FY17 Annual Interim Report on the Collaborative Strategy for Deterrent Barrier Research, Design, Implementation and Assessment to Minimize the Spread of Asian Carps in the Upper Mississippi River

Lead Agency: USFWS- La Crosse FWCO (USFWS)

Participating Agencies: USGS-Upper Midwest Environmental Services Center (USGS), Western Illinois University (WIU), Missouri Department of Conservation (MDC), US Army Corps of Engineers (USACE) , Minnesota Department of Natural Resources (MNDNR), Illinois Department of Natural Resources (ILDNR), Iowa Department of Natural Resources (IADNR), Wisconsin Department of Natural Resources (WIDNR), Southern Illinois University (SIU), National Park Service (NPS)

Introduction:

Invasive carps are established in the upper, middle, and lower Mississippi River and their expansion upstream threatens a variety of aquatic ecosystem services including fishing and recreational boating. The upper Mississippi River contains a series of locks and dams that may already limit upstream movement of invasive carp, and thus their spread, by limiting population growth at the reproductive front and minimizing pioneer fish from moving upstream in the system. If severe enough, passage restrictions might hinder reproductive success of invasive carp at the reproductive front because of their requisite migratory and mass spawning behavior, and drifting egg and larval life stages.

At the time of this writing, a collaborative deterrent strategy for the UMR is in the final stages of review. This document defines an intensive management zone (IMZ) in the Upper Mississippi River that includes an area from Lock and Dam 19 to Lock and Dam 14, bracketing the invasion front of Asian carp in the UMR. In concept, the IMZ would be bracketed by effective barriers to Asian carp passage at the upper and lower ends and intensive efforts to reduce Asian carp abundance in between. The goal of this project is to pursue and expand on the recommendations in the UMR deterrent strategy report including 1) identifying the steps necessary to deploy deterrents, 2) implementing and evaluating the use of promising deterrent technologies 3) evaluating the utility of operational modifications at locks and dams 4) maximizing native fish passage. Important information gaps and research needs regarding fish passage, fish distribution and movement around dams, dam design and hydrology, deterrent design and effectiveness, and gate operations should be filled as preliminary implementation steps begin.

The USFWS received additional funding in FY2017 to be used specifically to test a sound deterrent in the presence of high densities of Asian carp with the goal of identifying a mechanism for preventing upstream passage of Asian carp through lock chambers. One method for assessing the effectiveness of fish deterrents is using acoustic telemetry to assess fish passage rates, and this assessment has begun complimentary to the existing Asian carp acoustic monitoring project. Specifically, the study of Asian carp and native fish passage is ongoing at Lock and Dam 19 and in other locations. As deterrence planning is underway, the UMR Asian carp partnership added an objective to this project to expand and focus telemetry efforts on fish passage rates at key locations in the UMR.

Project Objectives:

1. Evaluate promising technologies and strategic locations, and complete UMR deterrent strategy report
2. Participate in regional workshops and webinars to better understand the state-of-the-science on and steps needed to test and deploy deterrent technologies at locks and dams
3. Support ongoing efforts to better understand the application of deterrents in lock chambers for invasive carp while minimizing effects on natives in the UMR
    a. Support efforts to test CO2 application at strategic locations in the UMR
    b. Support development of plans to test complex sound applications at strategic locations in the UMR
4. Quantify native and non-native fish passage at lock and dam 19, 15, and 14 as an assessment tool for the future testing of Asian carp deterrents.

Project Activities:

Participant agencies continued to pursue the development and implementation plan for the UMR deterrent strategy. Specifically:

- Final report on a deterrent strategy for the UMR was reviewed and approved by 4/5 state agencies and all federal partners. Because the final report makes management recommendations about locations for the future testing of sound barriers, some agencies may not be able to support the group’s recommendation.
- Agency representatives participated in the following meetings and conference calls to continue pursuing planning of deterrent evaluations..

Meetings:
One Lock and Dam 14 Asian Carp CO2 Deterrent Project Meeting
Two Upper Mississippi River Asian Carp Coordination Meetings

Conference Calls:
Four Upper Mississippi River Asian Carp Deterrent Strategy Team Conferences
Five Upper Mississippi River Asian Carp Coordination Conferences
Six Asian Carp CO2 Deterrent Coordination Team Conferences
Four Lock and Dam 14 Asian Carp CO2 Deterrent Project Conferences
Two Asian Carp Acoustic Deterrent Project (Kentucky, LD19) Conferences

Webinars and Workshops:
Asian Carp Acoustic Deterrent Workshop Webinar
Mississippi River Basin Asian Carp Project Updates Webinar
National Asian Carp Control Strategies Workshop

State-of-the-science were reviewed at these meetings and the team began identifying authorities and steps needing completion prior to implementing a deterrent evaluation at strategic locks and dams.

- Completed a pilot survey of fish community and behavior at Lock and Dams 14 and 15 to better understand how to deploy deterrents at these strategic locations to deter Invasive carp while minimizing effects to native species.

Project Highlights:
Objective 1 (evaluate promising technologies)

- University of Minnesota – Twin Cities modeled the effect of gate operations on fish passage at Lock and Dam 5 and continued field evaluation of gate flow modeling at Lock and Dam 2 and acoustic speakers at Lock and Dam 8.
- University of Minnesota – Duluth continued research on complex noise technology

Objective 1 (evaluate strategic locations)

- USFWS - Over 190 minutes of electrofishing conducted and 1700 yards of gill net fished in a two week effort at Lock and Dams 14 and 15
- USFWS and SIU - Nine hours of ARIS imagery collected and one comprehensive hydroacoustic survey completed at Lock and Dams 14 and 15
- USFWS - Over 3,700 fish sampled and 80 floy tags deployed in and around Lock and Dams 14 and 15
- Details of this work are included in this report in the section **USFWS Pilot survey of fish community and behavior at Lock and Dams 14 and 15 using traditional gears, Adaptive Resolution Imaging Sonar (ARIS), and hydroacoustics**

Objective 1 and 2:

- The MN DNR issued an RFP for a feasibility study at Lock and Dam 5 to compile the current state of knowledge of complex noise technology, complete an accounting of all costs associated with construction, operation, and maintenance along with an accounting of all technical problems and equipment failures associated with existing projects; gather pre-engineering data to inform potential design work, provide a synopsis of US Army Corps of Engineers requirements and support and Wisconsin support and provide an assessment and recommendations on the suitability and effectiveness of deterrent technologies at proposed site

Objective 3:

- This objective is currently being addressed at a higher agency level with several agency representatives working with funding under Great Lakes Restoration Initiative and outside of the UMR Asian carp ad-hoc. Coordination in the pursuit of testing CO2 is ongoing at Lock and Dam 14 as is evaluation of sound deterrents at Brandon Road Dam on the Illinois River and Barkley Dam on the Cumberland River. Results of these efforts will be directly relevant and will contribute to any future applications/efforts in the UMR.

Objective 4 USFWS/USGS:

- 363 Bighead, Silver, and Hybrid Carp have been tagged to date and 313 transmitters were active the entire year in 2017.
- Over 800 passage events have been recorded indicating that Asian carp populations from Pool 10 to Pool 26 intermix at different rates especially during spawning and when main spillway dam gates are open. Greater than 50% of tagged Asian carp used multiple pools with a year.
- In 2017, one female Silver Carp, which was tagged in Pool 19, was detected on a stationary receiver in Pool 10 >350 km upstream from where it was tagged. This suggests a small percentage of fish (<1%) move upstream as potential propagules for upstream populations.

Objective 4 MDC:

- Transmitters were implanted into 46 Bighead carp, 48 grass carp, 49 silver carp, 3 hybrid carp, 24 Bigmouth Buffalo, 23 Blue Sucker, 1 Blue Catfish, 20 Channel Catfish, and 25 Flathead Catfish 17 Walleye, 3 Sauger, 2 American Eel, 8 Paddlefish and 50 Lake Sturgeon.
- In the two years of the study (2016-2017), 55 fish were detected in the lock chamber, and 21 of these were detected on the receiver upstream of the chamber
- Of the 27 (49%) of Asian carp that approached the lock chamber, only 2 (4%) passed upstream into Pool 19
- Only Asian carp, Bigmouth Buffalo, Paddlefish, Blue Catfish, and Walleye were detected and assumed to have passed upstream into Pool 19.
- Although 22 of 50 Lake Sturgeon (44%) were detected in or approaching the lock chamber, none were detected moving into Pool 19.
- Detailed information that addresses this objective is included in the Annual UMR Interim Asian Carp Monitoring Report – 2017. This work was completed through interagency cooperation and collaboration that included ILDNR and WIU, MDC, USFWS, and USGS.

