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 1-14

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September 15, 2006
MNFI Report Number 2006-12

Abstract

We performed surveys at 14 sites within 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 13 species were found. No live individuals or empty shells of the northern riffleshell or rayed bean (*Villosa fabalis*) were found. The only live unionids observed, two giant floaters (*Pyganodon grandis*), were located within the Brancheau Tract of the DRIWR. All other unionid species recorded were represented by empty shell only. The prevalence of silt tolerant 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 unionids in the DRIWR. Dreissenid mussel shells (zebra mussel, *Dreissena polymorpha* and quagga mussel, *Dreissena bugensis*) were encountered frequently, however, live dreissenid mussels were observed at only two sites. Asian clams (*Corbicula fluminea*) were also found live. The presence of live zebra mussels attached to recently dead unionid shells and the abundance of zebra mussel shell observed in this study indicate a history of impact at survey sites in the DRIWR. Two sites were identified where no live dreissenid mussels were found, and where the substrate composition and current were apparently suitable for northern riffleshell and other listed mussels.

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.

An additional 22 sites were surveyed during the 2006 field season in a parallel project funded by the U.S. Fish and Wildlife Service.

Methods

Quantitative field surveys were performed at the DRIWR to determine the presence/absence, relative abundance, and status of native freshwater mussel species. The presence/absence of dreissenid mussels (*Dreissena polymorpha* and *Dreissena bugensis*) and Asian clams (*Corbicula fluminea*) was recorded. The infestation rate and intensity of dreissenid mussel infestation 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 will 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. 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 (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 allowed the divers to be closer and communicate easier at sites with very low visibility.

Mussels buried up to approximately 5cm below the substrate surface are detectable. 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 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 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 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 fourteen sites in five different areas were surveyed at the DRIWR (Table 1) (Figures 1-4). Thirteen unionid species were observed. No live individuals or empty shells of the northern riffleshell or rayed bean were found. The only live unionid mussels found, two giant floaters (*Pyganodon grandis*), were located within the Brancheau Tract of the DRIWR. All other unionid species recorded were represented by empty shell only (Table 2). None of the species found are state or federally listed, however the eastern pondmussel (*Ligumia nasuta*) is rare in Michigan. Fragile papershell (*Leptodea fragilis*), pink heelsplitter

