2			23	0.2
Lasmigona compressa	MS	1	<0.1			1	<0.1
Lasmigona costata	MS	D		D		D	
Leptodea fragilis		294	2.5	4	1.1	298	2.4
Ligumia recta	MS	218	1.8	7	2.0	225	1.8
Megalonaias nervosa	MT	2	<0.1	1	0.3	3	<0.1
Obliquaria reflexa		2,981	25.0	92	25.7	3,073	25.0
Obovaria olivaria	MS	6	0.1			6	<0.1
Plethobasus cyphyus	ME	D				D	
Pleurobema sintoxia	MT	7	0.1			7	0.1
Potamilus alatus		343	2.9	5	1.4	348	2.8
Potamilus ohiensis		106	0.9	3	0.8	109	0.9
Pyganodon grandis		256	2.1	2	0.6	258	2.1
Quadrula fragosa	ME, FE	D				D	
Quadrula metanevra	MT	1	<0.1			1	<0.1
Quadrula nodulata	ME	179	1.5	9	2.5	188	1.5
Quadrula pustulosa		182	1.5	10	2.8	192	1.6
Quadrula quadrula		1,489	12.5	40	11.2	1,529	12.4
Strophitus undulatus		196	1.6	5	1.4	201	1.6
Toxolasma parvus		D				D	
Tritogonia verrucosa	MT	D				D	
Truncilla donaciformis		52	0.4	D		52	0.4
Truncilla truncata		1,758	14.7	57	15.9	1,815	14.8
Utterbackia imbecillis		4	<0.1			4	<0.1
Total		11,932		358		12,290	
No. live species		28		15		28	
Total species		40		18		40	
No. sites		152		5		152	
Ave. time/site (min) ± stdev.		64.3±34.0				64.3±34.0	
CPUE (no. live/hour) ± stdev.		71.4±93.9				71.4±93.9	

[1]MS=Minnesota species of special concern, MT=Minnesota threatened, ME=Minnesota endangered, MX=extirpated from Minnesota, FE=Federally endangered.

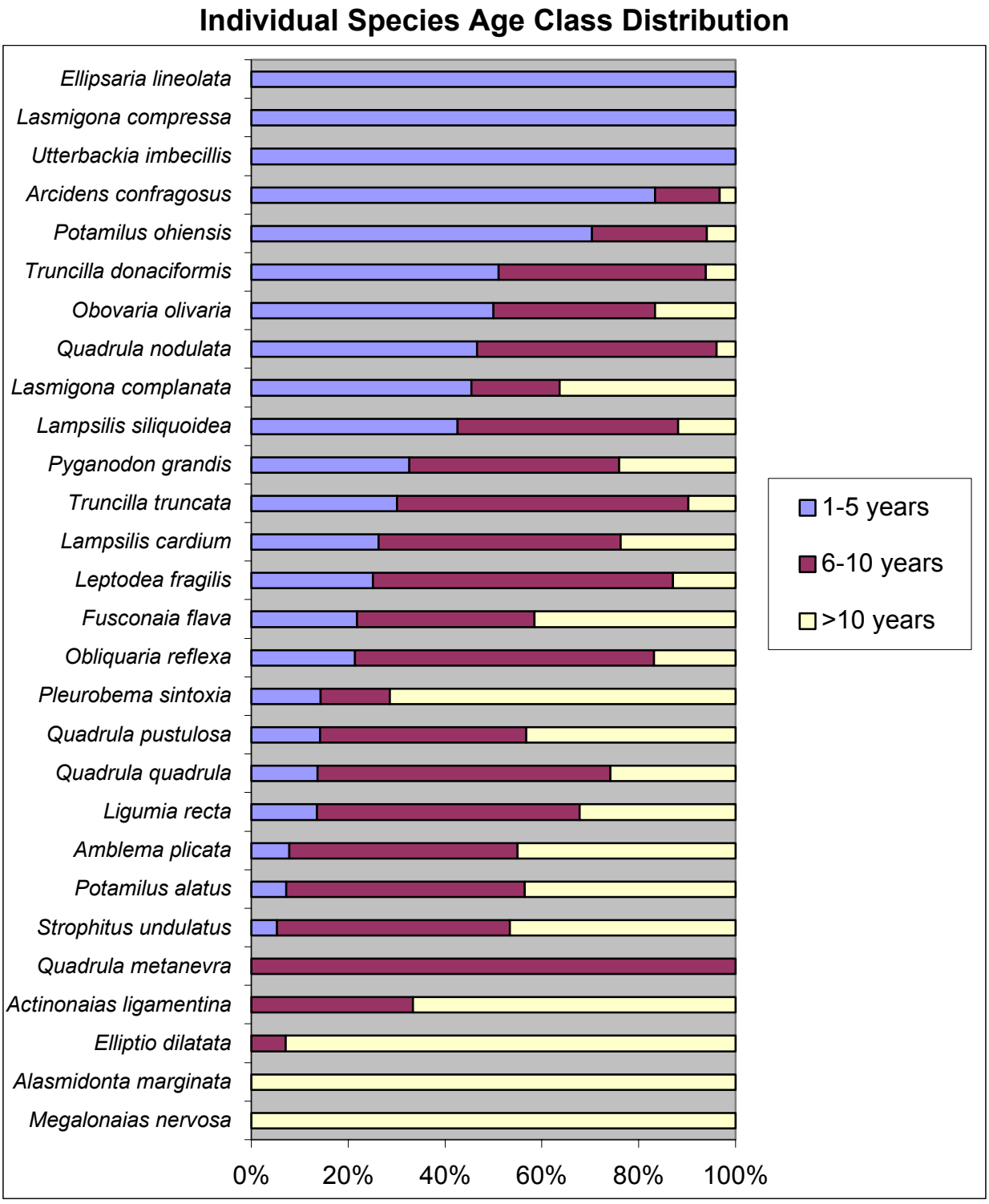


Figure 3-1. Individual species age class distributions from timed searches within the MNRRA Corridor, 2000-01.

Below are results by reach, organized from upstream to downstream for the Mississippi River proper followed by the two tributary reaches of the lower Minnesota and Rum rivers.

3.1.1 Coon Rapids Pool

Mussel species richness and abundance within the Coon Rapids (CR) Pool was relatively poor compared to the other reaches within the MNRRA Corridor (Figures 3-2 and 3-3). A total of 587 mussels representing six species were collected at 19 sites and average CPUE was 22.0 mussels/hr (Table 3-2). The community was dominated by plain pocketbook (*Lampsilis cardium*) (62.7%) followed by fatmucket (*Lampsilis siliqouidea*) (19.9%) and black sandshell (*Ligumia recta*) (14.8%), respectively. Despite low species richness and abundance, the CR Pool appears to support a healthier population of *L. recta*, a species of special concern in Minnesota, than the other MNRRA reaches.

Habitat in the upper reaches of the pool consisted of alternating riffles, runs, and pools with water depth typically <2m, conditions favored by mussels. However, only Sites 4 and 12 supported an abundant mussel community. Site 4 was at the lower end of NPS Island 101-01 near Goodin Island at approximately river mile 878.2 (Figure 3-4). A total of 229 live mussels were collected including 19 live *L. recta*. *Lampsilis cardium* dominated the community and overall CPUE was 152.7 mussels/hr (Appendix II). Site 12 was in the city limits of Anoka, MN. immediately above the HWY 169 Bridge on the left descending bank. This site was sampled in 2000 when the water was drawn down for repairs of the Coon Rapids Dam. A total of 175 live mussels of six species were collected along a large exposed gravel bar. Catch per unit effort was 105.0 mussels/hr and *L. cardium*, *L. siliqouidea*, and *L. recta* were abundant (see Appendix II).

Mussels were scarce in the downstream portion of the pool. This was probably due to the poorer habitat in the lower pool associated with impoundment (i.e., low flow, silt/sand substrate). Only 19 live mussels of two species were collected at four (13-15, 18) of the seven sites at the lower end of the pool. Mussels were completely absent from Sites 3, 16, 17, and 19 (see Figure 3-4 and Appendix II).

Upper CR Pool near Cloquet Island (Site 6, RM875.5).

L. recta (photo courtesy Kevin S. Cummings INHS).

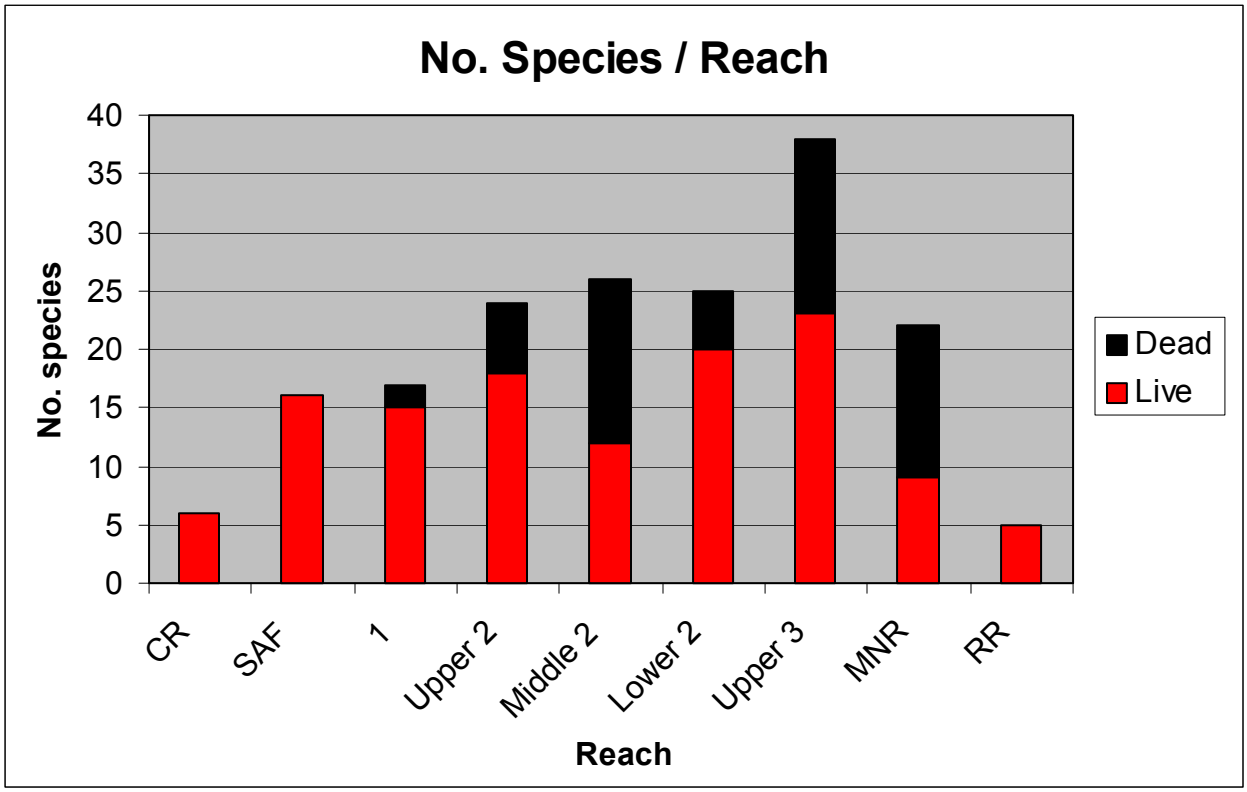


Figure 3-2. Mussel species richness within the MNRRA Corridor reaches from timed searches, 2000-01

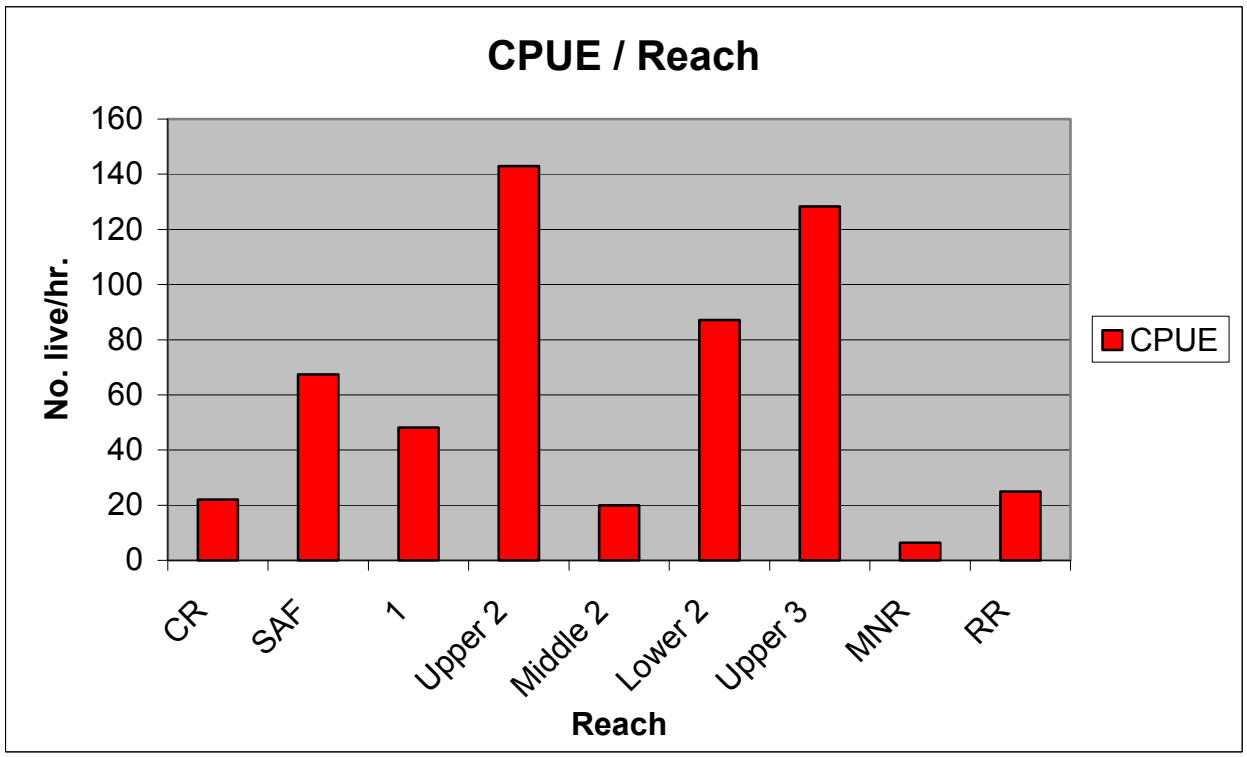


Figure 3-3. Mussel abundance (CPUE) within the MNRRA Corridor from timed searches, 2000-01.

Table 3-2. Mussel species richness and relative abundance for each Mississippi River reach within MNRRA, 2000-01.

	Mississippi River Pool (reach)													
	CR		SAF		1		Upper 2		Middle 2		Lower 2		Upper 3	
Species	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
*Actinonaias ligamentina**											D		6	0.2
*Alasmidonta marginata**							3	0.1					D	
Amblema plicata			35	1.6	173	21.4	675	28.0	100	57.1	293	9.1	622	25.0
*Arcidens confragosus**											26	0.8	4	0.2
*Cumberlandia monodonta**													D	
*Cyclonaias tuberculata**							D		D					
*Ellipsaria lineolata**													1	<0.1
*Elliptio crassidens**									D				D	
*Elliptio dilatata**					D		D		D				14	0.6
*Epioblasma triquetra**													D	
*Fusconaia ebena**									D		D		D	
Fusconaia flava			117	5.4	150	18.6	81	3.4	11	6.3	316	9.9	252	10.1
Lampsilis cardium	366	62.4	265	12.2	8	1.0	71	2.9	D		5	0.2	31	1.2
*Lampsilis higginsi**													D	
Lampsilis siliquoidea	117	19.9	65	3.0	1	0.1	4	0.2	D		D		2	0.1
*Lampsilis teres**													D	
Lasmigona complanata	4	0.7	1	<0.1	D		4	0.2	1	0.6	8	0.2	4	0.2
*Lasmigona costata**													D	
Leptodea fragilis			182	8.4	10	1.2	45	1.9	3	1.7	27	0.8	6	0.2
*Ligumia recta**	87	14.8	89	4.1	1	0.1	37	1.5	D		1	<0.1	2	0.1
*Megalonaias nervosa**													2	0.1
Obliquaria reflexa			138	6.3	62	7.7	349	14.5	35	20.0	1,224	38.2	1,173	47.2
*Obovaria olivaria**							D		D		D		6	0.2
*Plethobasus cyphyus**							D		D		D		D	
*Pleurobema sintoxia**			1	<0.1			D		D		1	<0.1	5	0.2
Potamilus alatus	1	0.2	246	11.3	6	0.7	23	1.0	3	1.7	18	0.6	39	1.6
Potamilus ohiensis			2	0.1	1	0.1	8	0.3	1	0.6	46	1.4	28	1.1
Pyganodon grandis	12	2.0	41	1.9	12	1.5	2	0.1	2	1.1	119	3.7	60	2.4
*Quadrula fragosa**									D				D	
*Quadrula metanevra**							D		D		1	<0.1	D	
*Quadrula nodulata**					28	3.5	62	2.6	4	2.3	78	2.4	7	0.3
Quadrula pustulosa					4	0.5	50	2.1	3	1.7	40	1.2	85	3.4
Quadrula quadrula			302	13.9	237	29.3	202	8.4	11	6.3	668	20.8	67	2.7
Strophitus undulatus			115	5.3	16	2.0	59	2.4			6	0.2	D	
Toxolasma parvus													D	
*Tritogonia verrucosa**									D				D	
Truncilla donaciformis			33	1.5			16	0.7			3	0.1		
Truncilla truncata			543	25.0	99	12.3	719	29.8	1	0.6	325	10.1	69	2.8
Utterbackia imbecillis									D		3	0.1	1	<0.1
Total	587		2,175		808		2,410		175		3,208		2,486	
No. live species	6		16		15		18		12		20		23	
Total species	6		16		17		24		26		25		37	
No. sites	19		20		14		13		9		40		22	
Ave time/site (min) ± stdev	84.2±39.8		96.8±34.8		71.8±26.9		63.3 ±30.2		58.3 ±34.3		55.3 ±28.1		48.5±22.7	
CPUE (No.live/hour) ± stdev	22.0±39.9		67.4±61.3		48.2±36.7		142.9 ±112.		20.0 ±60.5		87.1 ±99.4		128.3±120.9	

*Listed species; D=Collected as empty shell

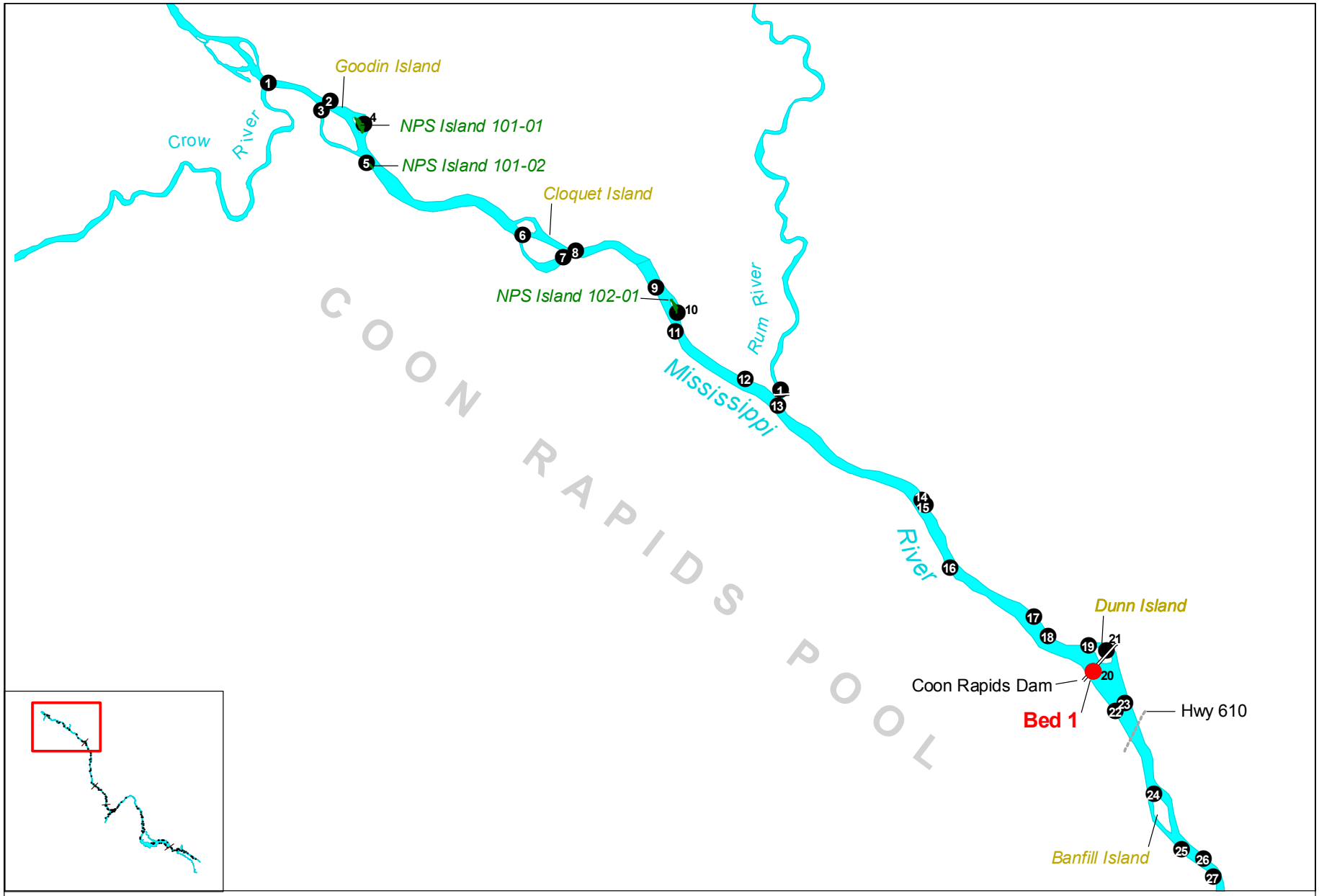


Figure 3-4. Sites sampled within the Coon Rapids Pool, 2000-01.