Recommendations:

Given the ongoing effort to test sound deterrents, there is a need to collect baseline movement data on Asian carp and native fishes that can be used to evaluate a sound deterrent in future years. This project proposes continued collection of movement information and fish passage in the UMR for the purpose of future analysis of sound deterrence.

A better understanding of the 3-dimensional position of native fish and Asian carp in the lock chamber and approach is needed to aid in deterrent design. Additionally, the team should identify key native fish and mussel species that require fish passage to support robust populations. Data are currently being collected by MDC and WIU on the frequency of native fish passage through Lock 19 and funding should continue to support this effort. Studies are needed to better understand the current impacts of LD 19 on native species, how a deterrent may further impact them, how that may be mitigated, and if possible, how to improve passage for natives under current LD 19 operation.

USFWS Pilot survey of fish community and behavior at Lock and Dams 14 and 15 using traditional gears, Adaptive Resolution Imaging Sonar (ARIS), and hydroacoustics

Methods:

All data were collected over the course of one week for the main and auxiliary locks at Lock and Dam 14 and one additional week for the main lock at Lock and Dam 15. The number of replicates in a day/week were dependent on weather and navigational traffic. Due to the operating schedule of the auxiliary lock at 14, survey efforts at this location were reduced to two days.

Fish behavior and movement through the lower and upper miter gates were observed using an ARIS Explorer 3000 (Sound Metrics). The ARIS sonar camera was mounted to a boat to allow for imagery to be captured in multiple locations around the lock system. Imagery was collected at two locations in each lock chamber (Figures 1-2). With the miter gates open, the boat was tied to the open miter gates and the ARIS collected fish passage imagery for up to 30 minutes at a time, viewing across the chamber at the lock entrance, perpendicular to flow. The 30 minute time frame was chosen because it was the estimate, provided by the lock masters, for how long the gates are open at these locations while a barge is entering or exiting.

After collection, fish passage imagery was evaluated by three independent reviewers. Fish counts and movement were analyzed and the average rates of fish movement observed by the three reviewers were calculated for each video and then for each position (e.g. downstream miter gate at Lock 15). These averages included the rate of upstream, downstream, and unknown swim direction observed at a location, as well as total individual fish observed. Individuals in a school of fish were not counted independently because the quality of the videos does not allow for accurate or consistent counting. Rather, the number of fish schools present was counted and the general swim direction of the entire group was noted. Interpretation of these data can be subjective, so a fourth reviewer was utilized in the event that one of the counts from the three reviewers was noticeably different from the others for a particular image file.

The fish community was surveyed in these areas using boat-mounted pulsed DC electrofishing and one dip netter (Figures 3-4). Conductivity and water temperature were measured and the LTRMP standardized electrofishing power settings table was used to ensure that appropriate power goals were met (Gutreuter et al. 1995). Fish were identified to species and counted. Up to 25 individuals of each species were measured for total length (TL) (except sturgeon were measured for fork length (FL) and paddlefish were measured for eye to fork length (EFL)). Fish over 25.4 cm captured downstream of the locks or within the lock chambers were also weighed and floy tagged. All fish over 30 cm TL, captured above or below the lock, were measured and weighed and those data contributed to the hydrocoustic analysis.

The fish communities in the downstream approach channel and inside the lock chamber, were sampled with 3.24-4” bar x 16-24’ gill nets (Figures 5-7). Due to turbulent tailwater flows, nets were not set in the downstream approach of the main chamber of lock 14. Nets were set within 100 yards of the lock chamber doors in the approach channel and in a zig-zag pattern inside the lock chamber. If barge traffic allowed, fish were driven by pounding on the boat or by electricity and then the nets were pulled. Fish were identified, counted, weighed, measured, and tagged (if applicable) in the same manner as those captured by electrofishing. Netting data from this portion of the project contributed to the analysis of the hydroacoustic data that were also collected. Netting and electrofishing efforts were conducted on at least two separate days to see if any tagged fish were recaptured. Catch per unit effort (CPUE) was calculated for each gear and Wilcox et al. (2004) was used to determine if any of the capture species were considered migratory and potentially migratory in the Upper Mississippi River.

Southern Illinois University (SIU) conducted mobile hydroacoustic surveys to identify the spatial and size distributions of fish in the downstream and upstream approach channels of the main and auxiliary locks and inside the lock chambers (Figures 8-9). Surveys were conducted by boat using two horizontally oriented 200 kHz split-beam BioSonics DT-X transducers, which were offset so that one ensonified the upper portion of the water column and the second sampled immediately below the surface transducer beam. A third transducer (70 kHz) was oriented vertically and used to measure water depth. Additional information about equipment and sampling specifications are explained in detail in MacNamara et al. (2016). The vessel surveyed one-mile upstream of each dam to and including the upstream approach channel, then proceeded into the full lock chamber and conducted a survey within the chamber. Additional surveys were conducted from one mile below each dam up to and including the downstream approach channels. Hydroacoustic data were analyzed by SIU. Data from the horizontal transducers were used to estimate fish densities. Electrofishing data from this project contributed to the analysis of the hydroacoustic data. Additional electrofishing was conducted in areas other than those targeted in this survey. Fish, meeting the aforementioned size requirements, captured from this additional effort downstream of the lock structure were floy tagged to increase sample size of tagged fishes below the lock structure. However, those additional electrofishing data were used solely for hydroacoustic analysis and were not used as part of the fish community dataset at the lock locations.

Figure 1. *Locations where stationary ARIS imagery was collected in the main chamber (yellow) and auxiliary chamber (red) of Lock 14 of the UMR.*

Figure 2. *Locations (yellow) where stationary ARIS imagery will be collected in the main chamber of Lock 15 of the UMR.*

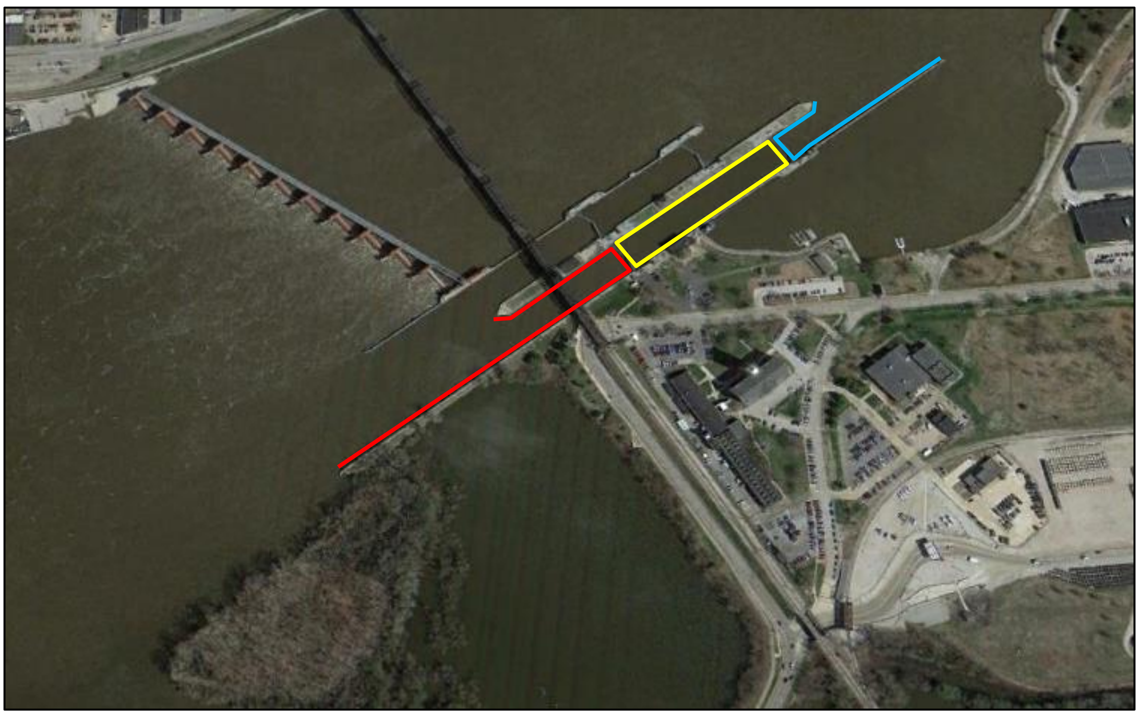

Figure 3. *Areas where pulsed DC electrofishing was conducted in the downstream approach (red), the lock chamber (yellow), and upstream approach (blue) of Lock 14 of the UMR.*