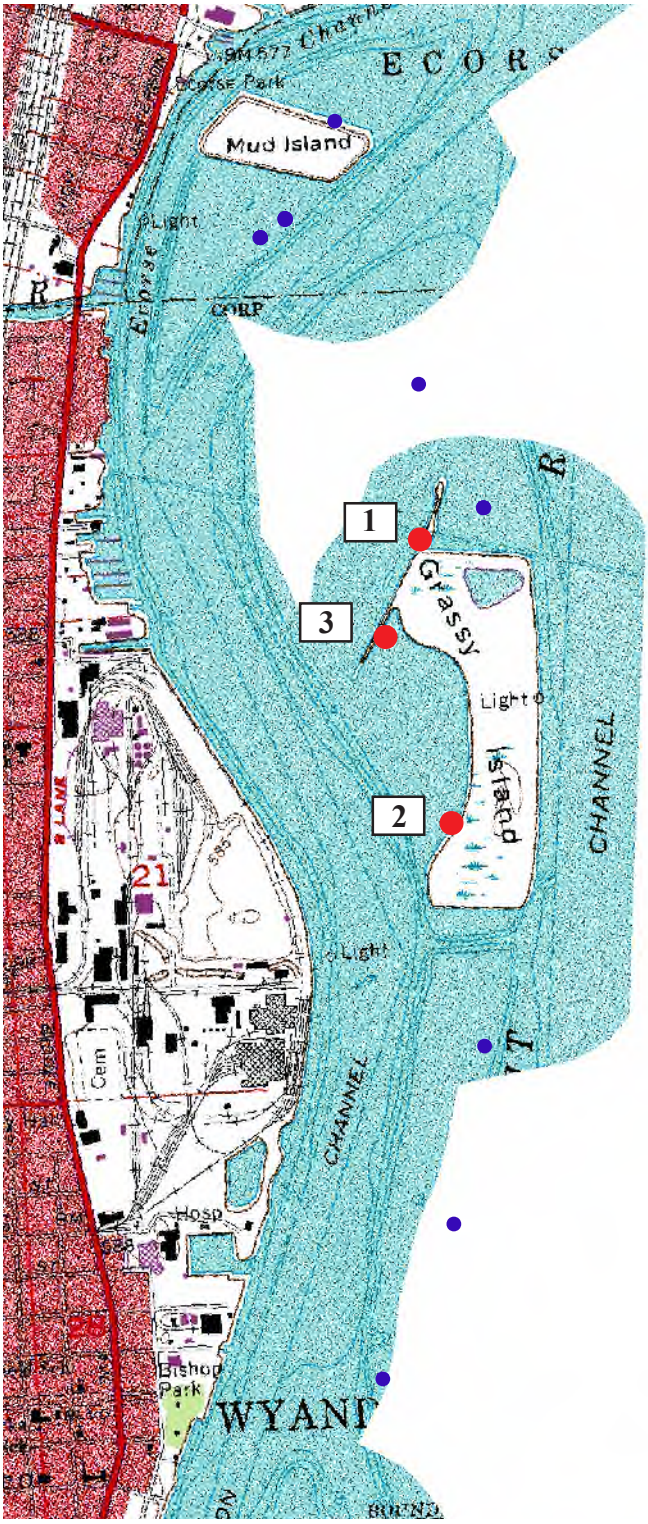

Figure 1. Survey Sites 1-3 (marked in red), located at Grassy Island, Detroit River. Sites marked in blue were surveyed in a parallel study funded by USFWS. (5.5cm = 1km)

(*Potamilus alatus*), and giant floater were the most abundant species overall (Table 3).
Live zebra mussels were observed at two sites (9 and 11). One live zebra mussel was observed at Site 9 and several hundred were observed at Site 11. Dreissenid mussel shells were encountered at an additional seven sites. No live unionids were observed with live dreissenid mussels attached, however, empty fragile papershell and threeridge (*Amblema plicata*) shells at Site 11 had numerous live zebra mussels attached to them. One live Asian clam was found at Site 9.

Three sites had substrate compositions and current similar to that required to support northern riffleshell (i.e. sand and gravel), these were Sites 6 and 7 at Humbug Island and site 10 at Calf Island (Table 4). Current speed, water clarity, dissolved oxygen, pH, and temperature are reported in Table 5. Conductivity was the only habitat measure that showed unusual variation. The two sites at the Berenholz area (11 and 12) were 1959 and 1703µS respectively, while all other sites ranged from 231 to 500µS. The sites at Berenholz were also the only sites with a significant amount of woody debris. Dozens of dead fish were noted in this 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, absence of live dreissenid mussels, and good current speed Sites 6 and 10 have the most potential to support northern riffleshell and other listed mussels. Site 6 is located at the northern end of Humbug Island, and Site 10 on the western side of Calf Island. The substrate composition at Sites 5 and 9 included sand and gravel but had relatively high proportions of silt. Also, live zebra mussels were found at Site 9. The current at sites 5 and 7 was low enough that they would likely not be able to support northern riffleshell. The substrate at these sites was also suitable for other listed unionids. All but two of the other listed mussel species with potential to occur in the study area have similar substrate requirements as northern riffleshell. 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 only species found live, the giant floater, is one of the most tolerant unionids to mud and silt substrates, and low current. It frequently occurs in ponds, lakes, and mud bottomed pools of rivers. Several species represented by shell, including the fatmucket (*Lampsilis siliquoidea*), pocketbook (*Lampsilis ventricosa*), white heelsplitter (*Lasmigona*