3.1.2 St. Anthony Falls Pool

Mussel species richness and abundance increased dramatically in the St. Anthony Falls (SAF) Pool from the CR Pool. The mussel fauna closely resembled the community found immediately below the Falls at St. Anthony (Pool 1 and Upper Pool 2) (see Table 3-2). A total of 2,175 mussels of 16 species were collected at 20 sites and average CPUE was moderately high (67.4 mussels/hr) in the SAF Pool. The community was dominated by *T. truncata* (25.0%) with three other species also abundant, *Q. quadrula* (13.9%), *L. cardium* (12.2%), and pink heelsplitter (*Potamilus alatus*) (11.3%) (see Table 3-2). Other common species (>5%) in the pool include fragile papershell (*Leptodea fragilis*) (8.4%), *O. reflexa* (6.3%), wabash pigtoe (*Fusconaia flava*) (5.4%), and the strange floater (*Strophitus undulatus*) (5.3%) (see Table 3-2).

It appears that mussels are expanding their range above St. Anthony Falls, historically a faunal barrier to upstream dispersal but now easily circumnavigated by navigation locks. Of the 16 live species that were collected from the SAF Pool, 10 have not been previously reported above the falls (Dawley 1947, Graf 1997). Several of these "new occurrence" species were common (>5%); *F. flava, L. fragilis, O. reflexa, P. alatus, Q. quadrula*, and *T. truncata* (see Table 3-2). Another species new to the pool, the round pigtoe (*Pleurobema sintoxia*), is listed as threatened in Minnesota.

A relatively young mussel community occurs in the SAF Pool (Figure 3-5). Overall in the SAF Pool, 71% of the individuals collected were <11 years old (70% of the 10 "new" species were <11 years old). Every species was represented by individuals <11 years old and all but one species was represented by individuals <6 years old. This indicates recent recruitment and is similar to other reaches within the MNRRA Corridor (see Figure 3-5). These data indicate that the 10 new species reported from the pool colonized the area recently.

Several sites sampled within the SAF Pool supported a dense and species rich mussel community. As with the CR Pool, these sites were located in the upper portion of the pool where habitat appeared most favorable. Habitat consisted of alternating riffles, runs, and pools and water depth was typically <2m. These sites were distributed from immediately below the Coon Rapids Dam downstream to just below the I-694 Bridge and are designated as Sites 21, 22, 25, 27, 29, 30, 32, and 33 (Figure 3-6). Species richness and abundance (CPUE) ranged from 10 to 13 live species and 82.7 to 204.0 mussels/hr for these sites, respectively (Appendix II). Mussels were most abundant (>200) at Site 21 (adjacent to Dunn Island along the left descending bank) and Site 25 (immediately below Banfill Island). Site 25 also harbored a species rich (12) mussel community and habitat was particularly noteworthy (sand/gravel/cobble compact substrate, 1-2m in depth). Additionally, the West channel adjacent to the next island downstream, Durnam Island, harbored a dense and species rich mussel community (Sites 29, 30, and 32). Finally, Site 33 consisted of a long (300-400m) narrow band of mussels along the

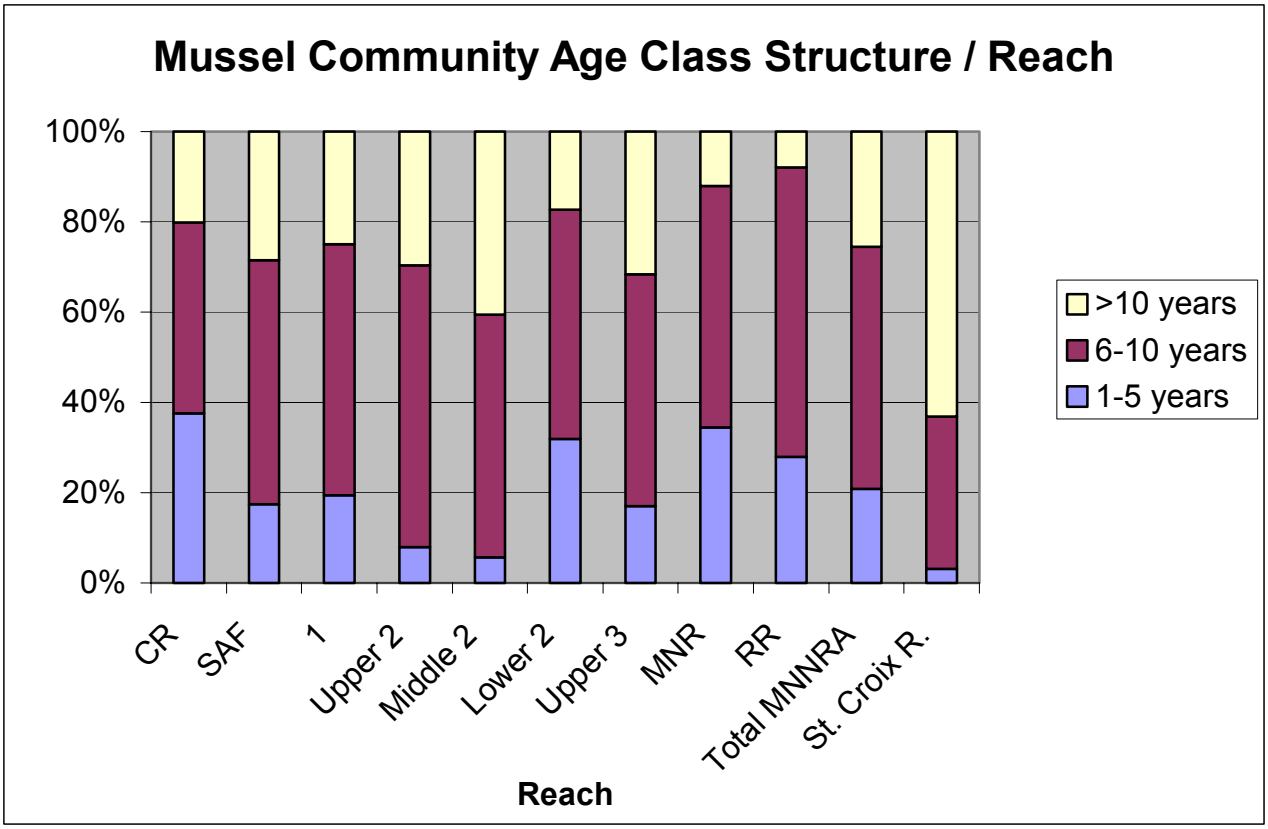


Figure 3-5. Mussel community age class structure for each reach within MNRRA, Total MNRRA, and in the lower St. Croix River, 2000-01.

outside right descending bank, downstream of the I-694 Bridge. Habitat at Site 33 consisted of a run with compacted sand/gravel/cobble substrate and water depth of 1-2m.

Although mussels were not abundant and habitat not as favorable as upstream, the lower portion of the SAF Pool (Sites 34-39) supported 11 live species (Appendix II). As with the lower CR Pool, substrate and flow were less than ideal for mussels due to the impounded nature of the lower SAF pool. This area also lies at the head of the navigation system and within a highly industrial region of Minneapolis. Adverse impacts to the aquatic environment were obvious (considerable barge traffic and loading facilities; trash and debris; and effluent discharges).

Upper SAF Pool near Site 25, looking upstream at Banfill Island (left) (RM 863.5)

The Falls at St. Anthony, from Site 40 between upper and lower St. Anthony Locks (RM 853.5)

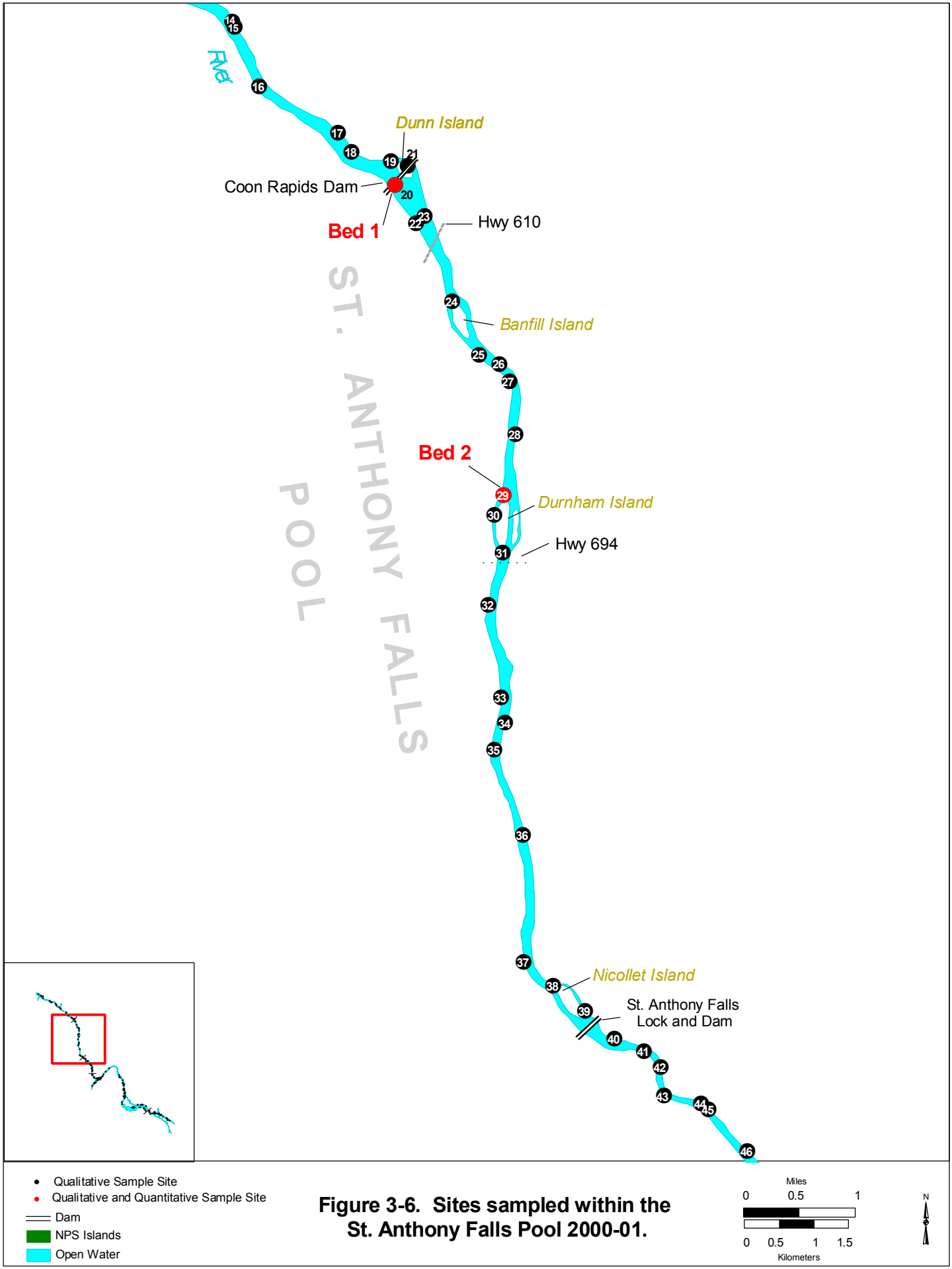


Figure 3-6. Sites sampled within the St. Anthony Falls Pool 2000-01.

3.1.3 Pool 1

Pool 1 supported a mussel community similar to the SAF Pool in species richness but mussels were slightly less abundant (see Figures 3-2 and 3-3). Relative abundance varied slightly in comparison with the SAF Pool. A total of 808 mussels of 15 species were collected at 14 sites and average CPUE was moderately low (48.2 mussels/hr) in Pool 1 (see Table 3-2). The community was dominated by *Q. quadrula* (29.3%), *A. plicata* (21.4%), and *F. flava* (18.6%) (see Table 3-2). Other abundant species (>5%) include *T. truncata* (12.3%) and *O. reflexa* (7.7%) and several species were fairly common including *Q. nodulata* (3.5%), one of two Minnesota endangered species found live within the MNRRA Corridor (see Table 3-2).

As with most other reaches, a relatively young community was found in Pool 1 (see Figure 3-5). Overall, 75% of the individuals collected were <11 years old and 93% and 80% of the species had individuals <11 and <6 years old, respectively. Six species had individuals that were all <11 years old including all 28 live *Q. nodulata* collected. As with the SAF Pool and most other MNRRA reaches, it appears mussels have recently reproduced here and/or have colonized Pool 1 probably from downstream reaches via fish infected with glochidia.

Unlike the CR and SAF pools, the most dense and species rich mussel communities were found in the middle and lower portion of Pool 1. Only Sites 46, 50, and 52 supported healthy populations in Pool 1 (Figure 3-7 and Appendix II). At all three sites, mussels were found along a sand bar or sand beach in 1-2.5m water depth in minimal flow. Site 46, located mid-pool, supported the highest number of species (12) and greatest density (135.8 mussels/hr (see Appendix II). Sites 50 and 52 were at the lower end of the pool and species richness (8 and 10, respectively) and abundance (76.7 and 74.0 mussels/hr, respectively) were similar between sites (see Figure 3-7 and Appendix II). All *Q. nodulata* were collected from the lower half of Pool 1 and one-half (14) of the individuals were collected from Sites 50 and 52 (see Appendix II and 2). This is not surprising given that *Q. nodulata* typically prefers softer substrates with low current velocity (pers. obs.).

Upper Pool 1, Site 42, downtown Minneapolis in the background (RM 853).

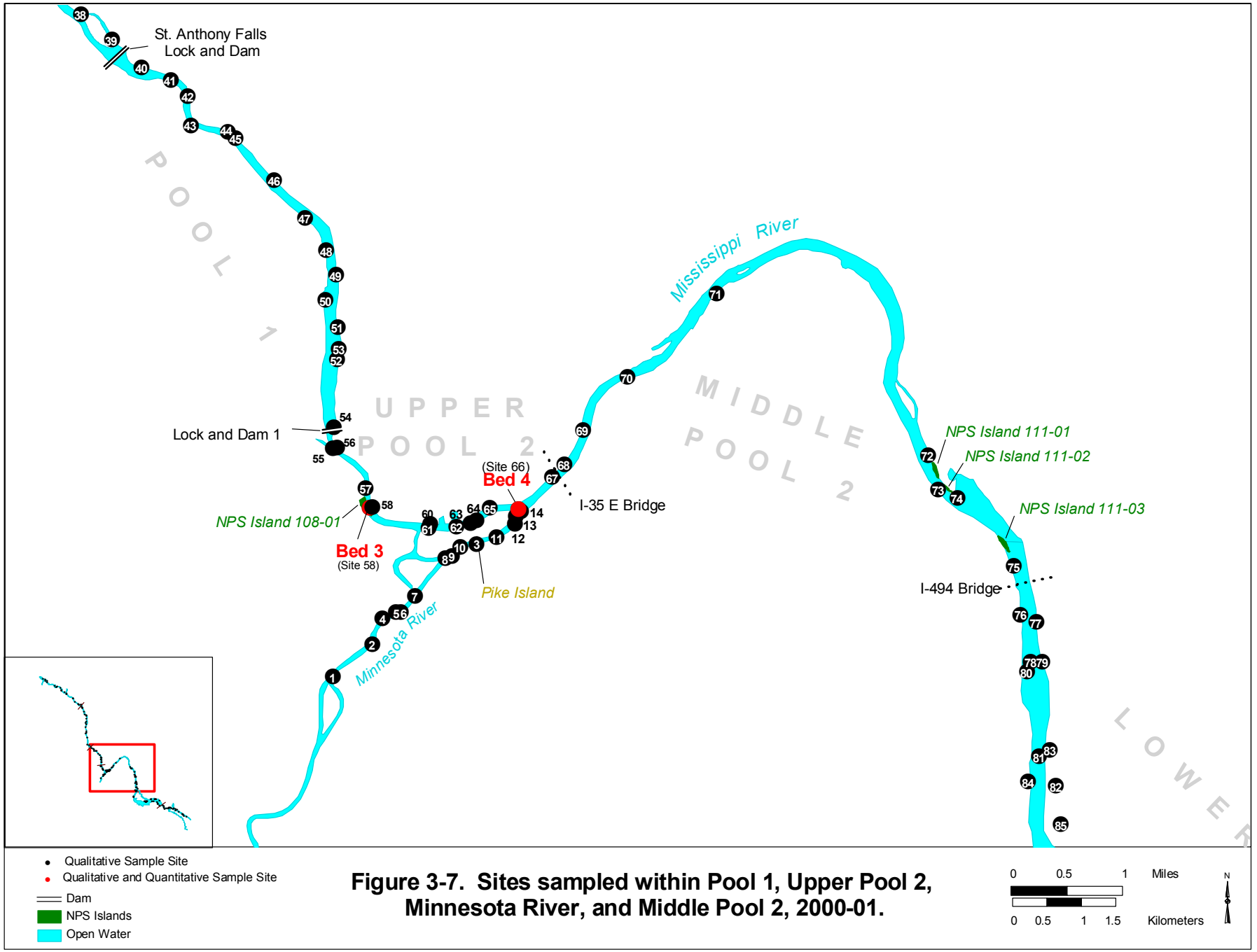


Figure 3-7. Sites sampled within Pool 1, Upper Pool 2, Minnesota River, and Middle Pool 2, 2000-01.

3.1.4 Upper Pool 2

The Upper Pool 2 reach supported the most dense and one of the most species rich communities among the reaches in the study (see Figures 3-2 and 3-3). A total of 2,410 mussels of 18 live species were collected at 13 sites and average CPUE was 142.9 mussels/hr (see Table 3-2). The community was dominated by T. truncata *(29.8%) and* A. plicata *(28.0%).* Obliquaria reflexa *(14.5%) and* Q. quadrula *(8.4%) were also relatively abundant (see Table 3-2). Most of the remaining species were uncommon (<5%) or rare (<1%) including three species listed for protection in Minnesota;* Q. nodulata *(2.6%) (endangered),* L. recta *(1.5%) (species of special concern), and* Alasmidointa marginata *(0.1%) (threatened) (see Table 3-2).*

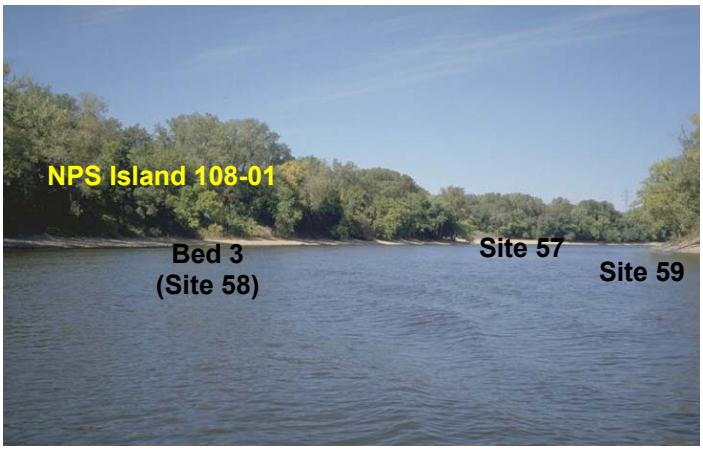
Young individuals again dominated the mussel community in Upper Pool 2 and most species were represented by young individuals. Overall, 70% of the individuals in the community were <11 years old (see Figure 3-5) and 78% of the species were represented by individuals <6 years old.. However, all three *A. marginata* collected within the entire MNRRA Corridor were from this reach and all were old individuals (>15 years old) (see Figure 3-1). Given the low number of individuals collected and the lack of recent reproduction, the potential exists for this species to become extirpated from the corridor. Conversely, approximately 88% of the *Q. nodulata* collected in Upper Pool 2 were <11, 20% were <6 years of age.

