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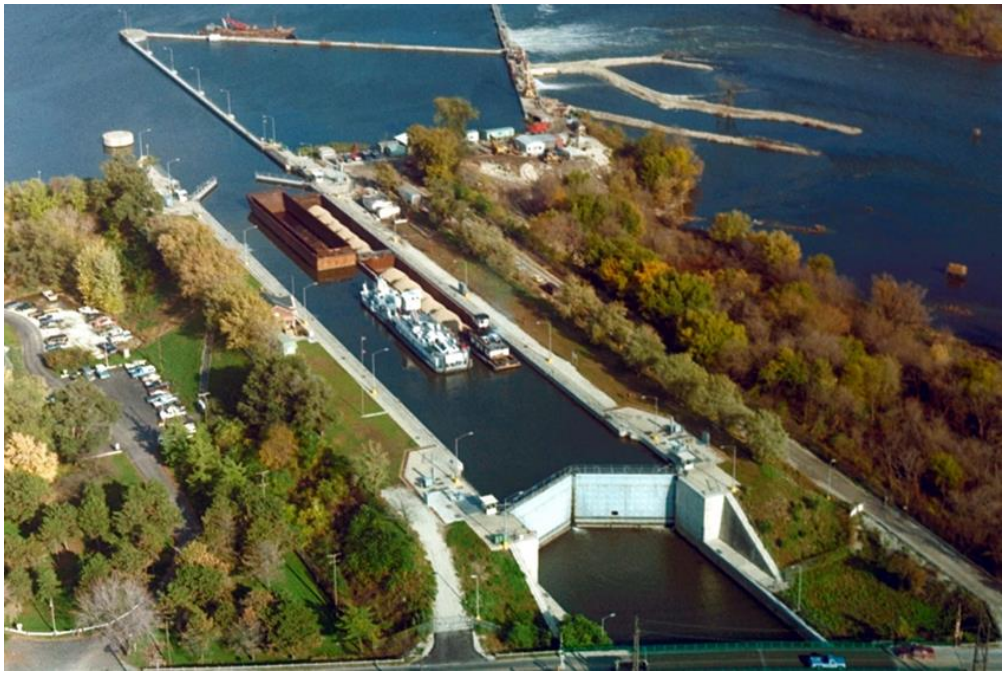
Evaluating the potential responses of native fish and mussels to proposed separation of Lake Michigan from the Illinois River Waterway at Brandon Road Lock and Dam



Altenritter, Matthew E.; Casper, Andrew F.

INHS Technical Report 2018 (29)

Prepared for Illinois Department of Natural Resources, Division of Fisheries

Illinois River Biological Station
704 North Schrader Avenue
Havana, IL 62644

Issued on 9 /24/2018

Unrestricted for immediate online release

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Acknowledgments

Several people and institutions were instrumental in the comprehensive nature of the data used in this report. These include Nathan Grider, Kevin Irons, Stephen Pescitelli, Diane Shasteen, and Tristan Widloe of the Illinois Department of Natural Resources Division of Fisheries, Jason DeBoer, Doyn Kellerhals, Kristopher Maxson, Olivea Mendenhall, Levi Solomon, Alison Stodola, Jeremy Tiemann, and Andrya Whitten of the Illinois River Biological Station, John McCabe of the Forest Preserves of Cook County, Jim Anderson of the Lake County Forest Preserve District, and Frank Veraldi of the U.S. Army Corp of Engineers. Support for this work was generously provided by the Great Lakes Restoration Initiative and Illinois Department of Natural Resources. Front cover photo of Brandon Road Lock and Dam was adopted from the United States Army Corps of Engineers, Rock Island District website at http://www.mvr.usace.army.mil/Missions/Navigation/Lock-and-Dam-Information/Lockport-Lock-and-Dam-Copy/.

Executive Summary

The Brandon Road Lock and Dam (BRLD) location is currently a focal point for developing a barrier to keep the four Asian carp species (i.e., Silver, Bighead, Grass, and Black) from entering Lake Michigan and the Great Lakes Basin. This location is being considered because it connects the Illinois River to the Chicago Area Waterway System (CAWS) and, ultimately, Lake Michigan. While the possible effect of the proposed barrier on commercial and recreational navigation is being widely debated, the impacts of the barrier on millions of dollars in aquatic resources restoration projects and decades of management efforts are less thoroughly considered.

In addition to blocking movements of non-native Asian carps, any barrier will also potentially eliminate upriver connectivity that is important to a variety of native fishes and freshwater mussels (hereafter referred to as mussels). Based on surveys of native fishes, we know that fish distribution and species richness in the Illinois River are steadily improving. However, very little is known about how or when fish move between habitats, and to what degree any of these might have been utilizing the lock chamber at BRLD to move upriver. The development of an upstream fish barrier, impassable by either non-native or native fishes, has potential unintended consequences for populations of native fish. We summarized long-term trends in aquatic resources to illustrate both what is known and what is uncertain about a barrier that interrupts upriver connectivity. This includes details about several potential impacts that were developed using the best and most comprehensive information collected by the IDNR-Division of Fisheries (IDNR-DF), Illinois Natural History Survey (INHS), and from the peer-reviewed literature. The summary focuses on long-term trends in species richness and presence or absence over time, found in the neighboring tributary rivers including the Des Plaines River, DuPage River, Kankakee River, Fox River, and upper Illinois River.

The primary impact of the proposed barrier project on native fish and mussels is the blockage of upriver fish movement from the Illinois River and its tributaries, past BRLD into the Des Plaines River and CAWS. Improvements in aquatic habitat quality and connectivity through dam removals upstream of BRLD have, and will continue to open additional aquatic habitat. Long-term fish community surveys in the Des Plaines River suggest numerous species of fish currently pass through the lock at BRLD, and that this helped some native fishes and functional groups such as the pollution intolerant Rosyface shiner (*Notropis rubellus*) re-establish in these formerly degraded reaches after conditions improved (Pescitelli 2017). Despite a record of improvement (similar to fishes) over recent decades, mussel diversity and numbers are currently limited in the Des Plaines River above BRLD. Recruitment of these invertebrates requires both a source of young and the fish-hosts to carry them into newly improved habitats. Data suggest there is a strong source of young below BRLD: seventeen species of mussels not currently present above BRLD have been documented just 21 kilometers or less below BRLD in the Dresden Pool of the upper Illinois River (an easily covered distance for fish). Thus, any reduction in upriver connectivity will be a threat to the ongoing improvement in both upstream fish and mussel populations.

The extent to which the current fish community above BRLD relies on connectivity through the lock to maintain community stability is uncertain. Though it appears likely continued increases in species richness upriver of BRLD would be truncated after implementation of a barrier, further targeted investigations into trends in recruitment, movement, and abundance may help guide choices of appropriate mitigation efforts. This information could also inform efforts to prioritize the management, translocation, or stocking used to supplement fish-hosts required for rehabilitation of mussels if a barrier is implemented at BRLD.

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Introduction

The rapid inland establishment and spread of aquatic nuisance species (ANS) like the Asian carps has been greatly accelerated by the presence of the nation's waterways and navigation infrastructure over the last century (Ricciardi 2006, Jacobs and Keller 2017). The resulting spread of invaders both threatens the integrity and stability of aquatic ecosystems and has resulted in enormous ecological and economic damages (USACE 2014). The Laurentian Great Lakes and Mississippi River basins have not been spared from this issue. While some seasonal or flood event based exchange between these two basins has likely occurred before the 1900's, construction of the Chicago Sanitary and Ship Canal after 1900 began an era of much greater interbasin transfer (Mills et al. 1993). This is when the city of Chicago reversed the flow of the Chicago River with the goal of flushing sewage into the Illinois River instead of Lake Michigan (Olson and Morton 2017). While the discharge of municipal and industrial effluent itself likely acted as a chemical barrier in the short-term, the reversal of flow substantially increased the depth of water in the river and fostered the development of extensive commercial navigation. This development coincided with the construction of a network of tributaries in the Chicago metro area (Chicago Area Waterway System; CAWS), and resulted in five water connections between the Great Lakes Basin and the Mississippi River Basin that all converge upstream of the BRLD site (USACE 2014). Together, these two changes had the intended effect of decreasing water-bourne disease outbreaks and tremendously benefited the regional shipping economy (EDRG 2016). However, they also led to the unintended consequences of steadily accelerating the number and economic costs of ANS moving between basins (Jacobs and Keller 2017).

In 2014, the United States Army Corp of Engineers (USACE) led the Great Lakes and Mississippi River Interbasin Study (GLMRIS), which was charged with outlining several potential ANS control options including another electric barrier, without endorsing any particular one. This precluded evaluation of the consequences to aquatic natural resources like fish and mussels (USACE 2014). With the subsequent release of the GLMRIS Brandon Road Draft Integrated Feasibility Study and Environmental Impact Statement report (USACE 2017), the BRLD site has been identified by as a recommended location for implementation of single-point control of upstream fish movement. However, the implications of such a barrier on the State of Illinois' investments in managing aquatic resources for the citizens of the State was not considered. In particular, undermining the movement of recreationally and commercially important native fish and mussels from the Illinois River into the restored and improving habitats of the Des Plains River and CAWS was not adequately documented or assessed.

Currently, passage through the lock chamber is the only pathway for upriver fish movement due to high rate of flow resulting from the 34 feet of hydraulic head above the dam (USACE 2007). While there is no direct tagging- or telemetry-based evidence of upstream passage at BRLD, indirect evidence can be found in recent IDNR-DF fish surveys on the upper Des Plaines River that suggest some species may have originated from areas below BRLD (Pescitelli 2017). The proposed BRLD fish barrier includes an engineered approach channel, complex noise, flushing locks, and an electric barrier (USACE 2017). While these are expressly intended to prevent the upriver movement of Asian carps, they also reduce or eliminate the possibility of upriver passage for native fish, mussels, and other aquatic organisms. If native fish are using the lock chamber at BRLD to move upriver, truncating this movement may eliminate any supplemental connectivity of fish from downstream locations and prevent future re-establishments of native fish or mussels not currently inhabiting the upper Des Plaines River or CAWS.

Substantial progress towards improving aquatic connectivity and habitats in areas above BRLD such as the upper Des Plaines River have been made by many stakeholders including the IDNR, forest preserve districts, and the US Army Corp of Engineers (USACE). Much of this work has focused on dam removals throughout the Des Plaines River watershed and includes the removal of nine main stem dams (Pescitelli 2017) at a cost of approximately $8.8 million dollars (IDNR-OWR 2017; Appendix 1). Two additional main stem dams on the Des Plaines River are currently being considered for future removal and

once complete, will result in 177 kilometers of free-flowing habitat (Pescitelli 2017). The Forest Preserve Districts of Lake and Cook counties in Illinois have also implemented many habitat restoration initiatives within the Des Plaines River Watershed at an approximate cost of $12.2 million dollars (Jim Anderson and John McCabe *personal communication*, Appendix 2). These include an additional dam removal and multiple projects aimed at stabilizing stream banks, rehabilitating stream channels and riparian vegetation, restoring flatwoods and vernal pool habitat, and facilitating the establishment of native vegetation while removing invasive trees, shrubs, and other plants (Appendix 2). The USACE is also considering an additional $6.71 million dollar investment in the Des Plains River to reduce flooding and restore degraded ecosystems (USACE 2015). In total, investments in habitat rehabilitation in the upper Des Plaines River watershed exceed $27 million dollars. Thus, it is important to know how native fish and mussels would be affected by the proposed barrier, to understand the best ways to maximize the benefits associated with significant investments in aquatic habitat improvements.

The costs of efforts to ameliorate any consequences of a fish barrier initiated at BRLD also should consider the potential of the Des Plaines River to function as a "self-sustaining" system. Assuming truncation of upriver connectivity is the primary consequence of a fish barrier at BRLD, upriver fish and mussel communities may be required to self-recruit, recruit fish from the neighboring CAWS, or possibly from Lake Michigan. Mitigation may therefore be necessary to supplement species that do not appear to be self-sustaining, or for species that are currently not present, but may have likely moved upriver at BRLD over the lifetime of the project.

The goal of this report is to summarize an understanding of the potential losses and gains among native fishes and mussels inhabiting the Des Plaines River resulting from the proposed fish barrier at BRLD. The specific objectives include, 1) the development of a conceptual model to highlight potential unintended consequences of a barrier, 2) documentation of the on-going improvement over time of the native fishes and mussels upstream of the proposed barrier, 3) identification of uncertainties regarding the potential consequences of fish barrier on native fishes and mussels, and 4) development of potential mitigation actions or plans that may help ameliorate negative outcomes for native fishes and mussels.

Methods

Conceptual model

We summarize what is known and unknown about the project using a conceptual model whose primary objective is to show potential pathways of change resulting from the proposed barrier at BRLD (Figure 1). We suggest the *primary stressors* in the conceptual model are the ANS control mechanisms (e.g., electric barrier, complex noise, engineered channel, and flushing locks etc.) that cumulatively produce a loss of upriver connectivity. The loss of upriver connectivity is thus an aggregate form of *primary stress* and we suggest this would result in reduced richness and abundance of native fishes and truncated richness of mussels (Tiemann et al. 2007).

We hypothesize that native fish richness (*a response category*) and abundance (*a separate response category*) above BRLD will both respond negatively to a fish barrier at BRLD because upriver movements of all fishes would be eliminated. Continuation of the ongoing rehabilitation of native fish richness would then be reliant upon passive immigration from Lake Michigan or active translocation or stocking efforts. Moreover, changes in species richness could affect functional group representation (*a third response category*), which also serves as a proxy of ecosystem health (Karr 1999). A final consideration is that any species currently found in low abundance above BRLD could have an increased susceptibility to stochastic extirpation events like disease, contamination, or summer/winter kills.

Freshwater mussel richness (*a fourth response category*) is also hypothesized to respond negatively to a fish barrier at BRLD because mussel larvae (i.e., glochidia) need to be transported into restored habitats by a fish-host (Sietman et al. 2001). Therefore, the elimination of upriver connectivity for any glochidia infested native fishes at BRLD would inadvertently prevent this life stage from accessing areas above BRLD, which currently hosts fewer species of mussels than areas below BRLD such as the Kankakee River (Price et al. 2012b), the lower Des Plaines River (EnviroScience 2017), or the upper Illinois River immediately above Dresden Island Lock and Dam (EAE 2014).

Though not the primary focus of the conceptual model, we also have attempted to connect a few select *impacted sectors* in the model in order to assess any trade-offs between aquatic resources and human use practices of a barrier at BRLD. These impacted sectors include river rehabilitation targeting the Des Plaines River above BRLD, navigation and shipping, and the continued possibility of downstream ANS transfer from the Great Lakes to the Mississippi River basin.