Figure 4. *Areas where pulsed DC electrofishing was conducted in the downstream approaches (red), lock chambers (yellow), and upstream approaches at Lock 14 of the UMR.*

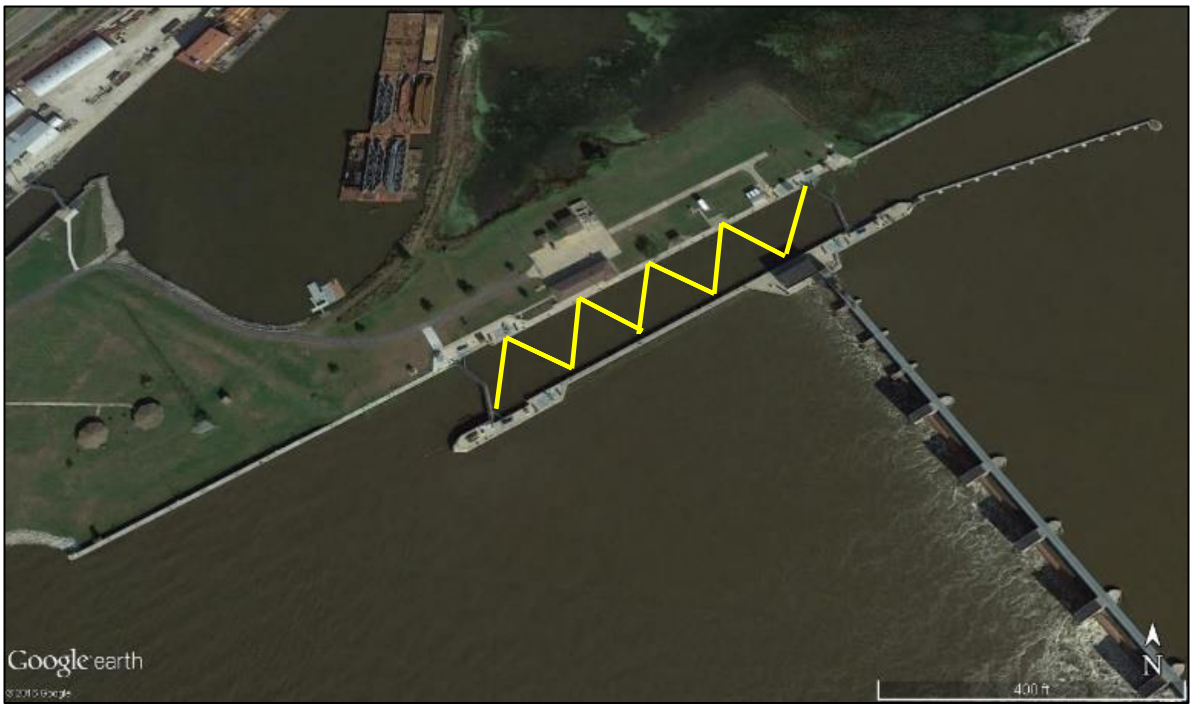

Figure 5. *Areas where gill nets (yellow) were set at the main chamber of Lock 14 the UMR.*

Figure 6. *Areas where pulsed gill nets were set at the lock chamber (yellow) and downstream approach channel (red) of Lock 14 auxiliary of the UMR.*

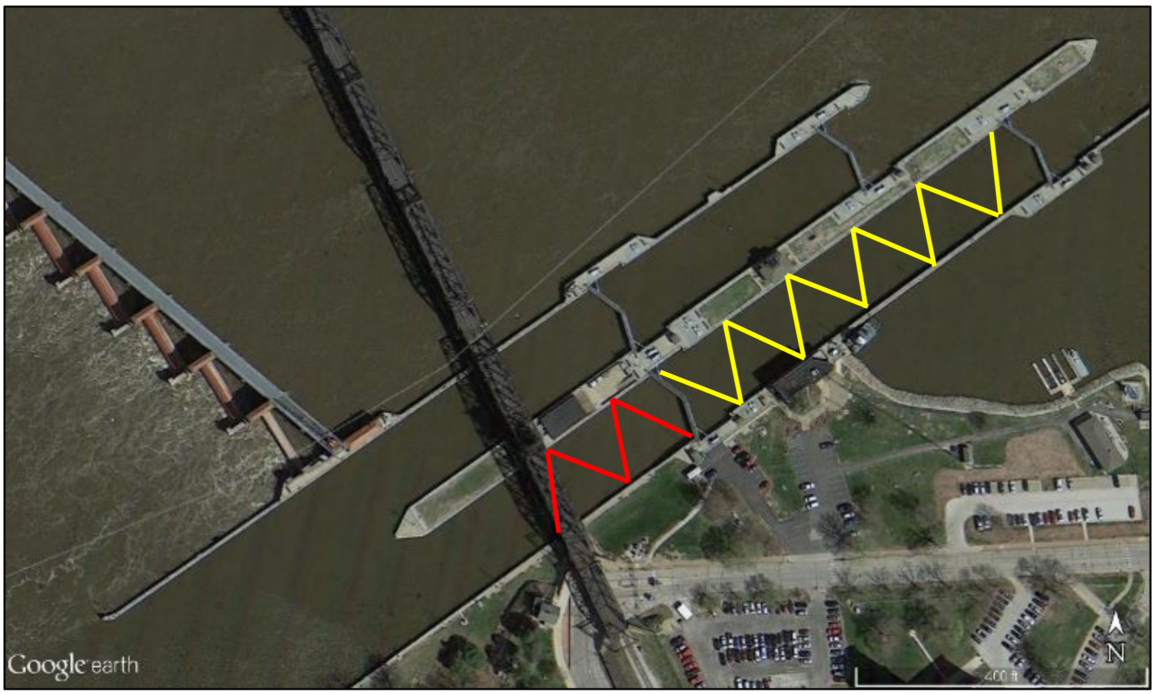

Figure 7. *Areas where gill nets were set in the lock chamber (yellow) and downstream approach channel (red) of Lock 15 of the UMR.*

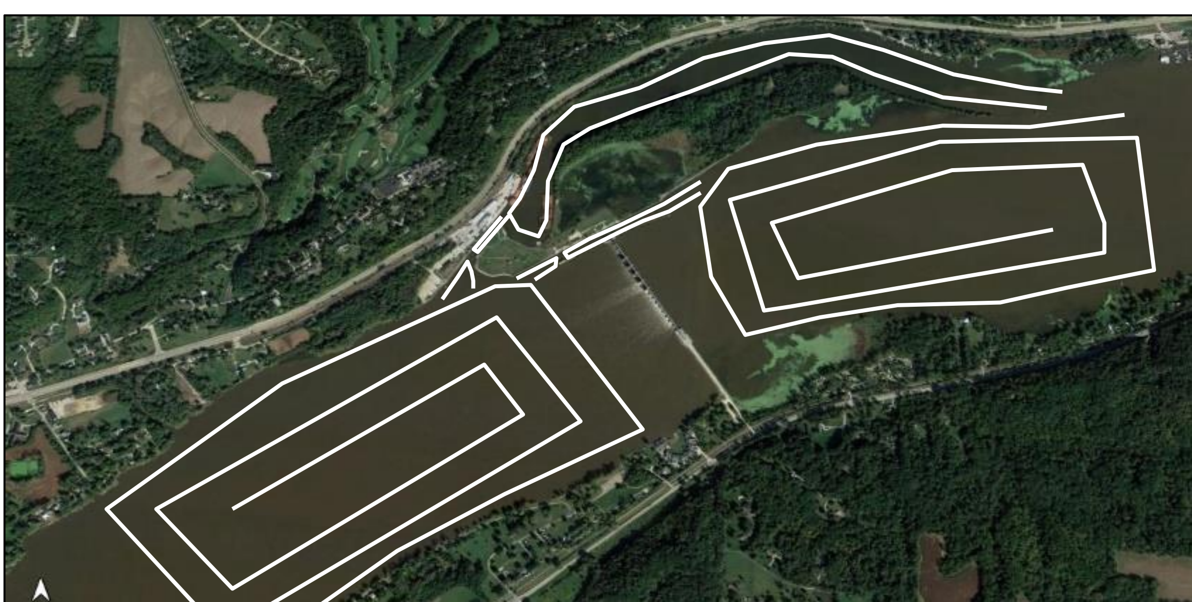

Figure 8. *Generalized paths of hydroacoustic surveys conducted around Lock and Dam 14 of the UMR.*

Figure 9. *Generalized paths of hydroacoustic surveys conducted at Lock and Dam 15 of the UMR.*

Results:

Lock 15

The review of the ARIS imagery proved to be fairly subjective and the interpretation of some of the videos varied widely between reviewers. Some videos required a fourth reviewer due to wide variations in counts. A total of 2.5 hours of ARIS imagery were collected at Lock 15. Due to the constraint of barge traffic, more data were collected at the downstream miter gates than at the upstream gates. When fish were observed at the lower miter gate, more individual and small groups of fish were observed swimming in an upstream direction than downstream (Figure 10). The number of schools counted were highly variable between reviewers, but generally the schools were observed moving in an upstream direction more commonly than downstream (Figure 11). Large numbers of fish moving in various directions close to the camera sometimes made it difficult to distinguish separate schools.