The Upper Pool 2 reach extends from immediately below Lock and Dam 1 to the lower end of Pike Island at the Mississippi River confluence with the Minnesota River (see Figure 3-7). Habitat in this reach appeared favorable for mussels with moderate flow and water depth from 1-4m. Substrate appeared stable, consisting of a consolidated mixture of sand, gravel, cobble, and boulder. Several sites harbored a dense and species rich mussel community including Sites; 54, 57-60, 62, 65, and 66 (see Figure 3-7). Catch per unit effort ranged from 114.5 to 336.0 mussels/hr among these sites (see Appendix II). Site 54 was adjacent to an unnamed island immediately downstream of Lock and Dam 1. Twelve species were collected here including *A. marginata* (threatened) and *L. recta* (special concern). Sites 58 and 66 were also sampled quantitatively because they supported the greatest number of species (15 and 14 respectively), included rare species, and had a high CPUE (see Appendix II).

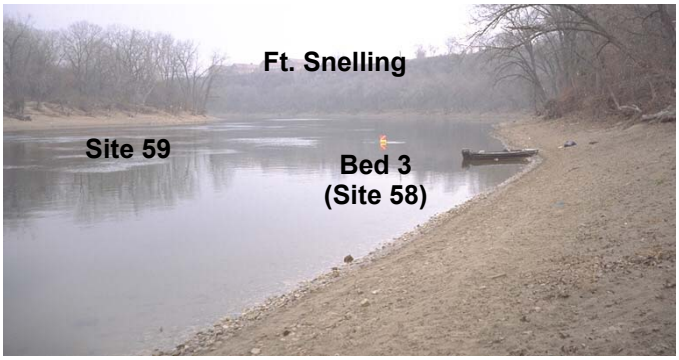
Over 1,000 live mussels of 15 species were collected from Sites 57, 58, and 59 which were positioned close together near NPS Island 108-01 (see Figure 3-7 and Appendix II). *Quadrula nodulata* and *L. recta* were present at all three sites. Site 60 was across the Mississippi River from the head of Pike Island and immediately upstream of the Watergate Marina. Mussels were most abundant at this site (CPUE 336.0 mussels/hr) and 13 species were collected (see Appendix II). Site 66 was the exception in habitat type for this reach. This site was at the lower end of Pike Island in an eddy, current velocity was low, and substrate consisted of silt and sand. Site 66 supported the second highest mussel abundance

(CPUE 287.3 mussels/hr) and number of species (14) in Upper Pool 2 (see Appendix II). Particularly noteworthy was the high number of *Q. nodulata* (39) collected at Site 66 (see Appendix II). *Quadrula nodulata* was collected live at eight of the 13 sites sampled in Upper Pool 2 but well over half (63%) were collected from Site 66 where it comprised nearly 8% of the mussel community (see Appendices I and II). As in Pool 1, *Q. nodulata's* high abundance at this site is not surprising given that the habitat found here is unique to Upper Pool 2 and seems favorable to this species (i.e., low flow and soft substrate). It's possible that Site 66 harbors a source population for *Q. nodulata* that facilitates its dispersal throughout Upper Pool 2 and lower Pool 1.

Lock and Dam 1 (Ford Dam), Site 54 is along an unnamed island and was a state listed species relocation area.



Looking upstream from Ft. Snelling, Bed 3 was a *L. higginsi* and state listed species relocation site (RM 846.2).



Looking downstream towards Ft. Snelling.

Very old (>15 years) *A. marginata* collected from Bed 3.

Healthy population of *Q. nodulata* collected near the base of Pike Island from Bed 4 (Site 66, RM 844.0).

3.1.5 Middle Pool 2

Although it supported 12 species, mussels were not abundant through most of the Middle Pool 2 reach. A total of 175 live mussels were found and average CPUE was 20.0 mussel/hr (see Appendix II). Mussels were sparse or absent from seven of the nine sites sampled (see Appendix II). Only one site, Site 68, supported a dense and species rich mussel community. This site was immediately downstream of the I-35E Bridge, approximately one mile below the Minnesota and Mississippi rivers confluence (see Figure 3-7 and Appendix II). A total of 138 mussels representing eight species were collected and CPUE was 184.0 mussels/hr at this site (see Appendix II). The community at this site was dominated by *A. plicata* (57.1%) and *O. reflexa* (20.0%). Also, included in the assemblage were four *Q. nodulata* (2.3%), the only site in this reach where this species was collected.

Only six live mussels were found in the approximate two mile stretch of river at the lower end of the reach where three NPS islands are located (NPS 111-01, 111-02, 111-03) (see Figure 3-7). Aquatic habitat was highly degraded in this area and substrate consisted primarily of silt and muck that appeared continually disturbed by barge prop blasts and mooring activities. Several barges were pushed up onto banks, and two sunken barges were observed.

Interestingly, this Middle Pool 2 reach once harbored at least 26 species. In addition to the 12 live species, we collected old shells of 14 additional species (see Table 3-2). The loss of species and lack of live mussels throughout the majority of the reach is probably a result of poor water quality and unstable degraded habitat. This reach is impacted directly by the Minnesota River, which has a long history of contributing considerable agricultural pollution (pesticides and herbicides) and erosional silt runoff (Bright et al. 1990) to the Mississippi River at the head of this reach. Although water quality in the Mississippi River has dramatically improved, it hasn't for the Minnesota River. Furthermore, most of this reach is within the city limits of St. Paul and loss of habitat via riverfront development, dredging, and industrial activities (i.e., barge loading facilities) have reduced and altered the aquatic habitat. The channel is rather constricted here, flow is often extreme and scouring in nature, and substrate in areas where scouring does not occur consists of silt, muck, and trash.

Looking downstream towards St. Paul from the base of Pike Island at the confluence of the Minnesota and Mississippi rivers.

Downtown St. Paul.

3.1.6 Lower Pool 2

The mussel community improves dramatically in the Lower Pool 2 reach compared to the reach immediately upstream. This reach is relatively long, extending 15 miles (24.1km) from the I-494 Bridge in South St. Paul downstream to Lock and Dam 2, and covers an extremely large surface area at the lower half of the reach (Figure 3-8). Forty sites were required to adequately sample this large area. A total of 3,208 mussels were collected representing 20 species and average CPUE was moderately high (87.1 mussels/hr) (see Table 3-2). The community was dominated by *O. reflexa* (38.2%) and *Q. quadrula* (20.8%). Three other species were also relatively abundant including; *T. truncata* (10.1%), *F. flava* (9.9%), and *A. plicata* (9.1%) (see Table 3-2). Several species were uncommon including five listed for protection in Minnesota; two endangered (*A. confra*gosus [0.8%] and *Q. nodulata* [2.4%]), two threatened (*P. sintoxia* [<0.1%] and *Quadrula metanevra* [<0.1%]), and one species of special concern (*L. recta* [<0.1%]) (see Table 3-2). *Arcidens confragosus* was mainly present at the lower end of the reach, whereas *Q. nodulata* was distributed throughout Lower Pool 2.

The mussel community in Lower Pool 2 was the youngest of all Mississippi River reaches. Overall, 83% of the individuals in the community were <11 years old (see Figure 3-5) and all but one of the species were represented with individuals <11 years old. All but one individual of *A. confragosus* were <11 years old and 85% were <6 years old. All *Q. nodulata* collected were <11 years old and 60% were <6 years old.

Four areas within Lower Pool 2, slightly less than half of the 40 sites sampled, supported healthy mussel populations. Three of these areas were in the lower half of Lower Pool 2, one of which was also quantitatively sampled. In the upper portion of Lower Pool 2, Sites 79 and 81 supported dense and species rich mussel communities (see Figure 3-8). Site 79 was at the lower end of an unnamed island at Newport, MN; 214 mussels of 13 live species were collected and CPUE was 183.4 mussels/hr. Site 81 was approximately 1.5 miles (2.4km) downstream of Site 79, immediately above an unnamed island and below River Heights Marina. A total of 155 mussels of 11 species were collected at this site and CPUE was 132.9 mussels/hr (see Appendix II). *Quadrula nodulata* was collected at both sites.

The three high quality areas in the lower end of the reach were located as follows: 1) between the lower end of Lower Grey Cloud Island and Spring Lake (Sites 96-100), also quantitatively sampled, 2) along the old channel that is parallel to the left descending bank immediately above Lock and Dam 2 (Sites 105-106, 109, 111, 114), and 3) along the old channel paralleling the right descending bank immediately above Lock and Dam 2 (Sites 110, 112, 113, 115) (see Figure 3-8). Over 700 mussels of 18 species were collected from area one (Sites 96-100) and CPUE ranged from 54.0 to 507.0 mussels/hr (see Appendix II). Included in the assemblage were all five state listed species found in Lower Pool 2 (see Appendix II). The area along the left descending bank above Lock and Dam 2 harbored 12 species and CPUE ranged

from

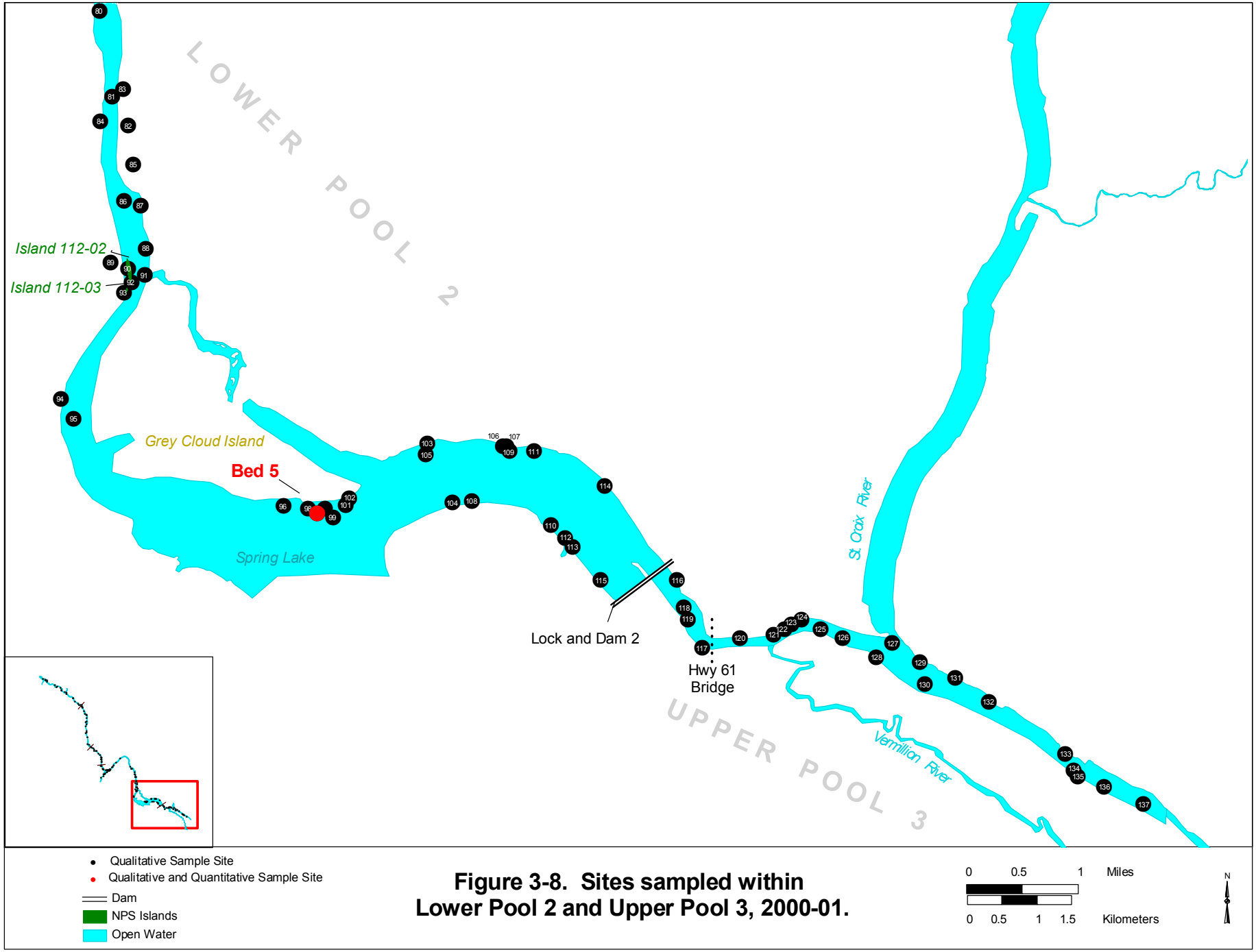


Figure 3-8. Sites sampled within Lower Pool 2 and Upper Pool 3, 2000-01.

116.7 to 159.6 mussels/hr (see Figure 3-8 and Appendix II*). Arcidens confragosus* and *Q. nodulata* were both collected from these sites. The area along the right descending bank above Lock and Dam 2 harbored 14 species and CPUE ranged from 62.7 to 188.0 mussel/hr (see Figure 3-8 and Appendix II) and both *A. confragosus* and *Q. nodulata* were present.

Two NPS Islands (112-02 and 112-03) are present within Lower Pool 2 (see Figure 3-8). The mussel community found at the three sites (90, 92, 93) sampled adjacent to these islands was fairly species rich but moderately populated. A total of 10 species were found including *Q. nodulata* and CPUE was <41 mussels/hr for all sites (see Appendix II).

Habitat within Lower Pool 2 was highly variable. In the upper portion, where the channel was more constricted, flow was moderate to fast and several islands and many wing dams were present. Substrate for the most part was silt and sand and mussels tended to occur along side channels or at the lower ends of islands where substrate was stable, being somewhat protected from erosive flows. These areas undoubtedly provide good fish habitat as well. Mussels also occurred in-between wing dams where flow was minimal and substrate stable. Habitat within the lower portion of the reach was typical of an impounded river. The navigation channel, guided by wing dams, winds through water-covered stump and debris fields. Substrate consisted primarily of silt and sand, and occasionally areas of the old riverbed were present which included cobble and boulder. Flow was minimal but wind and wave action resulting from the large surface area generally kept shallow areas silt free allowing mussels to survive. Flow however was moderate through the area adjacent to Lower Grey Cloud Island (Sites 96-100), and substrate consisted of clay and sand with some gravel and cobble. Most islands appeared to be dredge spoils and, as opposed to upstream, habitat around these islands was generally not favorable to mussels. Substrate was typically loose sand that apparently was slowly sloughing off from the human made islands that were nearly void of vegetation at the waters edge.

Lower portion of Lower Pool 2 (RM 819).

Q. nodulata , A. confragosus (center)

Side channel below Willie's Hidden Harbor, St. Paul Park, MN (RM 829).

Q. metanevra

3.1.7 Upper Pool 3

Upper Pool 3 was the most species rich reach in the study, and overall mussel abundance was second only to Upper Pool 2 (see Table 3-2). A total of 2,486 mussels of 23 species were collected and average CPUE was 128.3 mussel/hr. The community was dominated by *O. reflexa* (47.2%), *A. plicata* (25.0%), and *F. flava* (10.1%). The remaining species were uncommon or rare but include nine species listed for protection in Minnesota: 1) endangered - *Q. nodulata* (0.3%), *A. confragosus* (0.2%), 2) threatened - *Actinonaias ligamentina* (0.2%), *Ellipsaria lineoloata* (<0.1%), *Megalonaias nervosa* (0.1%), *Obovaria olivaria* (0.2%), *P. sintoxia* (0.2%), and 3) special concern - *Elliptio dilatata* (0.6%), *L. recta* (0.1%). Also noteworthy were the high number of additional species collected as empty shells. Most of the additional dead species collected were sub-fossil or long dead specimens indicating that historically at least 37 species were present within this reach (see Table 3-2). In this collection, two federally endangered species, *L. higginsi* and *Q. fragosa* and one species not previously recorded from the Upper Mississippi River above Lake Pepin, *Epioblasma triquetra*, were found as empty shells.

As with the other reaches within the MNRRA Corridor, the mussel community in Upper Pool 3 was relatively young. A total of 68% of the individuals were <11 years old (see Figure 3-4) and 87% and 74% of the species had individuals that were <11 and <6 years old, respectively. Comparatively, the mussel community of the lower St. Croix River, which empties into Upper Pool 3, shows a more typical age class structure of a healthy mussel community expected in a rather unaltered river (see Figure 3-5) in that many age classes are represented with older individuals dominating. Older individuals dominate the community, probably not because recruitment of young is low but because of increased survival due to the sustained quality of the system and the long-lived nature of mussels.

Although most of the 22 sites sampled had moderate species richness and density, six sites stand out as supporting very healthy mussel populations (Sites 121, 122, 129, 131, 135, 137). Sites 121 and 122 were very close together and between two wing dams downstream of the HWY 61 Bridge and immediately upstream the inlet to Conley Lake in Hastings, MN (see Figure 3-8). At these two sites, a total of 829 mussels of 18 species were collected and CPUE was >260 mussel/hour (see Appendix II). Included in the collections were *A. confragosus* (endangered), *E. lineolata* (threatened), *M. nervosa* (threatened), *O. olivaria* (threatened), and *L. recta* (special concern). At Site 121, along the bank there was evidence of a midden pile containing many sub-fossil or long dead specimens, probably discarded by humans, muskrats, or river otters. Among the species were *E. triquetra* (threatened), *Q. fragosa* (federally endangered), *Tritogonia verrucosa* (threatened), and *Plethobasus cyphyus* (endangered) (see Appendix II). Also of interest, many long dead shells were scattered along the exposed sand bar upstream at Site 118 near Hubs Bail Marina in Hastings, MN. Among the collection were empty shells of 17 species including *Cumberlandia monodonta* (threatened), *L. higginsi* (federally endangered), *Lampsilis teres* (endangered), and *Lasmigona costata* (special concern) among others (see Appendix II). These shells

were probably deposited by high flows depositing during the 2001 flood, as the sand bar was not present in 2000.

The remaining sites were downstream the confluence with the St. Croix River and no doubt at least historically were favorably influenced by the superior water quality of the St. Croix River emptying into the Mississippi River. Sites 129 and 131 are along the left descending bank (Wisconsin bank) and are to some degree probably still influenced by the high quality effluent of the St. Croix River. Site 129 was located off a point immediately downstream of the Prescott, WI public boat launch and private marinas (see Figure 3-8). A total of 12 live species were collected including *A. ligamentina* (threatened), *M. nervosa* (threatened), *P. coccineum* (threatened), *E. dilatata* (special concern), and *L. recta* (special concern) (see Appendix II). Site 131 was located between two wing dams where about 400 live mussels of 14 species were collected and CPUE was 313.6 mussels/hr (see Appendix II). Sites 135 and 137 were along the right descending bank near the downstream border of the MNRRA Corridor (see Figure 3-8). Site 135 was at the inlet to Truedale Slough and downstream of a wing dam and Site 137 was situated along a side channel of an unnamed island and between two wing dams. Over 250 mussels were collected representing 11 species and CPUE was >120 mussels/hr for both sites combined (see Appendix II).

Habitat for the most part in Upper Pool 3 consisted of a run with moderate flow and substrate consisted primarily of silt and sand. However, substrate immediately below the St. Croix River at Site 129 consisted of a consolidated mixture of sand, gravel, cobble, and boulder. Mussels tended to be found where flow was often minimized, usually along the slopes just off the banks and/or in-between wing dams in sand.

Sixteen of the 17 species collected from Site 122 (*A. plicata* missing) (RM 813).

Mississippi (left) and St. Croix (right) river confluence, near Prescott, WI (RM 811.5).

3.1.8 Minnesota River

Mussels were not abundant in the lower Minnesota River and the fauna was species poor compared to its historic complement of species and to the Mississippi River. Only 58 live mussels of nine species were collected at the 14 sites sampled and average CPUE was 6.4 mussels/hr (Table 3-3). *Leptodea fragilis* (36.2%) and *Potamilus ohiensis* (34.5%), species typical of soft substrates, were most abundant. An additional 13 species were collected as long dead specimens. Historically 30+ species occurred in this reach (Bright et. al. 1991) and the community very closely resembled that of the Mississippi River below St. Anthony Falls.

Most of the individuals collected were relatively young in this reach. Overall, 88% of the individuals were <11 years old (see Figure 3-4), one species was represented only by individuals >10 years old.

No sites in the Minnesota River supported a healthy mussel community. Eight of the 14 sites sampled contained <2 live mussels, only two sites contained >10 live mussels, and no site had >6 live species present (see Appendix II).