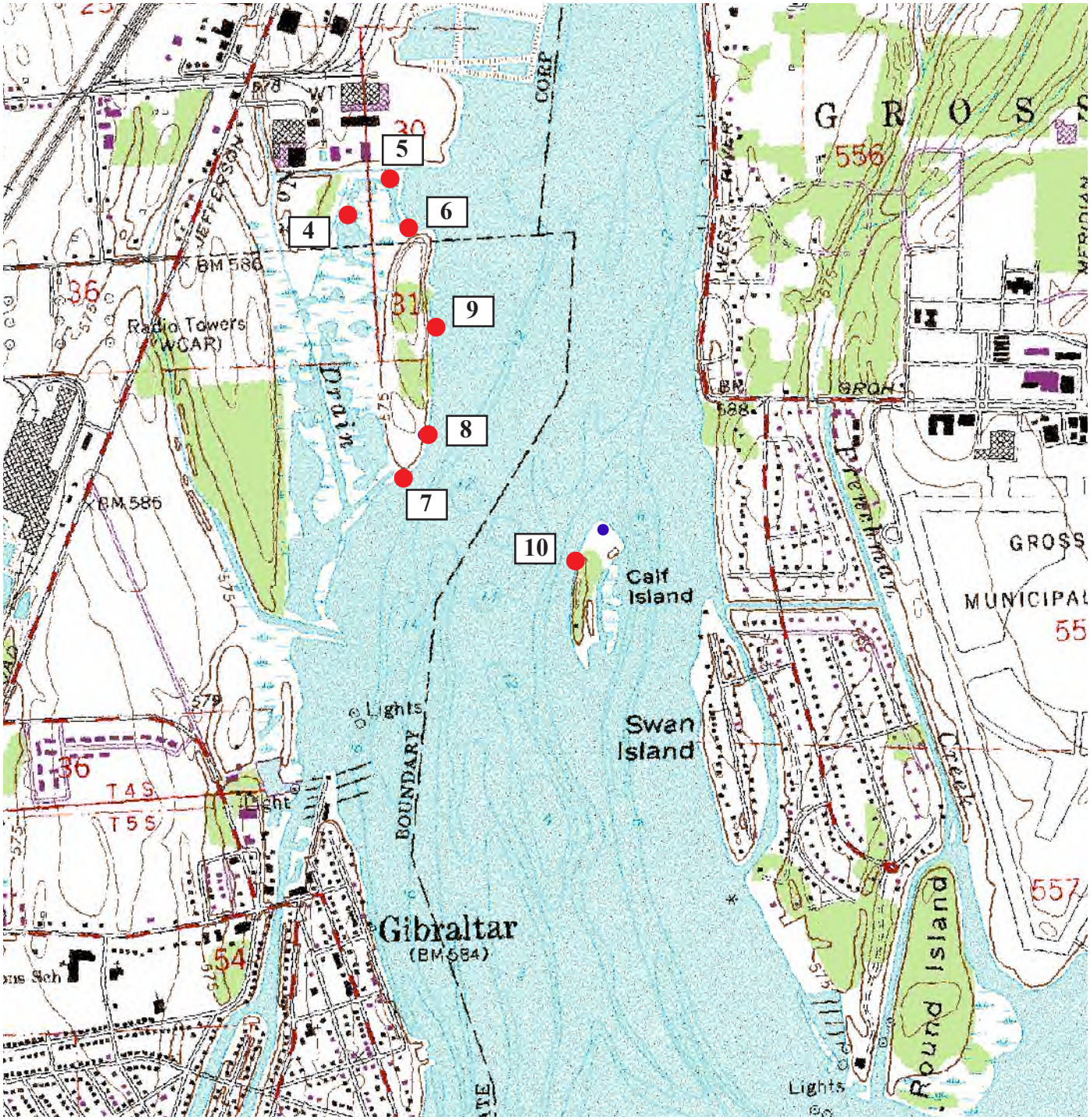

Figure 2. Survey Sites 4-10 (marked in red) located at Humbug Marsh, Humbug Island, and Calf Island, Detroit River. Sites marked in blue were surveyed in a parallel study funded by USFWS. (5.5cm = 1km)

