Status of Native and Exotic Mussels, Including the Northern Riffleshell (*Epioblasma torulosa rangiana*) and Rayed Bean (*Villosa fabalis*), at the Detroit River International Wildlife Refuge: Sites 15-36

Prepared by:
Peter J. Badra
Michigan Natural Features Inventory
P.O. Box 30444
Lansing, MI 48909-7944

For:
U.S. Fish and Wildlife Service,
Challenge Cost Share Fund

December 23, 2006
MNFI Report Number 2006-23

MICHIGAN STATE UNIVERSITY EXTENSION

Michigan Natural Features Inventory

Background photo: Site 34 in the Fermi/Swan Creek area. Photo by John Matousek. **Left inset photo:** Ready to start SCUBA transect search at Mamajuda Island Shoal. Photo by Peter Badra. **Right inset photo:** Unionid mussels found at Site 35 in the Fermi/Swan Creek area. Fragile papershell (*Leptodea fragilis*) center, mapleleaf (*Quadrula quadrula*) around edge. Photo by John Matousek.

Citation: Badra, P. J. 2006. Status of native and exotic mussels, including the northern riffleshell (*Epioblasma torulosa rangiana*) and rayed bean (*Villosa fabalis*), at the Detroit River International Wildlife Refuge: Sites 15-36. Report number MNFI 2006-23. Report to U.S. Fish and Wildlife Service, Ft. Snelling, MN. 15pp.

Table of Contents

List of Figures

List of Tables

Abstract

We performed surveys at 22 sites in the Detroit River International Wildlife Refuge (DRIWR) to determine the status of the northern riffleshell (*Epioblasma torulosa rangiana*) and other native mussel species (Unionidae). A total of 18 species were represented by live individuals and/or empty shell. No live individuals or empty shells of the northern riffleshell or rayed bean (*Villosa fabalis*) were found. Two empty shells of the state threatened wavy-rayed lampmussel (*Lampsilis fasciola*) were found at Site 28 off Grassy Island. The most abundant unionids found live were mapleleaf (*Quadrula quadrula*), threeridge (*Amblema plicata*), and lilliput (*Toxolasma parvus*). The occurrence of live lilliput mussels at the Fermi/Swan Creek area is of special note because there are relatively few known populations in Michigan. The prevalence of silt tolerant species and the high proportions of silt found at a majority of sites provides evidence that substrate composition is a factor contributing to the decline and/or exclusion of listed unionids in the DRIWR. Live zebra mussels were found attached to live unionid mussels at two sites in the Berenholz area and two sites in the Fermi/Swan Creek area. The presence of live zebra mussels attached to live uninoinds and recently dead unionid shells indicate a history impact at sites surveyed in the DRIWR. Sites 31 and 32 off Sugar Island may have the most potential to support northern riffleshell and other listed unionid species of the sites included in this study.

Introduction

The Detroit River International Wildlife Refuge (DRIWR) was created in 2001. It consists of islands, coastal wetlands, shoals, and riverfront lands including potential habitat for the federally listed as endangered northern riffleshell (*Epioblasma torulosa rangiana*). It is North America's only international wildlife refuge. The Refuge could potentially support some of the last populations of the federally endangered northern riffleshell and other rare unionids in Michigan. No formal, complete USFWS survey of the Refuge has been performed. Refuge species lists exist for plants, fish, birds, mammals, reptiles, amphibians and invertebrates based on reports from other conservation agencies and organizations. Mussels are absent from this list due to a lack of survey data.

The Detroit River has historically supported some of the most diverse native freshwater mussel (Unionidae) communities in Michigan, including globally significant populations of rare mussel species. Surveys in 1982 revealed a very rich mussel community, including the northern riffleshell, a federally listed endangered species; rayed bean (*Villosa fabalis*), a federal candidate species; snuffbox (*Epioblasma triquetra*), a state listed endangered species; and purple wartyback (*Cyclonaias tuberculata*) and round hickorynut (*Obovaria subrotunda*), both state species of special concern (Freitag 1984). In addition, several other mussels identified as "species of greatest conservation need" have documented occurrences in the Detroit River and could be present in the DRIWR (Michigan Natural Features Inventory conservation database 2006). These are: the state endangered salamander mussel (*Simpsonaias ambigua*), the state threatened wavy-rayed lampmussel (*Lampsilis fasciola*), and species of special concern hickorynut (*Obovaria olivaria*), rainbow (*Villosa iris*), and round pigtoe (*Pleurobema sintoxia* (=*coccineum*)).

The mussel communities in the Detroit River have experienced severe declines over the past 20 years due largely to the introduction of the zebra and quagga mussels (*Dreissena polymorpha* and *Dreissena bugensis*) (Schloesser *et. al.* 1998). The northern riffleshell had not been recorded in the Detroit River since 1996; however, several recently dead valves of the northern riffleshell were found by Michigan Natural Features Inventory (MNFI) staff in August of 2005, indicating the potential continued presence of this rare species. The status of native freshwater mussels, including the northern riffleshell, at the Detroit River International Wildlife Refuge needs to be ascertained in order to effectively manage these taxa. The decline of the northern riffleshell over its range is cited in its Recovery Plan to be siltation, impoundment, in-stream sand and gravel mining, and pollutants. Recovery objectives for the northern riffleshell include maintaining and restoring viable populations in 10 separate drainages. The Detroit River is one of eight drainages that have been identified as necessary for achieving recovery (U.S. Fish and Wildlife Service 1994).