Quantitative metrics

To use the conceptual model to evaluate how the proposed barrier might change the recovery trajectory of the upper river, stakeholders also need to understand the recent and historical trends of the resource categories (native fishes and mussels) currently inhabiting areas near BRLD. This includes not only the Des Plaines River above and below the BRLD, but also neighboring tributaries that may act as alternate or secondary sources for re-establishment of native fish and mussels. Therefore, along with the data collected in Des Plaines River, we also informed the model with fish and mussel surveys from the Kankakee River, DuPage River, Fox River, and upper Illinois River. Patterns and trends in native fish and mussel richness and presence or absence over time for those tributaries over time were compiled from the IDNR-DF and Illinois Natural History Survey. These included IDNR-DF basin surveys carried out every five years on rivers and streams throughout Illinois conducted using gear-standardized fish sampling protocols (Appendix 3). Survey data was collected from main stem sites within the tributaries (e.g., main stem Kankakee River) and partitioned into sections below or above the lowest main stem dam on the various rivers. In addition to reporting overall fish species richness within these river partitions, newly documented species in each basin survey were highlighted to emphasize cumulative community changes over time. The proportion of all surveys during which a species was documented was also assessed as a measure of species continuity over time.

Freshwater mussel survey information is more limited than fish data for this region though recent surveys have been carried out on the Des Plaines (Price et al. 2012a; EnviroScience 2017), Kankakee (Price et al. 2012b), DuPage (Price et al. 2012a), Fox (Shasteen et al. 2013), and upper Illinois Rivers (EAE 2014). From these reports, mussel richness was summarized as live plus recently dead individuals based on the presence of soft tissue and the condition of the shell. We also examined mussel fish-host relationships to identify mussels that may be unable to naturally re-colonize the Des Plaines River above BRLD if fish hosts are prevented from moving upriver. This was done by comparing a list of native fish species (as summarized here) with a list of the known hosts of extant mussel species (as summarized here). The INHS Freshwater Mussel Host Database (INHS-FMHD) was then queried to ascertain overlap between these two groups (http://wwx.inhs.illinois.edu/collections/mollusk/data/freshwater-mussel-host-database).

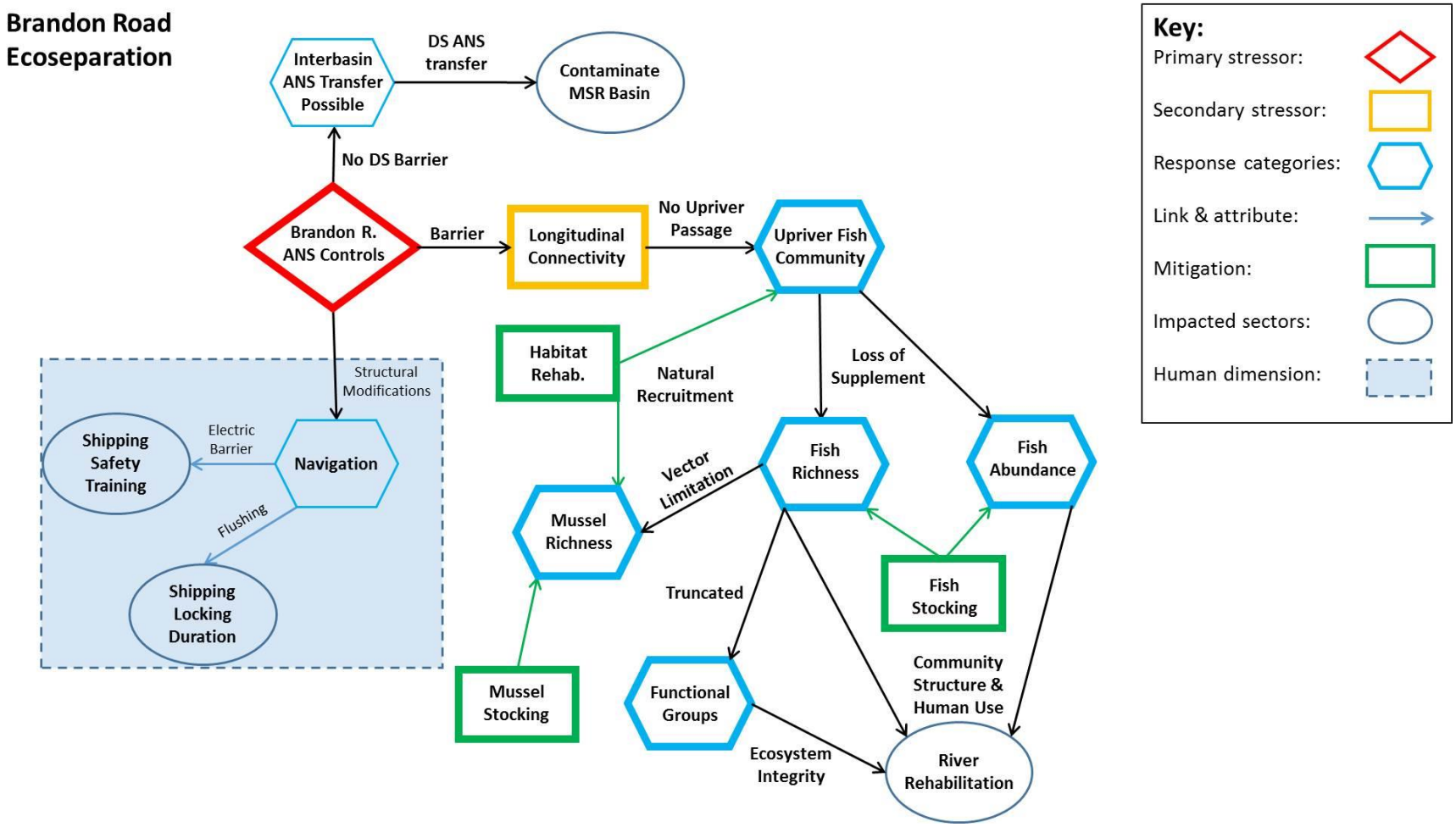

Figure 1. Conceptual model of hypothesized pathways of aquatic changes resulting from ANS controls at Brandon Road Lock and Dam. Limited human dimension aspects are included but were not the primary emphasis of the diagram.

Results

Des Plaines River

Five main stem fish surveys on the Des Plaines River between 1983 and 2013 documented a cumulative total of 77 unique native species (Table 1). Native fish species richness in the Des Plaines River has increased over time at both lower and upper main stem stations (Figure 2). Cumulative species richness as measured during the first basin survey in 1983 was 17 in the lower Des Plaines River and 40 in the upper Des Plaines River. By the 2013 basin survey, cumulative richness reached 40 and 71 in the lower and upper sections respectively. The number of newly observed species across the four basin surveys since the first in 1983 varied between 6 and 19 (Table 2 and 3). As of 2013, there were four native species and one non-native species surveyed in the lower Des Plaines River that have yet to be detected above BRLD during basin surveys. These included Bigmouth buffalo, Golden redhorse, Longear sunfish, Brook silverside and Grass carp.

Eight species of freshwater mussels were collected in the Des Plaines River above BRLD between 2009 and 2011 (Table 4). However, limited sampling efficiency due to safety concerns may mean this is an underestimate (D. Shasteen *personal communication*). Mussel surveys in the lower Des Plaines River and upper Illinois River (i.e., above Dresden Island Lock and Dam) within approximately 21 river kilometers of BRLD, revealed twenty-five species of mussels including two state threatened species (Black Sandshell, Purple Wartyback) inhabiting areas near the Dresden Island nuclear station in 2014 (EAE 2014). Seventeen of these twenty-five species have not recently been surveyed above BRLD. An additional species, the Flat Floater, was collected (approximately 3 rkm downriver of BRLD) in a survey conducted in 2017 (EnviroScience 2017).

Kankakee River

The Kankakee River hosts a rich fish community with 93 native species observed among main stem sampling sites surveyed between 1994 and 2010 (Table 1). The number of newly observed species during basin surveys varied from 4 to 15 and 3 to 20 in the lower and upper river respectively (Tables 5, 6). A total of 13 fish species were surveyed below the lowermost dam that have yet to be observed above and include 10 native species (Fantail darter, Goldeye, Mooneye, Redear sunfish, Sauger, Skipjack herring, Spottail shiner, Trout perch, and White bass) and three non-native species (Goldfish, Round goby, and White perch). Three of these species have been documented in the Des Plaines River above BRLD (Table 7). There are currently 31 species present in the Kankakee River that have yet to be documented in the Des Plaines River (Table 8). Importantly, there is also evidence of probable movement of fish from the Kankakee River to the upper Des Plaines River. Recent genetic analyses of Rosyface shiner (*Notropis rubellus*) sampled in the upper Des Plaines River indicates a shared haplotype with individuals originating in the Kankakee River, suggesting this small-bodied fish moved through the lock chamber at BRLD (P. Willink *unpublished data*). Moreover, it was not until the most recent basin survey in 2013 that this species was even collected in the upper Des Plaines River (Pescitelli 2017).

The Kankakee River also hosts a rich mussel community with 25 extant species documented in a recent survey (Price et al. 2012b). This includes the state threatened Black Sandshell (*Ligumia recta*), Purple Wartyback (*Cyclonaias tuberculata*), and Spike (*Elliptio dilatata*). Eighteen species of mussels found in Kankakee River main stem areas have not recently been surveyed in the Des Plaines River above BRLD (Table 4). However, 11 of these species have been documented in the Dresden pool near the confluence of the lower Des Plaines and Kankakee Rivers (Table 4).

Table 1. Cumulative native fish species richness by river tallied over multiple Basin Surveys conducted by the Illinois Department of Natural Resources Division of Fisheries. Gear types include AC electrofishing (BE), seine haul (SH), backpack electrofishing (PE), and DC electrofishing (BED).

River	Years Sampled	Gears	Native Species Richness
DuPage River	1983, 1997, 2002/2003, 2008, 2013	BE, SH	**55**
Des Plaines River	1983, 1997, 2003, 2008, 2013	BE, SH, BED	**77**
Fox River	1996, 2002, 2007, 2012	BE, SH, BED	**76**
Kankakee River	1994, 2000, 2005, 2010	BE, SH, PE	**96**

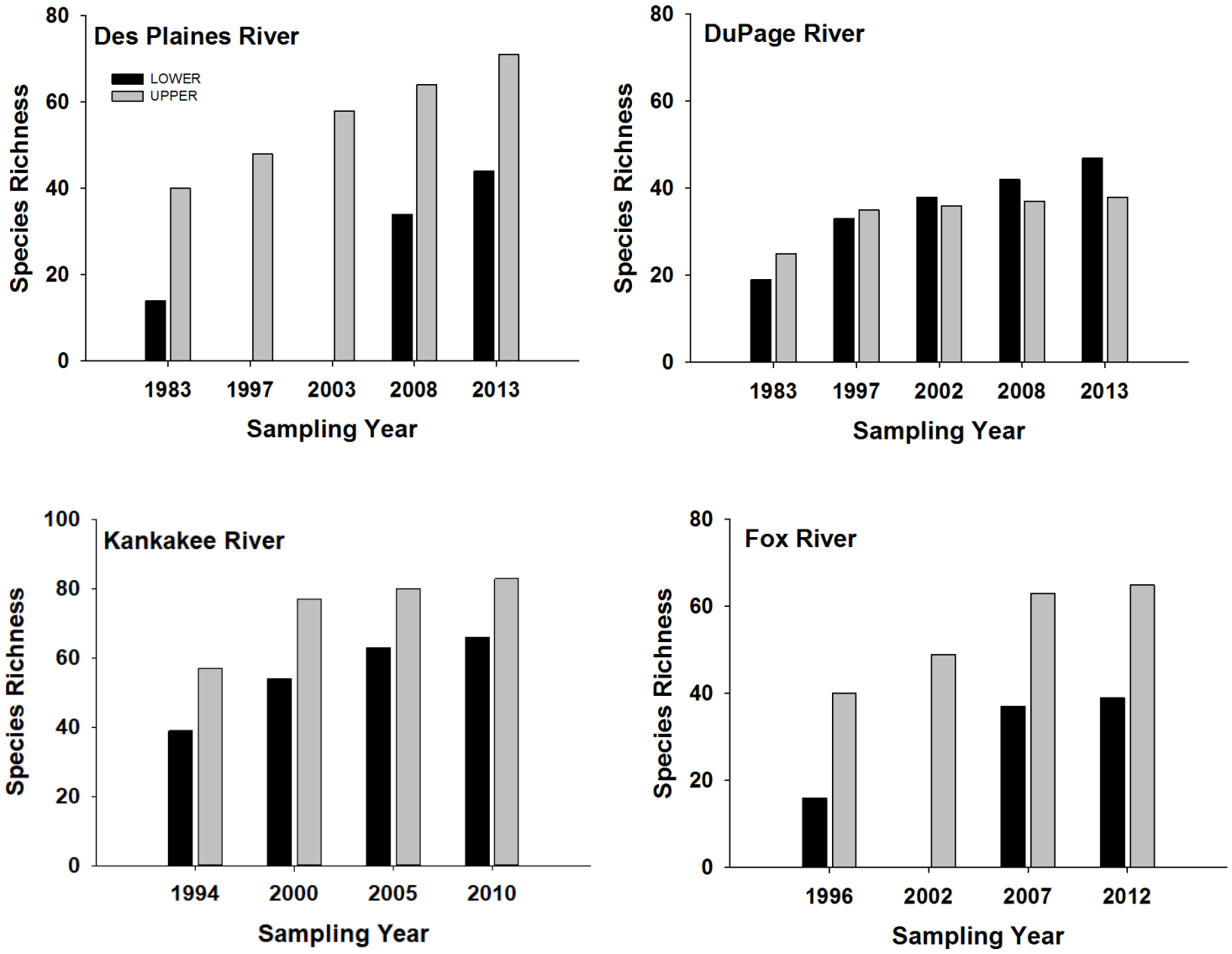

Figure 2. Changes in cumulative fish species richness over time measured during the Illinois Department of Natural Resources-Division of Fisheries Basin Surveys in the Des Plaines, DuPage, Kankakee and Fox Rivers. Lower (black bar) and Upper (grey bar) river segments include stations sampled below and above the lowermost dams on each river respectively.

Table 2. Fish species richness surveyed in the *lower* Des Plaines River between 1983 and 2013. An "X" indicates presence and grey shading indicates newly surveyed species. Fishes in red are non-native species that were surveyed during basin surveys.