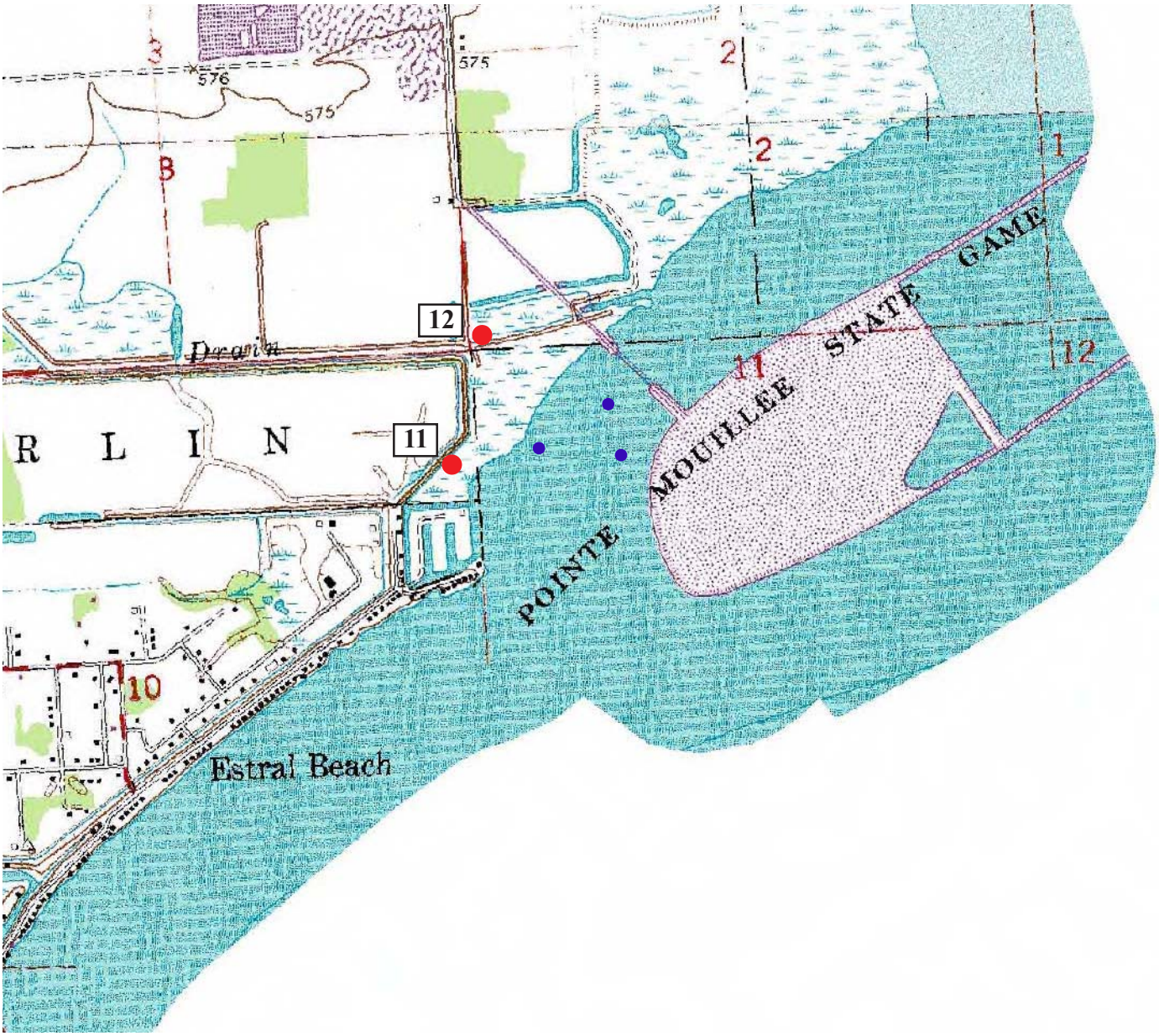

Figure 3. Survey Sites 11 and 12 (marked in red) located at the Berenholz tract, Lake Erie. Sites marked in blue were surveyed in a parallel study funded by USFWS. (5.5cm = 1km)