Habitat throughout this reach consisted of a run with variable flow. Substrate consisted of a layer of muck and silt mostly over sand but occasionally over gravel, cobble, and boulder. In many areas, the banks were sloughing into the river and many trees or dead falls existed along the river bottom. The river was extremely murky, brown in color, and full of algae.

Minnesota River (MN RM 3).

Dead falls along with a tremendous silt load and no doubt various agricultural pollutants entering the Mississippi River from the Minnesota River.

Table 3-3. Mussel species richness and relative abundance for the lower Minnesota and Rum rivers within MNRRA, 2000-01.

	Minnesota River		Rum River	
	No.	%	No.	%
*Actinonaias ligamentina**	D			
Amblema plicata	1	1.7		
*Arcidens confragosus**	D			
*Fusconaia ebena**	D			
Fusconaia flava	D			
Lampsilis cardium	1	1.7	4	16.0
Lampsilis siliquoidea	D		14	56.0
Lasmigona complanata	1	1.7		
*Lasmigona compressa**			1	4.0
Leptodea fragilis	21	36.2		
*Ligumia recta**	D		1	4.0
Obliquaria reflexa	D			
*Obovaria olivaria**	D			
*Pleurobema sintoxia**	D			
Potamilus alatus	7	12.1		
Potamilus ohiensis	20	34.5		
Pyganodon grandis	3	5.2	5	20.0
*Quadrula metanevra**	D			
*Quadrula nodulata**	D			
Quadrula pustulosa	D			
Quadrula quadrula	2	3.4		
Strophitus undulatus	D			
Truncilla truncata	2	3.4		
Total	58		25	
No. live species	9		5	
No. dead species	13		0	
Total species	22		5	
No. sites	14		1	
Ave time/site (min) ± stdev.	39.1 ± 19.4		60.0	
CPUE (no. live/hour) ± stdev.	6.4 ± 11.7		25.0	

*Listed species; D=Collected only as empty shell.

3.1.9 Rum River

Only one site was sampled on the RR reach from immediately below the spill over dam in Anoka, MN to its confluence with the Mississippi River at the CR Pool, a distance of a few hundred meters. A total of 25 live mussels were collected representing five species (see Table 3-3). The community at this site resembles the mussel community in the CR Pool (see Table 3-2 and 3-3), into which it empties, but with one exception. A single creek-heelsplitter (*Lasmigona compressa*), a species of special concern in Minnesota, was collected. This is the only record of this species in the MNRRA Corridor. This species typically inhabits headwaters of large rivers as well as smaller rivers and streams.

Habitat in the RR reach consisted primarily of a shallow run (<2m deep) with of a thick layer (0.5-1m) of loose shifting sand where mussels were absent. Mussels were only present near the river banks along a narrow seam of a consolidated mixture of sand, gravel, and cobble which appeared to be the original river bottom. The increased sediment load in this reach is probably due to increased upstream bank erosion from spring flooding that occurred in 2001. In addition, this spring flood event may have eroded sediment accumulations above the dam transporting them downstream into the sampling area.

L. compressa (photo courtesy Kevin S. Cummings INHS).

3.2 Quantitative Sampling

Beds 1, 2, 3, 4, and 5 correspond to qualitative Sites 20, 29, 58, 66, and 97, respectively. Beds 1 and 2 were located in the upper portion of the SAF Pool (see Figure 3-6), Beds 3 and 4 were located in Upper Pool 2 (see Figure 3-7), and Bed 5 was located in the lower portion of Lower Pool 2 (see Figure 3-8). Overall mussel density ranged from 0.8/m^2 at Bed 2 to 15.5/m^2 at Bed 3 (Table 3-4). Mussel density at Bed 3 was significantly greater than all other beds, density at Bed 2 was significantly less than all beds, and Beds 4 and 5 densities were significantly greater than Bed 1 ($df=4$, $F=21.5$, $P<0.001$). Beds 4 and 5 densities did not differ from each other ($P=0.99$), nor did Bed 1 differ from Bed 2 ($P=0.95$). Both. Below are results from each bed.

3.2.1 Bed 1 (Site 20)

This bed was located at the head of the SAF Pool about 300m below the Coon Rapids Dam along the right descending bank at the head of an unnamed island. Water depth was <1m in depth and habitat was a riffle/run with a sand and gravel substrate. Average mussel density was low (2.2/m^2) and a total of seven species were collected (see Table 3-4). Average age of mussels was 8.3 years (range 3-18) and 27.3% of the individuals were <6 years old (Table 3-5). Although density was rather low, this bed should be considered for future quantitative monitoring to provide trend data on a "marginal" mussel community. This community may provide an earlier warning to changes in water quality or habitat than higher density communities would.

3.2.2 Bed 2 (Site 29)

This bed was also located in the SAF Pool, along the side channel of Durnam Island. This area did not support a dense mussel community. Mussel density was 0.8/m^2 and only five live mussels of five different species were collected (see Table 3-4). Habitat within the area was a riffle/run and substrate was sand, gravel, and cobble. Because of the extremely low density and lack of species, this area should not be considered for future quantitative monitoring due to the considerable effort (i.e. high number of quantitative samples needed to detect change) required to obtain a statistically sound sample size.

3.2.3 Bed 3 (Site 58)

Mussel Bed 3 was located in Upper Pool 2 along NPS Island 108-01 (see Figure 3-7). State listed and the federally endangered *L. higginsi* were relocated to this bed from UMR Pools 11 and 14. Mussel density (15.5/m^2) and species richness (13) were highest here among the beds. *Obliquaria reflexa, A. plicata,* and *T. truncata* dominated the collection. Several species were rare including *Q. nodulata* and two species that had been relocated, *A. confragosus* and *Q. metanevra*. Individuals of relocated mussels were marked with a slash across the shell for future identification. The collection of only three relocated individuals of two species suggests that overall a relatively small number of mussels were relocated to the area and any impacts of increased density on the native community is probably not

Table 3-4. Mussel species density within Beds 1-5 from quantitative samples within the MNRRA Corridor, 2001.

	Mussel Bed																			
	1 (SAF Pool)				2 (SAF Pool)				3 (Upper Pool 2)				4 (Upper Pool 2)				5 (Lower pool 2)			
Species	No.	%	No./m²	2SE	No.	%	No./m²	2SE	No.	%	No./m²	2SE	No.	%	No./m²	2SE	No.	%	No./m²	2SE
Amblema plicata									38	24.5	3.8	0.4	55	50.9	5.2	0.4	1	1.4	0.1	0.1
Arcidens confragosus[1]									2	1.3	0.2	0.1								
Fusconaia flava									9	5.8	0.9	0.2	8	7.4	0.8	0.1	7	9.9	1.0	0.2
Lampsilis cardium	3	13.6	0.3	0.1	1	20.0	0.2	0.1	D				1	0.9	0.1	0.0				
Lampsilis siliquoidea	D				D															
Lasmigona costata	D																			
Leptodea fragilis	2	9.1	0.2	0.1					1	0.6	0.1	0.1	D				1	1.4	0.1	0.1
Ligumia recta	2	9.1	0.2	0.1	1	20.0	0.2	0.1	4	2.6	0.4	0.1								
Megalonaias nervosa[1]													1	0.9	0.1	0.0				
Obliquaria reflexa	4	18.2	0.4	0.1	1	20.0	0.2	0.1	44	28.4	4.4	0.4	17	15.7	1.6	0.2	26	36.6	3.6	0.5
Potamilus alatus	5	22.7	0.5	0.1					D				D							
Potamilus ohiensis													1	0.9	0.1	0.0	2	2.8	0.3	0.1
Pyganodon grandis									1	0.6	0.1	0.1					1	1.4	0.1	0.1
Quadrula metanevra[1]									1	0.6	0.1	0.1								
Quadrula nodulata									1	0.6	0.1	0.1	3	2.8	0.3	0.1	5	7.0	0.7	0.2
Quadrula pustulosa									4	2.6	0.4	0.1	6	5.6	0.6	0.1				
Quadrula quadrula	4	18.2	0.4	0.1	1	20.0	0.2	0.1	13	8.4	1.3	0.2	7	6.5	0.7	0.1	15	21.1	2.1	0.3
Strophitus undulatus	D								4	2.6	0.4	0.1	D				1	1.4	0.1	0.1
Truncilla donaciformis													D				D			
Truncilla truncata	2	9.1	0.2	0.1	1	20.0	0.2	0.1	33	21.3	3.3	0.3	9	8.3	0.9	0.1	12	16.9	1.7	0.2
Total	22		2.2	0.2	5		0.8	0.2	155		15.5	1.0	108		10.3	0.6	71		9.8	0.8
(n)	40				25				40				42				29			
No. live species	7				5				13				10				10			
Total species	10				6				15				14				11			
Zebra mussel density			0.0	0.0			0.0	0.0			0.0	0.0			0.0	0.0			0.1	0.1

2SE=2*Standard Error.

[1]Individuals were relocated from Mississippi River Pool 11.

Table 3-5. Mussel species age within Beds 1-5 from quantitative samples within the MNRRA Corridor, 2001.

	Mussel Bed																			
	1 (SAF Pool)				2 (SAF Pool)				3 (Upper Pool 2)				4 (Upper Pool 2)				5 (Lower Pool 2)			
Species	(n)	Ave.	Min.	Max.	(n)	Ave.	Min.	Max.	(n)	Ave.	Min.	Max.	(n)	Ave.	Min.	Max.	(n)	Ave.	Min.	Max.
Amblema plicata									38	12.6	1	25	55	15.0	4	32	1	14.0	14	14
Fusconaia flava									9	10.2	5	19	8	9.3	3	20	7	7.6	2	18
Lampsilis cardium	3	5.0	3	7	1	11.0	11	11					1	4.0	4	4				
Lampsilis siliquoidea																				
Lasmigona costata																				
Leptodea fragilis	2	6.0	5	7					1	11.0	11	11					1	7.0	7	7
Ligumia recta	2	5.0	5	5	1	9.0	9	9	4	8.0	6	11								
Megalonaias nervosa													1	28.0	28	28				
Obliquaria reflexa	4	6.3	3	9	1	10.0	10	10	44	9.9	5	17	17	8.8	3	16	26	8.2	3	15
Potamilus alatus	5	11.6	7	18																
Potamilus ohiensis													1	2.0	2	2	1	2.0	2	2
Pyganodon grandis									1	7.0	7	7								
Quadrula nodulata									1	8.0	8	8	3	10.3	8	13	5	3.6	2	5
Quadrula pustulosa									4	10.5	5	16	6	12.5	3	17				
Quadrula quadrula	4	11.3	10	13	1	13.0	13	13	13	9.2	6	12	7	11.7	5	16	15	7.9	3	15
Strophitus undulatus									4	12.3	8	18					1	9.0	9	9
Truncilla donaciformis																				
Truncilla truncata	2	8.5	6	11	1	7.0	7	7	33	7.8	2	18	9	7.7	5	13	12	4.4	2	9
Total	22	8.3	3	18	5	10.0	7	13	152	10.1	1	25	108	12.4	2	32	69	7.1	2	18
% <4 years old		9.1				20.0				3.2				3.7				19.7		
% <6 years old		27.3				40.0				8.4				13.0				40.8		

measurable or non-existent. A total of 563 mussels of eight species were relocated to this bed in an area covering several hundred square meters. No relocated *L. higginsi* were collected in quantitative samples and no dead relocated mussels were collected.

Average age of the mussel community was 10.1 years (range 1 to 25), and 8.4% and 3.2% of the individuals were <6 and <4 years old, respectively (see Table 3-5).

Habitat in Bed 3 was a run with moderate to high flows and substrate consisted of a consolidated mixture of sand, gravel, cobble, and boulder. The bed lies immediately off the riverbank, along a slope to the river bottom and out into the navigation channel approximately 1/3 of the way across the river. Because this area harbors a relatively dense, species rich mussel community that supports rare native as well as relocated species, this area should be monitored in the future.

3.2.4 Bed 4 (Site 66)

Mussel Bed 4 was also in Upper Pool 2. This bed was at the lower end of Pike Island near the confluence with the Minnesota River and served as a state listed species only relocation site. Mussel density was 10.3/m^2 and a total of 10 species were collected (see Table 3-4). Mussel species composition and density were slightly different than at Bed 3. *Amblema plicata* accounted for >50% of the mussels collected. Particularly noteworthy at Bed 4 was the collection of a relocated *M. nervosa*. No dead relocated mussels were collected. *Quadrula nodulata* density was 0.3/m^2 (see Table 3-4).

Among all species, average age of mussels at Bed 4 was 12.4 years (range 2 to 32) and was slightly greater than at Bed 3. A total of 13.0% and 3.7% of the individuals were <6 and <4 years old, respectively (see Table 3-5). *Qudrula nodulata* age ranged from 8 to 13 years old.

The slight differences between Beds 3 and 4 mussel communities were probably related to habitat. Bed 4 was in an eddy where flow was minimal and substrate consists of sand and silt. As with Bed 3, this area harbors a relatively dense and species rich mussel community including rare native as well as relocated species. We therefore recommend it to be monitored in the future.

3.2.5 Bed 5 (Site 97)

Mussel Bed 5 was located in Lower Pool 2 between Lower Grey Cloud Island and Spring Lake and in the vicinity of qualitative Site 97 (see Figure 3-8). This bed's boundary was approximated and it was difficult to delineate because of its very large size. To account for the large size, three clusters of quantitative samples were collected at arbitrary locations within the bed.

Mussel density was 9.8/m^2 at Bed 5 consisting of 10 species (see Table 3-4). *Obliquaria reflexa*

dominated the collection and other abundant species included *Q. quadrula* and *T. truncata*. *Quadrula nodulata* density was 0.7/m^2, which was highest among the beds (see Table 3-4).
The mussel community at Bed 5 was the youngest among the beds (see Table 3-5). Overall average was 7.1 years (range 2 to 18) and 40.8% and 19.7% of the individuals were <6 and <4 years old, respectively. All *Q. nodulata* were <6 years old.

The mussel community within Bed 5 should be monitored in the future and a more thorough delineation of the bed boundaries should be done in order to better sample the community during future monitoring.

3.3 Zebra Mussels

Zebra mussels (*D. polymorpha*) were absent above Lock and Dam 1 (Pool 1, CR and SAF Pool, and the Rum River) and sparse from UMR Pools 2-3 and the lower MNR. It should be noted, however, that zebra mussels are likely present in Pool 1 and the lower SAF Pool and we simply did not observe any, as they have been observed within the lock chambers at St. Anthony Falls (U.S. Army Corps of Engineers, pers. comm.). During quantitative sampling, zebra mussels were only collected from Bed 5 in Lower Pool 2 where density was 0.1/m^2 (see Table 3-4). Throughout the MNRRA Corridor below Lock and Dam 1, where zebra mussels were observed in this study, a total of 89 (1%) live native mussels collected had at least one zebra mussel attached. The number of individual zebra mussels attached to native mussels was minimal (mean 1.1, range 1 to 4). Zebra mussel infestation was greatest in Upper Pool 3 (2.6% native mussels infested) followed by lower MNR (1.7%), Lower Pool 2 (0.9%), Upper Pool 2 (<0.1%), and Middle Pool 2 (0%).

At this point it appears that zebra mussels are not reproducing since the zebra mussels observed were large (>15mm) isolated adult individuals. It may be that these individuals arrived on barges and other watercraft that transported them upriver into the MNRRA Corridor. Very few zebra mussels were observed attached to the substrate and no discernable difference in zebra mussel infestation was observed between 2000 and 2001.

3.4 Relocated mussels

A total of 2,435 mussels of eight species were relocated by the USACE, FWS, and the natural resources departments of Minnesota, Wisconsin, Illinois, and Iowa from Mississippi River Pool 11 near Cassville, WI (2000) and Pool 14 near Cordova, IL (2001) to four areas within the MNRRA Corridor (Table 3-6) (Davis 2002). All species were listed for protection in Minnesota including the federally endangered *L. higginsi*. Mussels were placed at three sites within Upper Pool 2 (54, 58, 66) and one site in Upper Pool 3 (122) (see Table 3-6). State listed species were relocated to all four sites and *L. higginsi* were only relocated to Sites 58 and 122.

Table 3-6. Number of mussels relocated from Mississippi River Pools 11 and 14 and their destination within MNRRA, 2000 and 2001.

	Upper Pool 2				Upper Pool 3	
Species	Site 54 No.	Site 58 (Bed 3) No.	Site 58 (Bed 3) No.	Site 66 (Bed 4) No.	Site 122 No.	Total No.
Arcidens confragosus		30		25	37	92
Ellipsaria lineolata	100	50		2	424	576
Elliptio dilatata		8				8
Lampsilis higginsi		99	271		101	471
Ligumia recta	60	20		59	400	539
Megalonaias nervosa	72	35		73	466	646
Pleurobema sintoxia		31			32	63
Quadrula metanevra		19			21	40
Total	232	292	271	159	1,481	2,435
No. species	3	8	1	4	7	8
Year relocated[1]	2000	2000	2001	2000, 2001	2000	

[1]All mussels relocated in 2000 were from Pool 11 and all relocated in 2001 were from Pool 14.

Relocated *L. higginsi*.

4.0 Discussion

This study provides important baseline data on the status of mussels within the MNRRA Corridor and should provide a benchmark for future reference. More specifically, the study provides information on the following:

- Current and historic species distributions throughout the corridor
- Mussel species richness and abundance (relative and CPUE) for individual sites, reaches, pools, and rivers throughout the corridor
- Age class structure of individual mussel species and mussel communities
- Identification of sites harboring healthy and poor mussel communities
- Description of the mussel communities associated with NPS Islands
- Specific site and bed locations.
- General aquatic habitat conditions throughout the corridor and their relation to the mussel fauna
- Mussel density, relative abundance, and age structure within five mussel beds
- Zebra mussel densities and estimates of colonization rates on native mussels

The mussel fauna of the UMR within the study area has improved dramatically since the 1970s. The mussel community was more species rich and mussels were more abundant in the Mississippi River below the Coon Rapids Dam (SAF Pool to Upper Pool 3) as compared to the CR Pool and the lower Minnesota River and Rum River. Upper Pool 3 supported the most species and greatest density of mussels followed by Pool 2 (all three sub-reaches combined) and the SAF Pool (see Table 3-2). However, within Pool 2, Upper Pool 2 (above the Minnesota River) mussel density was greater than Upper Pool 3 and species richness was nearly as high suggesting it is an exceptional habitat for mussels.

In addition, zebra mussels are extremely scarce, which is not the case below UMR Pool 4 where they are negatively impacting native mussel populations (Kelner and Davis 2002, MNDNR unpubl. data). Although zebra mussels have been present in the MNRRA Corridor for a decade, they apparently have not increased in abundance. Recently, zebra mussels have been reproducing in the Lake St. Croix portion of the St. Croix River (Kelner and Davis 2002), which could eventually impact Pool 3 by supplying larval zebra mussels.

For the most part the mussel fauna within the MNRRA Corridor was relatively young, indicating recent reproduction and recruitment of young individuals has occurred throughout the corridor. Older individuals are uncommon suggesting recolonization of formerly degraded habitat. Most species populations were dominated by individuals <11 years old (see Figure 3-1). It's our experience that age class distribution of a well-established species population is usually skewed toward older individuals

due to the lengthy survivorship of mussels (MNDNR unpubl. data). We found the age class distribution to be skewed towards younger individuals for nearly every species in this study, which supports Fuller's (1980) assertion that mussels were once nearly eliminated from the MNRRA Corridor. The relatively young mussel fauna may be a temporary condition. Given sufficient time coupled with sustained water quality, older individuals should become more dominant due to the long-lived nature of mussels. The mussel fauna of the St. Croix River has probably not changed much from historic conditions and older individuals dominate the community (see Figure 3-5), probably not because recruitment of young is low but because it has been consistent and survival rates of older individuals is high (MNDNR unpubl. data). Over time, age class structure within the MNRRA Corridor should look similar to that of the St. Croix River.

Four species within MNRRA were dominated by individuals >10 years old and were scarce, *A. ligamentina, E. dilatata, A. marginata,* and *M. nervosa*. It appears at this point, only *A. marginata* has potential to become extirpated from MNRRA. Three old (>15 years) individuals of this species were collected from Upper Pool 2 and may be a pre-impoundment remnant. This reach was the only area within MNRRA where Fuller (1980) found an assemblage of mussels and where this species might have been able to survive in low numbers. However, present habitat conditions are not ideal for this species in the UMR and it may be headed towards extirpation from MNRRA. This species is typical of smaller rivers and often associated with riffles (pers. obs.), which once extended from St. Anthony Falls to near the confluence with the Minnesota River (present day Pool 1 and Upper Pool 2), but since have been eliminated by impoundment. All *A. ligamentina* and *E. dilatata* were collected from sites immediately downstream of the St. Croix River along the Wisconsin bank in what we would identify as St. Croix waters. These two species are currently present in the St. Croix River (MNDNR unplubl. data) and are probably an extension of those populations. Apparently these species have not re-established themselves in the Mississippi River upstream of the St. Croix River where they once lived (as evidenced by the presence of long dead specimens), and it remains speculative if this species will. Only two *M. nervosa* were collected in Upper Pool 3 (one additional relocated individual was collected in Bed 4 [Upper Pool 2]). As with *A. ligamentina* and *E. dilatata*, this species may not have successfully re-colonized the UMR above the St. Croix River. However, with the addition (via relocation) of >600 individuals to Upper Pool 2 and Upper Pool 3, this species hopefully will naturally propagate within MNRRA, and its status should be considered for future monitoring.

