FY20 Annual Interim Report on the Collaborative Strategy for Deterrent Barrier Research, Design, Implementation and Assessment to Minimize the Spread of Asian Carp in the Upper Mississippi River

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Geographic Location: Upper Mississippi River, Pools 14-19

Participating Agencies: Illinois River Biological Station (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:

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 its effects on native and invasive fish species and their passage. Bigmouth buffalo 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 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. Biologists from IRBS will manually track using VR100 receivers to supplement information regarding bigmouth buffalo and bigheaded carp dispersal, dam passage, and habitat use. 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 preliminary data that detail bigmouth buffalo and bigheaded carp habitat use and passage over major pinch points in the UMR by:

(1) Acoustically tag and monitor 180 bigmouth buffalo and 132 bigheaded carp in the summer of 2020, in conjunction with previously tagged Asian carp and paddlefish species, to assess the frequency and timing of fish passage at Lock and Dams 14 through 19.

(2) Quantify bigmouth buffalo and bigheaded carp habitat use and selectivity in Pools 14, 15, and 19 in the UMR.

Project Highlights

- Three downstream passages were made by two bigmouth buffalo in 2020. One passage at LD 16 and two at LD 15 (one through the lock chamber).
- One bigmouth buffalo made a downstream passage at LD15 through the auxiliary lock. This individual remained in the upstream lock approach at LD 15 for 10 days but was unsuccessful in passage.
- The most extensive bigmouth buffalo movement documented was originally tagged in Pool 15 and moved downstream to Pool 17 (74 km) within two months.
- Bigmouth buffalo primarily used side channel (40%) and contiguous floodplain lake (36%) aquatic areas while bigheaded carp predominantly used channel border (44%) and side channel (35%) aquatic areas in summer 2020.
- One bighead carp demonstrated the ability to pass upstream through the lock chamber at LD 15 in 2017, 2018, 2019, and 2020 and LD 14 in 2020. Bigheaded carp are capable of having predictable yearly and seasonal movements through pinch point dams.
- Continued tracking will begin in April 2021 and will capture a broader scope of seasonal movements and habitat uses of our tagged individuals.

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). Navigational dams were created to regulate water levels for commercial barge transportation (Chen and Simons 1986). Between two navigational dams is a stretch of river referred to as a navigational pool and is named according to the navigational dam located downstream of the pool (Zigler et al. 2003).

Our study area was conducted in a 190.8-km reach between Navigational Pools 14 through 19 and four adjoining large tributaries, the Iowa River, Rock River, Wapsipinicon River, and the Skunk River (Fig. 1). Navigational Pools 14 through 19 contained areas of varying lengths, anthropogenic influences, vegetation, and habitat composition, and diverse landscapes, making each pool unique in aquatic area availability. Further information detailing navigational dam, navigational pool, and tributary characteristics can be found in Wilcox et al. (2004).

Fish Collection

We captured and tagged 180 bigmouth buffalo and 132 bigheaded carp (125 silver carp, 6 bighead carp, 1 bighead x silver carp hybrids) with acoustic transmitters in Pools 15, 16, and 19 in June 2020. 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 tags.

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 (16mm, 7 years, Nova Scotia, Canada) were implanted in bigheaded carp. VEMCO V-16-4x acoustic transmitters tags (16mm, 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 the fish if recaptured. Next, the surgeon would remove 6-10 scales posterior to the pelvic fin and below the lateral line. Using the scalpel, a 3-6 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.

Manual tracking

Manual tracking was conducted weekly from June-August 2020. Manual tracking provided supplementary information to the stationary receiver data and provided fine scale movement information. Predetermined tracking grids spaced 0.5-km apart were used for active efforts. A mobile receiver (VEMCO Model VR100) was used to detect fish. Once at a waypoint, the depth transducer was turned off to avoid noise interaction with the mobile receiver. The directional hydrophone (VEMCO Model VH165; 50-85 kHz) was placed into the water for 100 seconds while slowly turning the hydrophone. If a tag was detected, the directional hydrophone (50-84 kHz; Nova Scotia, Canada) was used to get a more precise location. If a fish was detected and tracked to a specific location the following data would be collected and recorded: pool collected in, crew, weather, tag ID, date, time, latitude, longitude, depth (m), water temperature (°C), specific conductivity (μS/cm), DO (mg/L), DO%, flow (ft/s), secchi (cm), and waypoint ID.