	Basin Survey				Basin Survey		
Species	**1983**	**2008**	**2013**	**Species**	**1983**	**2008**	**2013**
Black bullhead	X			Bowfin			X
Black crappie	X		X	Brook silverside			X
Bluegill	X	X	X	Longear sunfish			X
Bullhead minnow	X			Orangespotted sunfish			X
Carp	X	X	X	Pumpkinseed			X
Carp x Goldfish hybrid	X	X		Redear sunfish			X
Creek chub	X			Silver redhorse			X
Emerald shiner	X	X		Spotted sucker			X
Gizzard shad	X	X	X	White bass			X
Golden shiner	X	X	X				
Goldfish	X	X	X	Cumulative No. Species	17	36	45
Green sunfish	X	X	X	Cumulative No. Non-Native Species	3	5	5
Largemouth bass	X	X	X	Cumulative No. Native Species	14	31	40
Quillback	X		X	No. Species by Year	17	30	31
Shorthead redhorse	X	X					
Smallmouth bass	X	X	X				
White sucker	X						
Bigmouth buffalo		X	X				
Blackstripe topminnow		X					
Bluegill x Green sunfish hybrid		X	X				
Bluntnose minnow		X	X				
Channel catfish		X	X				
Flathead catfish		X	X				
Freshwater drum		X	X				
Golden redhorse		X	X				
Grass carp		X					
Longnose gar		X	X				
Mosquitofish		X					
River carpsucker		X	X				
Rock bass		X					
Round goby		X					
Smallmouth buffalo		X	X				
Spotfin shiner		X	X				
Spottail shiner		X					
Threadfin shad		X					
Yellow bullhead		X	X				

Table 3. Fish species richness surveyed in the *upper* Des Plaines River between 1983 and 2013. An "X" indicates presence and grey shading indicates newly surveyed species. Fishes in red are non-native species that were surveyed during basin surveys.

	Basin Surveys						Basin Surveys				
Species	1983	1997	2003	2008	2013	Species	1983	1997	2003	2008	2013
Bigmouth shiner	X	X	X	X	X	Channel catfish		X	X	X	X
Black bullhead	X	X	X	X	X	Freshwater drum		X	X	X	X
Black crappie	X	X	X	X	X	Hornyhead chub		X	X	X	X
Blackside darter	X	X	X	X	X	Orangespotted sunfish		X	X	X	X
Blackstripe topminnow	X	X	X	X	X	Silver redhorse		X			
Bluegill	X	X	X	X	X	Spotted sucker		X	X	X	X
Bluegill x Green sunfish hybrid	X	X	X	X	X	Walleye		X	X	X	X
Bluntnose minnow	X	X	X	X	X	Yellow bass		X		X	X
Bowfin	X	X	X	X	X	Blackchin shiner			X		
Bullhead minnow	X	X				Central stoneroller			X	X	
Carp	X	X	X	X	X	Mimic shiner			X	X	
Carp x Goldfish hybrid	X	X		X	X	Mosquitofish			X		X
Central mudminnow	X	X		X		Redfin shiner			X		
Common shiner	X	X	X			Round goby			X	X	X
Creek chub	X	X	X	X	X	Sauger			X	X	X
Emerald shiner	X	X	X	X	X	Smallmouth buffalo			X	X	X
Fathead minnow	X	X	X	X	X	Spottail shiner			X	X	X
Gizzard shad	X	X	X	X	X	Warmouth			X	X	X
Golden shiner	X	X	X	X	X	Flathead catfish				X	
Goldfish	X	X	X	X	X	Logperch				X	X
Green sunfish	X	X	X	X	X	River carpsucker				X	X
Johnny darter	X	X	X	X	X	Striped shiner				X	
Largemouth bass	X	X	X	X	X	Suckermouth minnow				X	X
Northern pike	X	X	X	X	X	Threadfin shad				X	
Pumpkinseed	X	X	X	X	X	Banded killifish					X
Pumpkinseed x Green sunfish hybrid	X	X				Grass pickerel					X
Quillback	X	X	X	X	X	Iowa darter					X
Red shiner	X					Longnose gar					X
Rock bass	X	X	X	X	X	Muskellunge					X
Sand shiner	X	X	X	X	X	Redear sunfish					X
Shorthead redhorse	X					Rosyface shiner					X
Smallmouth bass	X	X	X	X	X						
Spotfin shiner	X	X	X	X	X	Cumulative No. Species	40	48	58	64	71
Stonecat	X		X	X	X	Cumulative No. Non-Native Species	3	3	4	4	4
Tadpole madtom	X	X	X	X	X	Cumulative No. Native Species	37	45	54	60	67
Unidentified Sunfish hybrid	X					No. Species by Year	40	42	49	54	55
White crappie	X		X	X							
White sucker	X	X	X	X	X						
Yellow bullhead	X	X	X	X	X						
Yellow perch	X		X	X	X						

Table 4. Extant mussels sampled in the Des Plaines and DuPage Rivers (2009 - 2011), Kankakee (2010), Fox (2010 – 2012), and upper Illinois River main stem areas (near Dresden Island Nuclear in 2014, between Seneca, IL and Morris, IL, in 2017). Species occurrence may be based on the presence of shells only (e.g., recently dead). Mussel sampling sites located between Seneca, IL and Morris, IL are approximately 21 rkm below Dresden Island Lock and Dam and 42 rkm below BRLD. State threatened species are denoted with an asterisk (*).

Common Name	Scientific Name	Des Plaines River (Live + Dead)	DuPage River (Live + Dead)	Kankakee River (Live + Dead)	Above Dresden Island Lock and Dam & Dredsen Nuclear (Live)	Below Dresden Island Lock and Dam (Live)	Illinois River (between Seneca & Morris IL; Live + Dead)	Fox River (Live + Dead)
Black Sandshell*	Ligumia recta			X	X	X		
Creeper	Strophitus undulatus		X	X	X	X	X	
Deertoe	Truncilla truncata			X	X	X	X	
Elktoe	Alasmidonta marginata			X	X	X	X	X
Ellipse	Venustaconcha ellipsiformis			X				
Fatmucket	Lampsilis siliquoidea	X	X	X	X	X		
Fawnsfoot	Truncilla donaciformis			X				
Flutedshell	Lasmigona costata			X	X	X	X	
Fragile Papershell	Leptodea fragilis			X	X	X	X	X
Giant Floater	Pyganodon grandis	X	X	X	X		X	X
Hickorynut	Obovaria olivaria						X	
Lilliput	Toxolasma parvum	X	X	X	X			
Mapleleaf	Quadrula quadrula			X	X	X	X	X
Monkeyface	Quadrula metanevra			X				
Mucket	Actinonaias ligamentina			X	X	X	X	
Paper Pondshell	Utterbackia imbecillis	X			X			X
Pimpleback	Quadrula pustulosa			X	X	X	X	X
Pink Heelsplitter	Potamilus alatus			X	X	X	X	
Pink Papershell	Potamilus ohiensis				X			
Pistolgrip	Tritogonia verrucosa				X	X		
Plain Pocketbook	Lampsilis cardium	X	X	X	X	X	X	X
Purple Wartyback*	Cyclonaias tuberculata			X	X	X		
Rock Pocketbook	Arcidens confragosus				X		X	
Round Pigtoe	Pleurobema sintoxia			X				
Sheepnose	Plethobasus cyphyus			X				
Spike*	Elliptio dilatata			X				
Threehorn Wartyback	Obliquaria reflexa				X	X	X	
Threeridge	Amblema plicata	X		X	X	X	X	X
Wabash Pigtoe	Fusconaia flava	X		X	X	X	X	
Washboard	Megalonaias nervosa			X	X	X	X	
White Heelsplitter	Lasmigona complanata	X		X	X	X	X	X
Yellow Sandshell	Lampsilis teres				X	X		
TOTAL		**8**	**5**	**25**	**25**	**20**	**18**	**9**

Table 5. Fish species richness surveyed in the *lower* Kankakee River between 1994 and 2010. An "X" indicates presence and grey shading indicates newly surveyed species. Fishes in red are non-native species that were surveyed during basin surveys.

	Basin Surveys					Basin Surveys			
Species	**1994**	**2000**	**2005**	**2010**	**Species**	**1994**	**2000**	**2005**	**2010**
Bluegill	X	X	X	X	Black crappie		X	X	
Bluegill x Green sunfish hybrid	X				Black redhorse		X	X	X
Bluntnose minnow	X	X	X	X	Blackside darter		X	X	X
Brook silverside	X	X	X	X	Blackstripe topminnow		X	X	X
Bullhead minnow	X	X	X	X	Bowfin		X		
Carp	X	X	X	X	Central stoneroller		X	X	X
Channel catfish	X	X	X	X	Fantail darter		X		
Emerald shiner	X	X	X	X	Goldeye		X		
Flathead catfish	X		X	X	Grass pickerel		X	X	
Freshwater drum	X	X	X	X	Mooneye		X		
Gizzard shad	X	X	X	X	Redfin shiner		X		
Golden redhorse	X	X	X	X	Sand shiner		X	X	X
Green sunfish	X	X	X	X	Slenderhead darter		X	X	X
Hornyhead chub	X	X	X		Suckermouth minnow		X	X	X
Johnny darter	X	X	X	X	Walleye		X	X	X
Largemouth bass	X	X	X	X	Banded darter			X	X
Logperch	X	X	X	X	Black buffalo			X	X
Longear sunfish	X	X	X	X	Black bullhead			X	
Longnose gar	X	X	X	X	Golden shiner			X	
Mimic shiner	X	X	X	X	Goldfish			X	
Northern hog sucker	X	X	X	X	Northern pike			X	
Orangespotted sunfish	X	X	X	X	Rainbow darter			X	
Quillback	X	X	X	X	Sauger			X	X
River carpsucker	X		X	X	Spotted sucker			X	
River redhorse	X	X	X	X	White perch			X	
Rock bass	X	X	X	X	Fathead minnow				X
Rosyface shiner	X		X	X	Redear sunfish				X
Shorthead redhorse	X	X	X	X	Round goby				X
Silver redhorse	X	X	X	X	Threadfin shad				X
Skipjack herring	X	X							
Smallmouth bass	X	X	X	X	Cumulative No. Species	40	55	65	69
Smallmouth buffalo	X	X	X	X	Cumulative No. Non-Native Species	1	1	2	3
Spotfin shiner	X	X	X	X	Cumulative No. Native Species	39	54	63	66
Spottail shiner	X		X		No. Species by Year	41	48	55	47
Stonecat	X	X	X						
Striped shiner	X	X	X						
Trout-perch	X								
White bass	X	X							
White crappie	X			X					
White sucker	X								

Table 6. Fish species richness surveyed in the *upper* Kankakee River between 1994 and 2010. An "X" indicates presence and grey shading indicates newly surveyed species. Fishes in red are non-native species that were surveyed during basin surveys.

	Basin Surveys					Basin Surveys					Basin Surveys			
Species	**1994**	**2000**	**2005**	**2010**	**Species**	**1994**	**2000**	**2005**	**2010**	**Species**	**1994**	**2000**	**2005**	**2010**
American eel	X				River redhorse	X	X	X	X	Threadfin shad			X	
Banded darter	X	X	X	X	Rock bass	X	X	X	X	American brook lamprey				X
Bigmouth buffalo	X	X	X	X	Rosyface shiner	X	X	X	X	Creek chubsucker				X
Black buffalo	X	X	X	X	Sand shiner	X	X	X	X	Mosquitofish				X
Black crappie	X	X	X	X	Shorthead redhorse	X	X	X	X					
Black redhorse	X	X	X	X	Silver redhorse	X	X	X	X	Cumulative No. Species	58	78	81	84
Blackside darter	X	X	X	X	Silverjaw minnow	X		X		Cumulative No. Non-Native Species	1	1	1	1
Blackstripe topminnow	X	X	X	X	Slenderhead darter	X	X	X	X	Cumulative No. Native Species	57	77	80	83
Bluegill	X	X	X	X	Smallmouth bass	X	X	X	X	No. Species by Year	58	72	62	65
Bluntnose minnow	X	X	X	X	Smallmouth buffalo	X	X	X	X					
Bowfin	X	X	X	X	Spotfin shiner	X	X	X	X					
Brook silverside	X	X	X	X	Steelcolor shiner	X								
Bullhead minnow	X	X	X	X	Striped shiner	X	X	X	X					
Carp	X	X	X	X	Suckermouth minnow	X	X		X					
Channel catfish	X	X	X	X	Walleye	X	X	X	X					
Common shiner	X				Warmouth	X	X	X	X					
Creek chub	X		X		White sucker	X	X	X	X					
Fathead minnow	X	X		X	Yellow bullhead	X	X	X						
Freshwater drum	X	X	X	X	Blacknose dace		X							
Gizzard shad	X	X	X	X	Bluegill x Green sunfish hybrid		X	X	X					
Golden redhorse	X	X	X	X	Bluntnose darter		X							
Golden shiner	X	X	X	X	Brown bullhead		X							
Grass pickerel	X	X	X	X	Central mudminnow		X		X					
Green sunfish	X	X	X	X	Central stoneroller		X	X	X					
Highfin carpsucker	X			X	Emerald shiner		X	X						
Hornyhead chub	X	X	X	X	Ironcolor shiner		X		X					
Johnny darter	X	X	X	X	Lake chubsucker		X							
Largemouth bass	X	X	X	X	Longear sunfish x Bluegill hybrid		X							
Logperch	X	X	X	X	Pumpkinseed		X	X	X					
Longear sunfish	X	X	X	X	Rainbow darter		X	X						
Longnose gar	X	X	X	X	Red shiner x Spotfin shiner hybrid		X							
Mimic shiner	X	X	X	X	Shortnose gar		X							
Northern hog sucker	X	X	X	X	Spotted sucker		X	X	X					
Northern pike	X	X	X	X	Starhead topminnow		X	X	X					
Orangespotted sunfish	X	X	X	X	Stonecat		X	X	X					
Pirate perch	X	X	X	X	Tadpole madtom		X		X					
Quillback	X	X	X	X	Weed shiner		X							
Red shiner	X	X	X		White crappie		X		X					
Redfin shiner	X	X	X	X	Black bullhead			X						
River carpsucker	X	X		X	Flathead catfish			X	X					

Table 7. List of fish species found below, but not above, the lowermost main stem dam on the DuPage, Kankakee, and Fox Rivers and whether they have been observed above the BRLD on the Des Plaines River. An "X" indicates presence.

