Project Title: FY22 Annual Interim Report on the Collaborative Strategy for Deterrent Barrier Research, Design, Implementation, and Assessment to Minimize the Spread of Invasive Carp in the Upper Mississippi River

Geographic Location: Upper Mississippi River, Pools 14-20

Lead Agency: Illinois Natural History Survey

Participating Agencies: Illinois Natural History Survey-Illinois River Biological Station (INHS-IRBS), United States Fish and Wildlife Services (USFWS), United States Geological Survey-Upper Midwest Environmental Sciences Center (USGS-UMESC), Illinois Department of Natural Resources (ILDNR), Missouri Department of Conservation (MDC), Minnesota Department of Natural Resources (MNDNR)

Statement of Need: Invasive bighead carp and silver carp, collectively referred to as bigheaded carp, populations are increasing in abundance and expanding their upstream range in the Upper Mississippi River (UMR). Lock and Dam (LD) 19 is a major pinch point for bigheaded carp expansion, restricting all passage to the lock chamber. Fish that achieve upstream passage at this point later experience major impediments to passage at LD 14 and LD 15, which are infrequently at open river conditions. These major pinch points make excellent candidates for fish deterrent technologies that aim to impede further bigheaded carp establishment upstream. Before the deployment of deterrent technologies, it is critical to evaluate their effects on native and invasive fish species and their passage. Bigmouth buffalo, paddlefish, and bigheaded carp were chosen as representative species to study behaviors around and through dams in the UMR and provide the necessary information for future deterrent decisions. The established and extensive network of acoustic receivers on the UMR provides an excellent resource for evaluating bigmouth buffalo, paddlefish, and bigheaded carp movements. Through our close partnerships with state and federal collaborators (USFWS, USGS-UMESC, ILDNR, MDC, and MNDNR), the infrastructure is available to evaluate fish passage using the VR2W and VR2Tx network. Collectively, this information can be used to make informed decisions on deterrent technologies that are aimed at restricting bigheaded carp movements while permitting native species passage through UMR locks and dams.

Project Objectives:
The primary purpose of this research is to provide information on bigmouth buffalo, paddlefish, and bigheaded carp passage at Locks and Dams 14, 15, and 19, which are major pinch points in the UMR.

Project Highlights

- There were no instances of open river conditions documented at LD 14 and 15 from 2020 through 2022

- Upstream passages occurred through the lock chambers at all three focal dams and downstream passages occurred through the gated portion of the dams during 2022
- Upstream passages were documented for silver carp, bighead carp, grass carp, paddlefish, bigmouth buffalo, freshwater drum, white bass/striped bass hybrids, and northern pike

Methods:

Study area

The UMR is approximately 2,092 km long, flowing from Lake Itasca, MN to the confluence of the Ohio River. Credited as the nation's largest lock and dam system, the 29 locks and dams on the UMR are monitored by the U.S. Army Corps of Engineers to maintain a 2.75-m deep navigational channel (Smart et al. 1986). Navigation dams were created to regulate water levels for commercial barge transportation (Chen and Simons 1986). Between two navigation dams is a stretch of river referred to as a navigation pool and is named according to the navigation dam located downstream of the pool (Zigler et al. 2003).

Our study area was conducted in a 190.8-km reach between Navigation Pools 14 through 20 and four adjoining large tributaries, the Iowa River, Rock River, Wapsipinicon River, and the Skunk River (Figure 1). Navigation Pools 14 through 20 contain areas of varying lengths, anthropogenic influences, vegetation, habitat composition, and diverse landscapes, making each pool unique in aquatic area availability. Further information detailing navigation dam, navigation pool, and tributary characteristics can be found in Wilcox et al. (2004).