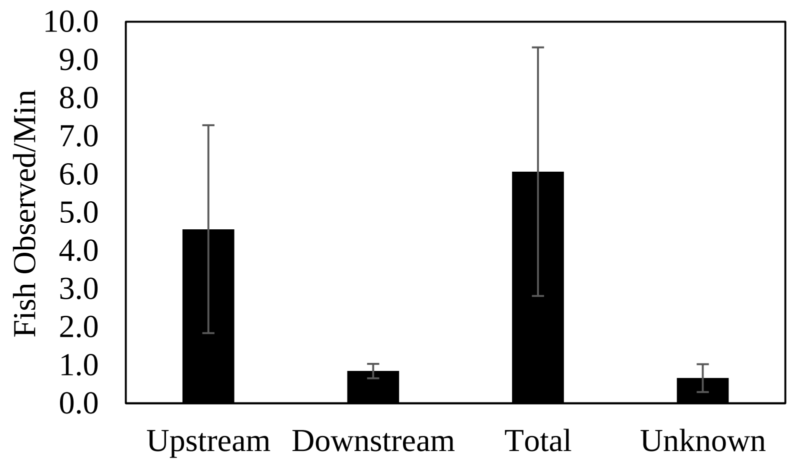

Figure 10. *Average rate (± SD) and swim direction of fish, observed using an ARIS camera, at the open, lower miter gates at Lock 15 of the UMR in August 2017 (n=3).*

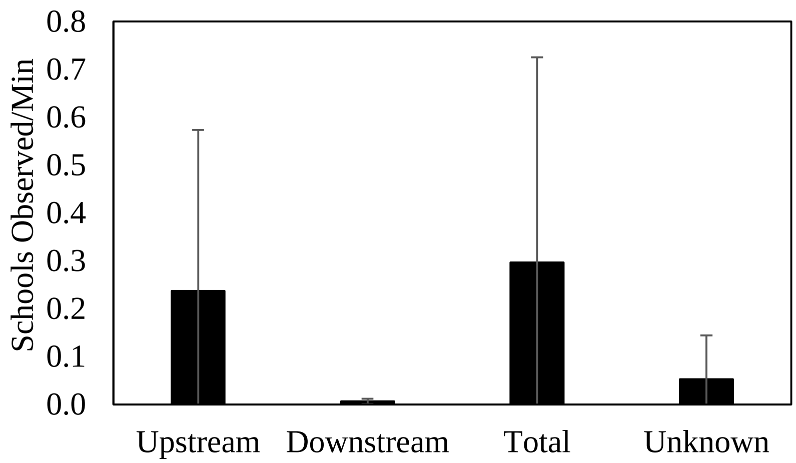

Figure 11. *Average rate (± SD) and swim direction of fish schools, observed using an ARIS camera, at the open, lower miter gates at Lock 15 of the UMR in August 2017 (n=3).*

The effort with traditional gears at Lock 15 was not split evenly among the three target areas surrounding the lock (Figure 3) because of irregular barge traffic. A total of 63 minutes of electrofishing were conducted and 900 yards of gillnet were set among the three target areas. At all sites, more electrofishing runs were completed than gill net sets because setting nets was time consuming and there was often not adequate time to complete a net set between barge tows. The net sets that were completed captured minimal fish compared to electrofishing, although most of the fish captured by electrofishing were small fish and would not have been captured by gill net anyway (Table 2). Most fish were captured in the downstream approach, however a greater number of species were captured in the lock chamber. In all three areas, Emerald Shiner comprised the majority of the total catch in numbers. Fish captured by this effort that are 1) known to move through UMR dams; and/or 2) migratory in UMR; and/or 3) probably migratory in the UMR included Bigmouth Buffalo, Channel Catfish, Freshwater Drum, Mooneye, Paddlefish, Smallmouth Buffalo, and White Bass (Wilcox et al. 2004).

Table 1. *Total catch and effort using two gears in three areas adjacent to the main chamber of Lock 15 of the UMR in August 2017.*

Site	Gear	Species Count	Total Count	Effort	CPUE
Upstream approach	Electrofishing	1	3	15 min	0.2 fish/min
Chamber	Electrofishing	7	155	32.8 min	4.7 fish/min
	Gill Netting	3	3	700 yd	<0.1 fish/yd
Downstream approach	Electrofishing	5	260	15 min	17.3 fish/min
	Gill Netting	1	1	200 yd	<0.1 fish/yd

Site	Electrofishing	Gill Netting
LOCK CHAMBER	**155**	**3**
Channel Shiner *Notropis wickliffi*	5	
Common Carp *Cyprinus carpio*		1
Emerald Shiner *Notropis atherinoides*	139	
Freshwater Drum *Aplodinotus grunniens*	1	1
Gizzard Shad *Dorosoma cepedianum*	1	
Mooneye *Hiodon tergisus*	5	

Paddlefish *Polyodon spathula*		1
Smallmouth Buffalo *Ictiobus bubalus*	1	
White Bass *Morone chrysops*	3	
DOWNSTREAM APPROACH	**260**	**1**
Bigmouth Buffalo *Ictiobus cyprinellus*	1	
Channel Catfish *Ictalurus punctatus*		1
Channel Shiner *Notropis wickliffi*	3	
Emerald Shiner *Notropis atherinoides*	250	
Mooneye *Hiodon tergisus*	5	
White Bass *Morone chrysops*	1	
UPSTREAM APPROACH	**3**	
Emerald Shiner *Notropis atherinoides*	3	
TOTAL	**418**	**4**

Table 2. *Species captured by gear at three sites adjacent to the main lock chamber at Lock and Dam 15 of the UMR in August 2017. Site titles are associated with the colored areas in Figure 3.*

The hydroacoustic surveys that were completed revealed that the density of fish, with total length ≥30 cm, within one mile of Lock and Dam 15 was greater downstream of the structure than upstream (Figures 12-13). Density hotspots below the dam were along either shoreline, particularly the shoreline just downstream of Sylvan slough, which is the first slough on the left descending bank below the lock. The majority of the fish observed (≥30 cm) both upstream and downstream of the lock and dam were less than 50 cm, which differs from the most common lengths of Silver and Bighead Carp observed the previous year in Pool 19 (Figure 14). There were fish ≥ 30 cm present in the lock chamber and in the upstream and downstream approaches at the time of sampling (Figure 15).

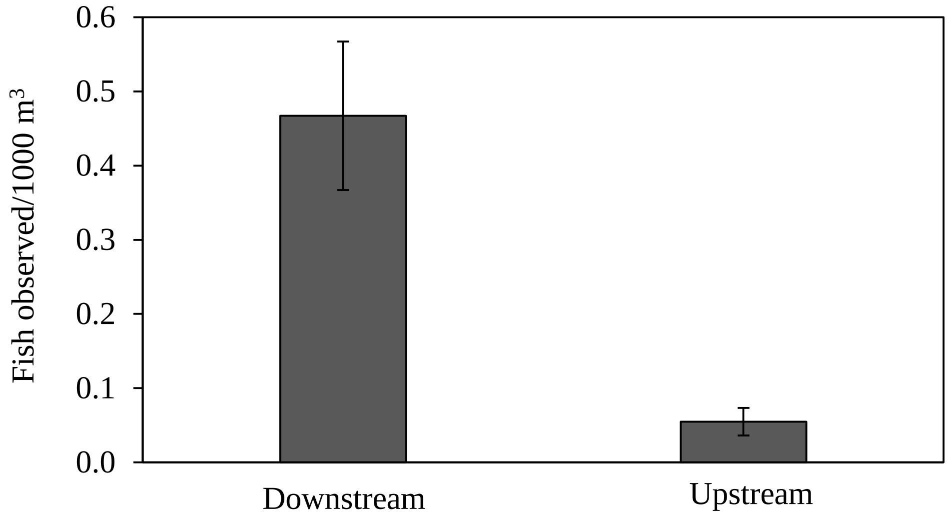

Figure 12. *Mean (SE) densities of fish (individuals ≥ 30 cm total length) observed from mobile hydroacoustic surveys conducted within one mile downstream and upstream of Lock and Dam 15 of the UMR in August 2017.*

