Appendix 27

Aquatic Invasive Species Monitoring Project

Summary Report for

2006-2012

To the

Fox River Navigational System Authority

By

Bart De Stasio, Ph.D.

Department of Biology
Lawrence University
Appleton, WI 54912

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Objectives

As stated in the Aquatic Invasive Species (AIS) Control and Monitoring Plan of the Fox River Navigational System Authority (FRNSA, June 2006 version, Appendix B), the objective of the Rapide Croche AIS Monitoring Plan is to "monitor the presence and map the distribution of fish and invertebrate AIS in the Fox River two pools immediately up and downstream of Rapide Croche Lock."

Monitoring studies have been conducted every summer between 2006 and 2012 at both upstream and downstream sites. The studies were completed under the supervision of Dr. Bart De Stasio, Ph.D., Department of Biology, Lawrence University, Appleton, WI. Between two and four students were employed during each summer to carry out the investigations. This report presents a summary of the monitoring data collected since 2006.

Sampling Design

As detailed in previous annual reports, monitoring occurred at six sites each summer along the lower Fox River, WI. Following an initial sampling of sites immediately upstream and downstream of the Rapide Croche dam, efforts were expanded further upstream and downstream in 2008. After that time sampling occurred at sites reaching from above Cedar Lock to below the DePere dam. One site immediately above and one below the Rapide Croche lock and dam (FR-3 and FR-4) were the same as those sampled in 2006 and 2007 (Tables 1 & 2, Figure 1). In addition, some samples were consistently collected at FR-6, near the Wrightstown municipal boat launch. Each sampling site designated a general area for sampling efforts, and was further separated into mid-channel versus near-shore sampling locations, depending on the type of sampling performed. Separate boats were employed upstream and downstream of the Rapide Croche dam site on each date, and all nets and equipment were sanitized thoroughly using bleach prior to the next sampling event according to the protocols established by the WI DNR to prevent the spread of AIS (http://dnr.wi.gov/fish/documents/disinfection_protocols.pdf).

Table 1. Latitude and Longitude coordinates of the six sites sampled along the lower Fox River, WI during summer 2006 and 2007.

Location	Latitude	Longitude
Upstream of Rapide Croche		
FR-1	N 44° 18.887	W 88° 12.691
FR-2	N 44° 18.889	W 88° 12.576
FR-3	N 44° 19.077	W 88° 11.962
Downstream of Rapide Croche		
FR-4	N 44° 18.947	W 88° 11.413
FR-5	N 44° 18.952	W 88° 11.022
FR-6	N 44° 19.238	W 88° 10.531

Table 2. Latitude and Longitude coordinates of the sites sampled along the lower Fox River, WI during summers 2008-2012.

Location	Latitude	Longitude
Upstream of Rapide Croche		
FR-A (above Cedar lock)	N 44° 16.562	W 88° 20.541
FR-B (above Kaukauna Guard lock)	N 44° 16.665	W 88° 17.042
FR-3 (above Rapid Croche lock)	N 44° 19.077	W 88° 11.962
Downstream of Rapide Croche		
FR-4 (below Rapid Croche lock)	N 44° 18.947	W 88° 11.413
FR-6 (Wrightstown Boat Launch)	N 44° 19.238	W 88° 10.531
FR-C (above DePere dam)	N 44° 25.813	W 88° 04.273
FR-D (below DePere dam)	N 44° 27.742	W 88° 03.354

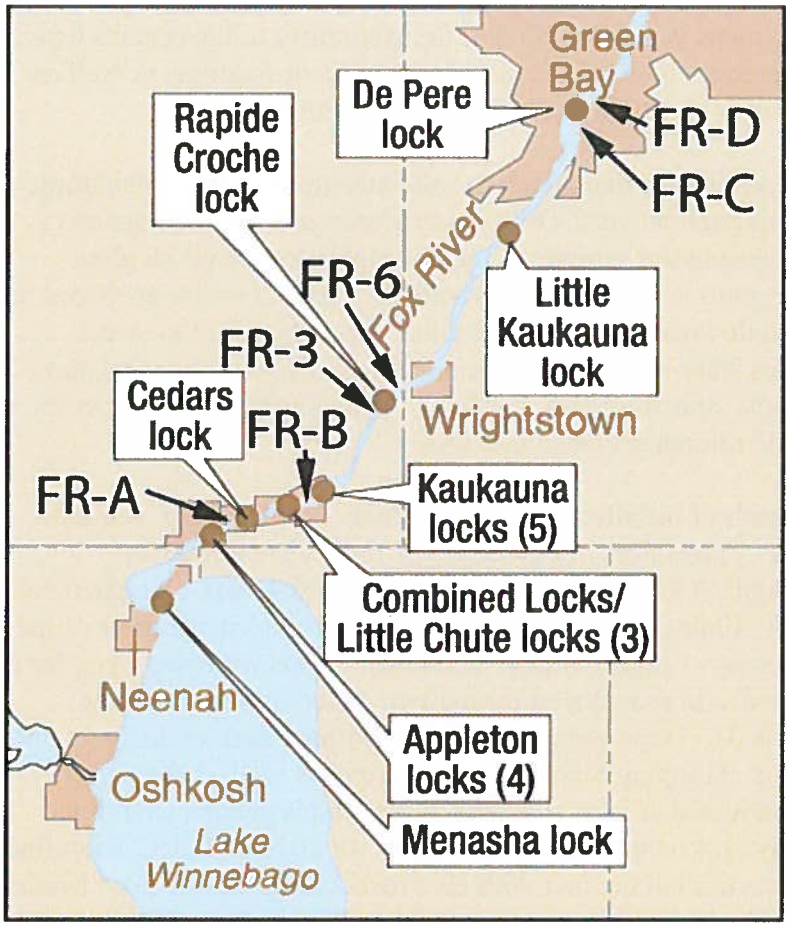

Figure 1. Map of sampling locations along the lower Fox River, WI during summers 2008-2012.