Fish Collection

We captured and tagged 180 bigmouth buffalo and 133 bigheaded carp (130 silver carp (Pool 15: 38, Pool 16: 92), three bighead carp (Pool 16: 3)) with acoustic transmitters in Pools 15 and 16 in June 2020. Additional paddlefish, bigmouth buffalo, lake sturgeon, and bigheaded carps were tagged by state and federal agencies in 2022. Fish were captured using 8.9 to 10.2 cm gill nets in conjunction with bigheaded carp contracted removal efforts. Individuals with the most vigor in the gill nets were chosen for surgery to optimize maximum recovery and survival potential. Our study fish were weighed (g), measured (mm), and tagged with VEMCO V16-6x or V16-4x acoustic transmitters.

Surgical Procedures

Surgical instruments were sterilized by placing them into a sterilizing tray containing 70% isopropyl alcohol for at least 15 minutes before surgery (Winter 1983; Summerfelt and Smith 1990). VEMCO V16-6x acoustic transmitters tags (95 x 16 mm, 7 years, Nova Scotia, Canada) were implanted in bigheaded carp. VEMCO V-16-4x acoustic transmitters tags (68 x 16 mm, 3 years, Nova Scotia, Canada) were implanted in bigmouth buffalo. Both styles of acoustic transmitters coded at 69 kHz at a random time interval between 30-90 s (Welch et al. 2009). Fish were only tagged if the tag weight was less than 2% of the body mass to avoid impaired swimming and growth (Winter 1983; Jepsen et al. 2002).

Fish were positioned on a V-board with the ventral side up and ample amounts of river water were pumped over the gills during surgery. Each fish received a jaw tag with a unique identification number to identify recaptured fish. Next, the surgeon would remove 6-10 scales

posterior to the pelvic fin and below the lateral line. Using the scalpel, a 3-4 cm incision was made into the peritoneal cavity. The acoustic transmitter was inserted anterior to the incision into the peritoneal cavity (Lubejko et al. 2017; Tripp et al. 2019). Using the simple interrupted suture technique (Summerfelt and Smith 1990), the incision was closed with three to five interrupted sutures (Ethilon FSLX) > 70 cm 2-0 monofilament suture (nylon, sterile, Ethilon Inc.). After the incision was closed, fish were returned to the river and released once the individual displayed orientation, equilibrium, and vigor to swim away. Fish were released within approximately 0.5 km of the capture location.

Stationary Receivers

A stationary VEMCO VR2W and VR2Tx acoustic monitoring system (Nova Scotia, Canada) maintained by INHS, USFWS, USGS-UMESC, MDC, and MNDNR allowed for collaboration on standardized acoustic telemetry methods and better-quantified fish movement. Stationary receivers were deployed using various mounting methods (e.g., navigation buoys, bottom-mounted, installed in ladder recesses of lock chambers). Our study had access to over 56 stationary receivers in Navigation Pools 5a through 19 and three real-time receivers (Pools 16 and 18). Stationary receivers were placed throughout different aquatic areas including the main navigational channel, backwaters, tributaries, and side channels. Locks and Dams 14 and 15 were equipped with fine-scale telemetry arrays to detect upstream and downstream fish passages through the lock chamber as well as passages through the gated portion of the dam (Figure 2).

Results and Discussion:

Lock and Dam 14 was not at open river conditions at anytime during 2022. Several fish from multiple species made passages upstream and downstream at LD 14 (Table 1). Bigmouth buffalo, paddlefish, and bighead carp made upstream passage. Upstream movements were through the lock chamber, and downstream movements likely occurred through the gated portion of the dam.

Lock and Dam 15 was not at open river conditions at anytime during 2022. Fish were still able to make several passages upstream and downstream (Table 2). A total of six upstream movements were detected, all of which occurred through the lock chamber. One by a bighead carp, four by bigmouth buffalo, and one by a paddlefish. There was a total of 17 downstream passages at Lock and Dam 15 (Table 2).

At Lock and Dam 19, there were 14 upstream passages through the lock chamber during 2022 (Table 3). There five upstream passages were completed by invasive carps (i.e., 3 silver carp, 1 bighead carp, 1 grass carp) and nine upstream passages were completed by native fish species (i.e., 6 bigmouth buffalo, 1 freshwater drum, 1 northern pike, 1 striped bass/white bass hybrid).