It appears from this study that the Coon Rapids Dam serves as a faunal barrier to upstream migration of mussels via their host fish, much as the Falls at St. Anthony have done historically. The Coon Rapids Dam is a spillover and hydropower dam that is virtually impassable to fish and mussels. Only six mussel species were found in the CR Pool, and the lower portion of the pool supported few mussels. The mussel community of the CR Pool very closely resembles that of the Mississippi River drainage above

this pool. Upstream of the Twin Cities the mussel fauna of the CR Pool may have been decimated in the first half of the 1900s as the lower reaches were. Municipalities upstream of the CR Dam, such as St. Cloud, MN were notorious for polluting the Mississippi River and the mussel fauna may have suffered as a result. The relatively young mussel community present today supports this hypothesis. When conditions improved, the only means by which mussels could recolonize the CR Pool was from tributaries or headwaters of the Upper Mississippi River. The mussel fauna in the CR Pool is different from lower reaches of the Mississippi River and similar to the headwater Upper Mississippi River fauna in that the community is dominated by *L. cardium* (62.4%), *L. siliqouidea* (19.4%) and *L. recta* (14.8%). This is very similar to what has been documented in the tributaries above the CR Dam and in the Mississippi River at St. Cloud (MNDNR unpubl. data).

The SAF Pool supports a mussel fauna today that is more difficult to interpret. The mussel fauna bears some similarity to its historic or upstream assemblage, but also to that of the river below the historic barrier. Some mussels undoubtedly survived past pollution and have begun to thrive, explaining the young age and high numbers of *L. cardium, L. siliqouidea*, and *L. recta*. In addition, of the 16 species found, 10 are species not previously reported above the falls. Apparently these species have arrived as larvae attached to fish that have used navigation locks to travel around the Falls of St. Anthony, and/or perhaps fish stocking activities inadvertently introduced these species into the pool. Only two species found in Pool 1, *Q. nodulata* and *Q. pustulosa*, were not found in the SAF Pool.

Middle Pool 2 and the lower Minnesota River are similar in that they both lack the healthy mussel community that they supported historically. Both have degraded habitat and apparent poor water quality. Middle Pool 2's poor water quality is no doubt a result of the Minnesota River emptying into the Upper Mississippi River at the head of this reach but its altered habitat is probably the result of a combination of factors. Silt from the Minnesota River contributes most of the silt and muck found in Middle Pool 2. However, the constricted nature of the Upper Mississippi River at this reach coupled with the industrial and urban presence creates an unstable substrate and poor habitat for mussels. The Minnesota River has a long history of pollution and siltation from agricultural run-off and stream bank erosion throughout the drainage (Bright et. al. 1990). It appears that the mussel fauna in the Minnesota River, and to a lesser degree Middle Pool 2, will not improve unless these issues in the Minnesota River Basin are addressed.

Upper Pool 2, Lower Pool 2, and Upper Pool 3 appear to support the healthiest mussel communities within MNRRA. All areas support a relatively high number of species (>17) and abundance is also high (CPUE >87 mussels/hr). All (27) but one species collected within the MNRRA Corridor were collected from these reaches and density of the three mussel beds within these areas ranged from 9.8/m^2 to 15.5/m^2. All three areas support a young population of *Q. nodulata* and Lower Pool 2 and Upper Pool 3

support a young and fairly healthy population of *A. confragosus*.

How *Q. nodulata* and *A. confragosus* arrived is somewhat puzzling, but is probably not linked to the St. Croix River, which empties into Upper Pool 3. These two species are not present in the lower St. Croix River, which would serve as ideal refugia for most of the Mississippi River mussel species due to its sustained high water quality and currently healthy mussel populations. This leads to speculation on the origin of the remaining species that are recolonizing the MNRRA Corridor.

It's very probable that a certain number of mussel species were able to survive at very low numbers in protected patches during the decades of extreme pollution within the Mississippi River above Pool 4, and are once again reproducing. Alternatively, the Upper Mississippi River mussel fauna below Lake Pepin (Pool 4), which serves as a natural catch-basin for contaminants, may be the source of recolonizing fauna. Fish carrying larvae from these mussels could be bringing them upstream into the MNRRA Corridor. In conjunction with certain species able to survive within the MNRRA Corridor, species may have migrated from tributaries such as the St. Croix River. Regardless of origin, the current mussel fauna is approaching the historic mussel fauna in species composition. Whatever the mechanism of recolonization, this reach of the Mississippi River between the Twin Cities and Hastings, MN, once nearly a dead zone, may now constitute one of the most significant big river mussel refuges in the Midwestern United States, and its status should be monitored closely in the future.

5.0 Recommendations

This inventory was the first step in managing the mussel fauna within the MNRRA Corridor. We recommend several locations for future long term monitoring of the mussel fauna. Long term monitoring is essential to establish trends in the community structure. This will provide better knowledge for conservation planning for individual species, restoration of critical habitat, recovery of listed species, and for sustaining the mussel resources for future generations. We recommend the following:

- Monitor Beds 1, 3, 4, and 5 biannually with quantitative and qualitative samples.
- Better delineate the boundaries of Bed 5
- Continue to fill in inventory gaps with timed searches, especially in SAF Pool and Lower Pool 2.
- Add quantitative monitoring sites in the following reaches so most reaches contain at least one monitoring site and include relocation sites:

    - **CR Pool**
        - Site 4 at the base of NPS Island 101-01.
    - **SAF Pool**
        - Site 25 immediately below Banfill Island
        - Site 33 downstream of the I-694 Bridge.
    - **Pool 1**
        - Site 46 located mid pool.
    - **Upper Pool 2**
        - Site 54 is a state listed relocation site.
        - Site 60 across from the head of Pike Island. Hornbach (pers. comm., Biology Department, Macalaster College, St. Paul, MN) quantitatively sampled this site in 1996 and it would serve as a good comparison.
    - **Lower Pool 2**
        - Better delineate Bed 5 and search for another site to monitor
    - **Upper Pool 3**
        - Site 122 above St. Croix River (*L. higginsi* and state listed species relocation site)
        - Site 131 located between two wing dams downstream of the confluence with the St. Croix River.
        - Monitor additional sites above and below the St. Croix River in order to assess impacts of the St. Croix's influence especially since zebra mussels are reproducing in the St. Croix River.

In addition, Table 5-1 (page 41) is a summary table showing sites organized by reach that were outlined in the results that were exceptional with respect to supporting a relatively healthy mussel community. These sites, if not mentioned above should also be considered for future monitoring depending upon funding. Consult Figures 3-4, 3-6, 3-7, and 3-8, and Appendix III for specific site location and Appendix II for a species list and abundance for each site.

Table 5-1. Sites with comparatively healthy mussel communities within MNRRA, 2000-01.

Mississippi River Pool (reach)						
CR	SAF	1	Upper 2	Middle 2	Lower 2	Upper 3
Site	Site	Site	Site	Site	Site	Site
4	(Bed 1) 20	46	54	68	79	121
12	21	50	57		81	122
	22	52	(Bed 3) 58		96	129
	25		59		(Bed 5) 97	131
	27		60		98	135
	(Bed 2) 29		62		99	137
	30		65		100	
	32		(Bed 4) 66		105	
	33				106	
					109	
					111	
					114	
					110	
					112	
					113	
					115	

6.0 Literature Cited

Bright, R., C. Gatenby, D. Olson and E. Plummer. 1990. A survey of mussels of the Minnesota River, 1989. Bell Museum of Natural History, University of Minnesota, St. Paul, MN., pp 1-36.

Dawley, C. (1947). Distribution of aquatic mollusks in Minnesota. *American Midland Naturalist* 38: 671-697.

Davis, M. 2002. Section 6 Grant Project Final Report, 2001: Emergency conservation relocation and reintroduction of Higgins' eye pearly mussel (Lampsilis higginsi) and other mussel species from zebra mussel affected area in the Upper Mississippi River. 17pp.

Fuller, S.L.H. 1980. Final report: Freshwater mussels (Mollusca: Bivalvia: Unionidae) of the Upper Mississippi River: obervations at selected sites within the 9-foot navigation channel project for the St. Paul District, United State Army Corps of Engineers, 1977-1979. Volume 1: Text. Academy of Natural Sciences of Philadelphia, Division of Limnology and Ecology, Philadelphia, PA. 175pp.

Graf, D. L. 1997. Distribution of unionoid (Bivalvia) faunas in Minnesota, USA. *Nautilus* 110: 45-54.

Havlik, M. E. and J. S. Sauer. 2000. Native freshwater mussels of the Upper Mississippi River System. Project Status Report 2000-04, Upper Midwest Environmental Sciences Center, U.S. Geological Service, La Crosse, Wisconsin. 2pp.

Kelner, D.E. and M. Davis. 2002. Final Report: Mussel (Bivalvia: Unionidae) surveys 2001: Lower St. Croix River from Stillwater, Minnesota (RM 23.7) to Prescott, Wisconsin (RM 1.7), Mississippi River Lock and Dam 3 tailwaters mussel bed mapping, Higgins' eye gravid female mussel collection. Prepared for U.S. Army Corps of Engineers, St. Paul District, St. Paul Minnesota. 45pp.

Miller, A. C. and B. S. Payne 1988. The need for quantitative sampling to characterize size demography and density of freshwater mussel communities. *American Malacological Bulletin* 6: 49-54.

Neves, R. J. and S. N. Moyer. 1988. Evaluation of techniques for age determination of freshwater mussels (Unionidae). *American Malacological Bulletin* 6: 179-188.

7.0 Appendices

Appendix I (pages 45-51)

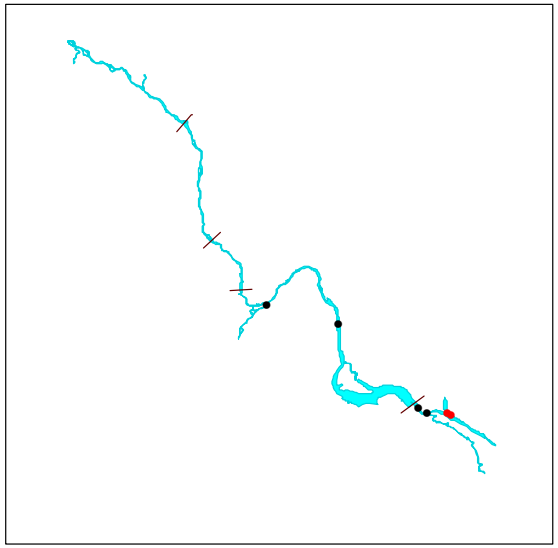
Individual mussel species distribution within the MNRRA Corridor, 2000-01.

Appendix II (pages 52-61)

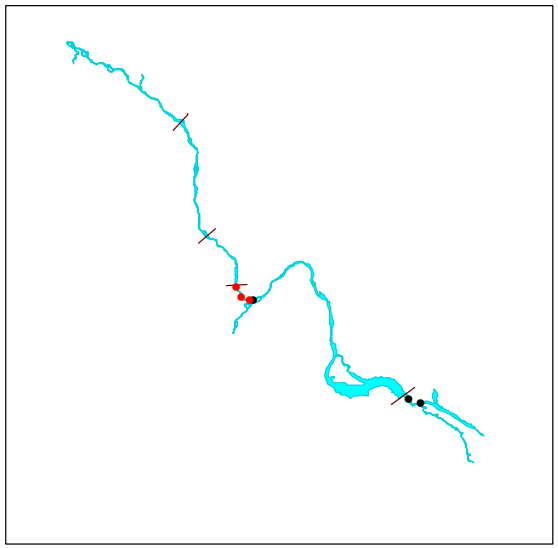
Number live mussels and species collected at sites sampled within the MNRRA Corridor,2000-01.

Appendix III (pages 62-63)

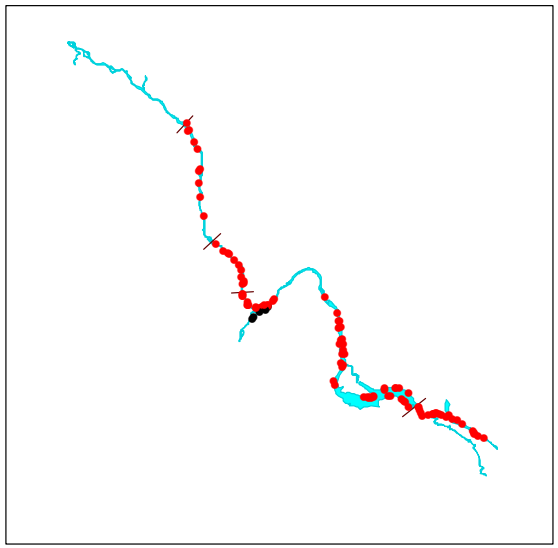
UTM coordinates (NAD 1983) for each site sampled.



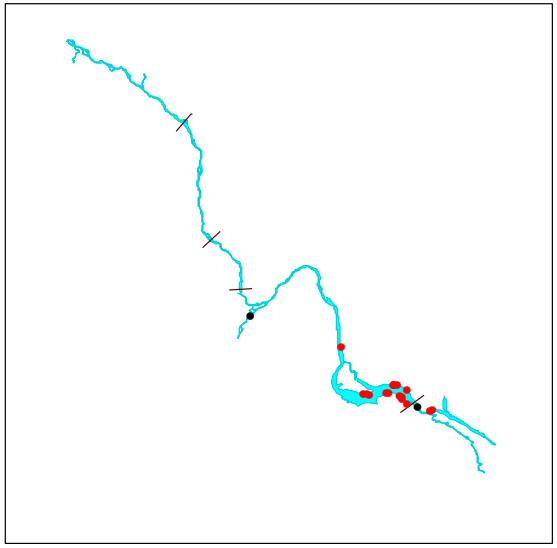
Actinonaias ligamentina Mucket



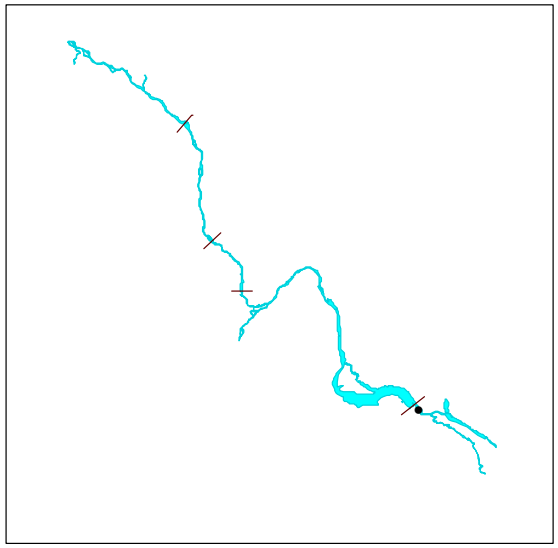
Alasmidonta marginata Elktoe



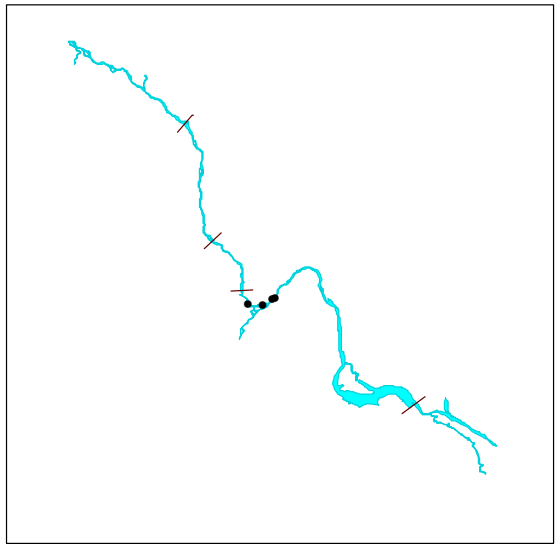
Amblema plicata Threeridge



Arcidens confragosus Rock-pocketbook



Cumberlandia monodonta Spectaclecase



Cyclonaias tuberculata Purple wartyback

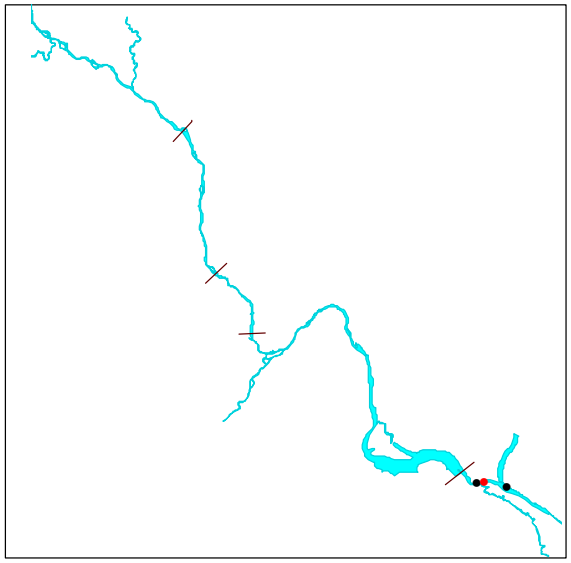
- Only Dead Shells Found
- Live Mussels Found
- Locks and Dams

Appendix I. Individual mussel species distribution within the MNRRA Corridor, 2000-01.