Sampling Activities

Plankton: On each sampling date oblique tows were performed at the mid-channel location of each site using a Wisconsin-type plankton net with retaining collar (mouth diameter=0.13m, mesh size=63 um). Samples were preserved in 80% ethyl alcohol and examined in the laboratory using 10X to 400X magnification. All zooplankton in the samples were identified to the species level, when possible, using Edmonson (1965), Balcer et al. (1984), Pennak (1989), Hopkins (1990), and Thorp and Covich (1991). Abundances in samples were not enumerated, but entire samples were examined to determine presence of each species.

Benthic invertebrates: Mid-channel areas were sampled using a standard Ekman grab sampler (0.15m X 0.15m box size). Replicate grab samples were collected at each site and filtered through a wash bucket with mesh bottom (mesh size=500um). Both shoreline areas at each site were sampled with a combination of dip netting and beach seining techniques. Animals captured were washed into sorting trays and later preserved with 80% ethyl alcohol. Specimens were identified in the laboratory to the species level, where possible, using the references listed above for plankton identifications as well as Pecharsky et al. (1990), Merritt et al. (2008) and Hilsenhoff (1995).

During 2006-2008 invertebrates that attach to solid substrates from a planktonic phase (i.e. zebra and quagga mussel veligers, *Dreissena polymorpha* and *D. bugensis*) were sampled using floating periphyton samplers. Each sampler contained 16 glass slides suspended in the water, onto which organisms settled. Samplers were anchored at each of the sites upstream and downstream of the Rapide Croche dam for two-week sampling periods. Glass slides were removed at the end of each two-week period and preserved in 80% ethyl alcohol. Specimens on the slides were identified to the species level, when possible, using the references listed previously.

Fish: Fish were sampled at each of the sites using a combination of trapping, seining, and electrofishing techniques. Three sizes of cod-end type traps were employed; standard "minnow" traps (length=0.42m, opening=22mm, mesh=6.4mm), elongated eel traps (length=0.78m, opening=40mm, mesh=6.4mm), and larger hand-made traps of the same design (length=2m, opening=125mm, mesh= 12.5mm). Traps were deployed for a maximum of 24 hours, emptied, and redeployed during two different periods of the summer at each site (see Table 3). Traps were set with and without bait on different dates to optimize the potential catch. Trapping included mid-channel as well as shoreline locations at each site. We conducted at least five beach seine hauls at each shoreline location on each sampling day (1/4 inch mesh, 20 ft length). In 2010 and 2012 shoreline habitats were also sampled in a limited manner with electroshocking (Smith-Root Model LR-20 Backpack Electrofisher). If possible, specimens from all sampling efforts were identified in the field to the species level and then released. Specimens of new species compared to existing records or specimens difficult to identify in the field were saved live for later identification in the laboratory. Upon return to the laboratory specimens were frozen or transferred to ethyl alcohol (70%) for long-term preservation. Specimens were identified to the species level when possible, using Hubbs and Lagler (2004), Lyons et al. (2000), and the Wisconsin Fish ID software (2005).

Results & Conclusions

The actual species collected in a given year vary, but overall the lists shown in Tables 3-5 provide a fairly comprehensive survey of native and invasive species of fish and invertebrates in the lower Fox River. Over the seven-year period we identified 47 species of fish (Table 3), 103 groups of benthic macroinvertebrates (Table 4) and 49 zooplankton taxa (Table 5). Fewer species of fish were observed above the Rapide Croche dam than below (29 above vs. 44 below), while slightly more benthic invertebrates and zooplankton taxa were found above than below this point (benthos: 84 above vs. 76 below; zooplankton: 44 above vs. 37 below). The addition in 2010 of sampling with a backpack electroschocker expanded our detection ability, however we still have a limited capacity to sample deep-water habitats for fish species. It is clear that our methods do not exhaustively sample sport fish known to inhabit the very lowest reaches of the river (i.e. brown trout, walleye, etc.), but this is consistent with the stated goals of the FRNSA charter which focus on invasive species that might spread beyond the barrier at Rapide Croche. Discussions are underway with the WI DNR to supplement our efforts to obtain more comprehensive general monitoring efforts for AIS in the lower Fox River.

Our sampling for AIS in the lower Fox River to date has demonstrated that some invasive species are already present both upstream and downstream of the Rapide Croche dam. Both zebra mussels and rusty crayfish were common both above and below the dam in all years examined (Table 4). A recent invader of the Great Lakes, the amphipod *Echinogammarus ischnus*, has also established populations both above and below the Rapide Croche dam. Common carp occurs both above and below this point, while round goby has been found in all sites below the current invasive species barrier at Rapide Croche (Table 3, Appendix). White perch has been found primarily just above the Rapide Croche dam (but also below the DePere dam recently). Three other invasive species have only been found during a single season, including the zooplankton groups spiny waterflea (*Bythotrephes longimanus*) and *Daphnia lumholtzii*, as well as the amphipod *Gammarus fasciatus* (Tables 4 & 5). These species do not appear to have established themselves yet, but are perhaps occasionally being brought in by boaters inadvertently. Our data do not show the presence of sea lamprey (*Petromyzon marinus*), which has been observed below the Rapide Croche barrier previously (Cochran 1994; also see separate report on sea lamprey sampling in 2011). Based on our results to date, it is apparent that our continued efforts should provide an early warning of additional AIS that become established in the lower Fox River in the navigational pools upstream and downstream of the Rapide Croche dam. Our monitoring efforts to date have provided a solid baseline against which we can compare future changes in the composition of fish and invertebrates in the river.