Due to a limited number of mussel surveys in recent years, what we know of mussel populations in the Detroit River is based mostly on surveys from the 1980s and 1990s. Surveys of a dredging site near the city of Gibraltar, now adjacent to the Detroit River Refuge, revealed 22 species. These included northern riffleshell, rayed bean, snuffbox, purple wartyback, round pigtoe, round hickorynut, and rainbow (Freitag 1984). Surveys of Belle Isle in 1996 documented 100

empty shells of northern riffleshell and 24 empty shells of snuffbox. Other listed species collected were round pigtoe, rainbow, purple wartyback, and rayed bean (Sweet 1998). In a survey of the Detroit-Windsor Tunnel area in 1997 fourteen mussel species were found including the listed northern riffleshell, purple wartyback, and rainbow. However no live individuals of any species were found. The absence of live unionids in this reach was attributed to the negative impact of dreissenid mussels (Schloesser and Kovalak 1997). Live riffleshells had been documented in this reach as recently as 1990 (Kovalak and Brusate 1990). This pattern of drastic decline in unionid populations in response to the spread of dreissenid mussels is thought to have occurred throughout much of the Detroit River. In spite of this impact, empty shells of northern riffleshell were found in the Detroit River, by MNFI staff, as recently as August 2005.

This report presents the results of MNFI's mussel surveys at 22 sites at the DRIWR in the summer of 2006. An additional 14 sites were surveyed during the 2006 field season in a parallel project funded by the Michigan Department of Natural Resources, Non-game Wildlife Fund.

Methods

Quantitative surveys were performed at the Detroit River International Wildlife Refuge to determine the presence/absence, relative abundance, and status of native freshwater mussel species. The presence/absence of dreissenid mussels (*Dreissena polymorpha* and *D. bugensis*), and Asian clams (*Corbicula fluminea*) was recorded. The colonization rate and intensity of dreissenid mussel colonization on unionids was determined where applicable. Several habitat parameters were measured at each site including current speed, water clarity, dissolved oxygen, pH, conductivity, and temperature. A qualitative assessment of habitat suitability for the northern riffleshell, rayed bean, and other mussels was made.

Methods for mussel surveys in the Refuge follow protocol developed by MNFI over the past several years surveying mussels in both deep and shallow river reaches. Generally, sites that are greater than approximately 70cm deep require SCUBA. Sites that are in less than 70cm of water are surveyed by wading with glass bottom buckets, although SCUBA is used at shallow sites when water clarity is very low. At sites where a boat and SCUBA are used, the nearest boat ramp is identified and used as an access point. Mussel habitat and signs of mussel beds, such as empty shells in muskrat middens, are identified from the boat or from shore and used as a basis for selecting survey sites within the identified areas. Handheld GPS units (Garmin 12XL) and topographic maps are used to document the position of survey sites. Latitude and longitude of each site was recorded.

The field crew for SCUBA sites typically consists of two divers and a third person who records data, assists divers with gear, and tends the boat while divers are in the water. Once signs of a mussel bed are identified, the boat is anchored and transects are set. In some cases, sites are surveyed without prior evidence of shell or live individuals other than apparently suitable habitat. Transects are set side by side approximately 3 to 8m apart, parallel to river flow. Transects are delineated using 10m lengths of 2.54cm nylon webbing with 4.5kg anchors tied to each end. An arms-width (approx. 0.8m) on each side of each transect is searched by passing the hands over and through the substrate to a depth of approximately 5cm of substrate. A buoy is tied to one or both anchors to mark the endpoints of each transect. Divers started working each pair of transects at the same time, moving in an upstream direction. Searching in an upstream direction minimized a decrease in visibility due to disturbance of fine sediments during surveys. Divers search a total of eight transects at each site (four transects per diver). Subsequent pairs of transects are placed directly upstream from the previous pair. At sites where the current is very fast transects are searched in the downstream direction. At some sites, longer transect lines were used to minimize the time required to set and reset them. One 40m transect line was used by two divers, one on each side covering a 3.2m wide transect for a total of 128m^2 area searched. This setup also allowed the divers to be in closer proximity and communicate easier at sites with very low visibility.

Mussels buried up to approximately 5cm below the substrate surface are detected. At sites with low underwater visibility, mussels are located primarily by feel as divers pass their hands through the substrate adjacent to the transect lines. Relatively clear water makes visual detection of mussels possible in addition to locating by hand. Live unionids are placed in mesh bags, brought to the surface, and identified after completing each transect. Length measurements of all individuals are taken. The presence/absence of dreissenid mussels is recorded, and the number of dreissenid mussels attached to each live unionid is determined. The presence of shell or live Asian clams are recorded when detected. Empty unionid shell

found during transect searches is either identified underwater or brought to the surface for identification. After processing, live unionids are planted back in the substrate, anterior end down, along transect lines in approximately the same density as they were found. The boat and outboard motor are either dried overnight or washed with a bleach solution to prevent the transportation of live dreissenid mussels between boat launch sites.

Substrate within each transect is characterized by estimating the percent composition by volume of each of the following six particle size classes (diameter); boulder (>256mm), cobble (256-64mm), pebble (64-16mm), gravel (16-2mm), sand (2-0.0625mm), silt/clay (<0.0625) (Hynes 1970). Current speed was measured by timing a neutrally buoyant object (35mm film canister filled with water) over one meter distance. Water clarity was measured with a transparency tube. This devise is a 1.2m tall clear plastic tube, open at the top and closed at the bottom with a black and white pattern similar to a Secchi disk. The tube is filled with water then drained using a valve until the Secchi pattern becomes visible through the top of the water column. The height of the water in the tube was then recorded. Woody debris and aquatic vegetation were noted when observed within the transect. Dissolved oxygen and temperature were recorded with a YSI Model 55 handheld meter. Conductivity and pH were recorded with an Oakton handheld meter.