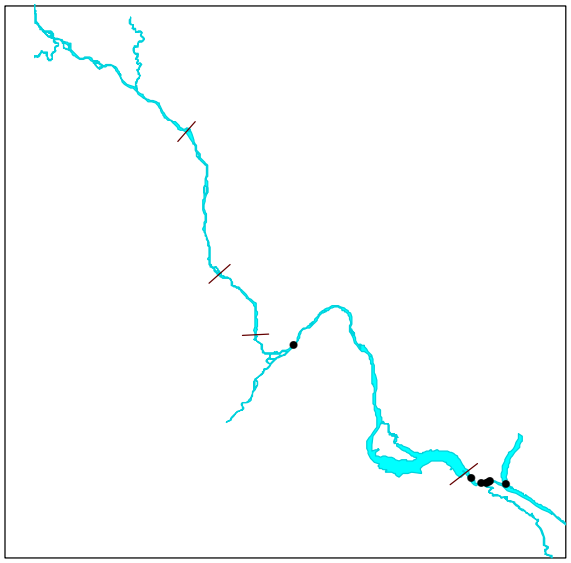
0 5 10 Miles

0 5 10 15 Kilometers

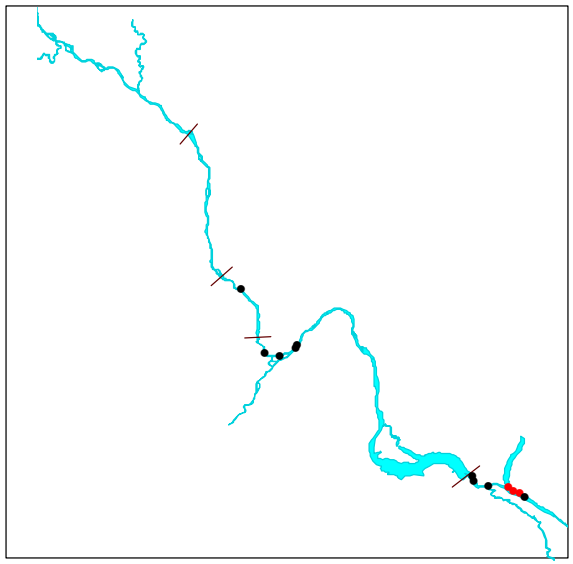
N



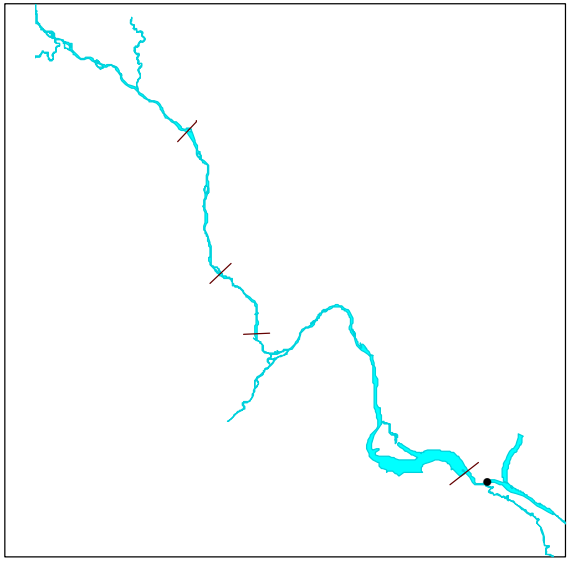
Ellipsaria lineolata Butterfly



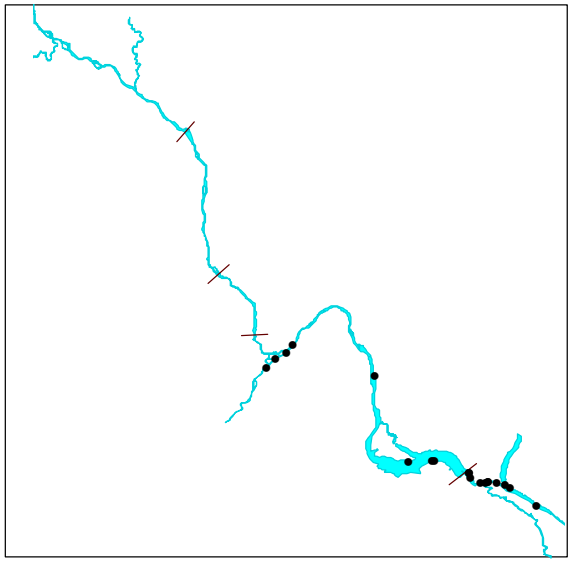
Elliptio crassidens Elephant-ear



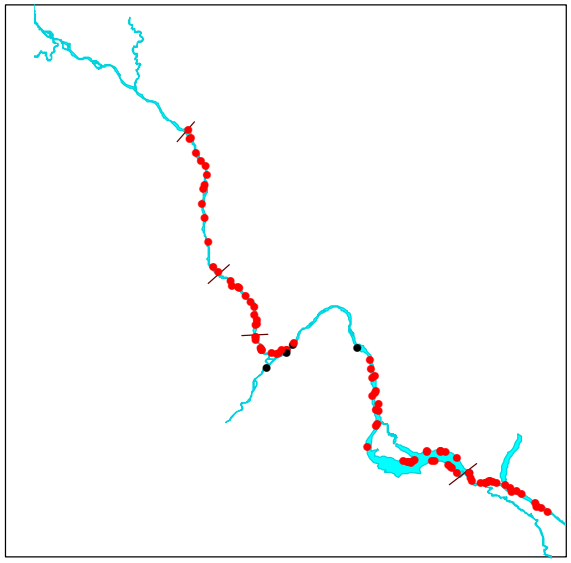
Elliptio dilatata Spike



Epioblasma triquetra Snuffbox



Fusconaia ebena Ebonyshell



Fusconaia flava Wabash pigtoe

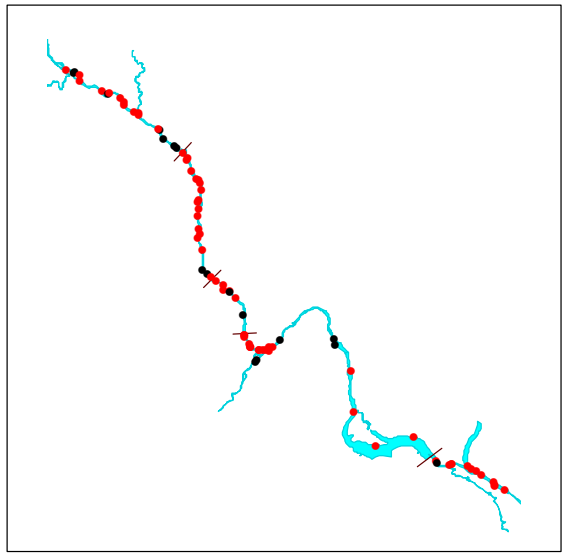
- Only Dead Shells Found
- Live Mussels Found
- Locks and Dams

Appendix I. Individual mussel species distribution within the MNRRA Corridor, 2000-01 (cont.).

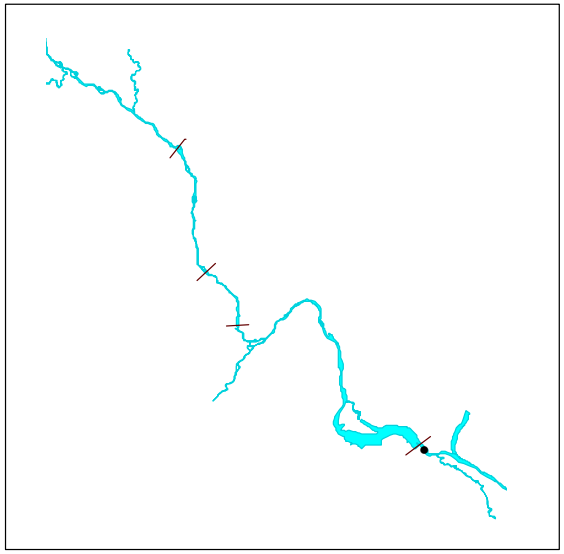
0 5 10 Miles

0 5 10 15 Kilometers

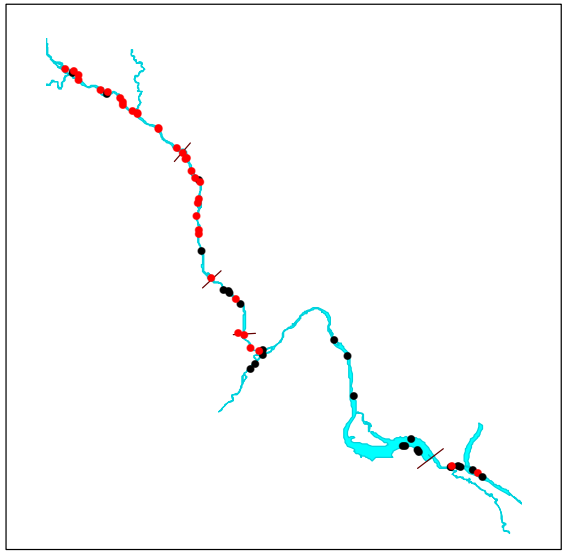
N



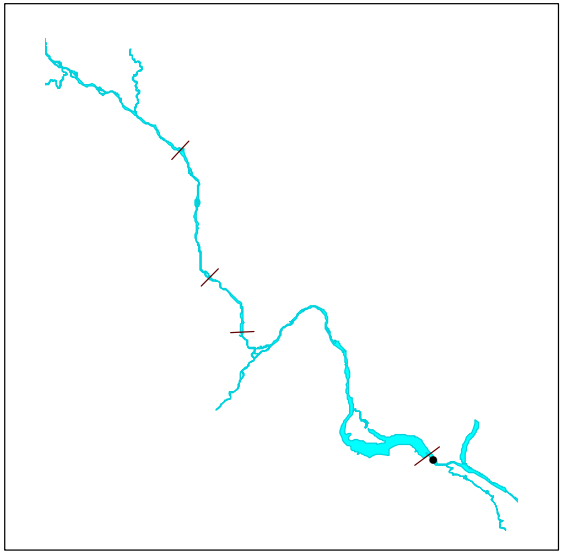
Lampsilis cardium Plain pocketbook



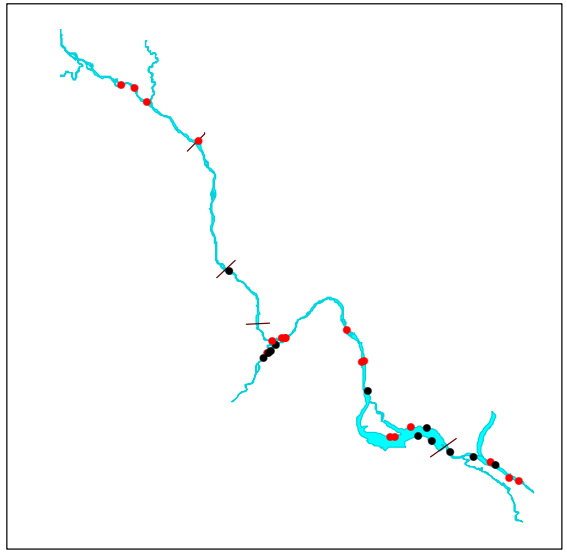
Lampsilis higginsi Higgins eye



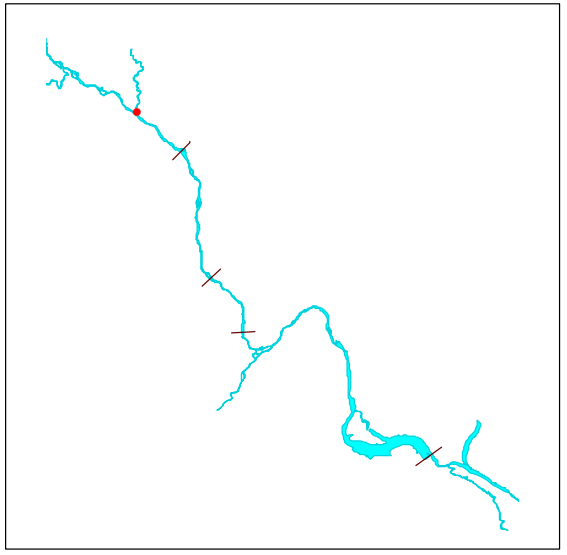
Lampsilis siliquoidea Fat mucket



Lampsilis teres Yellow sandshell



Lasmigona complanata White heelsplitter



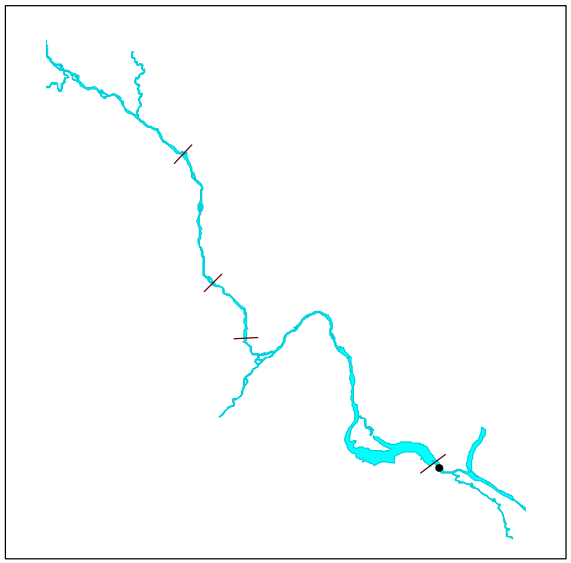
Lasmigona compressa Creek heelsplitter

- Only Dead Shells Found
- Live Mussels Found
- Locks and Dams

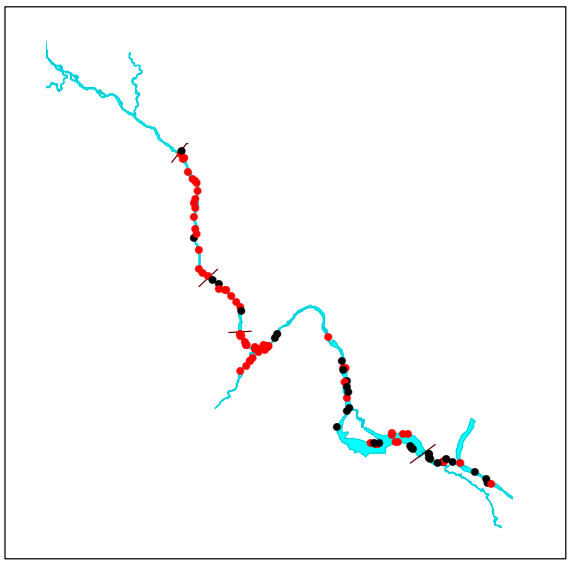
Appendix I. Individual mussel species distribution within the MNRRA Corridor, 2000-01 (cont.).

0 5 10 Miles
0 5 10 15 Kilometers

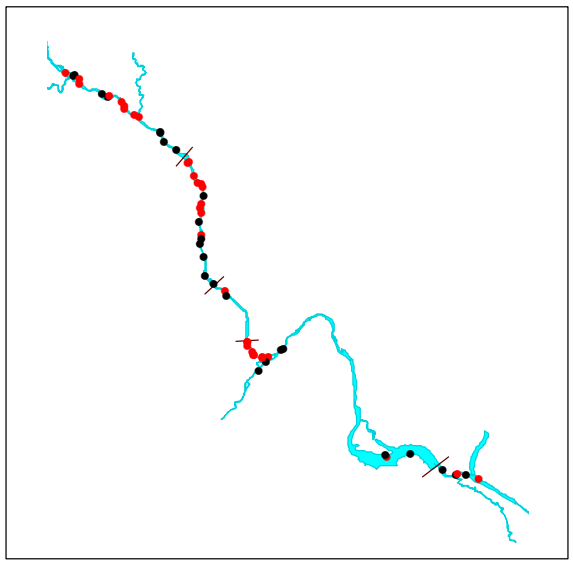
N



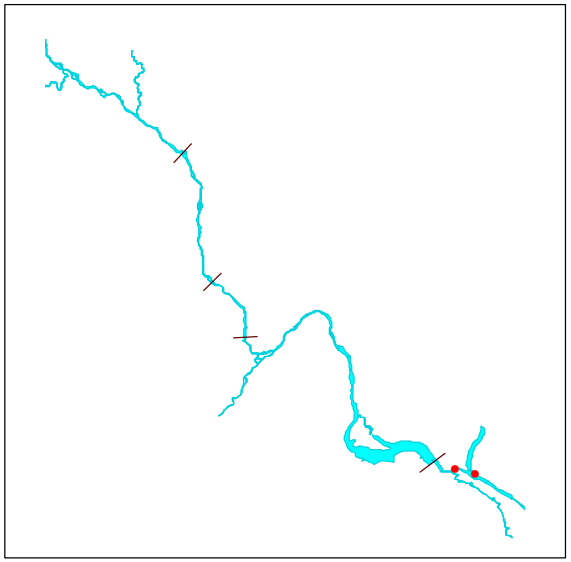
Lasmigona costata Fluted-shell



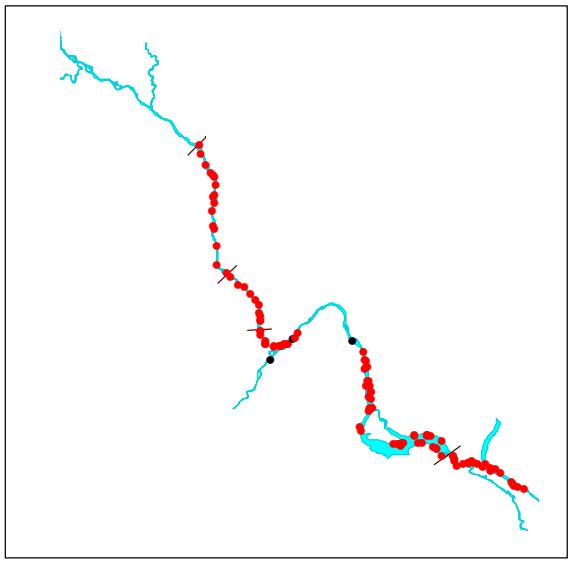
Leptodea fragilis Fragile papershell



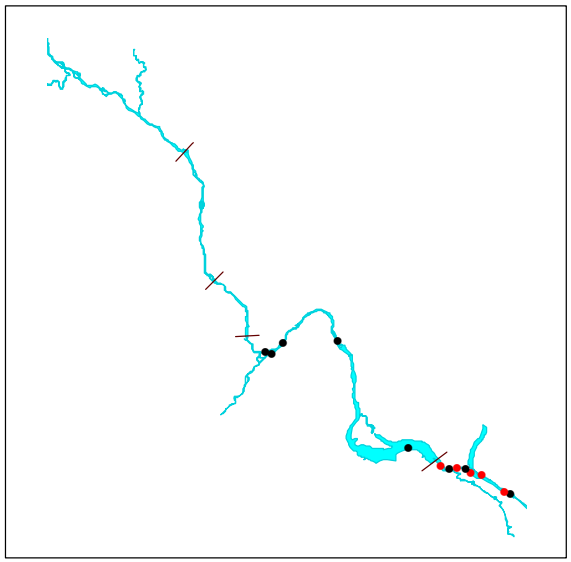
Ligumia recta Black sandshell



Megalonaias nervosa Washboard



Obliquaria reflexa Threehorn wartyback



Obovaria olivaria Hickorynut

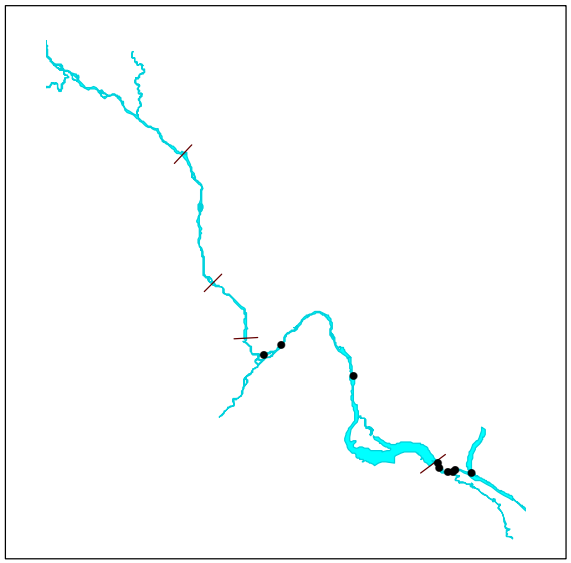
- Only Dead Shells Found
- Live Mussels Found
- Locks and Dams

Appendix I. Individual mussel species distribution within the MNRRA Corridor, 2000-01 (cont.).