Acknowledgements

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Table 3a. Summary of fish species collected above and below the Rapide Croche dam between 2006 and 2012. A "1" indicates presence of the group in at least one sampling location.

Fish Species	Above 2006	Above 2007	Above 2008	Above 2009	Above 2010	Above 2011	Above 2012	Below 2006	Below 2007	Below 2008	Below 2009	Below 2010	Below 2011	Below 2012
Alosa crysochloris (Skipjack herring)										1				
Ambloplites rupestris (Rock bass)		1	1	1	1	1	1	1		1	1	1	1	1
Ammocrypta clara (Western Sand Darter)											1			
Aplodinotus grunniens (Freshwater drum)		1					1			1	1			
Carpiodes carpio (River Carpsucker)				1	1						1			
Carpiodes cyprinus (Quillback)				1			1							1
Catostomus commersonii (White Sucker)				1			1				1		1	1
Cyprinella spiloptera (Spotfin Shiner)												1		
Cyprinus carpio (Common carp)	1	1	1	1	1	1	1	1	1	1			1	1
Dorosoma cepedianum (Gizzard Shad)							1				1			1
Enneacanthus obesus (Banded sunfish)												1		
Esox lucius (Northern pike)										1				
Etheostoma chlorosoma (Bluntnose darter)	1							1	1	1				
Etheostoma flabellare (Fantail darter)					1									
Etheostoma nigrum (Johnny darter)	1	1	1	1	1	1	1	1	1	1	1		1	1
Etheostoma sp. (Darter)							1				1			1
Fundulus diaphanus (Banded Killifish)												1		
Ictalurus punctatus (Channel catfish)	1	1							1					
Ictiobus cyprinellus (Bigmouth buffalo)							1	1			1			
Lepisosteus osseus (Longnose Gar)											1	1		
Lepomis cyanellus (Green sunfish)	1		1			1	1	1	1	1	1		1	1
Lepomis gibbosus (Pumpkinseed)					1	1	1					1	1	
Lepomis macrochirus (Bluegill)	1	1	1		1	1		1	1	1	1	1	1	
Lepomis sp. (Juvenile Sunfish)				1			1				1			

Table 3b. Continuation of summary of fish species collected above and below the Rapide Croche dam between 2006 and 2012. A "1" indicates presence of the group in at least one sampling location. Highlighted species are considered invasive.

Fish Species	Above 2006	Above 2007	Above 2008	Above 2009	Above 2010	Above 2011	Above 2012	Below 2006	Below 2007	Below 2008	Below 2009	Below 2010	Below 2011	Below 2012
Macrhybopsis hyostoma (Shoal chub)												1		
Micropterus dolomieu (Smallmouth bass)	1		1	1	1		1	1		1	1	1	1	1
Micropterus punctulatus (Spotted bass)					1									
Micropterus salmoides (Largemouth bass)			1	1	1	1	1		1	1				1
Minytrema melanops (Spotted sucker)												1		
Morone americana (White perch)					1		1							1
Morone chrysops (White Bass)											1			
Neogobius melanostomus (Round goby)										1	1	1	1	1
Notemigonus crysoleucas (Golden Shiner)											1			
Notropis atherinoides (Emerald Shiner)					1		1				1	1		1
Notropis hudsonius (Spottail Shiner)				1	1	1					1	1	1	1
Notropis sp. (Common Shiner)				1			1				1		1	1
Notropis wickliffi (Channel Shiner)													1	
Perca flavescens (Yellow perch)			1	1	1		1	1	1	1	1	1	1	1
Percina caprodes (Logperch)	1	1		1	1						1	1		
Percina phoxocephala (Slenderhead darter)									1					
Percopsis omiscomaycus (Trout-perch)								1		1	1	1		
Pimephales notatus (Bluntnose Minnow)				1	1		1				1	1		1
Pimephales promelas (Fathead Minnow)							1							1
Pimephales vigilax (Bullhead Minnow)														1
Pomoxis annularis (White crappie)												1		
Pomoxis nigromaculatus (Black Crappie)							1							1
Pumpkinseed X Green Sunfish hybrid		1	1		1		1							
Sander vitreus (Walleye)										1				
Totals	8	8	9	14	17	8	22	10	9	15	24	18	13	20

Table 4a. Summary of benthic macroinvertebrate species collected above and below the Rapide Croche dam between 2006 and 2012. A "1" indicates presence of the group in at least one sampling location. Highlighted species are considered invasive.

Macroinvertebrate Species	Above 2006	Above 2007	Above 2008	Above 2009	Above 2010	Above 2011	Above 2012	Below 2006	Below 2007	Below 2008	Below 2009	Below 2010	Below 2011	Below 2012
Amnicola sp. (Right Handed Snail)				1			1							
Anax sp. (dragonfly)										1				
Anthopotomus sp. (mayfly)									1					
Argia sp. (damselfly)			1	1					1	1				
Atherix													1	
Backswimmer (family: Notonectidae)	1	1	1					1	1	1				
Baetisca sp. (mayfly)		1			1				1				1	
Belostoma sp. (Giant water bug)			1	1	1		1		1	1	1	1		1
Buenoa sp. (waterboatman)	1	1	1					1	1	1				
Bulimus sp. (Right Handed Snail)				1							1			
Caddisfly larvae	1	1	1	1				1	1	1				
Caecidotea sp. (isopod)			1	1		1			1	1	1		1	
Caenidae sp. (mayfly)	1				1	1	1	1					1	1
Callibaetis sp. (mayfly)				1		1								
Callocorixa sp. (Waterboatman)				1										
Cenocorixa sp. (waterboatman)				1							1			
Chironomidae (midge fly)	1	1	1	1		1	1	1	1	1	1		1	1
Coenagrion sp. (damselfly)	1		1		1			1						
Corisella sp. (waterboatman)				1							1			
Corixidae sp. (waterboatman)				1	1	1					1	1	1	
Crangonyx pseudogracilis (amphipod)						1								
Crangonyx sp. (amphipod)			1	1	1	1				1	1		1	
Cymetra (waterboatman)												1		
Dasyhelea sp. (Diptera larvae)		1												
Dineutus sp. (whirligig beetle)	1							1			1			
Diplectrona						1							1	
Dixidae						1								
Dreissena polymorpha (zebra mussel)	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Dromogomphus sp. (dragonfly)								1						
Echinogammarus ischnus (amphipod)			1		1	1					1	1		
Elmidae Stenelmis (Riffle Beetle)													1	
Enallagma sp. (damselfly)		1	1	1	1	1			1	1	1	1		
Ephemerella sp. (mayfly)					1	1			1			1	1	
Erythemus sp. dragonfly)					1									