To maximize diver safety three factors in particular were addressed; water quality, current, and visibility. Bacteria counts in Lower Michigan rivers are often high enough that contact with river water should be avoided. Sediments in river substrates can also contain potentially hazardous substances. Reports of discharges into the river are monitored to avoid diving downstream from points of discharge for at least a week after an event. Drysuits with dry-hoods and full facemasks are used to minimize contact with river water and sediments. Current speeds at some sites make it necessary for divers to wear a heavier weight belt than usual. Transect lines not only delineate the area to be searched, but are also used as a hand line to help divers stabilize themselves in the current. Broken glass, scrap metal, zebra and quagga mussel shell, and other sharp debris are frequently encountered during tactile searches. Neoprene gloves (3mm) with kevlar reinforcement are worn to minimize the chance of injury. Water visibility in the Detroit River can vary from a few cm to greater than 3m. Transect lines are used to keep divers oriented to sampling areas during surveys. The person on the boat also spots divers to help them avoid hazards. Sites with relatively shallow water (approximately <70cm) were surveyed by wading with glass bottom buckets, visually and tactilely searching for mussels along transects.

Results

A total of twenty-two sites were surveyed in seven different areas at the DRIWR (Figures 1-4) (Table 1). Eighteen unionid species were represented by live individuals and/or empty shell. No live individuals or empty shells of northern riffleshell or rayed bean were found. Eight species were represented by live individuals and ten were represented by shell only. Live unionids were found at two sites within the Berenholz area and three sites within the Fermi/Swan Creek area. The only state or federally listed species found was the state threatened, wavy-rayed lampmussel (*Lampsilis fasciola*). Two empty wavy-rayed lampmussel shells were found at Site 28 off of Grassy Island. The most abundant unionids overall were mapleleaf (*Quadrula quadrula*), threeridge (*Amblema plicata*), and lilliput (*Toxolasma parvus*) (Table 2). A meander search of the beach adjacent to Site 36 revealed shells representing eleven unionid species, including one species, black sandshell (*Ligumia recta*), that was not found at any other site (Table 3).

Live zebra mussels (*Dreissena polymorpha*) were observed at eleven of the 24 sites surveyed. Live zebra mussels were found attached to live unionid mussels at two sites in the Berenholz area and two sites in the Fermi/Swan Creek area. The intensity of colonization ranged from a mean of 23.6 to 162.2 zebra mussels per live unionid. The highest frequency of zebra mussel colonization was observed at Site 36, where 95% of live unionids had zebra mussels attached. Length of zebra mussels ranged from approximate 2 to 30mm. Evidence of zebra mussel impact on unionid populations was also found in the Mamajuda Island Shoal area, where one live unionid had dreissenid bysal threads attached and a recent dead unionid shell had 25 live zebra mussels attached (Table 4).

The four sites off Sugar Island had substrate compositions similar to that required to support northern riffleshell, i.e. included significant components of sand and gravel along with other substrate size classes. Sites 28 and 33 at Grassy Island and Calf Island had substrates that would likely be marginal for northern riffleshell due to high proportions of sand and/or silt (Table 5).