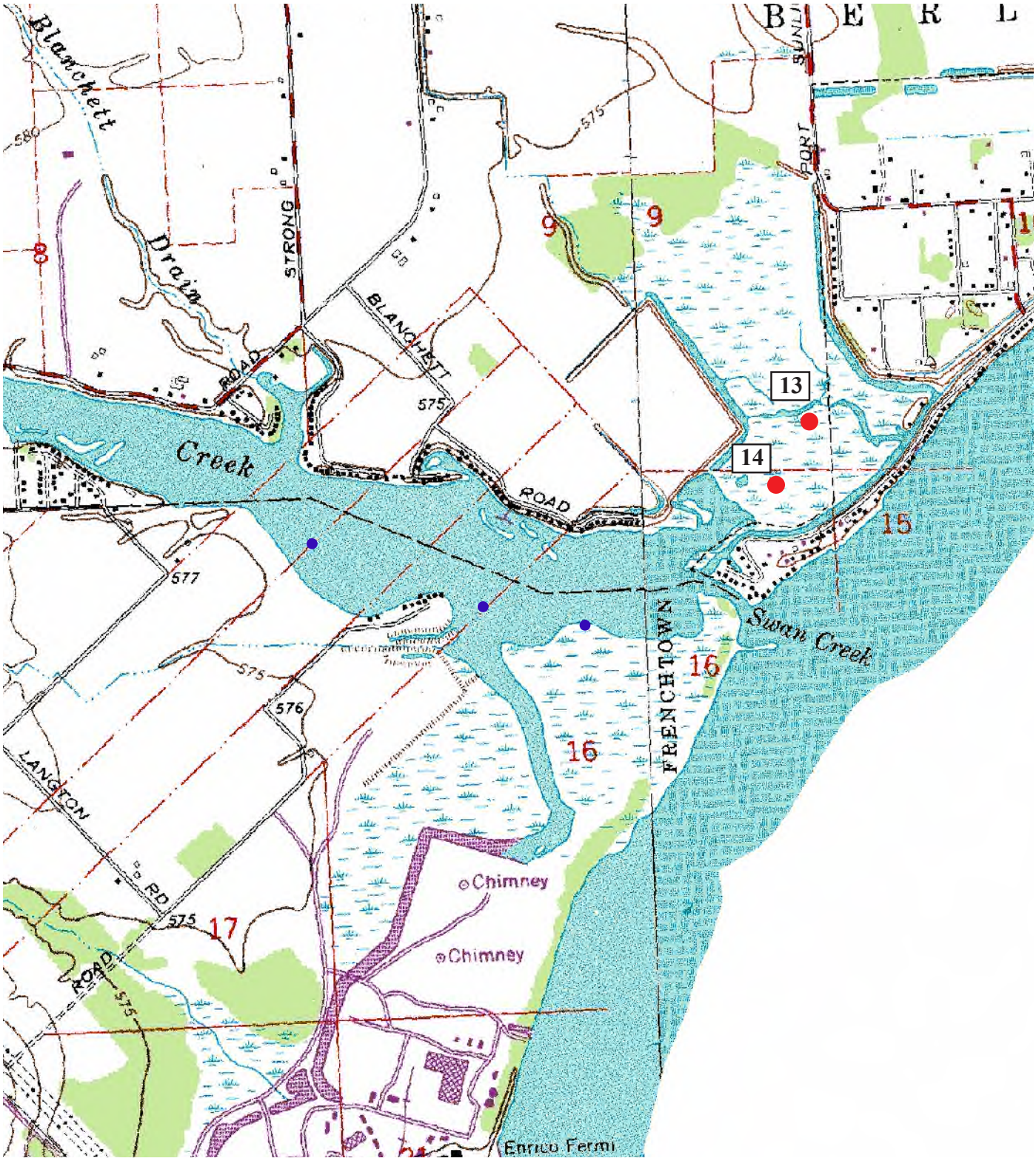

Figure 4. Survey Sites 13 and 14 (marked in red) located at the Brancheau tract, Swan Creek. Sites marked in blue were surveyed in a parallel study funded by USFWS. (5.5cm = 1km)

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

Site #	DRIWR area	Latitude	Longitude
1	Grassy Island	N 42.22876	W 085.13670
2	Grassy Island	N 42.22099	W 083.13604
3	Grassy Island	N 42.22590	W 083.13818
4	Humbug Marsh & Island	N 42.11329	W 083.18720
5	Humbug Marsh & Island	N 42.11416	W 083.18560
6	Humbug Marsh & Island	N 42.11294	W 083.18496
7	Humbug Marsh & Island	N 42.10627	W 083.18561
8	Humbug Marsh & Island	N 42.10738	W 083.18471
9	Humbug Marsh & Island	N 42.11022	W 083.18425
10	Calf Island	N 42.10388	W 083.17934
11	Berenholz	N 41.99179	W 083.22442
12	Berenholz	N 41.99502	W 083.22331
13	Brancheau	N 41.99504	W 083.24466
14	Brancheau	N 41.98116	W 083.24360

complanata), fragile papershell, pink heelsplitter, and strange floater (*Strophitus undulatus*), also tend to be tolerant to high levels of 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, which generally require lower proportions of silt and higher proportions of sand and gravel.

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 presence of live zebra mussels attached to recently dead unionid shells and the abundance of zebra mussel shell observed in this study indicate a history of dreissenid mussel impact on unionids at sites surveyed in the DRIWR. For example, ten species of unionids were found at Site 11 in the Berenholz tract. 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 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.