Table 4b. Continuation of summary of macroinvertebrate species collected above and below the Rapide Croche dam between 2006 and 2012. A "1" indicates presence of the group in at least one sampling location. Highlighted species are considered invasive.

Macroinvertebrate Species	Above 2006	Above 2007	Above 2008	Above 2009	Above 2010	Above 2011	Above 2012	Below 2006	Below 2007	Below 2008	Below 2009	Below 2010	Below 2011	Below 2012
Ferrisia sp. (Freshwater limpet)					1						1			1
Fossaria sp. (Right Handed Snail)				1									1	
Gammarus fasciatus						1							1	
Gammarus sp. (amphipod)			1	1	1	1	1		1	1	1		1	1
Gerridae *(water strider)*			1							1	1		1	
Gomphus sp. (dragonfly)									1					
Goniobasis						1							1	
Gyraulus sp. (Disc-Shaped Snail)				1			1							1
Haliplus sp. (Crawling Water Beetle)				1										
Hataerina sp. (damselfly)					1									
Helisoma sp. (Snail)											1		1	
Hespercorixa sp. (waterboatman)				1	1		1							1
Hexagenia sp. (mayfly)	1							1						
Hyalella azteca (amphipod)		1		1	1	1			1	1		1	1	
Hydracarina (Water Mite)					1	1	1				1	1	1	1
Ischnura sp. or *Anamolagrion sp.* (damselfly)							1			1		1		1
juvenile corixidae						1								
juvenile snail						1								
Juvenille Minnow						1								
Laccophilus sp. (water beetle)										1				
Leptocerus						1								
Lestes sp. (dragonfly)					1							1		
Libellulidae sp. (dragonfly)								1						
Limnogonus sp. (water strider)										1				
Limnoporus sp. (Water strider)											1			
Lymnaea sp. (freshwater snail)	1													
Macrobdella sp. (leech)					1		1							1
Mesovelia mulsanti (water treader)					1									
Metrobates (true bug)					1									
Molanna						1								
Monoporeia sp. (amphipod)				1	1	1			1	1	1	1	1	
Nehalemia sp. (damselfly)						1			1					
Nehalennia sp. (damselfly)				1						1	1			
Neoephemera (mayfly)						1								
Neogerris sp. (Waterstrider)				1										
Nepidae sp. (Water Scorpion)											1			
Notonecta sp. (Backswimmer)				1			1				1		1	

Table 4c. Continuation of summary of macroinvertebrate species collected above and below the Rapide Croche dam between 2006 and 2012. A "1" indicates presence of the group in at least one sampling location. Highlighted species are considered invasive.

Macroinvertebrate Species	Above 2006	Above 2007	Above 2008	Above 2009	Above 2010	Above 2011	Above 2012	Below 2006	Below 2007	Below 2008	Below 2009	Below 2010	Below 2011	Below 2012
Orconectes propinqus						1								
Orconectes rusticus (rusty crayfish)	1	1		1	1		1	1	1		1	1		1
Orconectes virilis (native crayfish)				1		1	1						1	
Palmacorixa sp. (Waterboatman)				1			1				1			1
Parameletus sp. (mayfly)						1			1					
Peltodytes (spotted beetle)						1								
Physella sp. (Left Handed Pond Snail)				1		1	1				1			1
Planaria sp. (flatworm)						1			1					
Plecoptera (Stonefly)											1			
Pleurocera sp. (Right Handed Snail)				1	1	1	1				1		1	1
Progomphus sp. (dragonfly)	1							1						
Pseudostenophylax sp. (Caddisfly)											1			
Pteronarcys sp. (stonefly)									1					
Ramphocorixa sp. (Waterboatman)				1		1					1			
Ranatra sp. (Water Scorpion)				1			1				1			1
Rhirhrogena sp. (mayfly)														
Semiaquatic Coleoptera						1								
Sialis sp. (alderfly)		1	1						1	1				
Sigara sp. (Waterboatman)				1	1							1		
Siphlonuridae (mayfly)						1								
Stagnicola sp. (Snail)				1			1							1
Stenacron sp. (mayfly)									1					
Stenelmis sp. (riffle beetle: adult & larvae)									1					
Stenonema sp. (mayfly)				1										
Tanyderidae						1							1	
Tarnetrum Sympetrum						1								
Thaumaleidae						1							1	
Trepobates sp. (Water strider)				1										
Trichocorizica sp. (waterboatman)				1			1				1			1
Trichoptera (Caddisfly larvae)						1								1
Tricorythodes (mayfly)						1							1	
Tubifex sp. (tubifex worm)		1							1					
Valvata sp. (Right Handed Snail)				1			1							
Vestidae (damselfly)					1									
Totals	12	12	15	38	26	41	21	13	25	20	31	14	26	19

Table 5a. Summary of species collected in zooplankton samples above and below the Rapide Croche dam between 2006 and 2012. A "1" indicates presence of the group in at least one sampling location. Highlighted species are considered invasive.