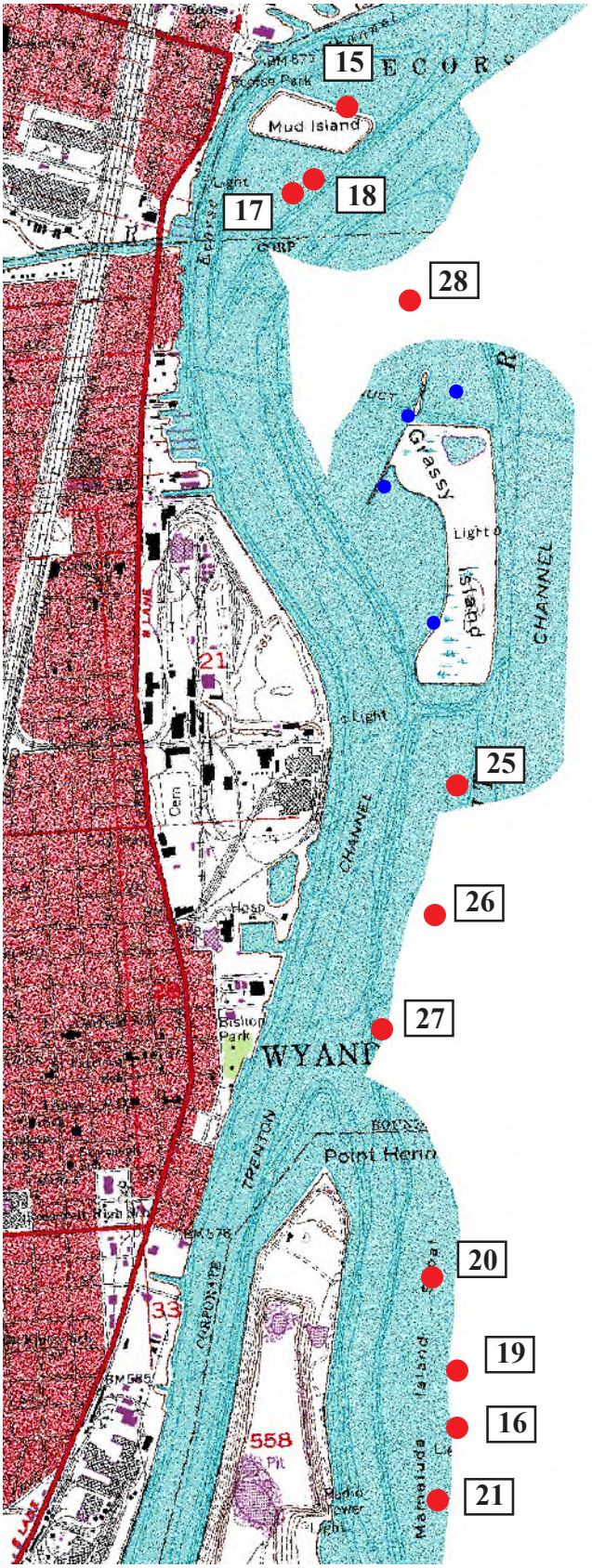

Figure 1. Survey Sites 15-21 and 25-28, at Mud Island, Grassy Island, and Mamajuda Island Shoal, Detroit River. Sites marked in blue were surveyed in a parallel study funded by Michigan DNR. (4.3cm = 1km)

Physical/chemical habitat measures are reported in Table 6. Conductivity was the only habitat measure that showed unusual variation. The three sites at the Berenholz area (22-24) ranged from 1023 to 1417µS, while all other sites ranged from 214 to 433µS. Water clarity was especially low, almost zero, at Site 17 off of Mud Island and Site 25 at Mamajuda Island Shoal. The only sites with a significant amount of woody debris were Site 16 at Mamajuda Island Shoal and Site 18 at Mud Island. Dozens of dead fish were noted in the Berenholz area while scoping mussel sites on May 31, 2006. A majority of the sites supported aquatic vegetation. Grassy Island had particularly dense aquatic vegetation.

Discussion

Due to the presence of sand and gravel substrates, relatively low proportions of silt, and good current speed it appears that Sites 29-32 at Sugar Island have the most potential to support northern riffleshell and other listed mussels. Historic records (1930) for northern riffleshell exist for Stony Island, 3.6km north of Sugar Island. However, the lack of live unionids and presence of zebra mussel shell at Site 29 and live zebra mussels at Site 30 cast some doubt as to whether these sites could currently support unionids. Unionids may also be limited by wave action at these sites. All but two of the other listed mussel species with potential to occur in the study area have similar substrate requirements as northern riffleshell, i.e. lower proportions of silt and higher proportions of sand and gravel. The exceptions are the salamander mussel, which occurs under flat rocks in mud or sand, and the round pigtoe, which occurs in mud, sand, or gravel (Cummings and Mayer 1992). The species found live in this study are all silt tolerant, and commonly found in sand and silt substrates. Four of the five sites where live unionids were found had substrates consisting of 100% silt, the remain site had 50% sand and 50% silt. The prevalence of these species and the high proportions of silt found at a majority of the sites provides evidence that substrate composition is a factor contributing to the decline and/or exclusion of listed species in the DRIWR.

Three unionid species were found that, while they are not currently state listed, are rare in Michigan. These are black sandshell (*Ligumia recta*), eastern pondmussel (*Ligumia nasuta*), and lilliput (*Toxolasma parvus*). The occurrence of live lilliput mussels at Sites 34-36 at the Fermi/Swan Creek area is of special note because there are relatively few known populations in

Figure 2. Survey Sites 22-24 at the Berenholz tract, Lake Erie. Sites marked in blue were surveyed in a parallel study funded by Michigan DNR. (5.5cm = 1km)

Michigan (Figure 5). The lilliput is ranked by NatureServe as "critically imperiled" (S1) in Ontario, "imperiled" (S2) in Indiana, "vulnerable" (S3) in Wisconsin, and "apparently secure" (S4) in Illinois (NatureServe 2006). It has been documented in 21 other states and provinces where its status ranges from "critically imperiled" (S1) to "secure" (S5). It is not yet ranked in Michigan. Though other unionids were heavily colonized by zebra mussels at Sites 34-36, only one lilliput was found with a zebra mussel attached.

Dreissenid mussels (zebra and quagga mussels) have been a major factor causing the decline of native mussel populations in the Detroit River (Schloesser *et. al.* 1998). The high zebra mussel colonization frequency and intensity of unionids found is this study confirms they are currently having a negative impact on unionid populations in the DRIWR. A history of impact from zebra mussels is also evident at the Berenholz area. Ten species of unionids were found at Site 11 at Berenholz (survey at this site funded by MDNR, Badra 2006). All were represented only by empty shell, and several recently dead individuals were infested with zebra mussels. Though the substrate was mainly comprised of silt this should not have had a negative impact on the species found, which included some of the most silt tolerant unionids (*e.g.* giant floater, strange floater, fat mucket, pink heelsplitter, and fragile papershell). Numerous divots were present in the substrate that were about 12cm in diameter and were very similar to the divot left when a unionid mussel is removed from the substrate. Most of the unionid shells at this site were found buried 10cm down at the bottom of these divots. There were