It appears that high levels of silt as well as infestation by dreissenid mussels have impacted the less silt tolerant unionid populations in the DRIWR. The five sites that were free of dreissenid mussel shell or live individuals had high proportions of silt (45-90%) and no gravel. Other stressors may also be having a negative impact. Conductivity in U.S. rivers generally ranges from 50 to1500µS. The relatively high conductivity at sites 11 and 12 in the Berenholz tract (1959 and 1703µS respectively) could be caused by a number of inorganic dissolved substances including anions: chloride, phosphate, nitrate, sulfate, etc. and cations: 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.

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)

		Grassy Island			Humbug Marsh & Island						Calf Island	Berenholz		Brancheau	
Species	Common Name	1	2	3	4	5	6	7[A]	8	9[B]	10[C]	11	12	13	14
Actinonaias ligamentina	Mucket											1			
Amblema plicata	Threeridge											4[D]			
Elliptio dilatata	Spike											1	4		
Fusconaia flava	Wabash pigtoe												1		
Lampsilis siliquoidea	Fatmucket	1										2			
Lampsilis ventricosa	Pocketbook											4			
Lasmigona complanata	White heelsplitter													2	
Leptodea fragilis	Fragile papershell											6[E]	14	1	
Ligumia nasuta	Eastern pondmussel											1[F]	3		
Potamilus alatus	Pink heelsplitter											11	12		1
Pyganodon grandis	Giant floater											1	5		2 Live, 3 Shells
Quadrula quadrula	Mapleleaf														1
Strophitus undulatus	Strange floater											1			
# species live or shell		1	0	0	0	0	0	0	0	0	0	10	6	2	3
Corbicula fluminea	Asian clam					S	S	S		L		S			
Dreissena polymorpha	zebra mussel	S	S			S	S	S		L	S	L	S		

[A] One very small (young) unidentifiable unionid shell and one unidentifiable fragment of a unionid shell were found at site 7.