Invasive carp upstream passages at Locks and Dams 14 and 15 occurred during decending limbs in the hydrograph and bigmouth buffalo movements occurred at a similar time to those of bigheaded carp (Figure 3, Figure 4).

Recommendation

We have documented bigmouth buffalo, paddlefish, and bigheaded carp passage across LDs 14, 15, and 19 over the course of our study. Limited sample sizes of additional native species

upstream passage have been documented at LD 19. The limited observed passages and dispersal from our tagged bigmouth buffalo, paddlefish, and bigheaded carp may have resulted from the low river conditions that resulted in zero open river days throughout our study period starting in June 2020 – December 2022 at both LD 14 and 15. Continued monitoring and data collection will be necessary to improve understanding of fish passage dynamics at these pinch point dams to help inform decisions on the potential to implement invasive species deterrents at these locations.

This and other recent studies have demonstrated that bigheaded carp show not only predictable yearly and seasonal movements but can lock through the pinch-point dams multiple times in successive years (Fritts et al. 2021; Turney et al. 2022). Understanding how fish species behave at these navigation dams is critical information for river researchers as they evaluate potential tools or technologies to slow or cease the progress of bigheaded carp expansion in the UMR.

Table 1. Upstream and downstream passage events in 2022 at Lock and Dam 14 in the Upper Mississippi River. The fine-scale receiver array was used to determine the route of the fish passage (i.e., through the dam gates or the lock chamber).

Lock and Dam 14	Upstream	Downstream
Lock chamber		
Bighead Carp	1	0
Silver Carp	0	0
Paddlefish	2	0
Bigmouth Buffalo	6	0
Dam gates		
Bighead Carp	0	0
Silver Carp	0	0
Paddlefish	0	4
Bigmouth Buffalo	0	1

Table 2. Upstream and downstream passage events in 2022 at Lock and Dam 15 in the Upper Mississippi River. The fine-scale receiver array was used to determine the route of the fish passage (i.e., through the lock chamber or the gated portion of the dam).

Lock and Dam 15	Upstream	Downstream
Lock chamber		
Bighead Carp	1	0
Silver Carp	0	0
Paddlefish	1	0
Bigmouth Buffalo	4	0
Dam gates		
Bighead Carp	0	2
Silver Carp	0	1
Paddlefish	0	10
Bigmouth Buffalo	0	3
Lake Sturgeon	0	1

Table 3. Upstream and downstream passage events in 2022 at Lock and Dam 19 in the Upper Mississippi River. The fine-scale receiver array was used to determine the route of the fish passage (i.e., through the lock chamber or the gated portion of the dam).

Lock and Dam 19	Upstream	Downstream
Lock chamber		
Bighead Carp	1	0
Silver Carp	3	0
Grass Carp	1	0
Freshwater Drum	1	0
Northern Pike	1	0
Striped Bass/White Bass hybrid	1	0
Bigmouth Buffalo	6	0
Dam gates		
Bighead Carp	0	1
Silver Carp	0	2
Bigmouth Buffalo	0	2