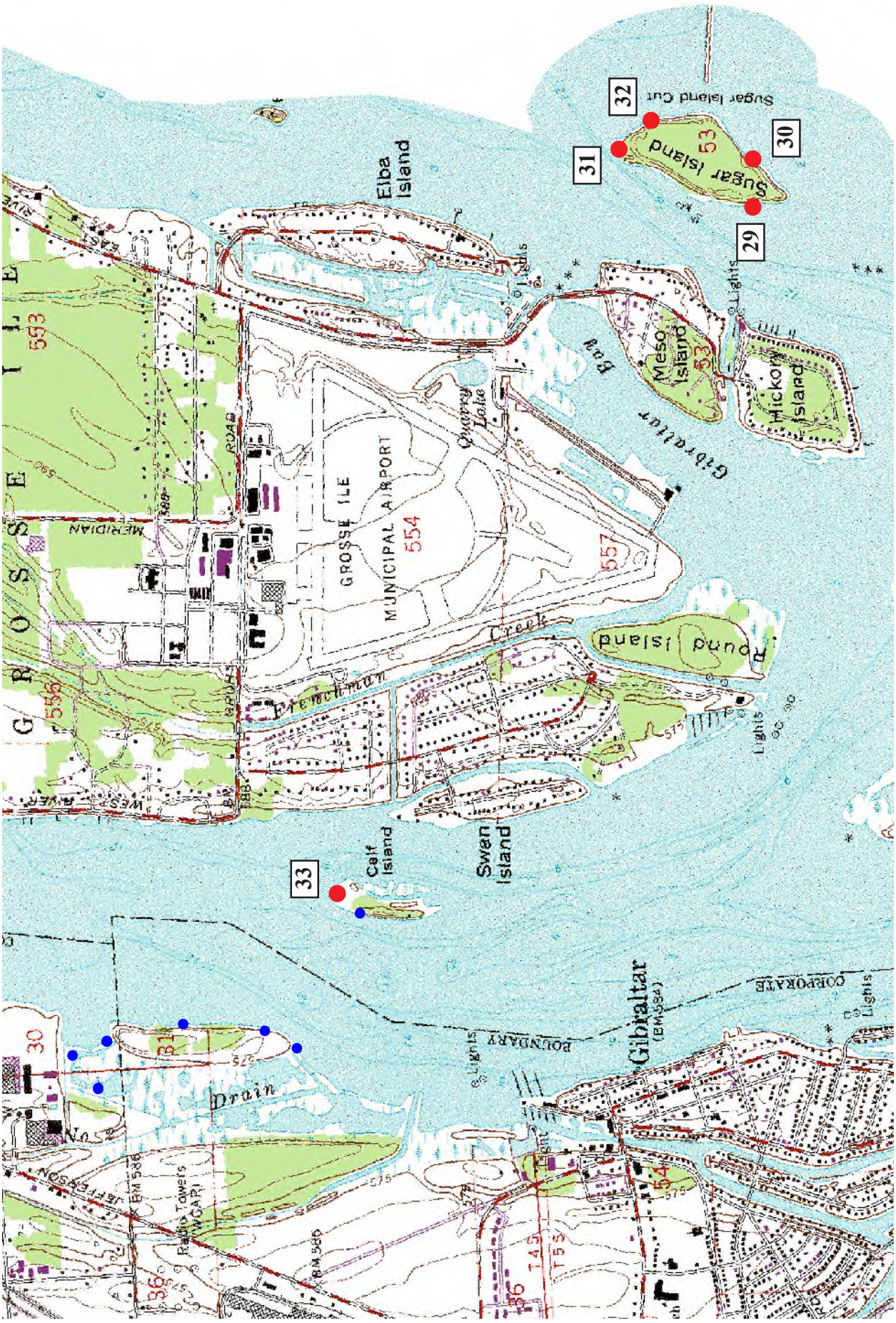

Figure 3. Survey Sites 29-33 at Sugar Island and Calf Island, Detroit River. Sites marked in blue were surveyed in a parallel study funded by Michigan DNR. (4.5cm = 1km)