[B] One unidentifiable fragment of a unionid shell was found as site 9.

[C] Three unidentifiable fragments of unionid shell were found as site 10.

[D] A live zebra mussel was attached to one of the threeridge shells at site 11.

[E] Several zebra mussels were attached to fragile papershell shells at site 11.

[F] Eastern pondmussel was found outside transect at site 11.

Table 3. Relative abundance of native mussel species based on number of shells found.

		Grassy Island	Berenholz		Brancheau	
Species	Common Name	1	11	12	13	14
Actinonaias ligamentina	Mucket		0.03			
Amblema plicata	Threeridge		0.13			
Elliptio dilatata	Spike		0.03	0.10		
Fusconaia flava	Wabash pigtoe			0.03		
Lampsilis siliquoidea	Fatmucket	1.00	0.06			
Lampsilis ventricosa	Pocketbook		0.13			
Lasmigona complanata	White heelsplitter				0.66	
Leptodea fragilis	Fragile papershell		0.19	0.36	0.33	
Ligumia nasuta	Eastern pondmussel		0.03	0.08		
Potamilus alatus	Pink heelsplitter		0.34	0.31		0.20
Pyganodon grandis	Giant floater		0.03	0.13		0.60
Quadrula quadrula	Mapleleaf					0.20
Strophitus undulatus	Strange floater		0.03			

Table 4. Percent composition of each substrate size class within transects, estimated visually for each site.

Site #	Boulder	Cobble	Pebble	Gravel	Sand	Silt
1					50	50
2		10[A]			45	45
3					25	75
4					50[B]	50[B]
5		10	10	20	20[C]	40
6			30	30	30	10
7		5	25	20	25	25
8				5	48	47
9		10		15	38	37
10		10	30	20	20	20
11					50	50
12					25	75
13					25	75
14					10	90

[A] Cobble consisted of concrete rip rap

[B] Substrate at site 4 consisted of organic material in these two size classes

[C] Included organic material

Table 5. 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)	Temperature (C)
1	Grassy Island	95	0.12	0.27	>120	Yes	No	10.57	8.51	231	19.4
2	Grassy Island	65	0	0	97	No	No	12.70	8.90	227	22.2
3	Grassy Island	90	0.09	0.20	120	Yes	No	11.97	8.85	229	19.8
4	Humbug Marsh & Island	70	0	0	111	Yes	No	-	8.34	299	21.9
5	Humbug Marsh & Island	66	0.04	0.09	106	Yes	No	8.24	8.19	296	21.5
6	Humbug Marsh & Island	65	0.19	0.43	100	No	No	8.90	7.58	295	20.6
7	Humbug Marsh & Island	45	0.03	0.06	84	Yes	No	9.68	8.28	293	21.1
8	Humbug Marsh & Island	70	0.09	0.21	80	Yes	No	9.38	8.22	290	21.8
9	Humbug Marsh & Island	72	0.10	0.23	90	No	No	9.36	8.29	295	22.6
10	Calf Island	46	0.17	0.38	119	No	No	9.63	8.45	246	20.2
11	Berenholz	45	0.06	0.14	26	Yes	Yes	11.51	8.18	1959	22.3
12	Berenholz	55	0.04	0.08	13	Yes	Yes	11.40	8.18	1703	-
13	Brancheau	50	0.07	0.15	16	Yes	No	9.42	8.36	500	26.3
14	Brancheau	48	0.09	0.19	6	Yes	No	9.59	8.54	487	28.1

Acknowledgments

Funding for this project was provided by the Michigan Department of Natural Resources, Nongame Wildlife 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, who's 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.er of the Great Lakes.

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