Zooplankton Species	Above 2006	Above 2007	Above 2008	Above 2009	Above 2010	Above 2011	Above 2012	Below 2006	Below 2007	Below 2008	Below 2009	Below 2010	Below 2011	Below 2012
Acanthocyclops vernalis	1	1	1	1	1	1	1	1	1	1	1		1	1
Acanthocyclops robustre					1									
Alona sp.							1		1				1	
Ascomorpha sp.												1		
Asplanchna sp.		1		1					1	1	1	1		
Bosmina longirostris	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Brachionus sp.		1		1						1	1	1		
Bythotrephes longimanus						1								
Caddisfly, juvenile						1								
Calanoid nauplius					1									
Cephalodella sp.				1										
Ceriodaphnia sp.				1	1						1	1		
Chydorus sp.		1	1	1	1		1		1	1	1	1		1
Chironomus, juvenile						1							1	
Cyclopoid nauplius												1		
Copepoda sp.					1							1		
Daphnia magna							1					1		1
Daphnia longiremis				1	1	1								
Daphnia lumholtzii					1									
Daphnia mendotae	1	1	1	1				1	1	1				
Daphnia parrula					1									
Daphnia pulicaria	1	1		1	1	1	1		1					1
Daphnia retrocurva						1							1	

Table 5b. Summary of species collected in zooplankton samples above and below the Rapide Croche dam between 2006 and 2012. A "1" indicates presence of the group in at least one sampling location. Highlighted species are considered invasive.

Zooplankton Species	Above 2006	Above 2007	Above 2008	Above 2009	Above 2010	Above 2011	Above 2012	Below 2006	Below 2007	Below 2008	Below 2009	Below 2010	Below 2011	Below 2012
Dicyclops nanus						1							1	
Diacyclops thomasi	1	1	1	1		1		1	1	1				
Diaphanosoma sp.	1	1		1		1	1	1	1		1	1	1	1
Epiphanes					1									
Eubosmina sp.	1	1			1	1	1	1	1		1	1	1	1
Eucyclops agilis		1						1	1					
Euchlanis sp.				1	1							1		
Gastropus Stylifer					1							1		
Harpacticoid nauplii				1	1							1		
Harpacticoid copepod											1			
Keratella sp.		1	1	1	1				1	1	1	1		
Lecane												1		
Leptodiaptomus ashlandi	1	1				1		1					1	
Leptodiaptomus siciloides	1	1	1	1		1			1	1				
Leptodiaptomus sicilis			1	1		1	1			1			1	1
Leptodora kindtii	1	1				1								
Mesocyclops edax	1	1	1	1		1	1	1	1	1	1		1	
Monostyla sp.											1			
Ostracod						1	1					1	1	1
Platyias patulus				1							1	1		
Polyarthra sp.				1	1									
Scapholeberis sp.		1							1					
Skistodiaptomus oregonesis	1	1	1	1		1	1	1	1	1	1		1	
Synchaeta sp.				1							1	1		
Testudinella sp.		1												
Tricocerca sp.					1						1	1		
Totals	12	19	10	22	19	19	12	10	16	12	16	20	13	9

Appendix to

Aquatic Invasive Species Monitoring Project

Summary Report for

2006-2012

To the

Fox River Navigational System Authority

By

Bart De Stasio, Ph.D.

Department of Biology
Lawrence University
Appleton, WI 54912

January 14, 2013

Appendix A. Fish species collected at each sampling location during 2009-2012. A "1" indicates presence on at least one sampling date. Highlighted species are considered invasive for the purposes of this project.

Fish 2009	**FR-A**	**FR-B**	**FR-3**	**FR-4**	**FR-C**	**FR-D**
Ambloplites rupestris (Rock bass)	1	1	1	1	1	
Ammocrypta clara (Western Sand Darter)						1
Aplodinotus grunniens (Freshwater drum)						1
Carpiodes carpio (River Carpsucker)	1					1
Carpiodes cyprinus (Quillback)	1					
Catostomus commersonii (White Sucker)	1					1
Cyprinus carpio (Common carp)			1			
Dorosoma cepedianum (Gizzard Shad)					1	1
Etheostoma chlorosoma (Bluntnose darter)					1	
Etheostoma nigrum (Johnny darter)	1		1	1		1
Etheostoma sp. (Darter)						1
Ictiobus cyprinellus (Bigmouth buffalo)						1
Lepisosteus osseus (Longnose Gar)				1		
Lepomis cyanellus (Green sunfish)					1	
Lepomis macrochirus (Bluegill)				1	1	
Lepomis sp. (Juvenile sunfish)	1	1	1	1	1	
Micropterus dolomieu (Smallmouth bass)	1	1		1	1	1
Micropterus salmoides (Largemouth bass)		1				
Morone chrysops (White Bass)						1
Neogobius melanostomus (Round goby)					1	1
Notemigonus crysoleucas (Goldet Shiner)				1		
Notropis atherinoides (Emerald Shiner)						1
Notropis hudsonius (Spottail Shiner)	1	1	1			1
Notropis sp (Common Shiner)	1			1	1	1
Perca flavescens (Yellow perch)	1	1		1		1
Percina caprodes (Logperch)		1				1
Percopsis omiscomaycus (Trout-perch)				1		
Pimephales notatus (Bluntnose Minnow)	1			1		1
Totals	11	7	5	11	9	17