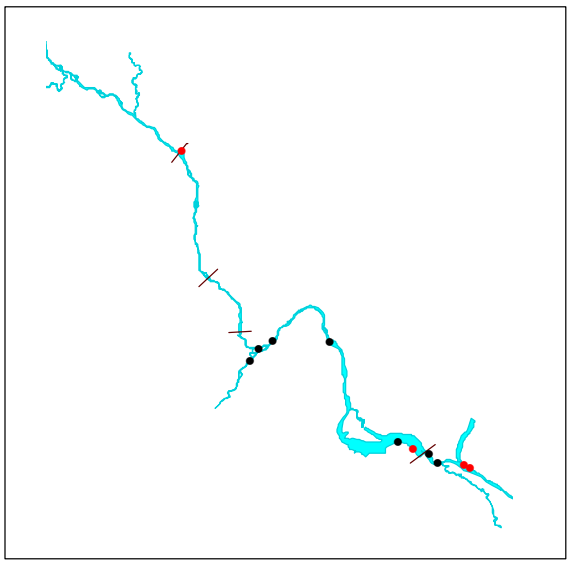
0 5 10 Miles

0 5 10 15 Kilometers

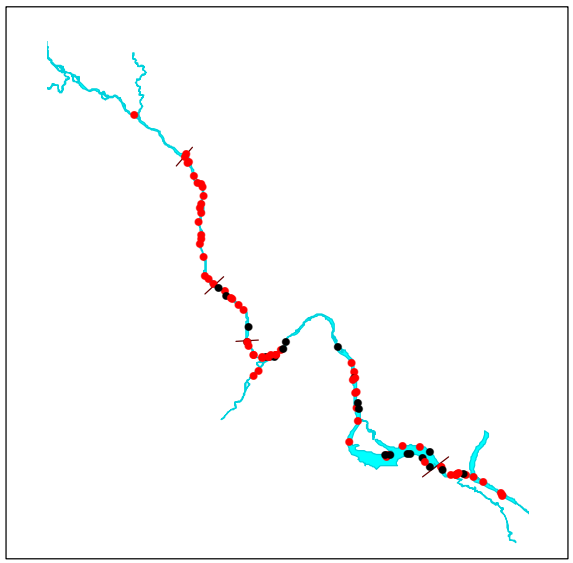
N



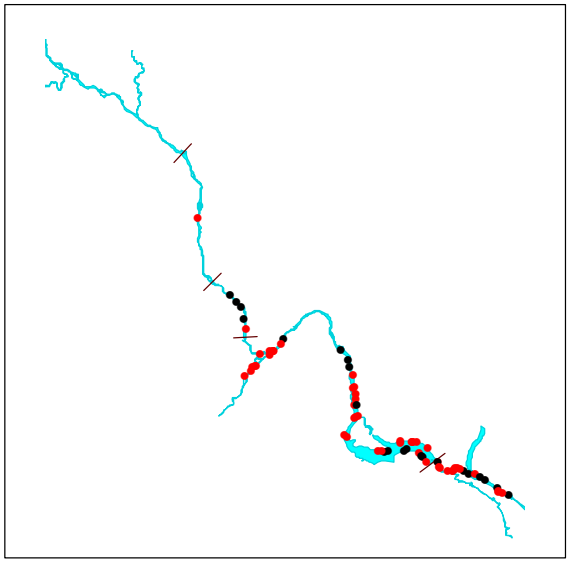
Plethoblasus cyphyus Sheednose



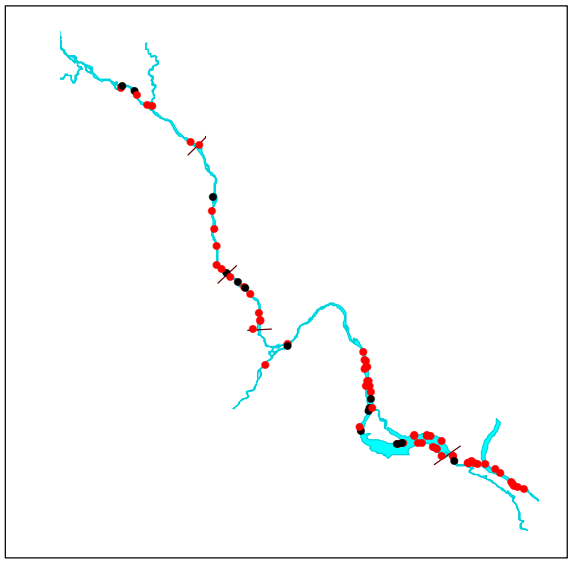
Pleurobema sintoxia Round pigtoe



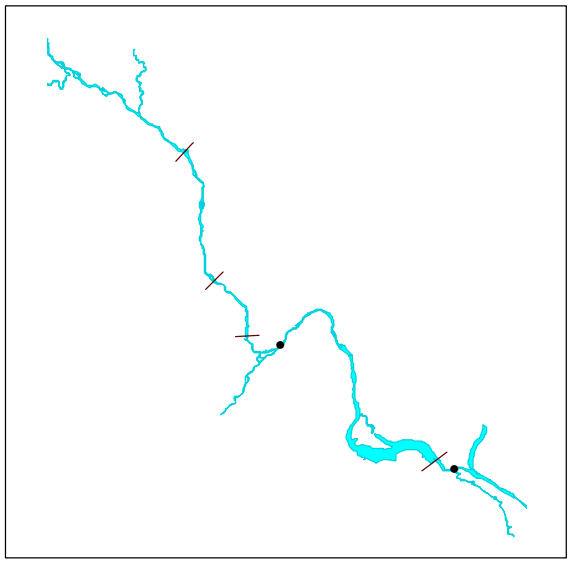
Potamilus alatus Pink heelsplitter



Potamilus ohiensus Pink papershell



Pyganodon grandis Giant floater



Quadrula fragosa Winged mapleleaf

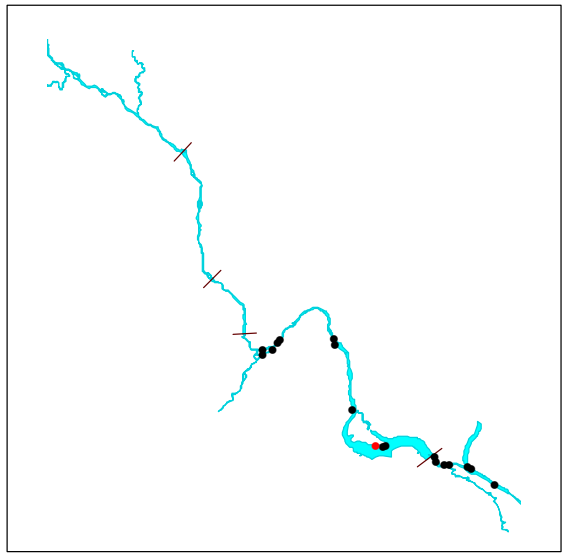
- Only Dead Shells Found
- Live Mussels Found
- Locks and Dams

Appendix I. Individual mussel species distribution within the MNRRA Corridor, 2000-01 (cont.).

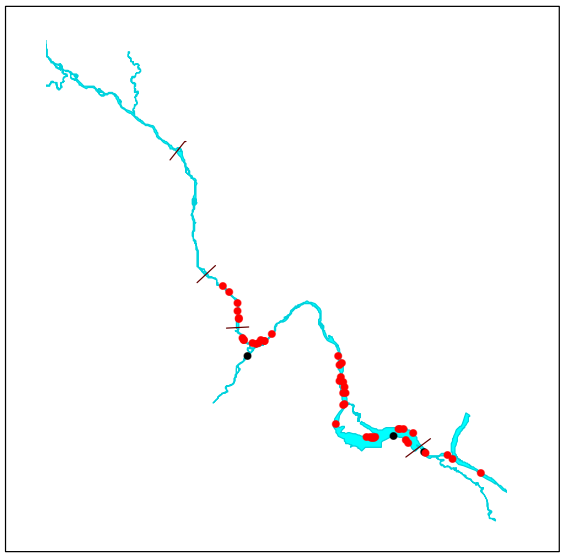
0 5 10 Miles

0 5 10 15 Kilometers

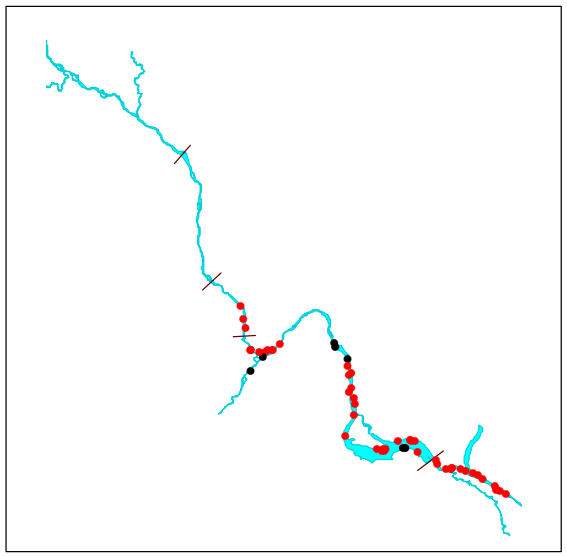
N



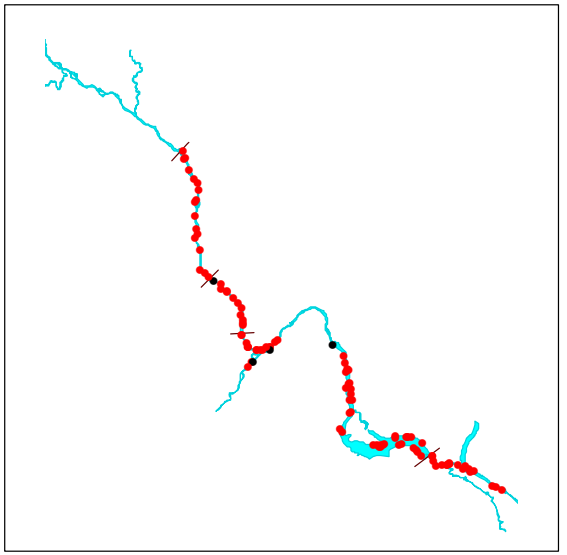
Quadrula metanevra Monkeyface



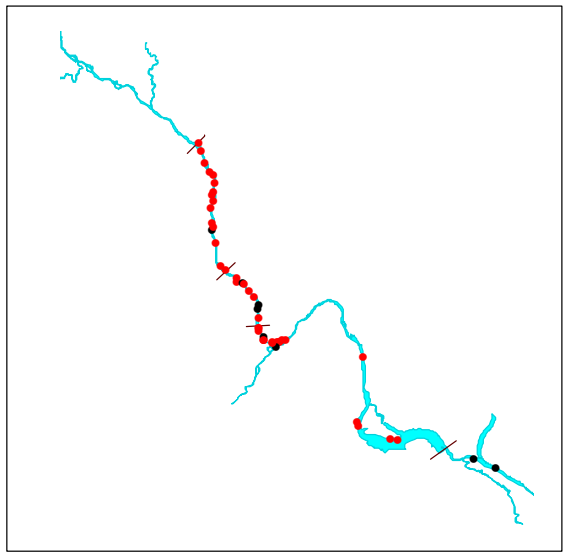
Quadrula nodulata Wartyback



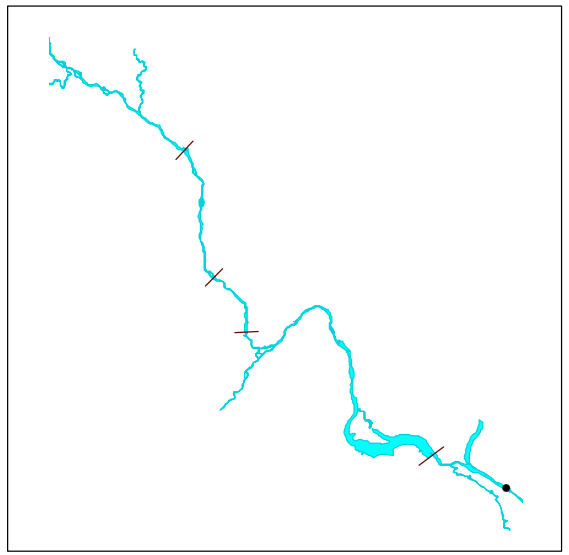
Quadrula pustolosa Pimpleback



Quadrula quadrula Mapleleaf



Strophitus undulatus Creeper



Toxolasma parvus Lilliput

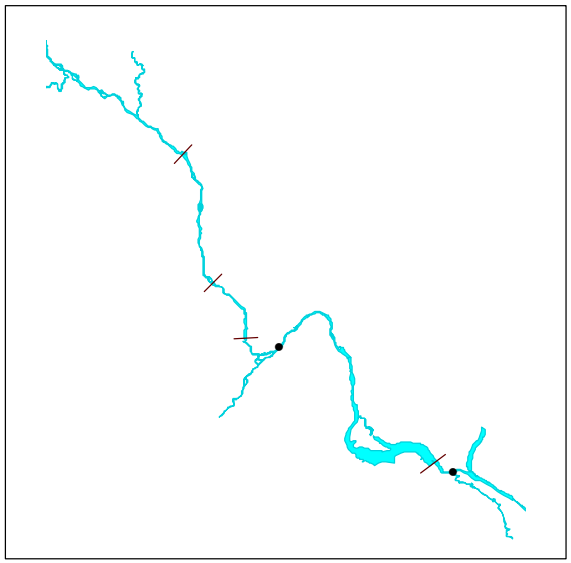
- Only Dead Shells Found
- Live Mussels Found
- Locks and Dams

Appendix I. Individual mussel species distribution within the MNRRA Corridor, 2000-01 (cont.).

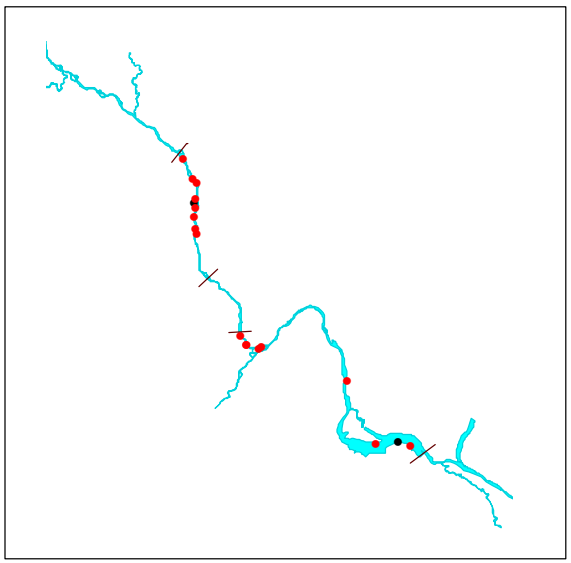
0 5 10 Miles

0 5 10 15 Kilometers

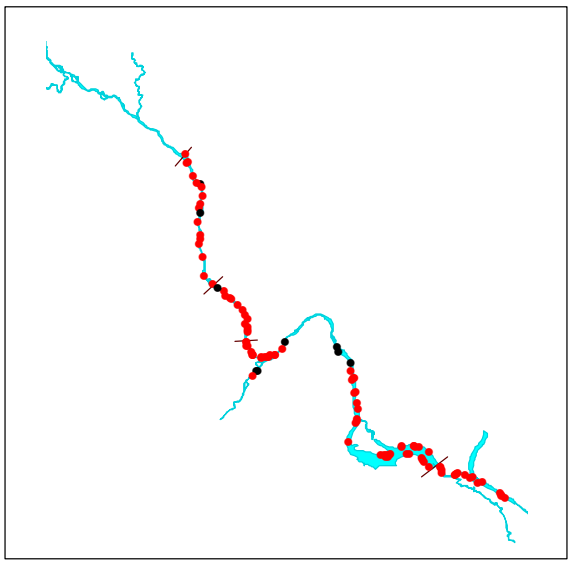
N



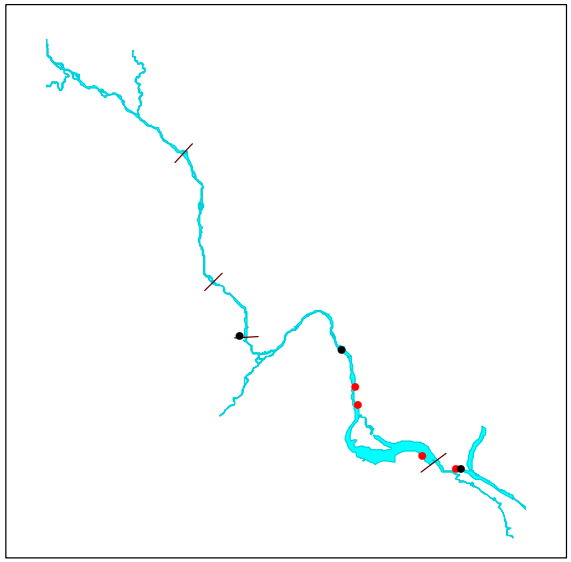
Tritogonia verrucosa Pistolgrip



Truncilla donaciformis Fawnsfoot



Truncilla truncata Deertoe



Utterbackia imbecillis Paper pondshell

- Only Dead Shells Found
- Live Mussels Found
- Locks and Dams

Appendix I. Individual mussel species distribution within the MNRRA Corridor, 2000-01 (cont.).

0 5 10 Miles

0 5 10 15 Kilometers

N

Appendix II. Number live mussels and species collected at sites sampled within the MNRRA Corridor, 2000-01.

	Coon Rapids Pool														
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Actinonaias ligamentina															
Alasmidonta marginata															
Amblema plicata															
Arcidens confragosus															
Cumberlandia monodonta															
Cyclonaias tuberculata															
Ellipsaria lineolata															
Elliptio crassidens															
Elliptio dilatata															
Epioblasma triquetra															
Fusconaia ebena															
Fusconaia flava															
Lampsilis cardium	5	D	D	202	4	4	D	8	22	6	23	89	1	2	D
Lampsilis higginsi															
Lampsilis siliquoidea	6	2	D	8	3	3	D	10	10	4	14	48	3	2	1
Lampsilis teres															
Lasmigona complanata							1		1			2			
Lasmigona compressa															
Lasmigona costata															
Leptodea fragilis															
Ligumia recta	1	D	D	19	1	D	D	7	12	7	8	32		D	D
Megalonaias nervosa															
Obliquaria reflexa															
Obovaria olivaria															
Plethobasus cyphyus															
Pleurobema sintoxia															
Potamilus alatus												1			
Potamilus ohiensis															
Pyganodon grandis							1	D	D	1		3			
Quadrula fragosa															
Quadrula metanevra															
Quadrula nodulata															
Quadrula pustulosa															
Quadrula quadrula															
Strophitus undulatus															
Toxolasma parvus															
Tritogonia verrucosa															
Truncilla donaciformis															
Truncilla truncata															
Utterbackia imbecillis															
No. live	12	2	0	229	8	7	2	25	45	18	45	175	4	4	1
No. live species	3	1	0	3	3	2	2	3	4	4	3	6	2	2	1
Total species	3	3	3	3	3	3	5	4	5	4	3	6	2	3	3
CPUE (no. live/hr.)	14.4	1.5	0.0	152.7	4.8	10.5	2.0	16.7	24.5	10.8	22.5	105.0	2.0	8.0	2.0

Appendix II *(cont)*. Number live mussels and species collected at sites sampled within the MNRRA Corridor, 2000-01.

	Coon Rapids Pool				St. Anthony Falls Pool										
Species	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Actinonaias ligamentina															
Alasmidonta marginata															
Amblema plicata						2	6	1	2	1				14	4
Arcidens confragosus															
Cumberlandia monodonta															
Cyclonaias tuberculata															
Ellipsaria lineolata															
Elliptio crassidens															
Elliptio dilatata															
Epioblasma triquetra															
Fusconaia ebena															
Fusconaia flava						46	5	2	2	2		9	6	6	15
Lampsilis cardium	D	D	D		7		26	4	6	19	16	13	1	88	58
Lampsilis higginsi															
Lampsilis siliquoidea			3		3		5	3	1	8	D	5		22	11
Lampsilis teres															
Lasmigona complanata						1									
Lasmigona compressa															
Lasmigona costata															
Leptodea fragilis					4	D	9	11	1	30	6	27	6	20	9
Ligumia recta	D	D					5	4	1	5	4	7	D	34	25
Megalonaias nervosa															
Obliquaria reflexa						2	21		21	11	1	11	5	18	19
Obovaria olivaria															
Plethobasus cyphyus															
Pleurobema sintoxia						1									
Potamilus alatus					3	1	83	9	8	13	12	22	3	42	16
Potamilus ohiensis															
Pyganodon grandis			7			35									D
Quadrula fragosa															
Quadrula metanevra															
Quadrula nodulata															
Quadrula pustulosa															
Quadrula quadrula						113	16	2	7	11		11	7	16	29
Strophitus undulatus						1		5	2	26		15	5	14	1
Toxolasma parvus															
Tritogonia verrucosa															
Truncilla donaciformis							14			3		5		6	D
Truncilla truncata						2	3	6	18	135	D	53	24	78	39
Utterbackia imbecillis															
No. live	0	0	10	0	17	204	193	47	69	264	39	178	57	358	226
No. live species	0	0	2	0	4	10	11	10	11	12	5	11	8	12	11
Total species	2	2	3	0	4	11	11	10	11	12	7	11	9	12	13
CPUE (no. live/hr.)	0.0	0.0	3.0	0.0	8.5	204.0	82.7	23.5	51.8	211.2	52.0	92.9	42.8	119.3	96.9

Appendix II *(cont)*. Number live mussels and species collected at sites sampled within the MNRRA Corridor, 2000-01.

	St. Anthony Falls Pool									Pool 1					
Species	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Actinonaias ligamentina															
Alasmidonta marginata															
Amblema plicata		1	1			3				1			2	6	13
Arcidens confragosus															
Cumberlandia monodonta															
Cyclonaias tuberculata															
Ellipsaria lineolata															
Elliptio crassidens															
Elliptio dilatata														D	
Epioblasma triquetra															
Fusconaia ebena															
Fusconaia flava		7	12			1		1	3			1	3	4	4
Lampsilis cardium	3	6	9	4	1	1	D	D	3	1		1	2	3	D
Lampsilis higginsi															
Lampsilis siliquoidea		2	1	2		D			2				D	D	D
Lampsilis teres															
Lasmigona complanata										D					
Lasmigona compressa															
Lasmigona costata															
Leptodea fragilis	3	20	12	8	D	10	1	1	4	D		D	5	1	1
Ligumia recta	2	D	2	D	D	D	D		D			1	D		
Megalonaias nervosa															
Obliquaria reflexa	1	5	4	7		5	2		5	1			6	1	
Obovaria olivaria															
Plethobasus cyphyus															
Pleurobema sintoxia															
Potamilus alatus	4	10	4	6	1	6	1	1	1	D		1	D	1	1
Potamilus ohiensis		2													D
Pyganodon grandis		1		1		1	2	1	D	1		D		1	D
Quadrula fragosa															
Quadrula metanevra															
Quadrula nodulata														1	
Quadrula pustulosa															
Quadrula quadrula		25	21	2	1	2	4	7	28	D		7	12	20	5
Strophitus undulatus	1	20	7	3	D	4		6	5			3	4	D	2
Toxolasma parvus															
Tritogonia verrucosa															
Truncilla donaciformis	2	1	1	1											
Truncilla truncata	D	93	63	15	1	1	4		8	D		19	32	7	6
Utterbackia imbecillis															
No. live	16	193	137	49	4	34	14	17	59	4	0	33	66	45	32
No. live species	7	13	12	10	4	10	6	6	9	4	0	7	8	10	7
Total species	8	14	12	11	7	12	8	7	11	9	0	9	11	13	11
CPUE (no. live/hr.)	13.7	105.3	117.4	42.0	2.7	14.6	10.5	17.0	39.3	4.0	0.0	36.0	66.0	38.6	29.5

Appendix II *(cont)*. Number live mussels and species collected at sites sampled within the MNRRA Corridor, 2000-01.