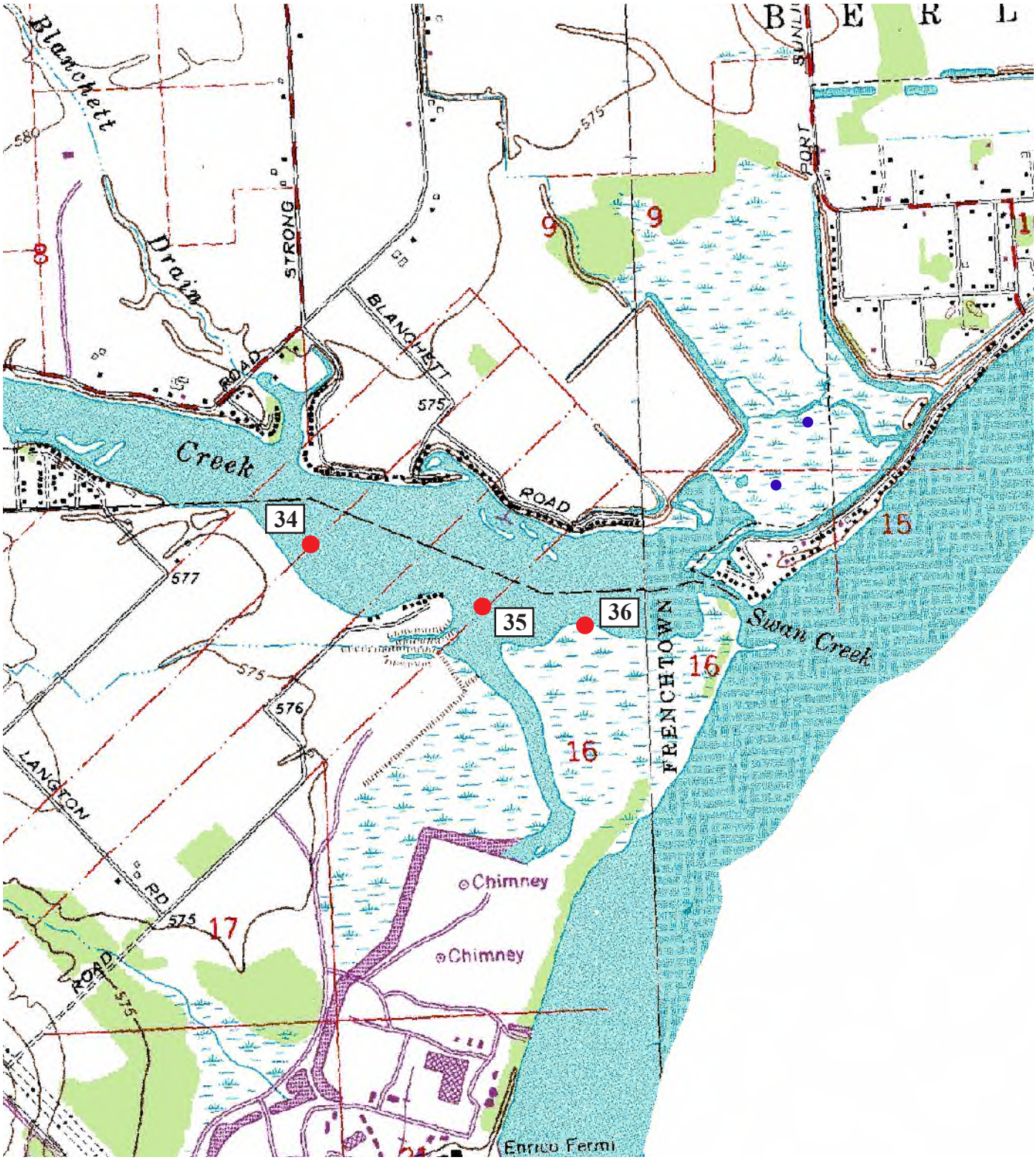

Figure 4. Survey Sites 34-36 at the Fermi/Swan Creek area. Sites marked in blue were surveyed in a parallel study funded by Michigan DNR. (5.5cm = 1km)

Table 1. Latitude and longitude of sites surveyed at the Detroit River International Wildlife Refuge.

Site #	DRIWR area	Latitude	Longitude
15	Mud Island	N 42.23941	W 083.13931
16	Mamajuda Island Shoal	N 42.19244	W 083.13628
17	Mud Island	N 42.23643	W 083.14207
18	Mud Island	N 42.23690	W 083.14115
19	Mamajuda Island Shoal	N 42.19446	W 083.13617
20	Mamajuda Island Shoal	N 42.09776	W 083.13719
21	Mamajuda Island Shoal	N 42.18980	W 083.13741
22	Berenholz	N 41.99194	W 083.21880
23	Berenholz	N 41.99217	W 083.22152
24	Berenholz	N 41.99323	W 083.21918
25	Mamajuda Island Shoal	N 42.21525	W 083.13516
26	Mamajuda Island Shoal	N 42.21066	W 083.13646
27	Mamajuda Island Shoal	N 42.20670	W 083.13912
28	Grassy Island	N 42.23249	W 083.13668
29	Sugar Island	N 42.08925	W 083.14646
30	Sugar Island	N 42.08915	W 083.14435
31	Sugar Island	N 42.09380	W 083.14365
32	Sugar Island	N 42.09269	W 083.14242
33	Calf Island	N 42.10466	W 083.17841
34	Fermi / Swan Creek	N 41.97822	W 083.26236
35	Fermi / Swan Creek	N 41.97630	W 083.25602
36	Fermi / Swan Creek	N 41.97568	W 083.25222

roughly 22 divots per square meter. Also buried underneath 10cm of substrate was a layer of large zebra mussel shells with a density on the order of 100s per square meter. The only live zebra mussels found were attached to recently dead uninoid shell. In light of these observations it appears that the following sequence of events took place. Zebra mussels spread into the area and infested the live unionid mussels there. Since the substrate was entirely silt and sand, the unionids provided the only hard stable substrate for zebra mussels to attach to. As unionid mortality increased the zebra mussels lost the substrate they need to survive, and the zebra mussel population crashed along with unionids.

Other stressors may also be having a negative impact. Conductivity in U.S. rivers generally ranges from 50 to 1500µS. The relatively high conductivity at sites 22-24 in the Berenholz tract (1023, 1044, and 1417µS respectively) could be caused by a number of inorganic dissolved substances including anions such as chloride, phosphate, nitrate, sulfate etc., and cations such as calcium, magnesium, aluminum, iron, etc. The elevated conductivity at Berenholz compared to the other areas surveyed could be caused by natural and/or man-made sources, including the water chemistry of Langton Drain which flows into the area. Further investigation into the potential effects of chlorinated sewage, road salt, oil, ammonia, and discharges of other substances on native mussels in the DRIWR may provide relevant information for their conservation. Though dreissenid mussels have had a clear and dramatic impact in this region, the conservation of native mussels in the DRIWR will require addressing water quality and habitat alteration as well.

Figure 5. Unionid mussels from Site 35 in the Fermi/ Swan Creek area. An empty shell of the exotic Asian clam (*Corbicula fluminea*) is on the far left. Five live lilliputs (*Toxolasma parvus*) are in the center. Two live mapleleaf (*Quadrula quadrula*) are on the far right.