Stationary Receivers

A stationary Vemco VR2W and VR2Tx acoustic monitoring system (Nova Scotia, Canada) maintained by USFWS, USGS-UMESC, MDC, and MNDNR allowed for collaboration on standardized acoustic telemetry methods and for better quantified fish movement. Stationary receivers were used employing various mounting methods (e.g. navigation buoys, bottom-mounted, and lock chambers). Our study had access to over 37 stationary receivers in Navigational Pools 5a through 19 and 2 real-time receivers (Pools 16 and 18). Stationary receivers were placed throughout different aquatic areas including main navigational channel, backwaters, tributaries, and side channels. A fine-scale VEMCO Positioning System (VPS) array was equipped with 20 stationary receivers at LD 15 to detect upstream and downstream fish passages through the lock chamber (Fig. 2).

Habitat Classification

Detections from manual tracking in the summer of 2020 were used for habitat analysis. Areas occupied by detected bigmouth buffalo and bigheaded carp were categorized according to an adaption of the Upper Mississippi River Long Term Resource Monitoring Program Procedures (Ratcliff et al. 2014) and the USGS-UMESC high-resolution land cover data sets. The six strata classes are based on geomorphic and physical features that represent permanent features within the UMR system (Wilcox 1993; Ratcliff et al. 2014). The seven strata types were Channel Border (CB), Contiguous Floodplain Lake (CFL), Isolated Floodplain Lake (IFL), Contiguous Impounded (CIMP), Main Navigation Channel (MNC), Side Channel (SC), and Tributary Channel (TRC). Further detailed descriptions for these strata classes can be found in Ratcliff et al. (2014). Detection coordinates were inserted into ArcMap 10.6.1 (ESRI 2011, Redlands, CA) and strata type were determined by the position and habitat description of coordinate points within the pool.

Results and Discussion:

Of the 180 bigmouth buffalo tagged with acoustic transmitters, 101 (56%) have been detected through passive and active tracking. There were 105,576 bigmouth buffalo detections recorded in 2020. Of these, 49,668 detections were recorded from stationary receivers, 55,746 were recorded from real-time receivers, and 162 detections were recorded from manual tacking receivers from July to August 2020. Two bigmouth buffalo have made three passages in 2020 (Table 1). One fish made a downstream passage at LD 15 and LD 16. The second fish made a downstream passage at LD 15 through the auxiliary lock and was detected in the downstream approach at LD 15 for 10 days but was unsuccessful in upstream passage. Of the three passages, only one had a known date of passage. The downstream passage at LD15 and LD16 occurred between 6/18/2020-7/16/2020. Stage ranged from 2.89-3.66 m and water temperature ranged 23.3-30.1°C. Sizes for the two individuals that made a successful passage over a dam was 758 and 617 mm, and 5.6 and 3.52 kg, respectively. Our most extensive movement observed was from one individual tagged in Pool 15 moved down to Pool 17 (74 km).

In 2020, 11 bigheaded carp (INHS and USGS fish) made a total of 22 passages consisting of 5 upstream and 17 downstream passages (Table 2). One silver carp made a total of six passages, three upstream passages at LD 16, 17, and 18, followed by downstream passages at LD 16, 17, and 18. The most notable bigheaded carp passage was made by a female bighead carp. This individual has demonstrated the ability to pass through both the lock and dam portion of LD 15 in successive years, occurring in the spring of 2017, 2018, 2019 and 2020. In 2020, this individual successfully passed through the main lock at LD 15 and followed by a passage through LD 14. This individual demonstrated the ability for bigheaded carp to have predictable yearly and seasonal movements as well as the ability to navigate through the lock chamber once learned. Five bigheaded carp also passed downstream at LD15 but the date of passage was unknown. These five passages occurred inbetween 6/12/2020-8/11/2020. River stage ranged from 2.18-3.80m and water temperature ranged from 21.98-30.1°C.