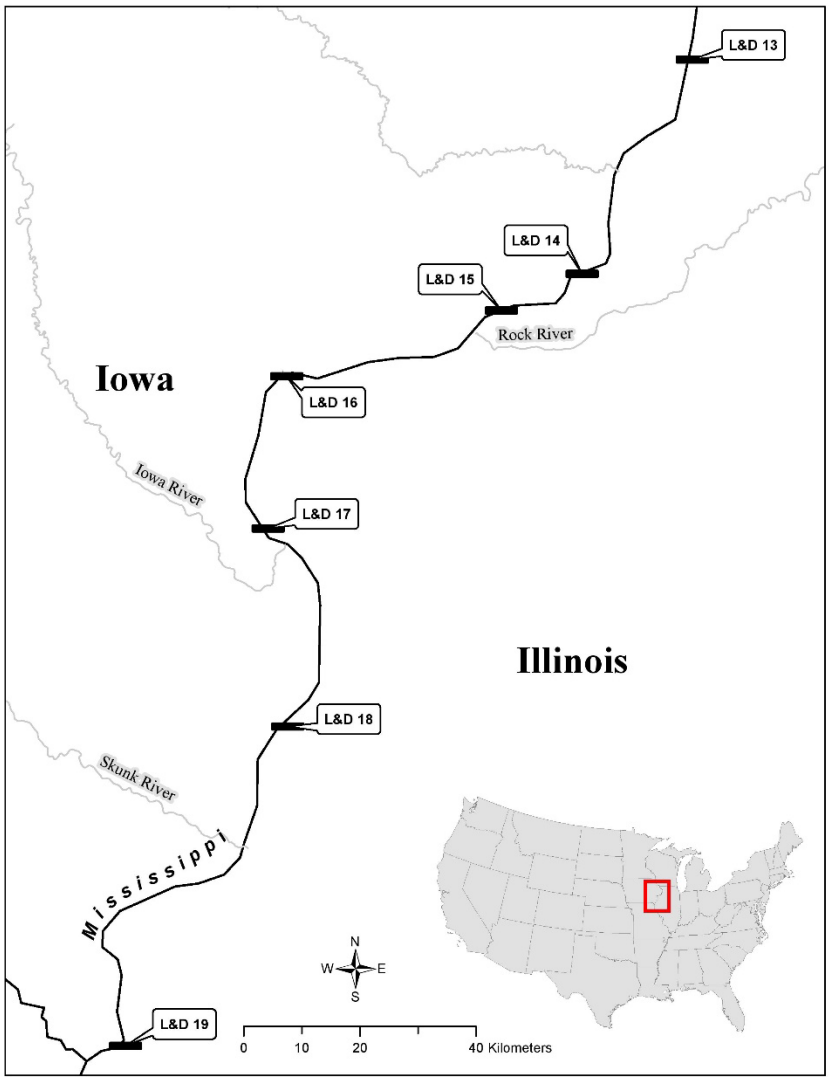

Figure 1. Locations of Lock and Dams (LD) 14-19 on the Upper Mississippi River.