	Pool 1								Upper Pool 2						
Species	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
Actinonaias ligamentina															
Alasmidonta marginata									1				1		
Amblema plicata	56	16	2		16	22	11	28	30	2	2	11	112	52	166
Arcidens confragosus															
Cumberlandia monodonta															
Cyclonaias tuberculata													D		
Ellipsaria lineolata															
Elliptio crassidens															
Elliptio dilatata													D		
Epioblasma triquetra															
Fusconaia ebena															
Fusconaia flava	41	8	1		45	9	20	14	11		1	3	9	8	7
Lampsilis cardium	1				D				10	3		11	17	11	8
Lampsilis higginsi															
Lampsilis siliquoidea	1	D							1				2		
Lampsilis teres															
Lasmigona complanata															
Lasmigona compressa															
Lasmigona costata															
Leptodea fragilis	1	1	1	D					15	1	2	1	12	3	1
Ligumia recta									5	1		2	11	7	6
Megalonaias nervosa															
Obliquaria reflexa	37	3	3		1	1	8	1	16		1	12	80	53	31
Obovaria olivaria															
Plethobasus cyphyus															
Pleurobema sintoxia															
Potamilus alatus	2	1				D			1		2		2	8	3
Potamilus ohiensis	D	D			D		1								1
Pyganodon grandis	3				1		2	4							
Quadrula fragosa															
Quadrula metanevra															
Quadrula nodulata	5		4		7		7	4				3	2	3	4
Quadrula pustulosa		1			1		2						9	2	10
Quadrula quadrula	45	14	8		43	1	55	27	56			17	34	16	11
Strophitus undulatus	3	2		D	D		2		17	2		D	14	5	10
Toxolasma parvus															
Tritogonia verrucosa															
Truncilla donaciformis										1			10		
Truncilla truncata	20	7	1	1	1	1	3	1	83	2	5	26	289	61	106
Utterbackia imbecillis															
No. live	215	53	20	1	115	34	111	79	246	12	13	86	604	229	364
No. live species	12	9	7	1	8	5	10	7	12	7	6	9	15	12	13
Total species	13	11	7	3	11	6	10	7	12	7	6	10	17	12	13
CPUE (no. live/hr.)	135.8	35.3	15.0	0.8	76.7	51.0	74.0	39.5	123.0	9.6	13.0	129.0	170.5	114.5	336.0

Appendix II *(cont)*. Number live mussels and species collected at sites sampled within the MNRRA Corridor, 2000-01.

	Upper Pool 2							Middle Pool 2							
Species	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
Actinonaias ligamentina															
Alasmidonta marginata	1	D													
Amblema plicata	10	24	10	1	73	182	2	88				2			8
Arcidens confragosus															
Cumberlandia monodonta															
Cyclonaias tuberculata				D			D	D							
Ellipsaria lineolata															
Elliptio crassidens							D								
Elliptio dilatata		D					D	D							
Epioblasma triquetra															
Fusconaia ebena							D								
Fusconaia flava		5	2		7	28	D	6					D		5
Lampsilis cardium	1	1	1		6	2		D				D	D		
Lampsilis higginsi															
Lampsilis siliquoidea	1	D										D			D
Lampsilis teres															
Lasmigona complanata	1				1	2						1			
Lasmigona compressa															
Lasmigona costata															
Leptodea fragilis	1	3			4	2		D	D			3			
Ligumia recta	3		2				D	D							
Megalonaias nervosa															
Obliquaria reflexa	10	10	3	1	15	117	D	29	1				D		5
Obovaria olivaria		D						D				D			
Plethobasus cyphyus		D						D							
Pleurobema sintoxia		D					D						D		
Potamilus alatus	1	D	1	1	1	3	2	D	D			D			1
Potamilus ohiensis					2	5		1	D					D	D
Pyganodon grandis						2									2
Quadrula fragosa							D								
Quadrula metanevra		D					D	D				D	D		
Quadrula nodulata		2	1		8	39		4							
Quadrula pustulosa			1		4	24		3				D	D		D
Quadrula quadrula	3	6	2		8	49	1	6					D		4
Strophitus undulatus	2	3	1	1	2	2									
Toxolasma parvus															
Tritogonia verrucosa							D								
Truncilla donaciformis		4		1											
Truncilla truncata	17	51	14	1	8	56		1	D			D	D		D
Utterbackia imbecillis														D	
No. live	51	109	38	6	139	513	5	138	1	0	0	6	0	0	25
No. live species	12	10	11	6	13	14	3	8	1	0	0	3	0	0	6
Total species	12	18	11	7	13	14	14	17	5	0	0	10	8	2	10
CPUE (no. live/hr.)	51.0	118.9	61.6	24.0	139.0	287.3	3.8	184.0	1.0	0.0	0.0	6.0	0.0	0.0	12.5

Appendix II *(cont)*. Number live mussels and species collected at sites sampled within the MNRRA Corridor, 2000-01.

	Lower Pool 2														
Species	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
Actinonaias ligamentina			D												
Alasmidonta marginata															
Amblema plicata	3	2	1	39	4	17	2	4	7	2	8	4		1	
Arcidens confragosus										1					
Cumberlandia monodonta															
Cyclonaias tuberculata															
Ellipsaria lineolata															
Elliptio crassidens															
Elliptio dilatata															
Epioblasma triquetra															
Fusconaia ebena				D											
Fusconaia flava	5			29	4	27		2	6	7	5	8			
Lampsilis cardium				1											
Lampsilis higginsi															
Lampsilis siliquoidea										D					
Lampsilis teres															
Lasmigona complanata				1	2							D			
Lasmigona compressa															
Lasmigona costata															
Leptodea fragilis	D		1	2	D	1	D	D		D	1				
Ligumia recta															
Megalonaias nervosa															
Obliquaria reflexa	15	8	8	110	13	60	6	15	1	14	35	3			1
Obovaria olivaria															
Plethobasus cyphyus				D											
Pleurobema sintoxia															
Potamilus alatus		1	D	2	2	1		1		D	1	D			
Potamilus ohiensis	D			5		1	2	2		2	1	D			
Pyganodon grandis	2	1	4	3	8	9	16	2	4	1		D			D
Quadrula fragosa															
Quadrula metanevra															D
Quadrula nodulata	3			5	2	4	2		2	3	4	1			
Quadrula pustulosa	1			3	4	8			2	2		1			
Quadrula quadrula	3		2	7	1	26	2	4	8	11	1	1			
Strophitus undulatus		1													
Toxolasma parvus															
Tritogonia verrucosa															
Truncilla donaciformis								1							
Truncilla truncata	1		1	7	3	1		1		1		1			1
Utterbackia imbecillis								1				1			
No. live	33	13	17	214	43	155	30	33	30	44	56	20	0	1	2
No. live species	8	5	6	13	10	11	6	10	7	10	8	8	0	1	2
Total species	10	5	8	15	11	11	7	11	7	13	8	12	0	1	4
CPUE (no. live/hr.)	79.2	13.0	11.3	183.4	34.4	132.9	40.0	19.8	32.7	52.8	30.5	40.0	0.0	1.0	1.3

Appendix II *(cont).* Number live mussels and species collected at sites sampled within the MNRRA Corridor, 2000-01.

	Lower Pool 2														
Species	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105
Actinonaias ligamentina															
Alasmidonta marginata															
Amblema plicata		1	1	1	1	9	14	1	8	6	1	4	1	3	13
Arcidens confragosus						1	2		1					1	
Cumberlandia monodonta															
Cyclonaias tuberculata															
Ellipsaria lineolata															
Elliptio crassidens															
Elliptio dilatata															
Epioblasma triquetra															
Fusconaia ebena							D							D	
Fusconaia flava		9	1		3	8	38	4	16	17	1	3	4	1	7
Lampsilis cardium		1				1									
Lampsilis higginsi															
Lampsilis siliquoidea														D	
Lampsilis teres															
Lasmigona complanata						1	3						1		
Lasmigona compressa															
Lasmigona costata															
Leptodea fragilis	D		D	D		3	2	D	1		D		1	3	1
Ligumia recta							1	D							
Megalonaias nervosa															
Obliquaria reflexa	7	17	22	5	15	47	109	14	42	61	25	7	17	8	117
Obovaria olivaria															
Plethobasus cyphyus															
Pleurobema sintoxia															
Potamilus alatus		1			1		1	D		1	D		1	D	
Potamilus ohiensis	1	2	2	1	2	1	D	1			D		1	D	2
Pyganodon grandis	3		D	1	D		3	D			D	2	8	1	2
Quadrula fragosa															
Quadrula metanevra						1			D		D				
Quadrula nodulata		1	1		8	1	17	1	3	2	4				
Quadrula pustulosa		2			2	1	2		1	3	1			D	2
Quadrula quadrula		2	2	10	4	42	102	5	38	34	3	9	21	12	14
Strophitus undulatus				1	2	1			1						
Toxolasma parvus															
Tritogonia verrucosa															
Truncilla donaciformis							1								
Truncilla truncata		3	3		5	11	22	1	15	8	2	1	36	3	17
Utterbackia imbecillis															
Total	11	39	32	19	43	128	317	27	126	132	37	26	91	32	175
No. live species	3	10	7	6	10	14	14	7	10	8	7	6	10	8	9
Total species	4	10	9	7	11	14	16	11	11	8	12	6	10	13	9
CPUE (no. live/hr.)	66.0	31.2	40.9	25.3	34.4	144.9	271.7	54.0	504.0	264.0	74.0	260.0	107.1	54.9	116.7

Appendix II *(cont)*. Number live mussels and species collected at sites sampled within the MNRRA Corridor, 2000-01.

	Lower Pool 2											Upper Pool 3				
Species	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121
Actinonaias ligamentina													D		D	
Alasmidonta marginata													D			D
Amblema plicata	1		2	1	34	2	57	22	6	10	21	1	2	2	17	35
Arcidens confragosus	2	1	1	1	3	4	2	3	1	2			D			2
Cumberlandia monodonta													D			
Cyclonaias tuberculata																
Ellipsaria lineolata															D	
Elliptio crassidens													D		D	D
Elliptio dilatata											D		D			D
Epioblasma triquetra																D
Fusconaia ebena			D								D		D		D	D
Fusconaia flava	9	2	2	3	50	5	8	22	3	7	3		1	7	7	18
Lampsilis cardium						2							1	D		4
Lampsilis higginsi													D			
Lampsilis siliquoidea			D	D	D		D									D
Lampsilis teres													D			
Lasmigona complanata			D			D	D						D			
Lasmigona compressa																
Lasmigona costata													D			
Leptodea fragilis	5		3		D	3	D	D			D		D	D	D	D
Ligumia recta			D										D			D
Megalonaias nervosa																
Obliquaria reflexa	32	2	11	36	99	80	49	50	56	7	38	1	57	18	62	161
Obovaria olivaria			D										2		D	
Plethobasus cyphyus											D		D		D	D
Pleurobema sintoxia			D					1			D				D	
Potamilus alatus			D		D	4		1	D	D	2		D		1	8
Potamilus ohiensis	3	1	D	4	2	8	D	D	1	1	1		2	1	2	8
Pyganodon grandis	4		4	4	4	6	7	8	10	2	3			D		10
Quadrula fragosa																D
Quadrula metanevra											D		D		D	D
Quadrula nodulata	5		D	3	1	1		2	2				D	2		
Quadrula pustulosa	1	1	D	1	1	1					1		6		1	8
Quadrula quadrula	37	12	13	15	54	39	36	52	29	17	3	1	1		3	14
Strophitus undulatus																
Toxolasma parvus																
Tritogonia verrucosa																D
Truncilla donaciformis			D		1											
Truncilla truncata	34	9	9	10	22	35	13	27	21	1	3		2	1		18
Utterbackia imbecillis							1									
No. live	133	28	45	78	271	190	173	188	129	47	75	3	74	31	93	286
No. live species	11	7	8	10	11	13	8	10	9	8	9	3	9	6	7	11
Total species	11	7	19	11	14	14	12	12	10	9	15	3	26	9	16	23
CPUE (no. live/hr.)	159.6	186.7	33.8	117.0	147.8	126.7	148.3	188.0	129.0	62.7	48.0	22.5	88.8	41.3	93.0	376.0

Appendix II *(cont)*. Number live mussels and species collected at sites sampled within the MNRRA Corridor, 2000-01.

	Upper Pool 3															
Species	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137
Actinonaias ligamentina						1		5								
Alasmidonta marginata																
Amblema plicata	89	5	1	9	22	26	1	40		192	33	27	2	52	9	36
Arcidens confragosus		2														
Cumberlandia monodonta																
Cyclonaias tuberculata																
Ellipsaria lineolata	1							D								
Elliptio crassidens	D	D				D										
Elliptio dilatata						1		12		1	D					
Epioblasma triquetra																
Fusconaia ebena	D				D	D		D					D			
Fusconaia flava	46	2	1	3	14	5		6	1	86	9	14	3	15	2	9
Lampsilis cardium	5					1		7		4	1	4	1	1		2
Lampsilis higginsi																
Lampsilis siliquoidea	1			D	D			D		1	D					
Lampsilis teres																
Lasmigona complanata					D					2	D			1		1
Lasmigona compressa																
Lasmigona costata																
Leptodea fragilis	2	1	D		D	1					D	D		D	2	
Ligumia recta	1				D			1								
Megalonaias nervosa	1							1								
Obliquaria reflexa	323	29	10	59	70	49	31	10	2	55	8	44	21	83	13	29
Obovaria olivaria	1				D		1			1					1	D
Plethobasus cyphyus	D					D										
Pleurobema sintoxia								1		4						
Potamilus alatus	20	1		D	2	1				1		1	1	1		
Potamilus ohiensis	4	1	2	1	D		D	1		D	D	D	1	1	3	D
Pyganodon grandis	7	2	1	1	3	2				8	2	6	3	7	2	3
Quadrula fragosa																
Quadrula metanevra						D		D					D			
Quadrula nodulata					1		3					1				
Quadrula pustulosa	6				3		2	2		26	11	3	2	8	2	4
Quadrula quadrula	17	1			7	3	1	1	2	5				6	1	1
Strophitus undulatus					D						D					
Toxolasma parvus																D
Tritogonia verrucosa																
Truncilla donaciformis																
Truncilla truncata	18	1			4	6	1		2	6		1	1	2	3	
Utterbackia imbecillis	1			D												
No. live	543	45	15	73	126	96	40	87	7	392	64	101	35	177	38	85
No. live species	17	10	5	5	9	11	7	12	4	14	6	9	9	11	10	8
Total species	20	11	6	8	17	15	8	16	4	15	12	11	11	12	10	11
CPUE (no. live/hr.)	265.3	67.5	22.5	146.0	84.0	115.2	80.0	65.3	26.3	313.6	65.1	121.2	70.0	124.9	57.0	127.5

Appendix II *(cont)*. Number live mussels and species collected at sites sampled within the MNRRA Corridor, 2000-01.

	Minnesota River														Rum River
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	1
Actinonaias ligamentina												D			
Alasmidonta marginata															
Amblema plicata						D	D		D		D	D		1	
Arcidens confragosus						D									
Cumberlandia monodonta															
Cyclonaias tuberculata															
Ellipsaria lineolata															
Elliptio crassidens															
Elliptio dilatata															
Epioblasma triquetra															
Fusconaia ebena						D			D			D			
Fusconaia flava						D						D			
Lampsilis cardium						D	D				1				4
Lampsilis higginsi															
Lampsilis siliquoidea		D				D			D						14
Lampsilis teres															
Lasmigona complanata		D			1	D	D		D						
Lasmigona compressa															1
Lasmigona costata															
Leptodea fragilis	2	5			4	4	1		1		3	D		1	
Ligumia recta						D			D						1
Megalonaias nervosa															
Obliquaria reflexa						D									
Obovaria olivaria											D				
Plethobasus cyphyus															
Pleurobema sintoxia					D										
Potamilus alatus		3				3						D		1	
Potamilus ohiensis	1	1		1	2	7					1			7	
Pyganodon grandis		3										D			5
Quadrula fragosa															
Quadrula metanevra									D			D			
Quadrula nodulata						D									
Quadrula pustulosa		D							D						
Quadrula quadrula		1			1	D						D			
Strophitus undulatus									D						
Toxolasma parvus															
Tritogonia verrucosa															
Truncilla donaciformis															
Truncilla truncata		2			D	D									
Utterbackia imbecillis															
No. live	3	15	0	1	8	14	1	0	1	0	5	0	0	10	25
No. live species	2	6	0	1	4	3	1	0	1	0	3	0	0	4	5
Total species	2	9	0	1	6	15	4	0	9	0	5	9	0	4	5
CPUE (no. live/hr.)	6.0	30.0	0.0	6.0	6.9	35.0	1.3	0.0	1.0	0.0	10.7	0.0	0.0	20.0	25.0

Appendix III. UTM coordinates (NAD 1983) for each site sampled.

Reach	Site	East	North	Reach	Site	East	North
Coon Rapids Pool	1	459081	5010507	Pool 1	47	483619	4977657
	2	460308	5010149		48	484068	4976959
	3	460137	5009960		49	484273	4976449
	4	460977	5009685		50	484055	4975914
	5	461036	5008918		51	484304	4975357
	6	464165	5007475		52	484291	4974666
	7	464973	5007033		53	484332	4974896
	8	465220	5007145	Upper Pool 2	54	484226	4973231
	9	466824	5006425		55	484206	4972804
	10	467258	5005912		56	484289	4972808
	11	467216	5005535		57	484901	4971966
	12	468613	5004588		58	484981	4971546
	13	469274	5004060		59	485043	4971567
	14	472148	5002174		60	486246	4971202
	15	472208	5002060		61	486219	4971115
	16	472716	5000817		62	486804	4971149
	17	474385	4999838		63	487095	4971226
	18	474669	4999442		64	487222	4971284
	19	475485	4999250		65	487514	4971547
St. Anthony Falls Pool	20	475577	4998740		66	488103	4971520
	21	475844	4999150	Middle Pool 2	67	488819	4972192
	22	476018	4997943		68	489076	4972459
	23	476200	4998100		69	489467	4973187
	24	476783	4996287		70	490398	4974303
	25	477346	4995174		71	492268	4976060
	26	477776	4994992		72	496722	4972652
	27	477972	4994622		73	496939	4971931
	28	478097	4993509		74	497340	4971759
	29	477853	4992239		75	498526	4970327
	30	477668	4991812	Lower Pool 2	76	498668	4969311
	31	477847	4991018		77	498994	4969145
	32	477544	4989918		78	498884	4968318
	33	477812	4987986		79	499129	4968313
	34	477886	4987441		80	498795	4968108
	35	477669	4986890		81	499056	4966313
	36	478257	4985080		82	499409	4965704
	37	478288	4982420		83	499286	4966464
	38	478906	4981929		84	498823	4965793
	39	479566	4981388		85	499515	4964885
Pool 1	40	480185	4980808		86	499305	4964110
	41	480799	4980544		87	499657	4964012
	42	481158	4980214		88	499771	4963116
	43	481220	4979602		89	499033	4962825
	44	482004	4979451		90	499395	4962689
	45	482161	4979334		91	499749	4962561
	46	482973	4978450		92	499466	4962414

Appendix III. UTM coordinates (NAD 1983) for each site sampled.

Reach	Site	East	North
Lower Pool 2	93	499305	4962187
	94	497982	4959959
	95	498260	4959541
	96	502663	4957707
	97	503376	4957542
	98	503182	4957653
	99	503701	4957468
	100	503539	4957649
	101	503975	4957719
	102	504049	4957874
	103	505685	4959020
	104	506215	4957770
	105	505657	4958786
	106	507277	4958960
	107	507352	4958960
	108	506618	4957815
	109	507418	4958853
	110	508279	4957294
	111	507931	4958852
	112	508587	4957044
	113	508740	4956850
	114	509422	4958131
Upper Pool 3	115	509327	4956154
	116	510937	4956147
	117	511454	4954721
	118	511076	4955562
	119	511157	4955330
	120	512255	4954928
	121	512966	4954998
	122	513187	4955106
	123	513332	4955219
	124	513545	4955316
	125	513947	4955119
	126	514412	4954942
	127	515451	4954824
	128	515125	4954521
	129	516040	4954419
	130	516138	4953960
	131	516778	4954094
	132	517478	4953596
	133	519087	4952497
	134	519265	4952149
	135	519357	4952017
	136	519899	4951801
	137	520736	4951434
Minnesota River	1	484209	4967999
	2	485028	4968681
	3	487232	4970792
	4	485255	4969232
	5	485535	4969349
	6	485637	4969352
	7	485938	4969700
	8	486571	4970481
	9	486705	4970535
	10	486891	4970727
	11	487656	4970922
	12	488036	4971215
	13	488059	4971376
	14	488157	4971481
Rum River	1	469314	5004373