Fish 2010	**FR-A**	**FR-B**	**FR-3**	**FR-4**	**FR-C**	**FR-D**
Ambloplites rupestris (Rock bass)	1	1	1		1	1
Carpiodes carpio (River Carpsucker)			1			
Cyprinella spiloptera (Spotfin Shiner)					1	
Cyprinus carpio (Common carp)	1	1	1			
Enneacanthus obesus (Banded sunfish)					1	
Etheostoma flabellare (Fantail darter)			1			
Etheostoma nigrum (Johnny darter)			1			
Fundulus diaphanus (Banded Killifish)						1
Lepisosteus osseus (Longnose Gar)					1	1
Lepomis gibbosus (Pumpkinseed)	1					1
Lepomis macrochirus (Bluegill)	1	1	1	1		
Macrhybopsis hyostoma (Shoal chub)						1
Micropterus dolomieu (Smallmouth bass)	1		1		1	
Micropterus punctulatus (Spotted bass)		1				
Micropterus salmoides (Largemouth bass)	1	1	1			
Minytrema melanops (Spotted sucker)						1
Morone americana (White perch)			1			
Neogobius melanostomus (Round goby)					1	1
Notropis atherinoides (Emerald Shiner)			1	1	1	1
Notropis hudsonius (Spottail Shiner)	1	1		1		
Perca flavescens (Yellow perch)	1	1	1			1
Percina caprodes (Logperch)			1		1	
Percopsis omiscomaycus (Trout-perch)					1	
Pimephales notatus (Bluntnose Minnow)		1	1		1	1
Pomoxis annularis (White crappie)					1	1
Sunfish Hybrid			1			
Totals	**8**	**8**	**14**	**3**	**11**	**11**

Fish 2011	**FR-A**	**FR-B**	**FR-3**	**FR-4**	**FR-C**	**FR-D**
Ambloplites rupestris (Rock bass)			1			1
Catostomus commersonii (White Sucker)						1
Cyprinus carpio (Common carp)	1					1
Etheostoma nigrum (Johnny darter)	1			1		
juvenile minnow				1		1
Lepomis cyanellus (Green sunfish)	1					1
Lepomis gibbosus (Pumpkinseed)	1	1	1	1		1
Lepomis macrochirus (Bluegill)		1	1	1		
Micropterus dolomieu (Smallmouth bass)				1		
Micropterus salmoides (Largemouth bass)		1				
Neogobius melanostomus (Round goby)				1		1
Notropis hudsonius (Spottail Shiner)		1	1	1		1
Notropis sp (Common Shiner)				1		1
Notropis wickliffi (Channel Shiner)				1		
Perca flavescens (Yellow perch)				1		1
Totals	**4**	**4**	**4**	**10**	**0**	**10**

Fish 2012	FR-A	FR-B	FR-3	FR-4	FR-C	FR-D
Ambloplites rupestris (Rock bass)	1	1	1	1		
Aplodinotus grunniens (Freshwater drum)		1				
Carpiodes cyprinus (Quillback)	1		1	1		1
Catostomus commersonii (White Sucker)	1				1	1
Cyprinus carpio (Common carp)	1	1	1		1	1
Dorosoma cepedianum (Gizzard Shad)			1	1	1	1
Etheostoma nigrum (Johnny darter)	1		1	1		
Etheostoma sp. (Darter)			1	1	1	1
Ictiobus cyprinellus (Bigmouth buffalo)	1					
Lepomis cyanellus (Green sunfish)	1					
Lepomis gibbosus (Pumpkinseed)	1	1				
Lepomis macrochirus (Bluegill)	1	1			1	1
Micropterus dolomieu (Smallmouth bass)	1		1	1	1	1
Micropterus salmoides (Largemouth bass)	1	1	1	1	1	1
Morone americana (White perch)			1	1	1	1
Neogobius melanostomus (Round goby)				1	1	1
Notropis atherinoides (Emerald Shiner)			1	1	1	1
Notropis hudsonius (Spottail Shiner)				1		
Notropis sp (Common Shiner)	1				1	
Perca flavescens (Yellow perch)	1	1	1	1	1	1
Pimephales notatus (Bluntnose Minnow)	1		1	1	1	1
Pimephales promelas (Fathead Minnow)		1	1	1		
Pimephales vigilax (Bullhead Minnow)				1		
Pomoxis nigromaculatus (Black Crappie)	1	1	1	1	1	
Pumpkinseed X Green Sunfish Hybrid	1					
Totals	16	9	14	16	14	13

Appendix B. Benthic macroinvertebrate species collected at each sampling location during 2009-2012. A "1" indicates presence on at least one sampling date. Highlighted species are considered invasive for the purposes of this project.

Macroinvertebrates 2009	**FR-A**	**FR-B**	**FR-3**	**FR-4**	**FR-C**	**FR-D**
Amnicola sp. (Right Handed Snail)	1		1			
Argia sp. (damselfly)	1					
Belostoma sp. (Giant water bug)			1	1		
Bulimus sp. (Right Handed Snail)	1	1		1		
Caecidotea sp. (isopod)	1	1	1	1		
Callibaetis sp. (mayfly)	1	1				
Callocorixa sp. (Waterboatman)	1					
Cenocorixa sp. (waterboatman)	1			1		
Chironomidae (bloodworm larvae)	1	1		1	1	1
Corisella sp. (waterboatman)	1	1				1
Corixidae (waterboatman)	1			1		1
Crangonyx sp. (amphipod)		1		1		
Dineutus sp. (whirligig beetle)				1		
Dreissena polymorpha (zebra mussel)	1	1	1	1	1	1
Echinogammarus ischnus (amphipod)					1	1
Enallagma sp. (damselfly)	1	1	1	1	1	1
Ferrisia sp. (Freshwater limpet)	1			1		
Fossaria sp. (Right Handed Snail)	1					
Gammarus sp. (amphipod)	1	1	1	1	1	
Gerridae *(water strider)*				*1*		
Gyraulus sp. (Disc-Shaped Snail)	1		1			
Haliplus sp. (Crawling Water Beetle)	1					
Helisoma sp (Snail)				1		
Hespercoriza sp. (waterboatman)	1	1	1			
Hyalella azteca (amphipod)	1	1	1			
Limnoporus sp. (Water strider)					1	
Monoporeia sp. (amphipod)		1		1		
Nehalennia sp. (damselfly)	1			1		
Neogerris sp. (Waterstrider)			1			
Nepidae sp. (Water Scorpion)				1		
Notonecta sp. (Backswimmer)			1	1		
Orconectes rusticus (rusty crayfish)			1			1
Orconectes virilis (native crayfish)	1					
Palmacorixa sp. (Waterboatman)	1	1	1	1		1
Physella sp. (Left Handed Pond Snail)	1	1	1	1		1