River	Species exclusive to LOWER river sections	Found above BRLD
DuPage River	Banded darter	
	Black redhorse	
	Blackside darter	X
	Central stoneroller	X
	Logperch	X
	Longnose gar	X
	Mimic shiner	X
	Red shiner	X
	River carpsucker	X
	River redhorse	
	Smallmouth buffalo	X
	Spottail shiner	X
	Striped bass x White bass hybrid (Wiper)	
	Striped shiner	X
	Suckermouth minnow	X
	Walleye	X
	Yellow bullhead	X
	TOTAL	**13/17 (76%)**
Kankakee River	Fantail darter	
	Goldeye	
	Goldfish	
	Mooneye	
	Redear sunfish	X
	Round goby	
	Sauger	X
	Skipjack herring	
	Spottail shiner	X
	Trout-perch	
	White bass	
	White perch	
	TOTAL	**3/13 (23%)**
Fox River	Black buffalo	
	Mooneye	
	Sauger	X
	Shortnose gar	
	Silver carp	
	Skipjack herring	
	Smallmouth buffalo	X
	Striped bass x White bass hybrid (Wiper)	
	Walleye x Sauger hybrid (Saugeye)	
	TOTAL	**2/9 (22%)**

Table 8. Species present in the DuPage, Kankakee, and Fox Rivers that have NOT been observed in the Des Plaines River above BRLD.

Species	DuPage River	Kankakee River	Fox River
Banded darter	X	X	X
Black redhorse	X	X	X
Northern hog sucker	X	X	X
River redhorse	X	X	X
Black buffalo		X	X
Blacknose dace		X	X
Bullhead minnow		X	X
Highfin carpsucker		X	X
Mooneye		X	X
Shortnose gar		X	X
Skipjack herring		X	X
Slenderhead darter		X	X
Starhead topminnow		X	X
Striped bass x White bass hybrid (Wiper)	X		
American brook lamprey		X	
American eel		X	
Bluntnose darter		X	
Brown bullhead		X	
Creek chubsucker		X	
Fantail darter		X	
Goldeye		X	
Ironcolor shiner		X	
Lake chubsucker		X	
Longear sunfish x Bluegill hybrid		X	
Pirate perch		X	
Rainbow darter		X	
Red shiner x Spotfin shiner hybrid		X	
Silverjaw minnow		X	
Steelcolor shiner		X	
Trout-perch		X	
Weed shiner		X	
White perch		X	
Pugnose minnow			X
Silver carp			X
Walleye x Sauger hybrid (Saugeye)			X
Total	**5**	**31**	**16**

DuPage River

The main stem of the DuPage River hosts the lowest fish species richness of the four rivers examined here with only 55 native fish species observed during basin surveys between 1983 and 2013 (Table 1). While fish species richness in both the lower and upper main stem DuPage River increased across basin surveys, increases in richness in the upper river appear truncated over time relative to the lower river (Figure 2). The number of newly observed species in the lower DuPage River varied between 4 and 14 among basin surveys (Table 9), while in the upper section it varied between 1 and 10 species (Table 10). There were also 16 native species of fish surveyed in the lower DuPage River that have not been captured above its lowest most main stem dam during any previous basin survey (Table 7). These included the Banded darter, Black redhorse, Blackside darter, Central stoneroller, Logperch, Longnose gar, Mimic shiner, Red shiner, River carpsucker, River redhorse, Smallmouth buffalo, Spottail shiner, Striped shiner, Suckermouth minnow, Walleye, and Yellow bullhead. One hybrid (Striped bass x White bass hybrid) also has yet to be sampled in the upper DuPage River, but is present in the lower main stem DuPage River. The DuPage River also hosts 5 fish species not currently observed in the Des Plaines River (Table 8).

Surveys of freshwater mussels in the DuPage River reveal a relatively limited community with only five live or recently dead species surveyed between 2009 and 2011 (Table 4; Price et al. 2012). As in the other rivers discussed earlier, limited sampling and the patchy distribution of mussels may underestimate of the actual extant mussel population in the DuPage River. Of the five mussel species considered extant in the DuPage River, a single species (Creeper, *Strophitus undulatus*) has not recently been documented in the Des Plaines River.

Fox River

Basin surveys in the Fox River show there are 76 native fish species inhabiting the main stem (Table 1). Native fish species richness in the lower and upper Fox River increased over time with the number of newly observed species at each basin survey varying from 4 - 25 and 2 - 16 respectively (Tables 11, 12). There were also nine fish species documented in the lower Fox River below the dam at Dayton, IL (~rkm 9) that were not documented in the upper segment during any other basin survey (Table 7). These species included six native species (Black buffalo, Mooneye, Sauger, Shortnose gar, Skipjack herring, and Smallmouth buffalo), one non-native species (Silver carp), and two hybrids (Striped bass x White bass hybrid and Walleye x Sauger hybrid). Sixteen species of fish surveyed in the Fox River have yet to be surveyed in the Des Plaines River above BRLD (Table 8).

Mussel surveys in the main stem Fox River suggest there are nine extant species (Table 4; Shasteen et al. 2013). Four of the nine mussel species surveyed in the Fox River have yet to be surveyed in the Des Plaines River above BRLD and include the Elktoe, Fragile Papershell, Mapleleaf, and Pimpleback (Table 4).

Species presence absence

Most species were encountered more than once during all basin surveys that spanned 30 years in the Des Plaines River, 30 years in the DuPage River, 16 years in the Kankakee River, and 16 years in the Fox River. The proportion of fish species present (i.e. surveyed) more than once ranged between 57% and 80% on the four rivers (Table 13). A subset of the species sampled once were only collected during the most recent surveys and represented new additions to the overall community. These new species additions varied between sites located below and above the lowest dams on each river. Newly surveyed species

accounted for between 4.5% and 22.5% of species sampled below the lowest most dams and between 2.6 and 10.4% of species sampled above the lowest dam (Table 13). In both the lower and upper sites, the highest proportions of new species additions occurred in the Des Plaines River with 9 (22.5%) new species surveyed in the lower sites in 2013 and 7 (10.4%) new species surveyed in the upper sites in the same year.

Indirect evidence of fish passage

The IDNR-DF basin survey data provide evidence that barriers like the one proposed for BRLD can limit the movement of individual fish into the Des Plains River, thereby cutting off the ongoing, slow increase in species richness. In three of the tributaries, multiple species of fish were found below the lowermost dam that were not observed above the dam (Kankakee River n = 13, DuPage River n = 17 and Fox River n = 9, Table 7). Many of the species apparently blocked from moving upriver in tributaries by dams have been observed above BRLD, providing further circumstantial evidence of fish passage through the existing locks. In particular, 23%, 76%, and 22% of fish species found exclusively below the lowermost main stem dams on the Kankakee, DuPage, and Fox Rivers respectively, have been surveyed above BRLD. Moreover, three species including the longnose gar (*Lepisosteus osseus*), smallmouth buffalo (*Ictiobus bubalus*), and spottail shiner (*Notropis hudsonias*) appear to be excluded from the upper reaches of two of the three rivers of interest, but have been observed above BRLD.

Identification of potential mussel hosts

A query of the INHS Freshwater Mussel Host Database revealed native fish surveyed for this study were potential hosts for between zero and 16 of the 32 mussel species considered extant in the rivers of interest (Table 14). This was also true for fishes sampled either in the lower and upper Des Plaines River. Though the majority (56%) of fishes surveyed in the Des Plaines River were potential hosts for between 0 and 4 mussel species, 44% were potential hosts for between 5 and 16 species of mussels (Figure 3). Fish species only recently observed above BRLD (i.e. since 2008), or denoted as migratory species (Anderson et al. 2017) were also potential hosts for between 0 and 10 mussel species. Noteworthy species that were only observed above BRLD since 2013 include the Longnose gar, Banded Killifish, and Logperch, which are potential hosts for 6, 10, and 6 mussel species respectively. Moreover, the intermittently sampled Flathead catfish and Striped shiner which were observed above BRLD in 2008, but not in 2013, may host as many as 9 and 8 species of mussels respectively. The flathead catfish may also support natural infestations of glochidia from the state threatened Purple Wartyback mussel (Appendix 5).

Table 9. Fish species richness surveyed in the *lower* DuPage River between 1983 and 2013. An "X" indicates presence and grey shading indicates newly surveyed species. Fishes in red are non-native species that were surveyed during basin surveys.

	Basin Survey							Basin Survey					
Species	**1983**	**1997**	**2002**	**2003**	**2008**	**2013**	**Species**	**1983**	**1997**	**2002**	**2003**	**2008**	**2013**
Bigmouth shiner	X		NA				Logperch				X	X	X
Black crappie	X	X		X		X	Northern hog sucker				X	X	X
Bluegill	X	X		X	X	X	River redhorse				X		
Bluntnose minnow	X	X			X	X	Silver redhorse				X	X	
Carp	X	X		X	X	X	Striped bass x White bass hybrid (Wiper)				X		
Creek chub	X	X					Banded darter					X	
Fathead minnow	X						Black redhorse					X	
Gizzard shad	X	X		X	X	X	Mimic shiner					X	X
Golden shiner	X					X	Smallmouth buffalo					X	
Goldfish	X						Longnose gar						X
Green sunfish	X	X			X	X	Pumpkinseed						X
Hornyhead chub	X				X		River carpsucker						X
Largemouth bass	X	X		X	X	X	Walleye						X
Quillback	X					X	Yellow bullhead						X
Red shiner	X												
Sand shiner	X	X				X	Cumulative No. Species	21	35	NA	40	44	49
Shorthead redhorse	X	X		X	X	X	Cumulative No. Non-Native Species	2	2	NA	2	2	2
Spotfin shiner	X	X			X	X	Cumulative Bo. Native Species	19	33	NA	38	42	47
Spottail shiner	X						No. Species by Year	21	26	NA	15	29	27
Striped shiner	X				X								
White sucker	X	X		X	X	X							
Blackside darter		X			X								
Blackstripe topminnow		X			X	X							
Bluegill x Green sunfish hybrid		X											
Central stoneroller		X			X								
Channel catfish		X			X	X							
Emerald shiner		X			X								
Freshwater drum		X											
Golden redhorse		X		X	X	X							
Johnny darter		X											
Longear sunfish		X			X								
Orangespotted sunfish		X			X	X							
Rock bass		X		X	X	X							
Smallmouth bass		X		X	X	X							
Suckermouth minnow		X			X								

Table 10. Fish species richness surveyed in the *upper* DuPage River between 1983 and 2013. An "X" indicates presence and grey shading indicates newly surveyed species. Fishes in red are non-native species that were surveyed during basin surveys.

	Basin Survey							Basin Survey					
Species	**1983**	**1997**	**2002**	**2003**	**2008**	**2013**	**Species**	**1983**	**1997**	**2002**	**2003**	**2008**	**2013**
Bigmouth shiner	X			NA			Blackstripe topminnow		X				
Black bullhead	X	X					Channel catfish		X	X		X	
Black crappie	X	X	X				Emerald shiner		X				
Bluegill	X	X	X		X		Freshwater drum		X				
Bluegill x Green sunfish hybrid	X	X					Johnny darter		X				
Bluntnose minnow	X	X					Longear sunfish		X	X		X	
Carp	X	X	X		X		Northern pike		X				
Carp x Goldfish hybrid	X						Orangespotted sunfish		X				
Central mudminnow	X						Rock bass		X	X		X	
Common shiner	X						Silver redhorse		X			X	
Creek chub	X						Hornyhead chub			X		X	
Fathead minnow	X						Stonecat					X	
Gizzard shad	X	X					Flathead catfish						X
Golden redhorse	X	X	X		X								
Golden shiner	X						Cumulative No. Species	28	38	39	NA	40	41
Goldfish	X						Cumulative No. Non-Native Species	3	3	3	NA	3	3
Green sunfish	X	X	X				Cumulative No. Native Species	25	35	36	NA	37	38
Largemouth bass	X	X	X		X		No. Species by Year	28	26	14	NA	14	1
Northern hog sucker	X	X	X		X								
Pumpkinseed	X												
Quillback	X	X											
Redfin shiner	X												
Sand shiner	X												
Shorthead redhorse	X	X	X		X								
Smallmouth bass	X	X	X		X								
Spotfin shiner	X	X											
White sucker	X	X	X		X								
Yellow perch	X												

Table 11. Fish species richness surveyed in the *lower* Fox River between 1996 and 2012. An "X" indicates presence and grey shading indicates newly surveyed species. Fishes in red are non-native species that were surveyed during basin surveys.

	Basin Surveys					Basin Surveys			
Species	**1996**	**2002**	**2007**	**2012**	**Species**	**1996**	**2002**	**2007**	**2012**
Black crappie	X	NA			Black buffalo				X
Bluegill	X		X	X	Silver carp				X
Carp	X		X	X	Spottail shiner				X
Channel catfish	X		X	X	Striped bass x White bass hybrid (Wiper)				X
Flathead catfish	X		X	X					
Freshwater drum	X		X	X	Cumulative No. Species	17	NA	39	42
Gizzard shad	X		X	X	Cumulative No. Non-Native Species	1	NA	2	3
Golden redhorse	X		X	X	Cumulative No. Native Species	16	NA	37	39
Green sunfish	X		X		No. Species Surveyed	17	NA	39	32
Highfin carpsucker	X		X	X					
Largemouth bass	X			X					
Longnose gar	X		X	X					
River carpsucker	X		X	X					
Shorthead redhorse	X		X	X					
Skipjack herring	X								
Smallmouth bass	X		X	X					
Smallmouth buffalo	X		X	X					
Black redhorse			X	X					
Blackstripe topminnow			X						
Bluntnose minnow			X	X					
Brook silverside			X						
Bullhead minnow			X						
Central stoneroller			X	X					
Common shiner			X						
Emerald shiner			X						
Fathead minnow			X						
Grass carp			X	X					
Johnny darter			X						
Logperch			X						
Mooneye			X	X					
Northern hog sucker			X	X					
Quillback			X	X					
Rock bass			X						
Sand shiner			X	X					
Sauger			X	X					
Shortnose gar			X	X					
Silver redhorse			X	X					
Spotfin shiner			X	X					
Suckermouth minnow			X						
Walleye			X	X					
Walleye x Sauger hybrid (Saugeye)			X						
White bass			X	X					

Table 12. Fish species richness surveyed in the *upper* Fox River between 1996 and 2012. An "X" indicates presence and grey shading indicates newly surveyed species. Fishes in red are non-native species that were surveyed during basin surveys.