Table 2. Native and non-native mussel species found during surveys. Numbers of empty shells are reported unless otherwise noted. (S=only shells found, L=live individuals found, F=shell fragments found, UF=unidentifiable shell fragments found)

		Mud Island			Mamajuda Island Shoal						
Species	Common Name	15	17	18	16	19	20	21	25	26	27
Actinonaias ligamentina	Mucket										
Amblema plicata	Threeridge										
Cyclonaias tuberculata	Purple wartyback									1	
Elliptio dilatata	Spike		1						1		
Fusconaia flava	Wabash pigtoe										
Lampsilis fasciola	Wavy-rayed lampmussel										
Lampsilis siliquoidea	Fatmucket		1			1					1
Lampsilis ventricosa	Pocketbook										
Lasmigona complanata	White heelsplitter										
Leptodea fragilis	Fragile papershell										
Ligumia nasuta	Eastern pondmussel										
Ligumia recta	Black sandshell										
Potamilus alatus	Pink heelsplitter							1			
Ptychobranchus fasciolaris	Kidney-shell										
Pyganodon grandis	Giant floater										
Quadrula quadrula	Mapleleaf										
Strophitus undulatus	Strange floater										
Toxolasma parvus	Lilliput										
# species live		0	0	0	0	0	0	0	0	0	0
# species live or shell		0	2	0	UF	1	UF	1	1	1	1
Corbicula fluminea	Asian clam										
Dreissena polymorpha	zebra mussel	L	L	L	L			L		S	L

Table 2. (cont.)

	Berenholz			Grassy Island	Calf Island	Sugar Island				Fermi / Swan Creek		
Species	22	23	24	28	33	29	30	31	32	34	35	36
A. ligamentina	1						1					
A. plicata	10 Live		1 Live									
C. tuberculata				1								
E. dilatata	1			1		1	6					
F. flava	1 Live						1					
L. fasciola				2								
L. siliquoidea	1						3					
L. ventricosa	1											
L. complanata			1 Live									
L. fragilis	1 Live	F	3 Live								1 Live	2 Live
L. nasuta	1						3		1			
L. recta												
P. alatus	2			2			*				1 Live	
P. fasciolaris				1								
P. grandis												
Q. quadrula	2 Live		6 Live							13 Live	15 Live	17 Live
S. undulatus											1 Live	
T. parvus										2 Live	5 Live	1 Live
# species live	4	0	4	0	0	0	0	0	0	2	5	3
# species live or shell	10	1	4	5	0	1	5	UF	1	2	5	3
C. fluminea											S	
D. polymorpha	L	S	L	S*	S	S	L				L	L

* Shell found outside transect

Table 3. Species found during a meander survey of the beach adjacent to Site 36 in the Fermi/Swan Creek area. All species were represented by shell only.

Species	Common Name	
Actinonaias ligamentina	Mucket	x
Amblema plicata	Threeridge	x
Cyclonaias tuberculata	Purple wartyback	
Elliptio dilatata	Spike	x
Fusconaia flava	Wabash pigtoe	x
Lampsilis fasciola	Wavy-rayed lampmussel	
Lampsilis siliquoidea	Fatmucket	x
Lampsilis ventricosa	Pocketbook	x
Lasmigona complanata	White heelsplitter	
Leptodea fragilis	Fragile papershell	x
Ligumia nasuta	Eastern pondmussel	x
Ligumia recta	Black sandshell	x
Potamilus alatus	Pink heelsplitter	x
Ptychobranchus fasciolaris	Kidney-shell	
Pyganodon grandis	Giant floater	x
Quadrula quadrula	Mapleleaf	
Strophitus undulatus	Strange floater	
Toxolasma parvus	Lilliput	
# species shell		11
Corbicula fluminea	Asian clam	
Dreissena polymorpha	zebra mussel	x

Table 4. Zebra mussel colonization data, including number of unionids colonized per site (ucz), mean number of zebra mussels per colonized unionid (zm/u), and the percentage of individuals at a site colonized (%cu).

		Mamajuda Island Shoal						Berenholz						Fermi / Swan Creek					
Species	Common Name	19			21			22			24			35			36		
		ucz	zm/u	%cu	ucz	zm/u	%cu	ucz	zm/u	%cu	ucz	zm/u	%cu	ucz	zm/u	%cu	ucz	zm/u	%cu
Amblema plicata	Threeridge							9	197.9	90	1	231	100						
Fusconaia flava	Wabash pigtoe							1	3	100									
Lampsilis siliquoidea	Fatmucket	1[A]		100															
Leptodea fragilis	Fragile papershell							1	147	100	2	40.5	66	1	16	100	1	42	50
Potamilus alatus	Pink heelsplitter				1[B]	25	100							1	84	100			
Quadrula quadrula	Mapleleaf							1[C]	15	50	6	40.8	100	2	6.5	13.3	17	53.6	100
Strophitus undulatus	Strange floater													1	5	100			
Toxolasma parvus	Lilliput																1	1	100
	Total	1		100	1	25	100	12	162.2	85.7	9	61.9	81.8	5	23.6	21.7	19	53.4	95

[A] Dreissenid bysal threads only

[B] Recent dead unionid shell

[C] An additional live *Q. quadrula* with Dreissenid bysal threads attached was found at site 22

Table 5. Percent composition of each substrate size class within transects, estimated visually for each site.

Site #	Boulder	Cobble	Pebble	Gravel	Sand	Silt
15		50[A]	15	15	10	10
16	10	60[A]	10	5	5	10
17						100
18						100
19					10	90
20					10	90
21						100
22[B]						100
23					80	20
24						100
25[C]					25	75
26					10	90
27[D]						
28[C]			10	10	40	40
29		10	20	20	30	20
30	10	40	20	10	10	10
31	5		10	35	40	10
32	10	20	20	20	20	10
33	2	3		10	75	10
34						100
35						100
36					50	50

[A] Cobble consisted of concrete rip rap

[B] Zebra mussel and snail shells present under 10-20cm thick layer of silt

[C] Clay also present at these sites

[D] Substrate characterization not possible due to very dense vegetation

Table 6. Habitat parameters measured at each site.