Pleurocera sp. (Right Handed Snail)	1	1		1		
Pseudostenophylax sp. (Caddisfly)						1
Ramphocorixa sp. (Waterboatman)	1			1		
Ranatra sp. (Water Scorpion)			1	1		
Sigara sp. (Waterboatman)			1			
Stagnicola sp. (Snail)	1		1			
Stenonema sp. (mayfly)			1	1		
Trepobates sp. (Water strider)			1			
Trichocorixica sp. (waterboatman)	1	1		1		1
Trichoptera (Caddisfly larvae)	1			1		
Valvata sp. (Right Handed Snail)	1					
Totals	29	16	19	26	6	11

Macroinvertebrates 2010	**FR-A**	**FR-B**	**FR-3**	**FR-4**	**FR-C**	**FR-D**
Baetis hiemalis (mayfly)	1					
Belostoma sp. (Giant water bug)	1				1	
Caenis sp. (mayfly)		1	1			
Coenagrion sp. (damselfly)		1				
Corixidae (waterboatman)			1	1		
Crangonyx sp. (amphipod)		1				
Cymetra (waterboatman)				1		
Dreissena polymorpha (zebra mussel)	1	1	1	1	1	1
Echinogammarus ischnus (amphipod)	1	1	1			1
Enallagma sp. (damselfly)			1	1		1
Ephemerella sp. (mayfly)		1				1
Erythemus sp. dragonfly)	1	1				
Ferrisia sp. (Freshwater limpet)	1					
Gammarus sp. (amphipod)	1		1			
Hataerina sp. (damselfly)		1				
Hespercoriza sp. (waterboatman)	1					
Hyalella azteca (amphipod)		1	1	1		
Hydrachnidia (water mite)	1					1
Ischnura sp. (damselfly)				1		
Lestes sp. (dragonfly)	1		1	1		
Macrobdella sp. (leech)		1				
Mesovelia mulsanti (water treader)			1			
Metrobates (true bug)			1			
Monoporeia sp. (amphipod)	1	1	1	1		1
Orconectes rusticus (rusty crayfish)		1	1			1
Pleurocera sp. (Right Handed Snail)		1				
Rhirhrogena sp. (mayfly)						1
Sigara sp. (Waterboatman)	1		1	1		
Vestidae (damselfly)			1			
Totals	**12**	**13**	**14**	**9**	**2**	**8**

Macroinvertebrates 2011	**FR-A**	**FR-B**	**FR-3**	**FR-4**	**FR-C**	**FR-D**
Atherix sp.				1		
Baetis hiemalis (mayfly)				1		1
Caecidotea sp. (isopod)	1			1		1
Caenis sp. (mayfly)	1		1	1		1
Callibaetis sp. (mayfly)			1			
Chironomidae (bloodworm larvae)	1	1	1	1	1	1
Corixidae (waterboatman)		1		1		1
Crangonyx pseudogracilis (amphipod)		1				
Crangonyx sp. (amphipod)		1		1		
Diplectrona	1		1	1		
Dixidae		1				
Dreissena polymorpha (zebra mussel)	1	1	1	1	1	1
Echinogammarus ischnus (amphipod)	1	1				
Enallagma sp. (damselfly)	1		1			
Ephemerella sp. (mayfly)		1		1		1
Fossaria sp. (Right Handed Snail)				1		
Gammarus fasciatus (amphipod)	1	1		1		
Gammarus sp. (amphipod)	1	1	1	1		
Gerridae *(water strider)*				1		
Goniobasis		1		1		
Helisoma sp (Snail)				1		
Hirudinea	1	1	1			
Hyalella azteca (amphipod)	1	1		1		
Hydrachnidia (water mite)		1	1	1		1
juvenile corixidae			1			
Leptocerus	1					
Molanna	1					
Monoporeia sp. (amphipod)		1	1	1		
Nehalennia sp. (damselfly)	1		1			
Neoephemera (mayfly)		1	1			
Notonecta sp. (Backswimmer)				1		
Orconectes propinqus	1					
Orconectes virilis	1		1			1
Paramyctiophylax	1					
Peltodytes (spotted beetle)	1					
Physella sp. (Left Handed Pond Snail)			1			
Planaridae	1					
Pleurocera sp. (Right Handed Snail)	1	1		1	1	
Ramphocorixa sp. (Waterboatman)		1	1			

Semiaquatic Coleoptera			1			
Siphlonuridae (mayfly)		1				
Tanyderidae		1		1		
Tarnetrum Sympetrum	1					
Thaumaleidae	1			1		1
Trichoptera (Caddisfly larvae)			1			
Tricorythodes (mayfly)	1	1	1			
Totals	**23**	**21**	**19**	**23**	**3**	**10**