	Basin Surveys					Basin Surveys			
Species	**1996**	**2002**	**2007**	**2012**	**Species**	**1996**	**2002**	**2007**	**2012**
Black crappie	X	X	X	X	Bigmouth shiner		X	X	X
Black redhorse	X	X	X		Black bullhead		X	X	X
Bluegill	X	X	X	X	Blackstripe topminnow		X	X	X
Bluegill x Green sunfish hybrid	X	X	X	X	Hornyhead chub		X	X	
Bluntnose minnow	X	X	X	X	Logperch		X	X	X
Brook silverside	X	X	X	X	Northern hog sucker		X	X	X
Bullhead minnow	X	X	X	X	River carpsucker		X		
Carp	X	X	X	X	Stonecat		X		
Channel catfish	X	X	X	X	Suckermouth minnow		X	X	
Emerald shiner	X	X	X	X	Common shiner			X	X
Flathead catfish	X	X	X	X	Fathead minnow			X	X
Freshwater drum	X	X	X	X	Banded darter			X	X
Gizzard shad	X	X	X	X	Slenderhead darter			X	X
Golden redhorse	X	X	X	X	Muskellunge			X	X
Golden shiner	X	X	X	X	Central stoneroller			X	X
Green sunfish	X	X	X	X	Starhead topminnow			X	
Highfin carpsucker	X	X	X	X	Northern pike			X	X
Johnny darter	X	X	X	X	Longnose gar			X	X
Largemouth bass	X	X	X	X	Creek chub			X	X
Orangespotted sunfish	X	X	X	X	Grass carp			X	
Pugnose minnow	X	X	X	X	Striped shiner			X	X
Pumpkinseed	X	X	X	X	Blacknose dace			X	X
Quillback	X	X	X	X	Bowfin			X	X
River redhorse	X	X			Grass pickerel			X	X
Rock bass	X	X	X	X	Goldfish			X	X
Rosyface shiner	X		X	X	Blackside darter				X
Sand shiner	X	X	X	X	Mimic shiner				X
Shorthead redhorse	X	X	X	X					
Silver redhorse	X	X	X	X	Cumulative No. Species	41	50	66	68
Smallmouth bass	X	X	X	X	Cumulative No. Non-Native Species	1	1	3	3
Spotfin shiner	X	X	X	X	Cumulative No. Native Species	40	49	63	65
Spottail shiner	X	X	X	X	No. Species Surveyed	41	46	62	59
Tadpole madtom	X								
Walleye	X	X	X	X					
Warmouth	X		X	X					
White bass	X	X	X	X					
White crappie	X		X	X					
White sucker	X	X	X	X					
Yellow bass	X	X	X	X					
Yellow bullhead	X	X	X	X					
Yellow perch	X	X	X	X					

Table 13. Trends in fish species presence and absence across basin surveys based on the proportion of species sampled in more than one basin survey, and the proportion of newly surveyed species observed in the most recent basin survey below (Lower Sites) and above (Upper Sites) the lowermost dam.

River	Fish Species Surveyed > 1 time (%)	% New Species Most Recent Survey	
		Lower Sites	Upper Sites
Des Plaines	67	22.5	10.4
DuPage	57	10.6	2.6
Kankakee	77	4.5	3.6
Fox	80	10.3	3.1

Table 14. List of fish hosts and the number of potential mussel species hosted. Migratory or backwater designation based on Anderson et al. (2017).

Fish Species	Migratory or Backwater	Potential # of Mussel Species Hosted	Fish Species	Migratory or Backwater	Potential # of Mussel Species Hosted	Fish Species	Migratory or Backwater	Potential # of Mussel Species Hosted
Bluegill	B	16	Northern pike	M/B	3	Creek chubsucker		0
White crappie	B	16	Northern hog sucker	M	3	Grass carp		0
Green sunfish		16	Quillback	M	3	Grass pickerel		0
Largemouth bass	M/B	14	Shorthead redhorse	M	3	Ironcolor shiner		0
Black crappie	B	14	Skipjack herring	M	3	Lake chubsucker		0
Sauger	M	13	Central mudminnow	B	3	Longear sunfish x Bluegill hybrid		0
Yellow perch	B	13	Fantail darter		3	Muskellunge		0
Creek chub		12	Goldfish		3	Red shiner x Spotfin shiner hybrid		0
Rock bass		12	Tadpole madtom		3	Silver carp		0
Freshwater drum	M/B	11	Smallmouth buffalo	M/B	2	Starhead topminnow		0
Channel catfish	M	10	Golden redhorse	M	2	Striped bass x White bass hybrid (Wiper)		0
Banded killifish		10	Goldeye	M	2	Threadfin shad		0
Pumpkinseed		10	Silver redhorse	M	2	Walleye x Sauger hybrid (Saugeye)		0
Walleye	M/B	9	Bowfin	B	2			
Flathead catfish	M	9	Shortnose gar	B	2			
Central stoneroller		9	Bullhead minnow		2			
Common shiner		9	Mimic shiner		2			
Golden shiner	B	8	Redfin shiner		2			
Orangespotted sunfish	B	8	River redhorse		2			
Longear sunfish		8	Sand shiner		2			
Spotfin shiner		8	Silverjaw minnow		2			
Striped shiner		8	Spottail shiner		2			
Warmouth	B	7	Bigmouth buffalo	M/B	1			
Bluntnose minnow		7	Black redhorse	M	1			
Gizzard shad		7	Highfin carpsucker	M	1			
Red shiner		7	Mooneye	M	1			
American eel	M	6	Pirate perch	B	1			
Longnose gar	M	6	Redear sunfish	B	1			
Smallmouth bass	M	6	Weed shiner	B	1			
Black bullhead	B	6	Blackchin shiner		1			
Johnny darter	B	6	Brook silverside		1			
Blacknose dace		6	Emerald shiner		1			
Carp		6	River carpsucker		1			
Logperch		6	Rosyface shiner		1			
Yellow bullhead		6	Stonecat		1			
White bass	M	5	Suckermouth minnow		1			
Brown bullhead		5	Trout-perch		1			
Rainbow darter		5	White perch		1			
White sucker	M/B	4	Spotted sucker	M/B	0			
Mosquitofish (WESTERN)	B	4	Blackstripe topminnow	B	0			
Banded darter		4	Pugnose minnow	B	0			
Blackside darter		4	Yellow bass	B	0			
Fathead minnow		4	American brook lamprey		0			
Hornyhead chub		4	Bigmouth shiner		0			
Iowa darter		4	Black buffalo		0			
Round goby		4	Bluegill x Green sunfish hybrid		0			
Slenderhead darter		4	Bluntnose darter		0			
Steelcolor shiner		4	Carp x Goldfish hybrid		0			

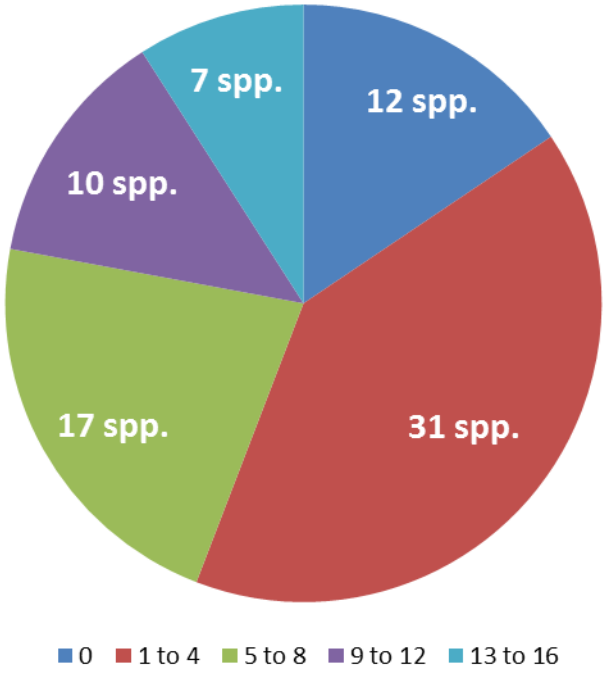

Figure 3. Number of fish species sampled in the Des Plaines River that may serve as potential hosts for between 0, 1 – 4, 5 – 8, 9 – 12, and 13 – 16 species of freshwater mussels.

Discussion

The issue: upriver connectivity

The proposed BRLD fish barrier is designed to prevent upstream movement of Asian carp that may enter the lock chamber, either actively (e.g., as swimming adults and juveniles) or passively (e.g., as drifting eggs and larvae) (USACE 2017). A collateral effect of this will be the elimination of longitudinal connectivity for native fishes and mussels with the upper Des Plaines River and CAWS. The inability of desirable native fishes to recolonize the improved, and improving portions of the upper Des Plaines River and CAWS will constrain recovering populations of key fish and undermine approximately $27 million dollars in federal, state, and local (i.e. Forest Preserve Districts) efforts to rehabilitate the upper river and its entire biological community. Ultimately, the barrier project is assuming that fish species richness and abundance will be self-sustaining above BRLD, there will be no catastrophic events (disease, fish kills), there will be immigration of native fishes from Lake Michigan, or that supplementation via either hatchery production or quarantine and translocation can support the current upward trajectories as efficiently and economically as unconstrained upstream movement.

Currently the assumption of self-sustaining Des Plaines River fish populations cannot be assessed because of an absence of population data. Despite the lack of a comprehensive assessment there is evidence that some species-specific recruitment can occur; existing IDNR basin surveys document the presence of young-of-year (YOY) smallmouth bass and bluegill in tributary stations but not in the main channel habitat (Pescitelli 2013, Pescitelli 2017). This means there is a high degree of uncertainty in predicting whether the fish assemblage can be self-sustaining without continuing immigration from below BRLD.

Evidence shows new species immigrating and recolonizing the upper Des Plaines River and the other tributaries from the river below BRLD (Pescitelli 2013, Gibson-Reinemer et al. 2017, Pescitelli 2017). For instance, there is evidence that a fish barrier has prevented fish from taking advantage of recent water quality improvements in the DuPage River. This tributary has an impassable dam situated 1.5 rkm upriver from its confluence with the lower Des Plaines River. The DuPage River below the impassable dam hosts 12 species of fish that have not been surveyed above the dam in any of the four basin surveys conducted since 1983, suggesting the additional fish have not been able to move upriver to colonize.

Long-term monitoring shows clearly that diversity has been improving substantially in the upper Illinois River basin and tributaries since the 1970's (McClelland et al. 2012; Gibson-Reinemer et al. 2017). This recovery includes many non-game species that are not reared or stocked in the basin, thus we conclude these fish populations are recovering passively through natural upstream dispersal and establishment. Many of the fish species are also returning to the tributaries such as the Kankakee and Fox Rivers below locks and dams or other barriers. While many of these fish are not yet present in the Des Plaines River, this basin was one of the most degraded and last to improve. Although the habitat and environment of the upper Des Plains River and CAWS are different environments for fish than the Illinois River, data shows that native populations are still expanding upriver (e.g., Walleye, Sauger, Smallmouth bass, and Redhorse spp. are present and expanding but would be blocked by the proposed project). An impassible barrier at BRLD means ongoing recovery would have to be through more active and intensive means, likely via expanded hatchery production or translocation of wild caught fish.

Downstream immigration of fishes from Lake Michigan into the CAWS and eventually into the upper Des Plaines River occurs, albeit on a limited basis. Examples include the non-native Round goby (*Neogobius melanostomus*) which was found along the Lake Michigan shoreline in the late 1990's but was first surveyed in the Des Plaines River in 2003 (Charlebois et al. 2001, Irons et al. 2006), the Banded

killifish, a state threatened species first surveyed in the upper Des Plaines River during an IDNR basin survey in 2013, and the Oriental weatherfish (Willink and Veraldi 2009, Tiemann et al. 2015). This indirect evidence is supported by source signatures measured by otolith $\delta^{13}C$, which revealed as much as 36% of fish sampled in the CAWS may have immigrated from Lake Michigan (Rude et al 2017). However, no fish sampled downstream of the CAWS in the Des Plaines River (including Emerald shiner, Green sunfish, Largemouth bass, and Round goby) during this study are thought to have originated in Lake Michigan. Thus, it appears emigration of fishes from Lake Michigan may supplement the fish community of the CAWS, but may not offset the losses resulting from a fish barrier at BRLD.

Recent improvements in the mussel community of the upper Illinois River has largely been attributed to long-term enhancements in the fish community (Sietman et al. 2001, McClelland et al. (2007, Gibson-Reinemer et al. 2017). Despite its historically diverse mussel community, the increases in numbers and diversity seen below BRLD have not yet reached the upper Des Plaines River (Price et al. 2012a). However, the river below the proposed barrier at BRLD is a rich source of mussels for recolonization hosting seventeen species still missing from the Des Plains including two state threatened species (the Black Sandshell and Purple Wartyback). A fish barrier at BRLD would limit longitudinal connectivity of 85 potential species of fish hosts and which is critical for sustaining the recovery of these mussels (Sietman et al. 2001; Benson et al. 2017).

Anticipated changes in fish and mussel richness and presence over time

Steady improvements in fish species richness and abundance have occurred throughout the Illinois River basin (McClelland et al. 2012; Gibson-Reinemer et al. 2017). These are in large part due to improvements in water quality resulting from the Clean Water Act (1972) that allowed native species to reestablish in formerly uninhabitable main stem and tributary habitats. A similar trend of increasing species richness was also observed in the lower portions of the Des Plaines, DuPage, Kankakee, and Fox Rivers (Pescitelli 2013; Pescitelli 2017). However, the DuPage, Kankakee, and Fox Rivers all have impassable main stem dams that limit the upriver movement of fish to the first 1.5, 16, and 9 rkm respectively. On the DuPage River, the putative effects of limited habitat availability (i.e. 1.5 rkm below the first dam) on patterns in species richness could serve to illustrate the potential effects of a barrier at BRLD on fish.

The changes in fish species richness over time in the DuPage River provides us with a good idea of how the upper river might respond to a proposed barrier to fish movement. Of noteworthiness are the patterns in species richness over time as surveyed above and below the dam in Channahon, IL. Above the dam at Channahon, IL, only 3 species appear to have returned between 2002 and 2013 (Hornyhead chub, Stonecat, and Flathead catfish). In contrast, at least 13 newly observed native species have returned to the DuPage River below the dam (Logperch, Northern hog sucker, River redhorse, Silver redhorse, Banded darter, Black redhorse, Mimic shiner, Smallmouth buffalo, Longnose gar, Pumpkinseed, River carpsucker, Walleye, and Yellow bullhead) and one hybrid (Striped bass x White bass hybrid). The implication is that fish inhabiting the lower DuPage River are unable subsidize the upstream native. If we think of this tributary dam example as analogous to the proposed main stem barrier at BRLD, this suggests that over time the upstream assemblages would be negatively affected.

In some cases, certain species of fish may show little response to a fish barrier at BRLD if they are currently capable of maintaining self-sustaining populations. Though direct evidence of successful spawning and recruitment by most fishes inhabiting the upper Des Plaines River is lacking, trends in the temporal stability or consistency at which certain species of fish were sampled may provide indirect evidence of recruitment. For example, 67% of fishes sampled in the Des Plaines River were surveyed during more than one basin survey spanning at least five years, and 41% were sampled during all basin

surveys that spanned from 1983 to 2013. Alternatively, in the case of the upper Des Plaines River, consistent fish presence may also indicate a degree of fish passage at BRLD. Therefore, greater uncertainty may exist regarding the anticipated consequences of a fish barrier for fish that are only intermittently surveyed, or that are thought to have only recently arrived above BRLD.