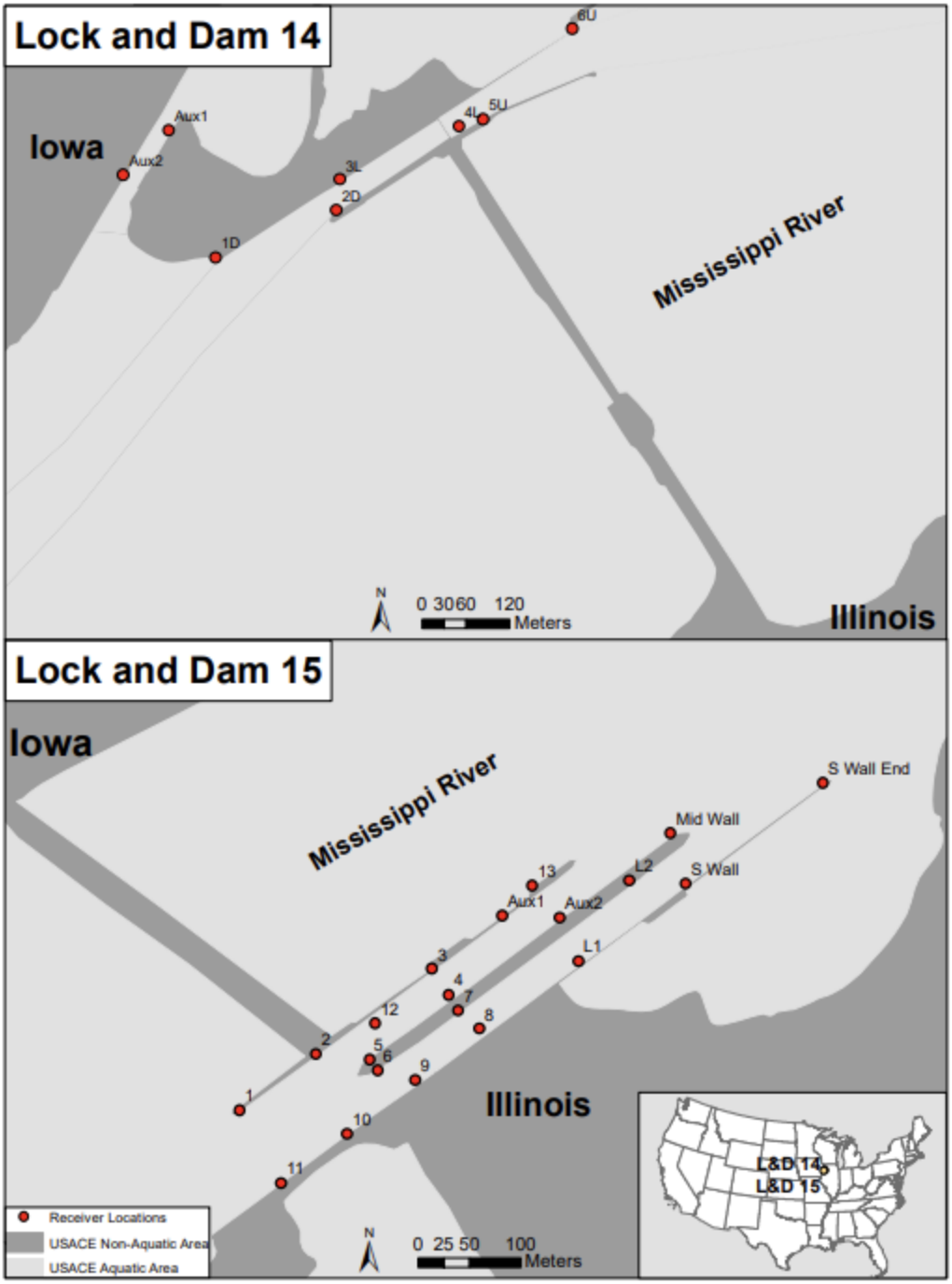

Figure 2. VEMCO fine-scale telemetry arrays at Lock and Dam (LD) 14 in Le Claire, IA, and LD 15 located in Davenport, IA. The VEMCO receiver locations are displayed by the red dots and are dispersed throughout the main and auxiliary locks. At LD 14 (top) there are 2 receivers in the downstream approach, 2 receivers in the main lock, 2 receivers in the auxiliary lock, and 2 receivers positioned above LD 14. At LD 15 (bottom) there are 12 receivers in the downstream approach, 2 receivers in the main lock, 2 receivers in the auxiliary lock, and four receivers positioned above LD 15.