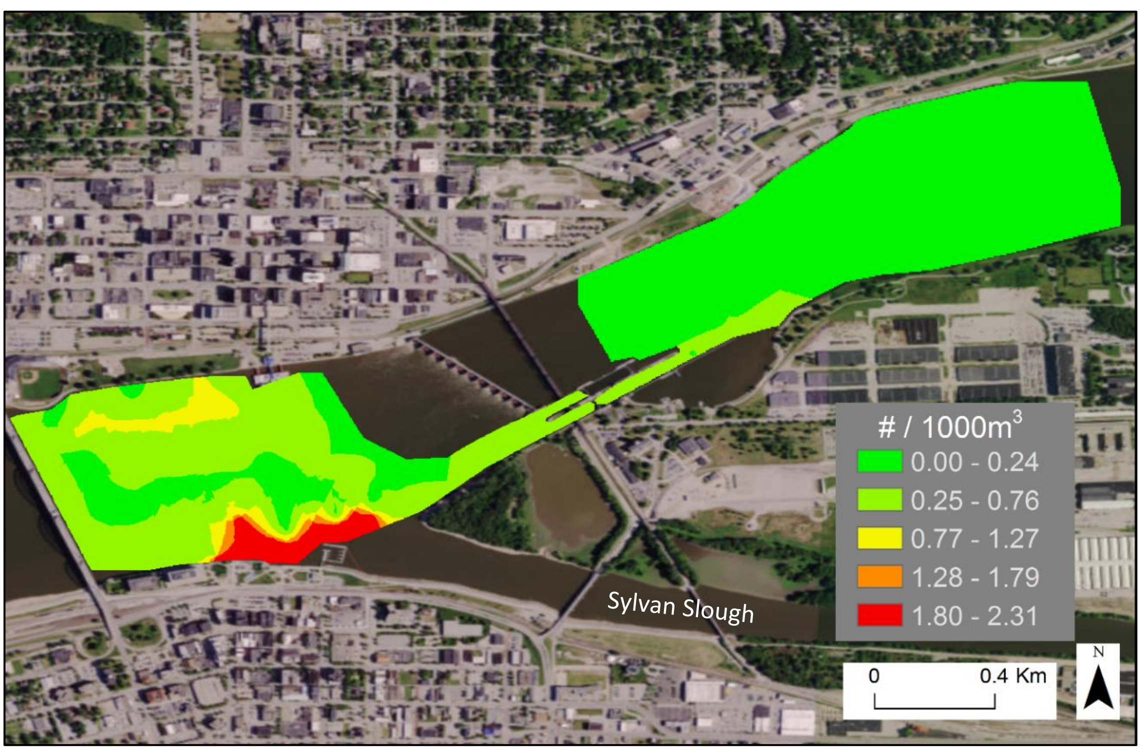

Figure 13. *Densities of all fish ≥ 30 cm total length detected from mobile hydroacoustic surveys upstream and downstream of Lock and Dam 15 of the UMR in August 2017.*

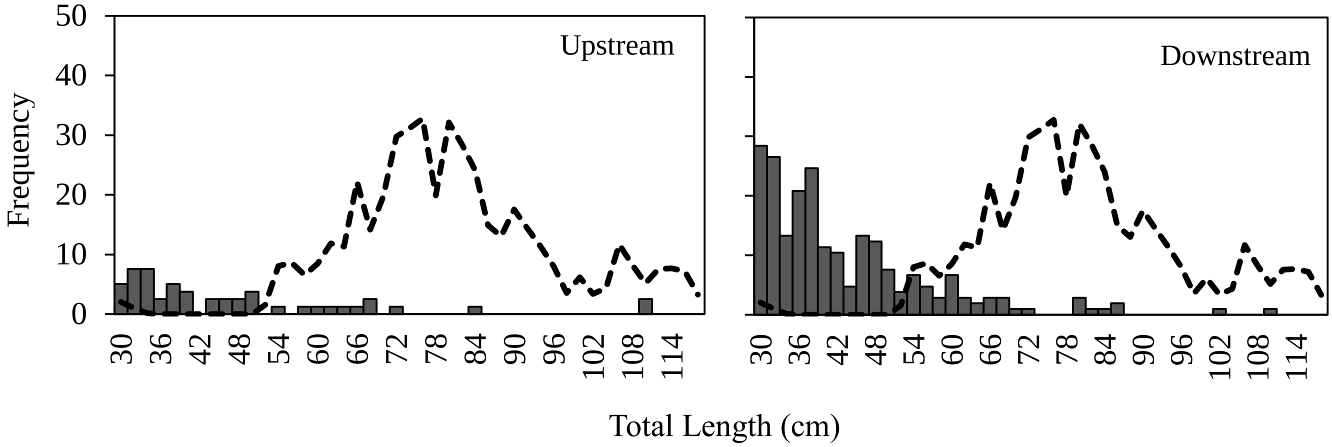

Figure 14. *Size distribution of fishes (gray bars) observed using mobile hydroacoustic surveys within one mile upstream (left) and downstream (right) of Lock and Dam 15 of the UMR in August 2017. Also included for comparison are the combined size distributions of Silver and Bighead Carp (dashed line) observed in Pool 19 by mobile hydroacoustic surveys conducted by Southern Illinois University in December 2016.*

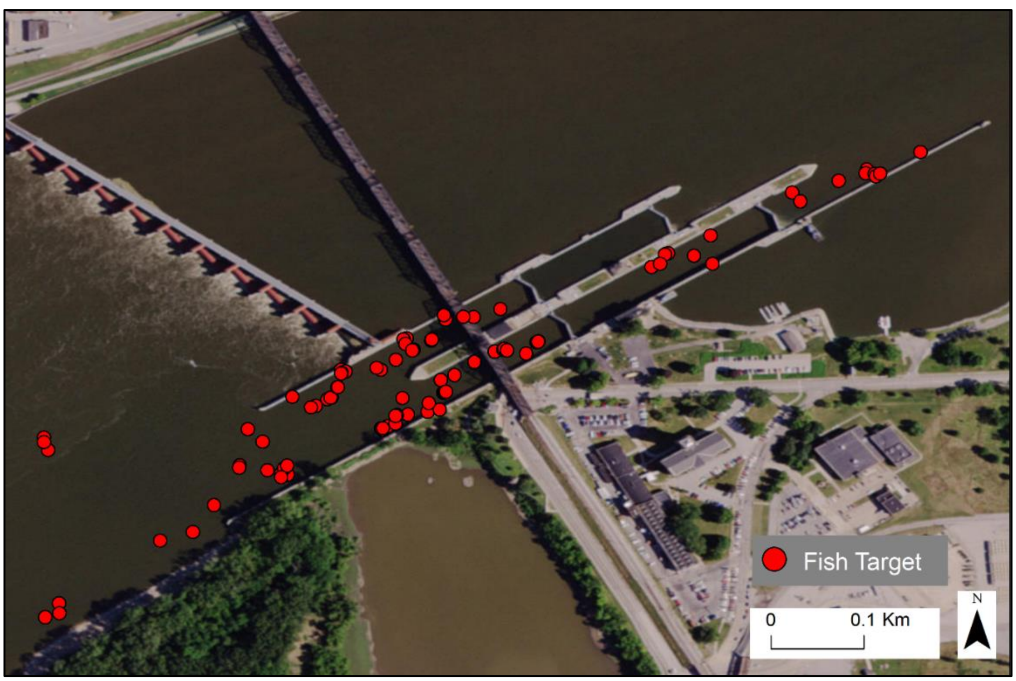

Figure 15. *Locations of all fish ≥ 30 cm in total length detected from mobile hydroacoustic surveys around Lock and Dam 15 in August 2017.*

Lock 14

At Lock 14, both the main and auxiliary chambers were sampled in the same week, however more effort was expended in the areas associated with the auxiliary lock than those associated with the main lock (Figure 4) The auxiliary lock was not open to recreational traffic during the week and could be readily sampled while the main lock was tied up with barge traffic (Table 3).