Although improvements in the mussel community of the upper Illinois River have been attributed to improvements in water quality and the rebound of their fish hosts over time (Sietman et al. 2001), the elimination of the only corridor for fish movement, and the glochidia they may be carrying, is anticipated to exclude any new species of mussels from naturally recolonizing the upper Des Plaines River. The DuPage River may again provide a good idea of how mussels might respond to a fish barrier at BRLD. For example, the DuPage River maintains a disparate mussel community of only 5 recently surveyed species (Price et al. 2012), despite its relatively close proximity (6 rkm) to the Dresden Island Nuclear Station on the upper Illinois River, where 25 species of mussels currently exist. As indicated by the inability of multiple species of fish to pass the lowest dam on the DuPage River, a fish barrier at BRLD might be expected to similarly stop fish movement, thereby excluding mussels originating from more species rich downstream locations.

Evidence of fish passage

Comparisons of the fish assemblages above and below BRLD, where upriver passage through the lock chamber is possible, with fish assemblages in the adjacent tributaries where impassable dams are in place (e.g. the DuPage, Kankakee, and Fox Rivers), provides indirect evidence of how the native fishes might be affected. This is particularly evident when contrasting above and below the barrier on the DuPage River with above and below the prosed barrier at BRLD. In the case of the DuPage River, seventeen species of fish surveyed below the dam have yet to be surveyed above. However, thirteen of these seventeen species have been surveyed above BRLD on the Des Plaines River. Additionally, nine of these thirteen species have only been surveyed since 2003 suggesting relatively recent movements above BRLD. Those nine recent arrivals include the moderately intolerant Logperch in 2008 (Grabarkiewicz and Davis 2008) and intolerant Rosyface Shiner in 2013 (Grabarkiewicz and Davis 2008), further suggesting water quality may now be suitable for hosting previously excluded pollution sensitive fishes. In the absence of studies tracking these native fish, these changes in distribution over time strongly suggest the species can pass upriver through BRLD.

Additionally, the total number of lock passages may also be associated with equalizing fish community similarity. On the Monongahela River, PA, a positive relationship was observed between the maximum number of lockages per year (2004 – 2008) at six main stem lock and dams and the degree of similarity (based on Jaccard's coefficient of similarity) in large-bodied fishes sampled above and below these lock and dams (Argent and Kimmel 2011). The maximum number of lockages per year among the six structures on the Monongahela River varied between approximately 1,700 and 8,100 (Argent and Kimmel 2011). Between 1990 and 2016, the number of lockages at BRLD varied between 2,786 and 4,453 (USACE Navigation Data Center 2018) which falls within the range of lockages thought to facilitate increased community similarity in the Monogahela River.

Although some uncertainty exists regarding fish passage through the lock chamber at BRLD, a diverse array of fishes has been collected in lock chambers from other rivers (Margraf and Knight 2002; Hendrick et al. 2004). For example, twenty-five species were collected from the lock chamber at the Morgantown lock and dam on the Monogahela River, PA, after rotenone application in September of 2003 (Hendrick et al. 2004). The surveyed families included Cyprinidae (11 species), Ictaluridae (3 species), Percidae (3 species), Centrarchidae (2 species) Atherinopsidae (1 species), Catostomidae (1 species), Sciaenidae (1 species), Lepisosteidae (1 species), Moronidae (1 species), and Clupeidae (1

species). Rotenone surveys conducted at the same lock and dam between 1973 and 1990 also indicate additional Centrarchids (7 species), Ictalurids (2 species), a Catostomid (1 species), an Escosid (1 species), and un-classified redhorse and darter species had also been surveyed over time (Weller et al. 1991). The presence of these species in the lock does not automatically imply successful passage. However, combined with the observed positive relationship between maximum number of lockages and fish community similarity above and below locks observed by Argent and Kimmel (2011), it provides incremental information needed to support upriver lock passage as a mechanism facilitating rehabilitation of the fish community above BRLD.

Potential mitigation approach

Current trends in the upper Des Plaines River and other tributaries in the region indicate that fish species richness has improved over time, and that freshwater mussels while present, still require considerable rehabilitation (McClelland et al. 2012, Gibson-Reinemer et al. 2017, Pescitelli 2017). It is noteworthy that there appears to be still more potential for additional fish and mussel rehabilitation in the upper Des Plaines River: many species not currently found in the upper Des Plaines River do occur in downstream tributaries. Thus, the main effect of a proposed fish barrier will be reducing upriver movement of native fish and by extension preventing further recovery of the fish and mussel assemblages. Ameliorating for the loss of connectivity should be the focus of any potential mitigation efforts.

Uncertainty exists regarding which species of fish inhabiting the upper Des Plaines River might be most at risk of decline or extirpation if a fish barrier were installed at BRLD. Moreover, even less is known about how mussels in this same area might respond. Much of this uncertainty stems from a paucity of direct evidence of successful reproduction and recruitment by the majority of native fishes or mussels in this section of river. This knowledge gap brings into question the sustainability of both communities without access to a downriver source of immigration. There is greater certainty however in the outcome that post fish barrier implementation at BRLD, no new additions of fish or mussel species currently absent from the upper Des Plaines River would be possible via natural movements through the lock.

Prioritizing fish species for mitigation

Confirming reproduction and recruitment trends in over 50 species of native fish inhabiting the upper Des Plaines River may not be feasible on a species by species basis. Therefore, differentiating among species commonly observed, or observed in more than one basin survey spanning five or more years could serve as a starting point. Fish species not commonly observed or only recently observed in the upper Des Plaines River could then be given higher priority as missing or potentially underrepresented (Pescitelli 2017). In contrast, those species of fish that are successfully spawning and recruiting in the upper Des Plaines River or are poor candidates for hatchery rearing could be prioritized for translocation efforts. While not all species currently raised in the Illinois fish hatchery system are applicable to mitigation efforts on the warm water Des Plaines River, the infrastructure could be used to supplement targeted species for mitigation. Translocation of wild fish immediately after capture to supplement the fish community of the upper Des Plaines River would not be permitted out of concern for unintended transfer of invasive species and disease (K. Irons *personal communication*). A quarantine period for wild fish could be recommended prior to release in the wild and implemented at currently operational hatchery systems in Illinois.

Mitigation for freshwater mussels

There are relatively few documented instances of successful freshwater mussel mitigation. Often, reducing fragmentation and habitat restoration are noted as less expensive and more successful steps towards long-term rehabilitation of mussel populations (Haag and Williams 2014). However, hatchery propagation and release of mussels has been successful in the past. For example, Neves 2004 notes the successful propagation and release of nine species of endangered freshwater mussels in Tennessee and Virginia. Prioritizing mussel species for rehabilitation should be contingent on making sure the appropriate host fish are doing well, or for which mitigation is planned to occur. As such, attempts could be made to infest either quarantined wild fish or hatchery produced fish with glochidia from target mussel species. Given the potentially low success rate of laboratory fish infestation resulting in subsequent juvenile transformation in the wild, longer and intensive rearing of mussels to juveniles prior to release is another option (D. Shasteen *personal communication*). Our query of mussel host data revealed a paucity of information regarding the species of mussels many fish may serve as hosts for under natural conditions (INHS-FMHD 2018). Any wild fish taken with the purpose of eventual translocation (post quarantine) could opportunistically be surveyed for natural infestation of mussel glochidia. Such work could help close knowledge gaps regarding mussel host relationships and may help identify mussels most likely to have been transported naturally upriver of BRLD prior to barrier establishment.

References

Benson, J.A., P.G. Close, B.A. Stewart, and A. Lymbery. 2017. Upstream recolonization by freshwater mussels (Unionoida: Hyriidae) following installation of a fishway. Aquatic Conservation, DOI: 10.1002/aqc.2861.

Charlebois, P.M., Corkum, L.D., Jude, D.J. and Knight, C., 2001. The round goby (*Neogobius melanostomus*) invasion: current research and future needs. Journal of Great Lakes Research, 27(3), pp.263-266.

EA Engineering (EAE). 2014. Freshwater mussel survey in the Illinois River near the Dresden nuclear station (RM 271-272.5). Prepared for Exelon Generation Company, LLC. Appendix H.

Economic Development Research Group (EDRG). 2016. An economic impact and cluster analysis of Illinois River lock and dam facilities for beneficial users. Final Report prepared for the Illinois Chamber of Commerce Foundation, the Illinois Soybean Association, the Illinois Corn Marketing Board, the Illinois Farm Bureau, and the Chemical Industry Council of Illinois. 155pp.

EnviroScience. 2017. Freshwater mussel survey for the Houbolt road bridge over the Des Plaines River Joliet, Illinois. Report prepared for Geosyntec Consultants, Project No.: 10029.

Gibson-Reinemer DK, RE Sparks, JL Parker, JA DeBoer, MW Fritts, McClelland MA, Chick JH, and AF Casper. Ecological Recovery of a River Fish Assemblage following the Implementation of the Clean Water Act. BioScience 67: 957-970 DOI: 10.1093/biosci/

Haag, W.R. and Williams, J.D., 2014. Biodiversity on the brink: an assessment of conservation strategies for North American freshwater mussels. Hydrobiologia, 735(1), pp.45-60.

Hedrick, J., C. O'Bara, and F. Jernejcic. 2004. Monongahela River biotic evaluations of the Point Marion and Hildebrand Pools, West Virginia, 2003-2004. Monongahela River Mine Pool Study 2003, West Virginia Division of Natural Resources.

Hubert, W.A., and M.C. Fabrizio. 2007. Relative abundance and catch per unit effort. *In* Analysis and Interpretation of Freshwater Fisheries Data. *Edited by* C.S. Guy and M.L. Brown. American Fisheries Society, Bethesda, Maryland.

Illinois Department of Natural Resources Office of Water Resources (IDNR-OWR). 2017. "Safety at dams." https://www.dnr.illinois.gov/waterresources/pages/safetyatdams.aspx (accessed 12/7/2017).

Illinois Natural History Survey – Freshwater Mussel Host Database (INHS-FMHD) 2018. http://wwx.inhs.illinois.edu/collections/mollusk/data/freshwater-mussel-host-database. *Accessed* 1/5/2018.

Irons, K.S., McClelland, M.A. and Pegg, M.A., 2006. Expansion of round goby in the Illinois waterway. The American Midland Naturalist, 156(1), pp.198-200.

Jacobs, A.I. and Keller, R.P., 2017. Straddling the divide: invasive aquatic species in Illinois and movement between the Great Lakes and Mississippi basins. Biological Invasions, 19(2), pp.635-646.

Karr, J.R. 1999. Defining and measuring river health. Freshwater Biology 41:221-234.

Margraf, F.J., and C.T. Knight. 2002. Evaluation of fish sampling using rotenone in a navigation lock. Fisheries Research 55:297-305.

McClelland, M.A., G.G. Sass, T.R. Cook, K.S. Irons, N.N. Michaels, T.M. O'Hara, and C. S. Smith. 2012. The long-term Illinois River fish population monitoring program. Fisheries 37:340-350.

Mills EL, Leach JH, Carlton JT, Secor CL (1993) Exotic species in the Great Lakes: a history of biotic crises and anthropogenic introductions. J Great Lakes Res 19:1–54

Neves, R. 2004. Propagation of endangered freshwater mussels in North America. Journal of Conchology Special Publication 3.

Olson, K.R. and Morton, L.W., 2017. Chicago's 132-year effort to provide safe drinking water. Journal of Soil and Water Conservation, 72(2), pp.19A-25A.

Pescitelli. S. 2013. Status of fish assemblages and sport fishery in the Des Plaines River watershed and trends over 30 years of basin surveys 1983 – 2013. Illinois Department of Natural Resources Division of Fisheries.

Pescitelli. S. 2017. Des Plaines River fishery management plan: January 2017. Illinois Department of Natural Resources Division of Fisheries.

Price, A.L., D.K. Shasteen, and S.A. Bales. 2012a. Freshwater mussels of the Des Plaines River and Lake Michigan tributaries in Illinois. Illinois Natural History Survey Technical Report 2012 (10). Champaign, Illinois. 16pp.

Price, A.L., D.K. Shasteen, and S.A. Bales. 2012b. Freshwater mussels of the Kankakee River. Illinois Natural History Survey Technical Report 2012 (12). Champaign, Illinois. 16pp. + appendix.

Ricciardi A 2006. Patterns of invasion in the Laurentian Great Lakes in relation to changes in vector activity. Divers Distrib 12:425–433. doi:10.1111/j.1366-9516.2006.00262.x.

Rude, N.P., A.J. Young, and G.W. Whitledge. 2017. Movement of small-bodied fishes from Lake Michigan into Chicago area waterways: insights from otolith chemistry. Journal of Applied Ichthyology 2017:1-7.

Shasteen, D.K., S.A. Bales, and A.P. Stodola. 2013. Freshwater mussels of the Fox River basin in Illinois. Illinois Natural History Survey Technical Report 2013 (12). Champaign, Illinois. 21pp. + appendix.

Sietman, B.E., S.D. Whitney, D.E. Kelner, K.D. Blodgett, and H.L. Dunn. 2001. Post-extirpation recovery of the freshwater mussel (Bivalvia: Unionidae) fauna in the upper Illinois River. Journal of Freshwater Ecology 16:273-281.

Tiemann, J.S., Taylor, C.A., Wylie, D., Lamer, J., Willink, P.W., Veraldi, F.M., Pescitelli, S.M., Lubinski, B., Thomas, T., Sauer, R. and Cantrell, B., 2015. Range expansions and new drainage records for select Illinois fishes. Illinois State Academy of Science. Transactions, 108, p.47.

USACE (US Army Corps of Engineers). 2007. Illinois River Basin Restoration Comprehensive Plan with Integrated Environmental Assessment.

USACE (US Army Corps of Engineers). 2014. The Great Lakes and Mississippi River Interbasin Study.

USACE (US Army Corps of Engineers). 2015. Upper Des Plaines River and Tributaries, Illinois and Wisconsin Integrated Feasibility Report and Environmental Assessment.

USACE (US Army Corps of Engineers). 2017. GLMRIS Brandon Road Draft Integrated Feasibility Study and Environmental Impact Statement report.

USACE (US Army Corps of Engineers) Navigation Data Center. 2018. http://www.navigationdatacenter.us/lpms/lpms.htm. *Accessed* 4/27/18.

Weller, R., W.B. Perry, F. Jernejcic, and S.A. Perry. 1991. Improvements in fish populations of the Monongahela River, West Virginia, after reduction of acid mine drainage. Proceedings of the Annual Conference of Southeast Fish and Wildlife Agencies 45:407-414.

Willink, P.W. and Veraldi, F.M., 2009. The Fishes of Will County, Illinois. Fieldiana Zoology, pp.1-61.