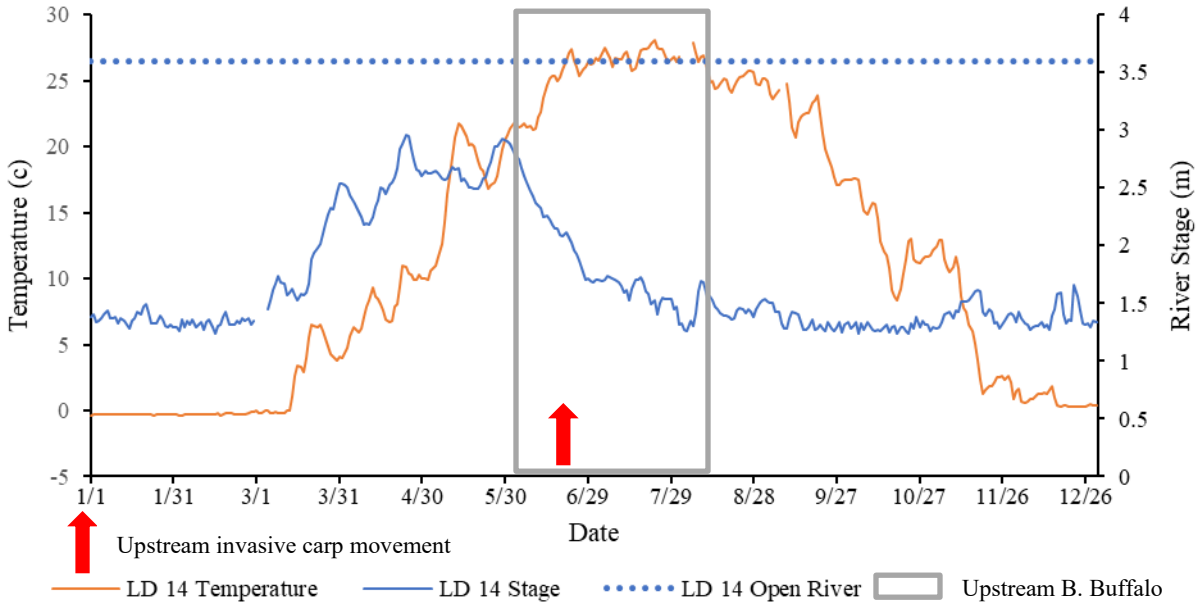

Figure 3. The relationship between average water temperature, river stage, and successful passage events at Lock and Dam (LD) 14 in 2022.

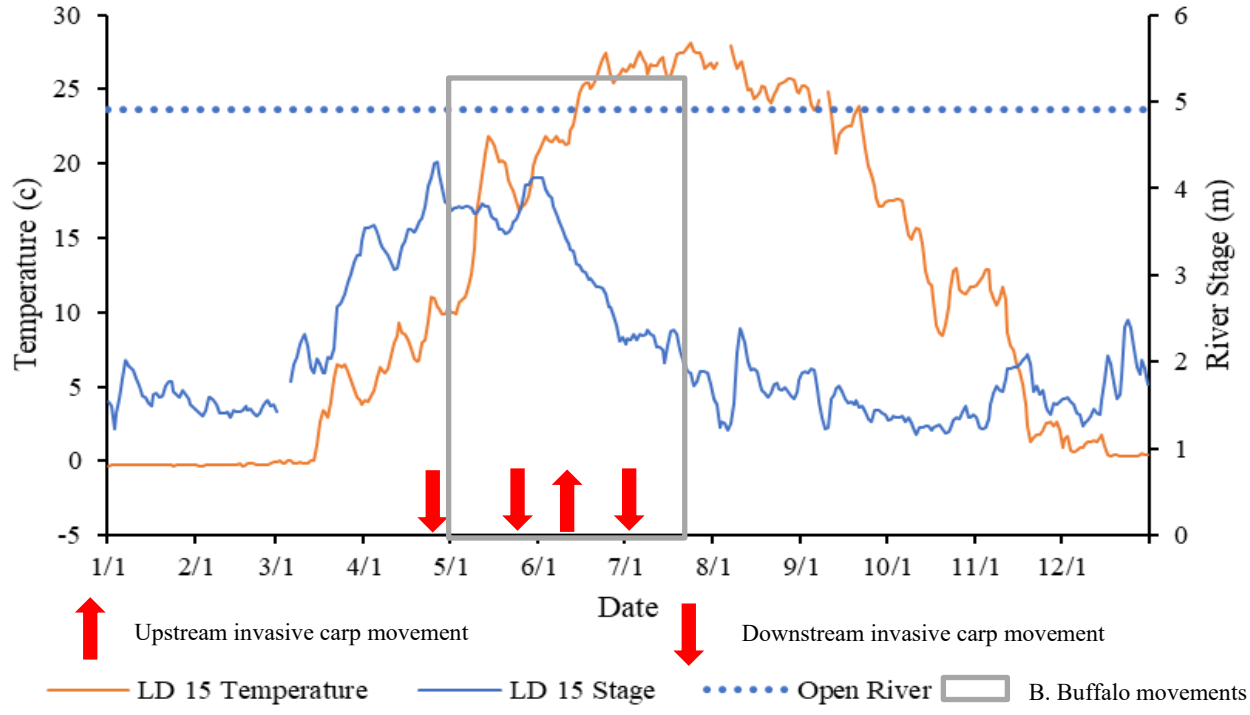

Figure 4. The relationship between average water temperature, river stage, and successful passage events at LD 15 in 2022.

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