A total of 2 and 4.5 hours of imagery were collected at the main and auxiliary chambers of Lock 14, respectively. Schools of small fish frequented the imagery and some schools were in view for nearly the entire length of a 30 minute recording. More individual fish were observed at the main lock than at the auxiliary lock, however at both locations, there were more fish swimming in a downstream direction than in an upstream direction (Figure 16). Conversely there were more schools of fish observed at the auxiliary lock than the main lock (Figure 17).

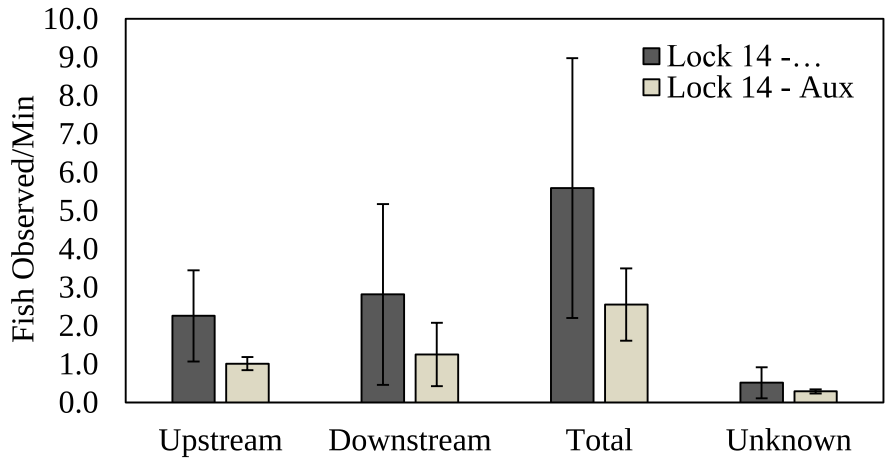

Figure 16. *Average rates (± SD) and swim direction of fish, observed using an ARIS camera, at the open, lower miter gates of the main (n=3) and auxiliary (n=5) chambers of Lock 14 of the UMR in August 2017.*

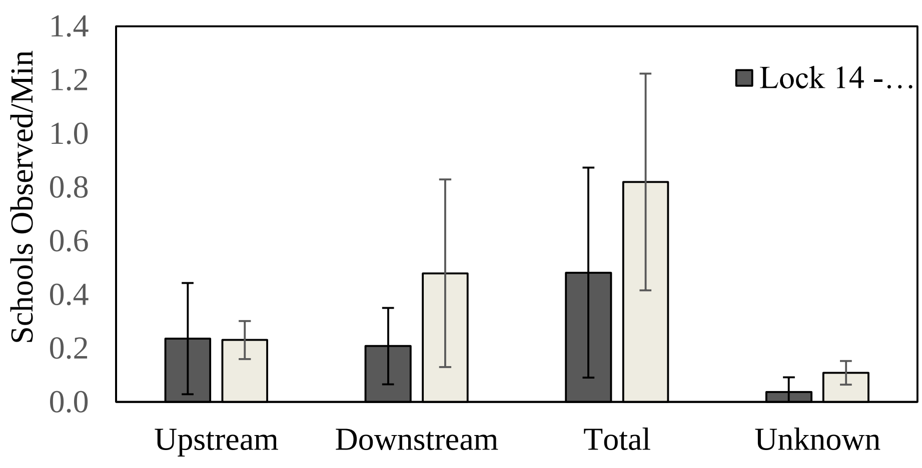

Figure 17. *Average rates (± SD) and swim direction of fish schools, observed using an ARIS camera, at the open, lower miter gates of the main (n=3) and auxiliary (n=5) chambers of Lock 14 of the UMR in August 2017.*

Similar to Lock 15, traditional gears were deployed opportunistically at Lock 14, so total effort with each gear was not equal. Just over 39 minutes and 88 minutes of electrofishing were conducted and 300 yards and 500 yards of gillnet were set in areas associated with the main and auxiliary locks, respectively.

At the main lock, the total catch was similar in the upstream and downstream approaches and these catches were noticeably greater than the total catch inside the chamber (Table 3). Emerald Shiner comprised the majority of the catch for the main lock, followed by gizzard shad, and zero fish were captured by gill netting (Table 4). Fish captured by this effort that are 1) known to move through UMR dams; and/or 2) migratory in UMR; and/or 3) probably migratory in the UMR included Bigmouth Buffalo, Channel Catfish, Largemouth Bass, Mooneye, and White Bass (Wilcox et al. 2004).

Due to the small size of the walled approach channels of the auxiliary lock, electrofishing runs in these areas were extended to included additional shoreline above and below this lock. At the auxiliary lock, the total catch was much higher in the downstream approach channel and lock chamber than in the upstream approach, however efforts in the chamber captured half as many species (Table 3). Emerald Shiner comprised the overwhelming majority of the fish captured in the auxiliary chamber and downstream approach, followed by Gizzard Shad and Largemouth Bass (Table 5). Largemouth Bass, Bluegill, and Common Carp were the most commonly captured species in the upstream approach area. Fish captured by this effort that are 1) known to move through UMR dams; and/or 2) migratory in UMR; and/or 3) probably migratory in the UMR included Bigmouth Buffalo, Bluegill, Channel Catfish, Freshwater Drum, Flathead Catfish, Largemouth Bass, Mooneye, Sauger, Shorthead Redhorse, Smallmouth Buffalo, Spotted Sucker, and White Bass (Wilcox et al. 2004).

Table 3. *Total catch and effort using two gears in three areas adjacent to the main and auxiliary chambers of Lock 14 of the UMR in August 2017.*

Chamber	**Site**	**Gear**	**Species**	**Total Catch**	**Effort**	**CPUE**
Main	Upstream approach	Electrofishing	5	72	15 min	4.8 fish/min
	Chamber	Electrofishing	3	16	11.7 min	1.4 fish/min
		Gill Netting	0	0	300 yd	0 fish/yd
	Downstream approach	Electrofishing	3	68	12.7 min	5.4 fish/min
Auxiliary	Upstream approach	Electrofishing	12, 1 hybrid	131	31.1 min	4.2 fish/min
	Chamber	Electrofishing	6	721	27.5 min	26.2 fish/min
		Gill Netting	0	0	400 yd	0 fish/yd
	Downstream approach	Electrofishing	15	997	30 min	33.2 fish/min
		Gill Netting	1	2	100 yd	<0.1 fish/min

Table 4. *Species captured by electrofishing in three areas adjacent to the main lock chamber at Lock and Dam 14 for the UMR in August 2017. Gill netting was also conducted but captured zero fish. Site titles are associated with the colored areas in Figure 4.*

Site	**Count**
LOCK CHAMBER	**16**

Emerald Shiner *Notropis atherinoides*	9
Gizzard Shad *Dorosoma cepedianum*	6
Mooneye *Hiodon tergisus*	1
DOWNSTREAM APPROACH	**68**
Bigmouth Buffalo *Ictiobus cyprinellus*	1
Emerald Shiner *Notropis atherinoides*	63
Gizzard Shad *Dorosoma cepedianum*	4
UPSTREAM APPROACH	**72**
Channel Catfish *Ictalurus punctatus*	1
Emerald Shiner *Notropis atherinoides*	35
Gizzard Shad *Dorosoma cepedianum*	32
Largemouth Bass *Micropterus salmoides*	3
White Bass *Morone chrysops*	1
TOTAL	**156**

Table 5. *Species captured by gear at three sites adjacent to the auxiliary lock chamber at Lock and Dam 14 of the UMR in August 2017. Site titles are associated with the colored areas in Figure 4.*

Site	Electrofishing	Gill Netting
CHAMBER	**721**	
Brook Silverside *Labidesthes sicculus*	1	
Channel Shiner *Notropis wickliffi*	1	
Emerald Shiner *Notropis atherinoides*	606	
Gizzard Shad *Dorosoma cepedianum*	81	
Largemouth Bass *Micropterus salmoides*	30	
White Bass *Morone chrysops*	2	
DOWNSTREAM APPROACH	**997**	**2**
Bigmouth Buffalo *Ictiobus cyprinellus*	1	
Bluegill *Lepomis macrochirus*	1	
Channel Catfish *Ictalurus punctatus*	1	
Channel Shiner *Notropis wickliffi*	1	
Common Carp *Cyprinus carpio*	2	2
Emerald Shiner *Notropis atherinoides*	796	
Freshwater Drum *Aplodinotus grunniens*	10	
Gizzard Shad *Dorosoma cepedianum*	142	
Largemouth Bass *Micropterus salmoides*	30	
Logperch *Percina caprodes*	1	
Mooneye *Hiodon tergisus*	1	
River Carpsucker *Carpiodes carpio*	1	
Sauger *Sander canadense*	1	
Spotted Sucker *Minytrema melanops*	1	
White Bass *Morone chrysops*	8	
UPSTREAM APPROACH	**131**	
Bluegill *Lepomis macrochirus*	26	
Brook Silverside *Labidesthes sicculus*	4	
Common Carp *Cyprinus carpio*	17	
Emerald Shiner *Notropis atherinoides*	3	
Flathead Catfish *Pylodictus olivaris*	1	
Freshwater Drum *Aplodinotus grunniens*	3	
Gizzard Shad *Dorosoma cepedianum*	1	
Green Sunfish *Lepomis cyanellus*	4	
Green Sunfish x Bluegill *L. cyanellus x L. macrochirus*	2	
Largemouth Bass *Micropterus salmoides*	62	
Pumpkinseed *Lepomis gibbosus*	1	
Shorthead Redhorse *Moxostoma macrolepidotum*	1	
Smallmouth Buffalo *Ictiobus bubalus*	6	
TOTAL	**1849**	**2**