Appendix 1. Estimated costs associated with nine dam removals on the main stem Des Plaines River. Removals were carried out through collaborations with the IDNR, USACE, Forest Preserves of Cook County, and the Lake County Forest Preserve District.

Watershed	**Waterbody**	**Dam Name**	**Removal Cost**
Des Plaines River	Des Plaines River	Ryerson Dam	$397,727
Des Plaines River	Des Plaines River	Armitage Avenue Dam	$402,991
Des Plaines River	Des Plaines River	Fairbanks Avenue Dam	$400,000
Des Plaines River	Des Plaines River	Hoffman Dam	$2,500,000
Des Plaines River	Des Plaines River	Dam No. 2	$153,000
Des Plaines River	Des Plaines River	Dam No.1	$186,000
Des Plaines River	Des Plaines River	Wright Woods / Dam No.1A	$457,517
Des Plaines River	Des Plaines River	MacArther Woods/ Dam No.1B	$457,517
Des Plaines River	Des Plaines River	Dempster Street	$274,990
Des Planies River	Seavey Ditch	Golf Coarse Dam	$60,000
Des Plaines River	East Branch DuPage River	Churchill Woods	$1,062,000
Des Planies River	West Branch DuPage River	Warrenville Dam	$1,036,000
Des Planies River	West Branch DuPage River	McDowell Grove Dam	$1,427,540
		Dam Removal Costs	**$8,815,282**

Appendix 2. Estimated costs associated with additional habitat improvements and rehabilitation efforts in the upper Des Plaines River watershed. Habitat improvements and rehabilitation were carried out through collaborations with the IDNR, Forest Preserves of Cook County, and the Lake County Forest Preserve District.

Location	Adjacent Waterbody	Efforts	Cost
Des Plaines River watershed	Des Plaines River	IDNR willow plantings	$15,000
Santa Fe Prairie	Des Plaines River	IDNR rock bar habitat installation	$36,505
Lake County Forest Preserve District	Des Plaines River	Des Plaines River woodland restoration, flatwood and vernal pool inundation and water retention	$2,300,000
	Thorngate Creek, Des Plaines River triburary	Step pool structure installation and stabilization	$320,000
	Stoneroller Creek, Des Plaines River tributary	Creek stabilization	$425,000
	Unnamed tributary to Des Plaines River (Wright Woods Forest Preserve)	Creek stabilization	$75,000
	North Mill Creek, Des Plaines River tributary	Dam removal, stream channel and riparian habitat restoration	$4,200,000
Forest Preserves of Cook County	Des Plaines River (Portwine Woods)	Tree removal and brush clearing, native sedge, grass, and wildflower restoration	$1,100,000
	Salt Creek, Des Plaines River tributary (Bemis Woods)	Invasive species control, prescribed fire (2017)	$749,000
	Des Plaines River (Black Partridge Woods)		
	Salt Creek, Des Plaines River tributary (Brookfield Woods)		
	Salt Creek, Des Plaines River tributary (Busse Woods)		
	Des Plaines River (Cermak Woods)		
	Des Plaines River (Dam 1 Woods)		
	Buffalo Creek, Des Plaines River tributary (Deer Grove West)		
	Buffalo Creek, Des Plaines River tributary (Jens Jensen)		
	Des Plaines River (G.A.R. Woods)		
	Des Plaines River (Kloempken)		
	Des Plaines River (Lake Avenue Woods)		
	Des Plaines River (McCormick Woods)		
	Des Plaines River (River Trail Nature Center)		
	Des Plaines River (Robinson Woods)		
	Salt Creek, Des Plaines River tributary, (Salt Creek Nature Preserve)		
	Des Plaines River (Schiller Woods)		
	Des Plaines River (Thatcher Woods)		
	Salt Creek, Des Plaines River tributary (Wolf Road Paririe)		
	Buffalo Creek, Des Plaines River Tributary (Deer Grove)	Tree removal, shrub clearing, invasive species monitoring and clearing, hydrology repairs	$3,000,000
		Additional Habitat Improvement Costs	**$12,220,505**

Appendix 3. River specific effort, gear, and station summaries for the Des Plaines, DuPage, Kankakee, and Fox Rivers.

River	Year	Site	River segment	Gear	Effort
DuPage River	1983	GB-01	Lower	1BE	45
DuPage River	1983	GB-11	Middle	1BE	40
DuPage River	1997	GB-01	Lower	1BE	30
DuPage River	1997	GB-11	Middle	1BE	35
DuPage River	2002	GB-11	Middle	1BE	60
DuPage River	2003	GB-01	Lower	1BE	30
DuPage River	2008	GB-01	Lower	1BE/1SH	60/na
DuPage River	2008	GB-11	Middle	1BE/1SH	60/na
DuPage River	2013	GB-01	Lower	1BE/2BE/1SH	30/30/na
DuPage River	2013	GB-11	Middle	1BE	60
Fox River	1996	DT-46	Lower	1BE	60
Fox River	1996	DT-36, 03, 69, 06, 22	Middle	1BE/2BE	30/30
Fox River	1996	DT-09	Middle	1BE/2BE	25/40
Fox River	2002	DT-36, 03, 69, 09, 06, 22	Middle	1BE/2BE/1SH	30/30/na
Fox River	2007	DT-46	Lower	1BE/2BE/1SH	30/30/na
Fox River	2007	DT-36, 03, 69, 09	Middle	1BE/2BE/1SH	30/30/na
Fox River	2007	DT-03, 22	Middle	1BE/2BE	30/30
Fox River	2007	DT-51, 23, 35	Upper	1BE/2BE	30/30
Fox River	2012	DT-46	Lower	1BE/2BE/1SH	30/30/na
Fox River	2012	DT-36, 03, 69, 09, 22	Middle	1BE/2BE/1SH	30/30/na
Fox River	2012	DT-06	Middle	1BE/2BE/1SH/2SH	30/30/na/na
Fox River	2007	DT-51, 23, 35	Upper	1BE/2BE/1SH	30/30/na
Kankakee River	1994	F-01	Lower	1BE	60
Kankakee River	1994	F-11	Lower	1BE/1SH	60/na
Kankakee River	1994	F-14	Lower	1BE/1SH	30/na
Kankakee River	1994	F-04, 07, 08, 12, 13	Middle	1BE/1SH	60/na
Kankakee River	1994	F-02, 03, 06, 09, 15	Upper	1BE/1SH	60/na
Kankakee River	2000	F-01, 14	Lower	1BE/2BE/1PE/1SH	30/30/30/na
Kankakee River	2000	F-11	Lower	1BE/1PE/1SH	30/30/na
Kankakee River	2000	F-04, 07, 08, 13	Middle	1BE/2BE/1PE/1SH	30/30/30/na
Kankakee River	2000	F-12	Middle	1BE/2BE/1PE/1SH	30/30/38.66/na
Kankakee River	2000	F-02, 06, 15	Upper	1BE/2BE/1PE/1SH	30/30/30/na
Kankakee River	2000	F-03	Upper	1BE/2BE/1PE/1SH	30/20/38.5/na
Kankakee River	2000	F-09	Upper	1BE/2BE/1PE/1SH	35/30/33.33/na
Kankakee River	2005	F-01, 11, 14	Lower	1BE/2BE/1PE/1SH	30/30/15/na
Kankakee River	2005	F-04, 07, 08, 12, 13	Middle	1BE/2BE/1PE/1SH	30/30/15/na
Kankakee River	2005	F-02, 03, 06, 09, 15	Upper	1BE/2BE/1PE/1SH	30/30/15/na
Kankakee River	2010	F-01, 11, 14	Lower	1BE/2BE/1SH	30/30/na
Kankakee River	2010	F-04, 07, 08, 12, 13	Middle	1BE/2BE/1SH	30/30/na
Kankakee River	2010	F-02, 03, 06, 09, 15	Upper	1BE/2BE/1SH	30/30/na

Appendix 3. (cont.)

River	Year	Site	River segment	Gear	Effort
Des Plaines River	1983	G-12	Lower	1BE	60
Des Plaines River	1983	G-03, 08, 18, 24, 30, 32	Upper	1BE	60
Des Plaines River	1983	G-07, 11, 33, 36	Upper	1BE	30
Des Plaines River	1983	G-25, 26, 34	Upper	1SH	.
Des Plaines River	1983	G-28, 35	Upper	1BE	45
Des Plaines River	1997	G-07, 28, 35	Upper	1BE	35
Des Plaines River	1997	G-08	Upper	1ES	14
Des Plaines River	1997	G-11	Upper	1BE	60
Des Plaines River	1997	G-18	Upper	1BE/1SH	30/na
Des Plaines River	1997	G-25	Upper	1BE	24
Des Plaines River	1997	G-33	Upper	1BE	30
Des Plaines River	2003	G-05	Upper	1BE	40
Des Plaines River	2003	G-06	Upper	1BE/1PE	30/30
Des Plaines River	2003	G-07, 11, 18, 25	Upper	1BE/2BE/1SH	30/30/na
Des Plaines River	2003	G-08	Upper	1ES	15
Des Plaines River	2003	G-14	Upper	1BE	45
Des Plaines River	2003	G-15, 16, 38, 39, 45	Upper	1BE	30
Des Plaines River	2003	G-30	Upper	1BE	20/23*
Des Plaines River	2003	G-33	Upper	1BE/2BE/1SH	30/23/na
Des Plaines River	2003	G-35	Upper	1BE/2BE/1SH	30/20/na
Des Plaines River	2003	G-46	Upper	1BE/1SH	30/na
Des Plaines River	2008	G-02, 33	Upper	1BE/1SH	60/na
Des Plaines River	2008	G-03	Upper	1BE/2BE	30/30
Des Plaines River	2008	G-07, 25, 35	Upper	1BE	60
Des Plaines River	2008	G-08	Upper	1ES	42
Des Plaines River	2008	G-11	Upper	1BE/1SH	60/na
Des Plaines River	2008	G-18	Upper	1BE/2BE/1SH	30/30/na
Des Plaines River	2008	G-01	Lower	1BE/2BE	30/30
Des Plaines River	2008	G-12	Lower	1BE/1SH	30/na
Des Plaines River	2013	G-01	Lower	1BE/2BE	30/30
Des Plaines River	2013	G-12	Lower	1BED	60
Des Plaines River	2013	G-25, 07, 35, 15, 30, 33, 18, 03)	Upper	1BE/1SH	60/na
Des Plaines River	2013	G-96	Upper	1BE	30
Des Plaines River	2013	G-06	Upper	1BE/1SH	40/na
Des Plaines River	2013	G-36	Upper	1BE/1SH	45/na
Des Plaines River	2013	G-38, 44, 01	Upper	1BE	60
Des Plaines River	2013	G-02	Upper	1BE/1SH	55/na
Des Plaines River	2013	G-11	Upper	1BE/1SH	50/na

*Two effort values reported under one gear designation.

Appendix 4. Cumulative fish species richness across all sampling periods as denoted in Appendix 3.

Species	Des Plaines	DuPage	Kankakee	Fox	Species	Des Plaines	DuPage	Kankakee	Fox
American brook lamprey			X		Northern hog sucker		X	X	X
American eel			X		Northern pike	X	X	X	X
Banded darter		X	X	X	Orangespotted sunfish	X	X	X	X
Banded killifish	X				Pirate perch			X	
Bigmouth buffalo	X		X		Pugnose minnow				X
Bigmouth shiner	X	X		X	Pumpkinseed	X	X	X	X
Black buffalo			X	X	Pumpkinseed x Green sunfish hybrid	X			
Black bullhead	X	X	X	X	Quillback	X	X	X	X
Black crappie	X	X	X	X	Rainbow darter			X	
Black redhorse		X	X	X	Red shiner	X	X	X	
Blackchin shiner	X				Red shiner x Spotfin shiner hybrid			X	
Blacknose dace			X	X	Redear sunfish	X		X	
Blackside darter	X	X	X	X	Redfin shiner	X		X	
Blackstripe topminnow	X	X	X	X	River carpsucker	X	X	X	X
Bluegill	X	X	X	X	River redhorse		X	X	X
Bluegill x Green sunfish hybrid	X	X	X	X	Rock bass	X	X	X	X
Bluntnose darter			X		Rosyface shiner	X		X	X
Bluntnose minnow	X	X	X	X	Round goby	X		X	
Bowfin	X		X	X	Sand shiner	X	X	X	X
Brook silverside	X		X	X	Sauger	X		X	X
Brown bullhead			X		Shorthead redhorse	X	X	X	X
Bullhead minnow	X		X	X	Shortnose gar			X	X
Carp	X	X	X	X	Silver carp				X
Carp x Goldfish hybrid	X	X			Silver redhorse	X	X	X	X
Central mudminnow	X		X		Silverjaw minnow			X	
Central stoneroller	X	X	X	X	Skipjack herring			X	X
Channel catfish	X	X	X	X	Slenderhead darter			X	X
Common shiner	X		X	X	Smallmouth bass	X	X	X	X
Creek chub	X	X	X	X	Smallmouth buffalo	X	X	X	X
Creek chubsucker			X		Spotfin shiner	X	X	X	X
Emerald shiner	X	X	X	X	Spottail shiner	X	X	X	X
Fantail darter			X		Spotted sucker	X		X	
Fathead minnow	X	X	X	X	Starhead topminnow			X	X
Flathead catfish	X		X	X	Steelcolor shiner			X	
Freshwater drum	X	X	X	X	Stonecat	X		X	X
Gizzard shad	X	X	X	X	Striped bass x White bass hybrid (Wiper)		X		X
Golden redhorse	X	X	X	X	Striped shiner	X	X	X	X
Golden shiner	X	X	X	X	Suckermouth minnow	X	X	X	X
Goldeye			X		Tadpole madtom	X		X	X
Goldfish	X	X	X		Threadfin shad	X		X	
Grass carp	X			X	Trout-perch			X	
Grass pickerel	X		X	X	Unidentified Carpsucker			X	
Green sunfish	X	X	X	X	Unidentified lamprey			X	
Highfin carpsucker			X	X	Unidentified Redhorse			X	
Hornyhead chub	X	X	X	X	Unidentified Sunfish hybrid	X			
Iowa darter	X				Unidentified Stoneroller		X		
Ironcolor shiner			X		Walleye	X	X	X	X
Johnny darter	X	X	X	X	Walleye x Sauger hybrid (Saugeye)				X
Lake chubsucker			X		Warmouth	X		X	X
Largemouth bass	X	X	X	X	Weed shiner			X	
Logperch	X	X	X	X	White bass	X		X	X
Longear sunfish	X	X	X		White crappie	X		X	X
Longear sunfish x Bluegill hybrid			X		White perch			X	
Longnose gar	X	X	X	X	White sucker	X	X	X	X
Mimic shiner	X	X	X	X	Yellow bass	X			X
Mooneye			X	X	Yellow bullhead	X	X	X	X
Mosquitofish	X		X		Yellow perch	X			X
Muskellunge	X			X	**TOTALS**	**77**	**53**	**99**	**76**

Appendix 5. Mussel fish-host relationships documented for the 32 mussel species and 109 fish species surveyed throughout the Des Plaines, DuPage, Kankakee, and Fox Rivers. Relationships identified using the Illinois Natural History Survey Freshwater Mussel Host Database. Grey highlighted cells indicate mussel fish-host relationships where either natural infestation or natural transformation was noted in the database.