Site #	DRIWR area	Depth (cm)	Current speed (m/sec)	Current speed (mph)	Water clarity (cm)	Aquatic vegetation?	Woody debris?	DO (mg/L)	pH	Conductivity (µS)	Water temperature (C)
15	Mud Island	48	0.02	0.04	>120	Yes	No	9.63	8.61	217	19.4
16	Mamajuda Island Shoal	45	0.11	0.24	114	Yes	Yes	8.10	7.85	232	22.0
17	Mud Island	101	0.12	0.28	1	Yes	No	8.51	8.31	269	20.8
18	Mud Island	115	0.05	0.11	74	Yes	Yes	7.79	7.15	247	22.3
19	Mamajuda Island Shoal	213	0.04	0.10	92	No	No	8.22	8.92	217	22.3
20	Mamajuda Island Shoal	183	0.06	0.14	110	Yes	No	7.35	8.94	227	24.6
21	Mamajuda Island Shoal	183	0.09	0.20	111	Yes	No	8.97	8.84	219	23.8
22	Berenholz	105	0.05	0.12	37	Yes	No	8.17	8.60	1023	23.1
23	Berenholz	70	0.10	0.23	53	Yes	No	8.16	8.70	1044	25.2
24	Berenholz	90	0.00	0.00	27	No	No	6.29	8.55	1417	25.6
25	Mamajuda Island Shoal	160	0.03	0.07	1	Yes	No	7.43	8.95	230	23.5
26	Mamajuda Island Shoal	305	0.03	0.07	125	Yes	No	7.54	8.85	-	23.4
27	Mamajuda Island Shoal	213	0.11	0.24	122	Yes	No	8.07	8.80	221	23.6
28	Grassy Island	122	0.12	0.28	118	Yes	No	7.70	8.85	220	23.6
29	Sugar Island	63	0.12	0.26	78	No	No	7.82	9.00	215	23.9
30	Sugar Island	35	0.07	0.17	89	No	No	6.54	8.92	218	25.1
31	Sugar Island	82	0.32	0.71	>124	No	No	7.63	8.99	216	24.1
32	Sugar Island	61	0.10	0.23	>128	No	No	7.34	9.03	214	24.8
33	Calf Island	70	0.24	0.55	>121	Yes	No	7.39	8.87	225	24.5
34	Fermi / Swan Creek	105	0.06	0.13	24	No	No	7.98	8.83	433	27.0
35	Fermi / Swan Creek	115	0.06	0.14	22	Yes	No	8.52	8.68	379	27.5
36	Fermi / Swan Creek	-	-	-	-	No	No	9.23	8.59	374	26.8

Acknowledgments

Funding for this project was provided by the U.S. Fish and Wildlife Service, Challenge Cost Share Fund. Thank you to Barb Hosler (USFWS), and to Dr. John Hartig, Steve Dushane, Stephanie Millsap, and the rest the staff of the Detroit River International Wildlife Refuge who sparked interest in this project and provided direction and advice. Thank you to John Matousek and Colleen McLean, whose assistance in the field for this project is greatly appreciated. I would also like to thank the MNFI administrative staff (Dr. Patrick Brown, Lyn Scrimger, Sue Ridge, and Connie Brinson) for providing essential support for this project.

Literature Cited

Badra, P. J. 2006. Status of native and exotic mussels, including the northern riffleshell (*Epioblasma torulosa rangiana*) and rayed bean (*Villosa fabalis*), at the Detrroit River International Wildlife Refuge: Sites 1-14. Report number MNFI 2006-12. Report to Michigan Dept. of Natural Resources, Nongame Wildlife Fund, Lansing, MI. 12pp.

Cummings, K. S., and C. A. Mayer. 1992. Field guide to freshwater mussels of the Midwest. Illinois Natural History Survey Manual 5. 194 pp.

Hynes, H. B. N. 1970. The Ecology of Running Waters. Liverpool University Press, Liverpool, page 24.

Freitag, T. M. 1984. Recent naiad molluscs of the Detroit River. Report for U.S. Army Corps of Engineers, Detroit District.

Kovalak, W. P. and W. Brusate. 1990. Survey of the freshwater mussels of the Detroit River in the vicinity of the Renaissance Center. Report prepared for Amerivest Properties, Sterling Heights, Michigan.

NatureServe. 2006. NatureServe Explorer: An online encyclopedia of life [web application]. Version 6.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: December 22, 2006)

Schloesser, D. W. and W. P. Kovalak. 1997. Survey of the freshwater mussels of the Detroit River in the vicinity of the Detroit-Windsor (auto) tunnel. Report for Parsons Brinkerhoff Michigan, Inc.

Schloesser, D. W., W. P. Kovalak, G. D. Longton, K. L. Ohnesorg, and R. D. Smithee. 1998. Impact of zebra and quagga mussels (*Dreissena spp.*) on freshwater unionids (*Bivalvia: Unionidae*) in the Detroit River of the Great Lakes. A.M.N. 155

Sweet, D. 1998. Species collected during April 14, 1996 Mussel Patrol on Belle Isle. Report of survey results to Michigan Natural Features Inventory.

U.S. Fish and Wildlife Service. 1994. Clubshell (*Pleurobema clava*) and northern riffleshell (*Epioblasma torulosa rangiana*) recovery plan. Hadley, Massachusetts. 68pp.