Mobile hydroacoustic surveys that were completed around Lock and Dam 14 showed that the canal (Le Claire Canal) upstream of the auxiliary chamber had a higher density of fish ≥ 30 cm than the area upstream of the main lock chamber (Figure 18). The downstream area is shared by the main and auxiliary locks (Figure 19), but the density of fish present there was similar to the area upstream of the main chamber. These two areas have similar habitat features which include main channel and main channel border habitat. The canal upstream of the auxiliary lock is separated from the main channel, has minimal flow, and has more shoreline habitat. Density hotspots above the main lock included the upper Iowa shoreline adjacent to the main channel, which is bordered by lotus and lilies. Similarly the upper end of Le Claire Canal is a density hotspot as well as the auxiliary lock chamber itself. The area upstream of the main lock and the downstream areas had fairly similar size frequency distributions, with the majority of the fish detected smaller than 54 cm and therefore smaller than the most common sizes of Bighead and Silver Carp detected the previous year in Pool 19 (Figure 20). While the vast majority of fish detected in Le Claire Canal were also smaller that the majority of the Asian carp detected in Pool 19 in 2016, there were also numerous fish that fell within a similar size range as the Asian carp. There were fish targets ($\geq$ 30 cm) in both lock chambers, however there were more targets detected above and below the auxiliary chamber. Also, fish targets appeared to be clustered into two areas of the main chamber and more scattered in the auxiliary chamber (Figure 21).

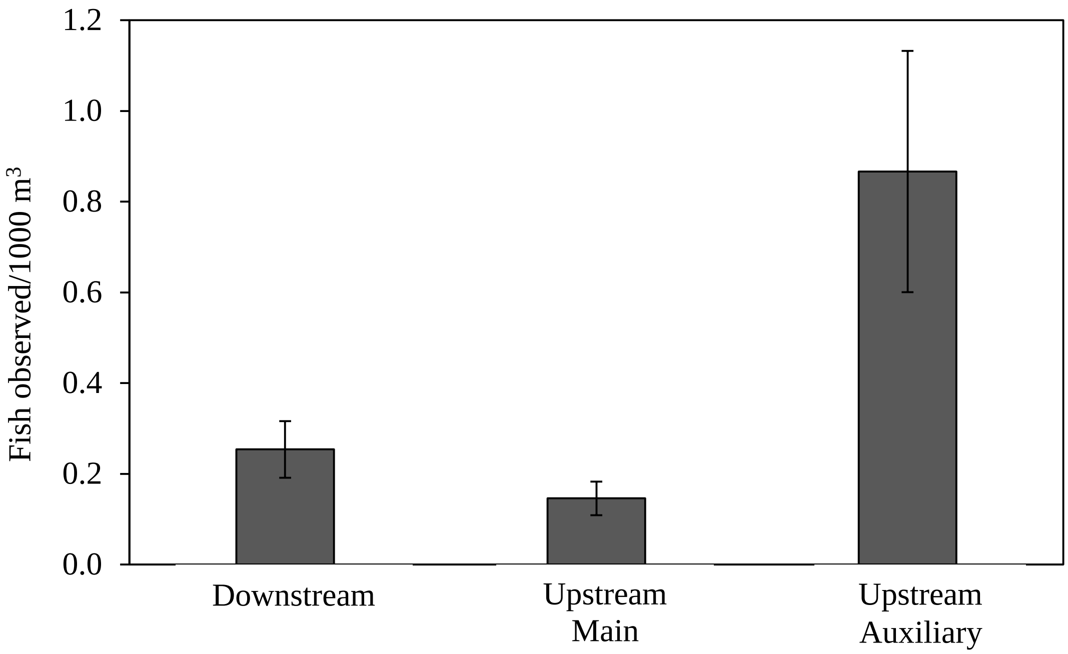

Figure 18. *Mean (SE) densities of fish (individuals $\geq$ 30 cm total length) observed from mobile hydroacoustic surveys conducted within one mile downstream and upstream of the main and auxiliary locks of Lock and Dam 14 of the UMR in August 2017.*

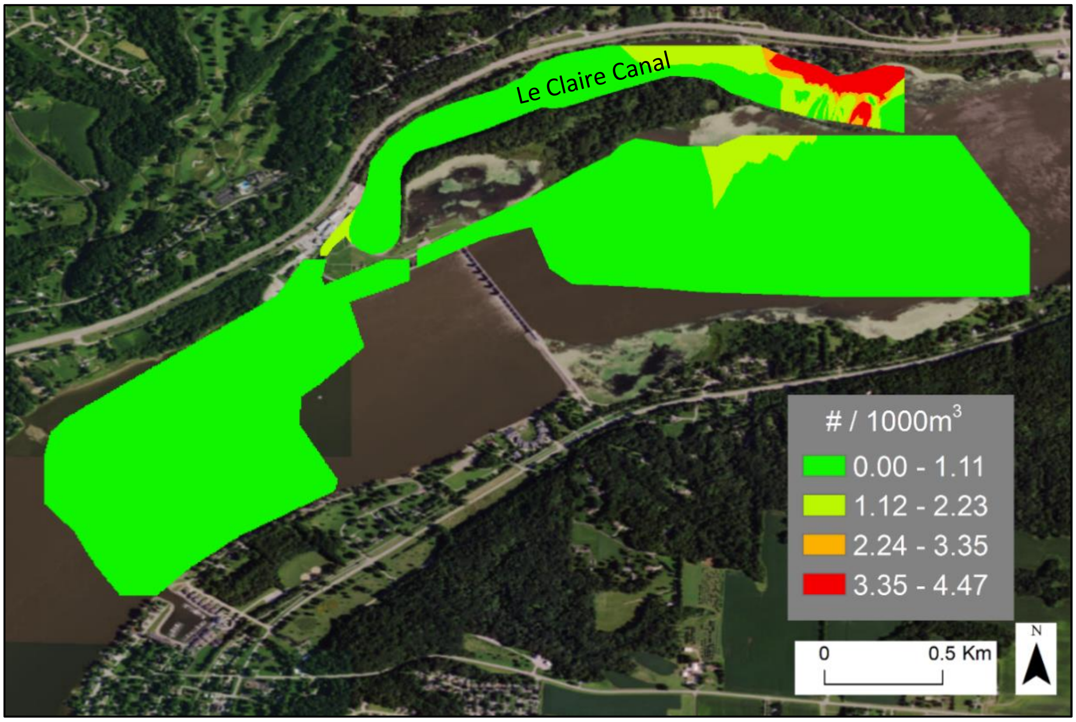

Figure 19. *Densities of all fish ≥ 30 cm total length detected from mobile hydroacoustic surveys upstream and downstream of Lock and Dam 14 of the UMR in August 2017.*