Macroinvertebrates 2012	FR-A	FR-B	FR-3	FR-4	FR-C	FR-D
Amnicola sp. (Right Handed Snail)			1			
Belostoma sp. (Giant water bug)		1	1	1		
Caenis sp. (mayfly)		1				1
Chironomidae (bloodworm larvae)	1		1	1	1	1
Dreissena polymorpha (zebra mussel)	1	1	1	1	1	
Ferrisia sp. (Freshwater limpet)						1
Gammarus sp. (amphipod)	1	1		1		
Gyraulus sp. (Disc-Shaped Snail)		1				1
Hespercoriza sp. (waterboatman)		1				1
Hydrachnidia (water mite)	1	1	1	1	1	1
Ischnura sp. (damselfly)	1	1	1	1	1	1
Macrobdella sp. (leech)	1	1				1
Notonecta sp. (Backswimmer)		1	1			
Orconectes rusticus (rusty crayfish)	1	1	1			1
Orconectes virilis (native crayfish)	1	1	1			
Palmacorixa sp. (Waterboatman)	1	1		1		1
Physella sp. (Left Handed Pond Snail)	1	1		1	1	1
Pleurocera sp. (Right Handed Snail)	1	1	1	1		1
Ranatra sp. (Water Scorpion)	1	1	1	1		
Stagnicola sp. (Snail)	1			1		1
Trichocorixica sp. (waterboatman)	1			1	1	1
Trichoptera (Caddisfly larvae)				1		
Valvata sp. (Right Handed Snail)	1	1				
Totals	15	17	11	13	6	14

Appendix C. Zooplankton species collected at each sampling location during 2009-2012. A "1" indicates presence on at least one sampling date. Highlighted species are considered invasive for the purposes of this project.

Zooplankton 2009	**FR-A**	**FR-B**	**FR-3**	**FR-4**	**FR-C**	**FR-D**
Acanthocyclops vernalis	1	1	1			
Ascomorpha sp.					1	
Asplanchna sp.		1	1	1	1	1
Bosmina longirostris	1	1		1	1	1
Brachionus sp.			1	1	1	1
Cephalodella sp.	1					
Ceriodaphnia sp.	1	1	1	1		1
Chydorus sp.		1	1			1
Daphnia longiremis	1	1	1			
Daphnia mendotae	1	1				
Daphnia pulicaria	1	1				
Diacyclops thomasi	1					
Diaphanosoma sp.	1	1	1	1	1	1
Eubosmina sp.					1	1
Euchlanis sp.		1	1			
Harpacticoid Copepod				1		
Harpacticoid Nauplii		1				
Keratella sp.	1	1	1	1	1	1
Leptodiaptomus siciloides	1	1	1			
Mesocyclops edax	1	1		1		
Monostyla sp.					1	
Ostracod	1	1	1	1	1	
Platyias patulus						1
Polyarthra sp.	1					
Skistodiaptomus oregonesis	1	1		1	1	
Synchaeta sp.			1	1	1	1
Tricocerca sp.				1		
Totals	15	16	12	12	11	10

Zooplankton 2010	**FR-A**	**FR-B**	**FR-3**	**FR-4**	**FR-C**	**FR-D**
Acanthocyclops robustre	1					
Acanthocyclops vernalis			1			
Ascomorpha sp.					1	
Asplanchna sp.						1
Bosmina longirostris	1	1	1	1	1	
Brachionus sp.					1	1
Calanoid nauplius	1	1				
Ceriodaphnia sp.	1	1	1		1	1
Chydorus sp.	1	1	1	1	1	1
Copepoda sp.	1		1	1	1	
Cyclopoid nauplius				1		1
Daphnia longiremis	1					
Daphnia lumholtzii		1				
Daphnia magna						1
Daphnia parrula	1					
Daphnia pulicaria	1					
Diaphanosoma sp.				1		
Epiphanes			1			
Eubosmina sp.			1			1
Euchlanis sp.	1	1	1	1		1
Gastropus Stylifer	1					
Harpacticoid Nauplii	1		1			1
Keratella sp.	1	1	1	1	1	1
Lecane					1	
Ostracod					1	1
Platyias patulus						1
Polyarthra sp.	1		1			
Synchaeta sp.						1
Tricocerca sp.	1			1		
Totals	**15**	**7**	**11**	**8**	**9**	**13**

Zooplankton 2011	**FR-A**	**FR-B**	**FR-3**	**FR-4**	**FR-C**	**FR-D**
Acanthocyclops vernalis	1	1	1	1		1
Alonas sp.					1	
Bosmina longirostris		1				1
Bythotrephes longimanus		1				
Caddisfly, juvenile		1				
Chironomus, juvenile		1	1	1		1
Daphnia longiremis	1	1				
Daphnia pulicaria	1					
Daphnia retrocurva		1		1		
Diacyclops thomasi	1	1				
Diaphanosoma sp.	1	1	1			1
Dicyclops nanus	1		1	1		1
Eubosmina sp.	1	1		1		
Leptodiaptomas ashlandi		1				1
Leptodiaptomus sicilis	1					
Leptodiaptomus siciloides	1	1		1		1
Leptodora kindti	1	1				
Mesocyclops edax	1	1		1	1	1
Ostracod	1	1	1	1	1	1
Skistodiaptomus oregonesis	1	1		1		
Totals	**13**	**16**	**5**	**9**	**3**	**9**

Zooplankton 2012	FR-A	FR-B	FR-3	FR-4	FR-C	FR-D
Acanthocyclops vernalis	1	1	1	1	1	1
Alona sp.	1	1				
Bosmina longirostris	1		1	1		1
Chydorus sp.		1	1	1	1	1
Daphnia magna			1			1
Daphnia pulicaria		1	1		1	1
Diaphanosoma sp.		1	1		1	1
Eubosmina sp.	1	1	1	1		1
Leptodiaptomus siciloides	1	1				1
Mesocyclops edax	1	1				
Ostracod	1	1	1	1	1	1
Skistodiaptomus oregonesis	1	1				
Totals	8	10	7	5	5	8