	Freshwater Mussels																															
Fish Species (common name)	**Black Sandshell** (*Ligumia recta*)	**Creeper** (*Strophitus undulatus*)	**Deertoe** (*Truncilla truncata*)	**Elktoe** (*Alasmidonta marginata*)	**Ellipse** (*Venustaconcha ellipsiformis*)	**Fatmucket** (*Lampsilis siliquoidea*)	**Fawnsfoot** (*Truncilla donaciformis*)	**Flutedshell** (*Lasmigona costata*)	**Fragile Papershell** (*Leptodea fragilis*)	**Giant Floater** (*Pyganodon grandis*)	**Hickorynut** (*Obovaria olivaria*)	**Lilliput** (*Toxolasma parvum*)	**Mapleleaf** (*Quadrula quadrula*)	**Monkeyface** (*Quadrula metanevra*)	**Mucket** (*Actinonaias ligamentina*)	**Paper Pondshell** (Utterbackia imbecillis)	**Pimpleback** (*Amphinaias pustulosa*)	**Pink Heelsplitter** (*Potamilus alatus*)	**Pink Papershell** (*Potamilus ohiensis*)	**Pistolgrip** (*Tritogonia verrucosa*)	**Plain Pocketbook** (*Lampsilis cardium*)	**Purple Wartyback** (*Cyclonaias tuberculata*)	**Rock Pocketbook** (*Arcidens confragosus*)	**Round Pigtoe** (*Pleurobema sintoxia*)	**Sheepnose** (*Plethobasus cyphyus*)	**Spike** (*Elliptio dilatata*)	**Threehorn Wartyback** (*Obliquaria reflexa*)	**Threeridge** (*Amblema plicata*)	**Wabash Pigtoe** (*Fusconaia flava*)	**Washboard** (*Megalonaias nervosa*)	**White Heelsplitter** (*Lasmigona complanata*)	**Yellow Sandshell** (*Lampsilis teres*)	**Potential # of Mussel Species Hosted**
American brook lamprey																																0
American eel	X							X							X								X			X			X		6
Banded darter		X			X			X																	X						4
Banded killifish	X			X				X		X					X	X							X		X	X				X		10
Bigmouth buffalo								X																								1
Bigmouth shiner																																0
Black buffalo																																0
Black bullhead		X						X									X			X		X							X			6
Black crappie	X	X				X		X		X					X	X					X					X		X	X	X	X	X	14
Black redhorse																												X					1
Blackchin shiner										X																							1
Blacknose dace		X								X				X	X										X	X						6
Blackside darter		X			X			X																			X						4
Blackstripe topminnow																																	0
Bluegill	X	X				X		X		X		X		X	X	X					X				X		X		X	X	X		X	16
Bluegill x Green sunfish hybrid																																	0
Bluntnose darter																																	0
Bluntnose minnow		X				X		X		X				X											X	X							7
Bowfin								X																						X			2
Brook silverside										X																							1
Brown bullhead		X						X									X			X										X			5
Bullhead minnow								X																		X							2
Carp	X							X		X					X									X							X		6
Carp x Goldfish hybrid																																	0
Central mudminnow		X						X																X									3
Central stoneroller	X	X						X		X				X	X										X	X				X			9
Channel catfish		X						X					X			X	X			X		X	X					X		X			10
Common shiner		X		X		X		X		X				X											X	X			X				9
Creek chub		X		X				X		X				X	X	X				X				X	X	X					X		12
Creek chubsucker																																	0

Appendix 5. (cont.)

	Freshwater Mussels																															
Fish Species (common name)	**Black Sandshell** (*Ligumia recta*)	**Creeper** (*Strophitus undulatus*)	**Deertoe** (*Truncilla truncata*)	**Elktoe** (*Alasmidonta marginata*)	**Ellipse** (*Venustaconcha ellipsiformis*)	**Fatmucket** (*Lampsilis siliquoidea*)	**Fawnsfoot** (*Truncilla donaciformis*)	**Flutedshell** (*Lasmigona costata*)	**Fragile Papershell** (*Leptodea fragilis*)	**Giant Floater** (*Pyganodon grandis*)	**Hickorynut** (*Obovaria olivaria*)	**Lilliput** (*Toxolasma parvum*)	**Mapleleaf** (*Quadrula quadrula*)	**Monkeyface** (*Quadrula metanevra*)	**Mucket** (*Actinonaias ligamentina*)	**Paper Pondshell** (Utterbackia imbecillis)	**Pimpleback** (*Amphinaias pustulosa*)	**Pink Heelsplitter** (*Potamilus alatus*)	**Pink Papershell** (*Potamilus ohiensis*)	**Pistolgrip** (*Tritogonia verrucosa*)	**Plain Pocketbook** (*Lampsilis cardium*)	**Purple Wartyback** (*Cyclonaias tuberculata*)	**Rock Pocketbook** (*Arcidens confragosus*)	**Round Pigtoe** (*Pleurobema sintoxia*)	**Sheepnose** (*Plethobasus cyphyus*)	**Spike** (*Elliptio dilatata*)	**Threehorn Wartyback** (*Obliquaria reflexa*)	**Threeridge** (*Amblema plicata*)	**Wabash Pigtoe** (*Fusconaia flava*)	**Washboard** (*Megalonaias nervosa*)	**White Heelsplitter** (*Lasmigona complanata*)	**Yellow Sandshell** (*Lampsilis teres*)	**Potential # of Mussel Species Hosted**
Emerald shiner																																1
Fantail darter		X			**X**			X																				**X**				3
Fathead minnow		X						X						X											X							4
Flathead catfish		X						X					**X**				**X**			X		**X**			**X**		X		**X**			9
Freshwater drum			**X**				**X**	X	**X**	**X**								**X**	**X**					**X**			X	**X**		**X**			11
Gizzard shad								**X**		**X**														**X**			**X**	X			**X**	**X**		7
Golden redhorse				X																									**X**					2
Golden shiner		X		X				**X**		X														X		X	X				X			8
Goldeye																												**X**				X			2
Goldfish								X		X						X																		3
Grass carp																																		0
Grass pickerel																																		0
Green sunfish	X	X				X		X		**X**		X		**X**	**X**	X					X		X			X		X		X	X	**X**	16
Highfin carpsucker																																	X	1
Hornyhead chub				X				X						X												X								4
Iowa darter		X			X					**X**																	X							4
Ironcolor shiner																																		0
Johnny darter		X			**X**			X		**X**		X															X							6
Lake chubsucker																																		0
Largemouth bass	X	X				X		X		**X**					**X**	X					X						X		**X**	X	X	X	**X**	14
Logperch		X			X			X																			X		**X**		X			6
Longear sunfish	X	X				X		X		X						X															X	X		8
Longear sunfish x Bluegill hybrid																																		0
Longnose gar								X		X																	X				**X**	**X**	**X**	6
Mimic shiner								X																		X								2
Mooneye																													**X**					1
Mosquitofish (WESTERN)								X								**X**				**X**					X								4
Muskellunge																																		0
Northern hog sucker				**X**				X																					**X**					3
Northern pike								X																			X		**X**					3
Orangespotted sunfish	X							X		X		X			X									X								X	**X**	8
Pirate perch								X																										1
Pugnose minnow																																		0
Pumpkinseed	X	X				**X**		X		X						X					X						X		**X**	X				10
Quillback				X				X																X										3

Appendix 5. (cont.)

	Freshwater Mussels																															
Fish Species (common name)	**Black Sandshell** (*Ligumia recta*)	**Creeper** (*Strophitus undulatus*)	**Deertoe** (*Truncilla truncata*)	**Elktoe** (*Alasmidonta marginata*)	**Ellipse** (*Venustaconcha ellipsiformis*)	**Fatmucket** (*Lampsilis siliquoidea*)	**Fawnsfoot** (*Truncilla donaciformis*)	**Flutedshell** (*Lasmigona costata*)	**Fragile Papershell** (*Leptodea fragilis*)	**Giant Floater** (*Pyganodon grandis*)	**Hickorynut** (*Obovaria olivaria*)	**Lilliput** (*Toxolasma parvum*)	**Mapleleaf** (*Quadrula quadrula*)	**Monkeyface** (*Quadrula metanevra*)	**Mucket** (*Actinonaias ligamentina*)	**Paper Pondshell** (Utterbackia imbecillis)	**Pimpleback** (*Amphinaias pustulosa*)	**Pink Heelsplitter** (*Potamilus alatus*)	**Pink Papershell** (*Potamilus ohiensis*)	**Pistolgrip** (*Tritogonia verrucosa*)	**Plain Pocketbook** (*Lampsilis cardium*)	**Purple Wartyback** (*Cyclonaias tuberculata*)	**Rock Pocketbook** (*Arcidens confragosus*)	**Round Pigtoe** (*Pleurobema sintoxia*)	**Sheepnose** (*Plethobasus cyphyus*)	**Spike** (*Elliptio dilatata*)	**Threehorn Wartyback** (*Obliquaria reflexa*)	**Threeridge** (*Amblema plicata*)	**Wabash Pigtoe** (*Fusconaia flava*)	**Washboard** (*Megalonaias nervosa*)	**White Heelsplitter** (*Lasmigona complanata*)	**Yellow Sandshell** (*Lampsilis teres*)	**Potential # of Mussel Species Hosted**
Rainbow darter		X			**X**			X		**X**														X							5
Red shiner	X							X		X				X										X	X			**X**				7
Red shiner x Spotfin shiner hybrid																																0
Redear sunfish								X																								1
Redfin shiner	X									X																						2
River carpsucker				X																												1
River redhorse								**X**																							**X**	2
Rock bass	X	X		X		X		X		**X**					X	X							**X**			X		X			X	12
Rosyface shiner	X																															1
Round goby	X					X				X					X																	4
Sand shiner		X				X																										2
Sauger	X		**X**			X	**X**	X						**X**	**X**						**X**			**X**	**X**			**X**		X	**X**		13
Shorthead redhorse				**X**				X															X						**X**			3
Shortnose gar																													X			**X**	2
Silver carp																																	0
Silver redhorse				X				X																									2
Silverjaw minnow															X													X					2
Skipjack herring										**X**																		**X**			**X**			3
Slenderhead darter		X						X																			X				X			4
Smallmouth bass		X				X		X							**X**						X						X						6
Smallmouth buffalo				X																			X										2
Spotfin shiner		X						X						X		X								**X**	X				**X**	**X**			8
Spottail shiner								X																	X								2
Spotted sucker																																	0
Starhead topminnow																																	0
Steelcolor shiner								X						X											X				**X**				4
Stonecat								X																									1
Striped bass x White bass hybrid (Wiper)																																	0
Striped shiner				X		X		X		**X**				X									X		X		X						8
Suckermouth minnow																									X								1
Tadpole madtom						**X**									**X**																**X**			3
Threadfin shad																																	0
Trout-perch								X																									1

Appendix 5. (cont.)

	Freshwater Mussels																															
Fish Species (common name)	**Black Sandshell** (*Ligumia recta*)	**Creeper** (*Strophitus undulatus*)	**Deertoe** (*Truncilla truncata*)	**Elktoe** (*Alasmidonta marginata*)	**Ellipse** (*Venustaconcha ellipsiformis*)	**Fatmucket** (*Lampsilis siliquoidea*)	**Fawnsfoot** (*Truncilla donaciformis*)	**Flutedshell** (*Lasmigona costata*)	**Fragile Papershell** (*Leptodea fragilis*)	**Giant Floater** (*Pyganodon grandis*)	**Hickorynut** (*Obovaria olivaria*)	**Lilliput** (*Toxolasma parvum*)	**Mapleleaf** (*Quadrula quadrula*)	**Monkeyface** (*Quadrula metanevra*)	**Mucket** (*Actinonaias ligamentina*)	**Paper Pondshell** (Utterbackia imbecillis)	**Pimpleback** (*Amphinaias pustulosa*)	**Pink Heelsplitter** (*Potamilus alatus*)	**Pink Papershell** (*Potamilus ohiensis*)	**Pistolgrip** (*Tritogonia verrucosa*)	**Plain Pocketbook** (*Lampsilis cardium*)	**Purple Wartyback** (*Cyclonaias tuberculata*)	**Rock Pocketbook** (*Arcidens confragosus*)	**Round Pigtoe** (*Pleurobema sintoxia*)	**Sheepnose** (*Plethobasus cyphyus*)	**Spike** (*Elliptio dilatata*)	**Threehorn Wartyback** (*Obliquaria reflexa*)	**Threeridge** (*Amblema plicata*)	**Wabash Pigtoe** (*Fusconaia flava*)	**Washboard** (*Megalonias nervosa*)	**White Heelsplitter** (*Lasmigona complanata*)	**Yellow Sandshell** (*Lampsilis teres*)	**Potential # of Mussel Species Hosted**
Walleye	X	X				**X**		X							**X**								X		X	X						1
Walleye x Sauger hybrid (Saugeye)																																1
Warmouth				**X**		**X**						**X**				**X**												**X**		**X**		**X**	1
Weed shiner																				**X**												1
White bass						X				**X**					**X**													**X**		**X**			1
White crappie	**X**	X				**X**				**X**		X			**X**		**X**		**X**		**X**			**X**			**X**		**X**	**X**	X	X	**X**	1
White perch	X																																1
White sucker				**X**				**X**																X							X		1
Yellow bass																																	1
Yellow bullhead		X						X		**X**										X		X									X		1
Yellow perch	X	X				**X**		X		**X**					**X**	X					X					X		X		X	X	X	1
Number of potential host species	**4**	**4**	**0**	**2**	**0**	**5**	**0**	**4**	**0**	**4**	**0**	**2**	**0**	**0**	**4**	**2**	**1**	**0**	**1**	**2**	**3**	**1**	**3**	**0**	**0**	**3**	**1**	**4**	**1**	**5**	**3**	**3**	1
Number of hosts displaying NI and/or NT	**3**	**2**	**2**	**4**	**4**	**9**	**2**	**4**	**1**	**22**	**0**	**2**	**1**	**3**	**11**	**4**	**4**	**1**	**2**	**2**	**3**	**1**	**5**	**2**	**1**	**5**	**2**	**20**	**4**	**11**	**4**	**8**	1