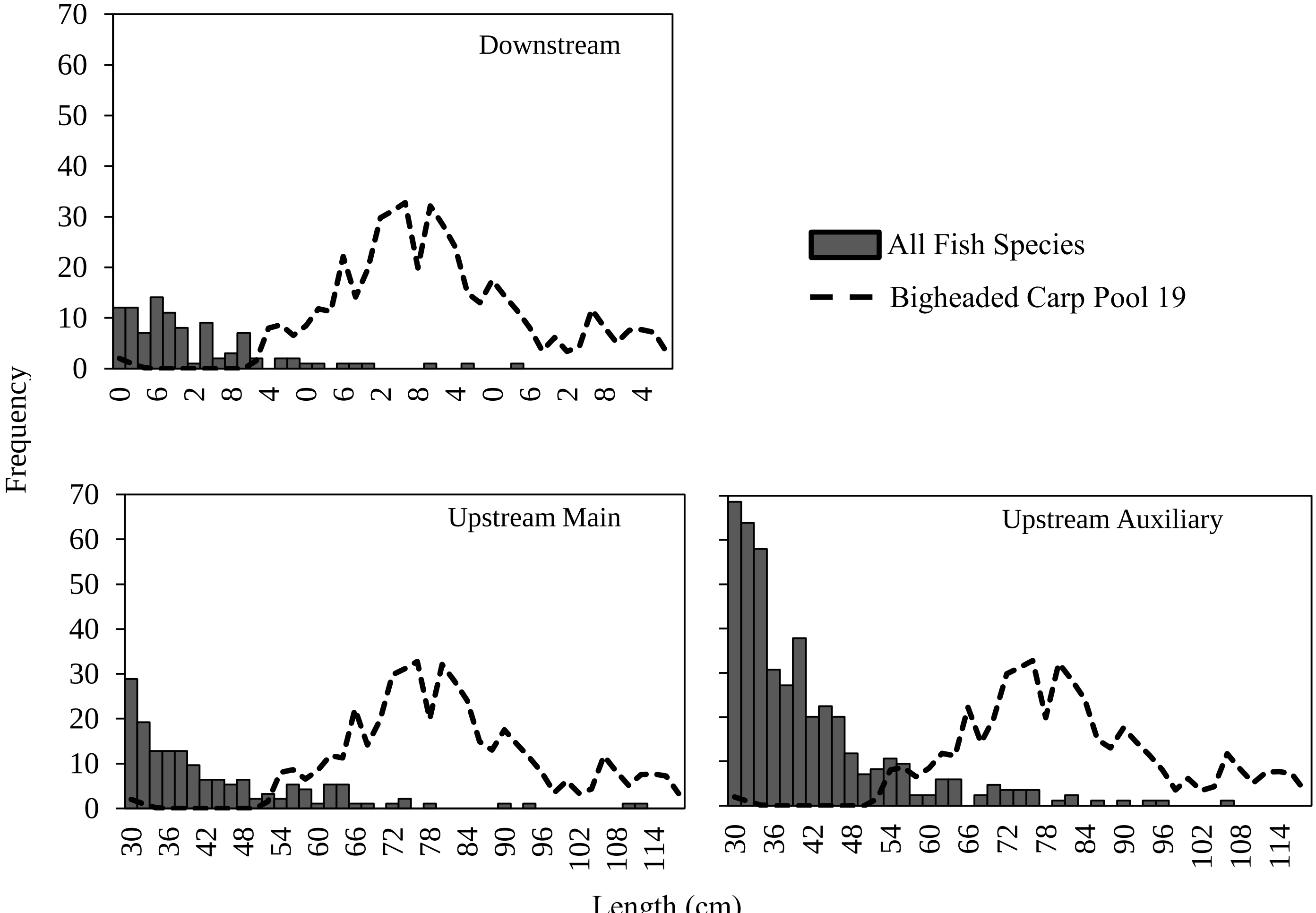

Figure 20. *Size distribution of fishes (gray bars) observed using mobile hydroacoustic surveys within one mile upstream (bottom) and downstream (top) of the main and auxiliary chambers of Lock and Dam 14 of the UMR in August 2017. Also included for comparison are the combined size distributions of Silver and Bighead Carp (dashed line) observed in Pool 19 during December 2016 by mobile hydroacoustic surveys conducted by Southern Illinois University.*

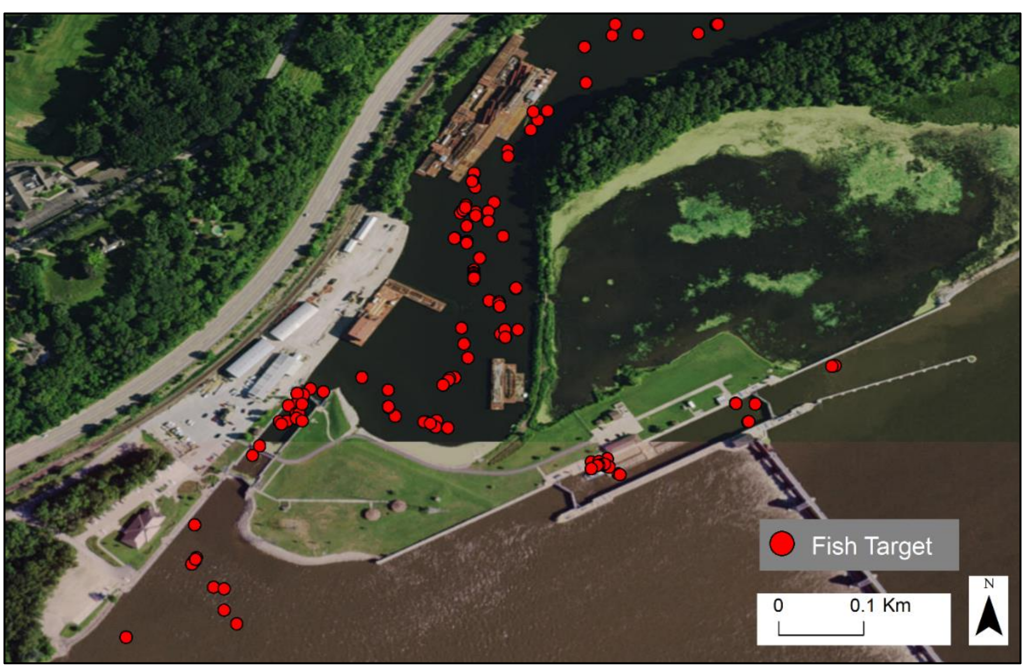

Figure 21. *Locations of all fish ≥ 30 cm in total length detected from mobile hydroacoustic surveys around Lock and Dam 14 in August 2017.*

Discussion:

It was apparent throughout data collection that barge traffic is a huge hindrance to data collection of any kind at both main lock chamber locations sampled in this project. The time spent waiting for barges to clear far exceeded the time spent collecting data at the desired locations. Gill netting proved to be too time consuming to fit into the short windows of time between lockages and therefore few adequate sets were made. When net sets were made in the lock chambers it was often difficult to drive fish to the nets given the short time frames available and confined spaces for maneuvering. The physical aspects of the lock structures also proved to make sampling with traditional gears challenging. At Lock 14, the proximity of the approach channel to the dam tailwaters made it difficult and potentially unsafe to set nets in that area, especially when rushed by approaching barge traffic. Similarly, the depth of the chambers and approaches also made electrofishing fairly inefficient unless fish were closer to the surface. Most of the catch consisted of more pelagic species and we likely did not sample the bottom portion of the water column adequately.

Of the gears used during this project, the mobile hydroacoustic surveys and ARIS camera collected the most data for the time spent deploying them. Both of these technologies could be useful in the future to gather data on changes to the size structure of the fish community, density hotspots, and behavior in response to a deterrent. The ARIS footage was difficult to review at times and moving forward, steps should be taken to reduce the variability among reviewer counts.

Recommendations:

Considering the significant amounts of barge traffic in these areas, it is likely that regular and thorough sampling of these locations with traditional gears would require some type of agreement with the Army Corps of Engineers and commercial navigators so that more time could be spent sampling in the lock. Electrofishing efforts should include deep-water electrofishing equipment so that the full depth of the water column can be sufficiently sampled.

To establish a more robust pre-deterrent data set, sampling should be conducted year around to capture how the size structure and distribution of the fish community fluctuates throughout the year. At a minimum, mobile hydroacoustic surveys could be conducted seasonally for this reason. In order to make better predictions about what species are represented by the fish targets detected in the mobile hydroacoustic surveys, fish species should be sampled using multiple gears in the pools surrounding these locks.

The increased use of telemetry tags in both native and non-native fish species is encouraged to better understand current lock usage and fish behavior in the lock and lock approach. Data collection with this technology would be minimally affected by barge traffic and would provide species-specific passage data.

The data collected during this project should serve as a starting point for pre-deterrent data collection at these locations. A more robust sampling plan will be required to fully evaluate pre- and post-deterrent fish community changes. Hydroacoustics and telemetry would be the technologies best suited for this purpose with the supplemental use of traditional gears only if adequate time can be given for deployment and if equipment is altered to suit deep-water habitats. Moving forward in deterrent research and evaluations, ARIS may be best utilized to evaluate the immediate response of fish to the deterrent stimuli and their ability to penetrate and habituate to said stimuli.

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