A total of 162 bigmouth buffalo were detected during manual tracking. Of these detections, 64 (40%) were found in side channels, 51 (32%) were found in contiguous floodplain lakes, 37 (23%) were found in channel borders, 6 (4%) were found in contiguous impounded habitat, and 4 (3%) were found in tributary channels (Figure 1). There were also 127 Asian carp detected while manual tracking, 56 (44%) were found in channel borders, 45 (35%) were found in side channels, 12 (9%) were found in contiguous floodplain lakes, 8 (6%) were found in

tributary channels, and 6 (5%) were found in contiguous impounded habitat. Currently, manual tracking has only occurred during summer (July-August). However, future manual tracking will include more months to identify seasonal changes to habitat use. Therefore, we will classify seasonal aquatic area use into four main categories: spring (March-May), summer (June-August), fall (September-November), and winter (December-February).

In 2020, bigmouth buffalo mainly used habitats of side channels (40%), backwater habitats (36%), and channel borders (23%). Bigmouth buffalo seemed to prefer areas with low velocity. Bigheaded carp mainly used habitats of channel borders (44%) and side channels (35%). Bigmouth buffalo and bigheaded carp have been shown to occupy similar habitats throughout the year, which can lead to interspecies competition. Sampson et al. (2009) observed diet overlaps between bigheaded carp and native species (e.g., gizzard shad, bigmouth buffalo, paddlefish). It is possible that diet overlap and competition are occurring where these species are inhabiting the same areas (e.g., side channels, channel borders).

Recommendation

We have been actively and passively tracking bigmouth buffalo for approximately five months. Limited evidence of bigmouth buffalo and bigheaded carp passage across LD 14, 15, and 19 demonstrates the need for continued data collection prior to implantation of invasive species deterrents at these locations. We believe the limited passages and dispersal from our tagged bigmouth buffalo were attributed to tagging after the expected spawning period and low river conditions that resulting in zero open river days after June 2020.

Our efforts and studies by Fritts et al. (2021) and Turney et al. (unpublished) have demonstrated that bigheaded carp show not only predictable yearly and seasonal movements but have the ability to lock through LD 15 multiple times. Further, we observed one bighead carp capable of locking through LD 15 in 2017, 2018, 2019, and 2020 as well as another pinch point dam, LD 14, in 2020. The ability for bigheaded carp to navigate the lock chamber at pinch point locations further demonstrates the urgency and need for continued research at these dams.

Table 1. Bigmouth buffalo upstream and downstream passage events from June 2020 – January 2021 at LD 14-19 in the Upper Mississippi River. The total is the combined upstream and downstream passages. N represents that number of unique bigmouth buffalo that completed upstream and downstream passage through the lock or dam. At LDs 15 and 19, 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	Upstream	Downstream	Total	N
14				
15				
Dam		**1**	**1**	**1**
Lock		**1**	**1**	**1**
16		**1**	**1**	**1**
17				
18				
19				
Dam				
Lock				

Table 2. Bigheaded carp upstream and downstream passage events in 2020 at LD 14-19 in the Upper Mississippi River. The total is the combined upstream and downstream passages. N represents that number of unique bigheaded carp that completed upstream and downstream passage through the lock or dam. At LDs 15 and 19, 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	Upstream	Downstream	Total	N
14	**1**		**1**	**1**
15				
Dam		**5**	**5**	**5**
Lock	**1**		**1**	**1**
16	**1**	**6**	**7**	**6**
17	**1**	**4**	**5**	**4**
18	**1**	**2**	**3**	**2**
19				
Dam				
Lock				

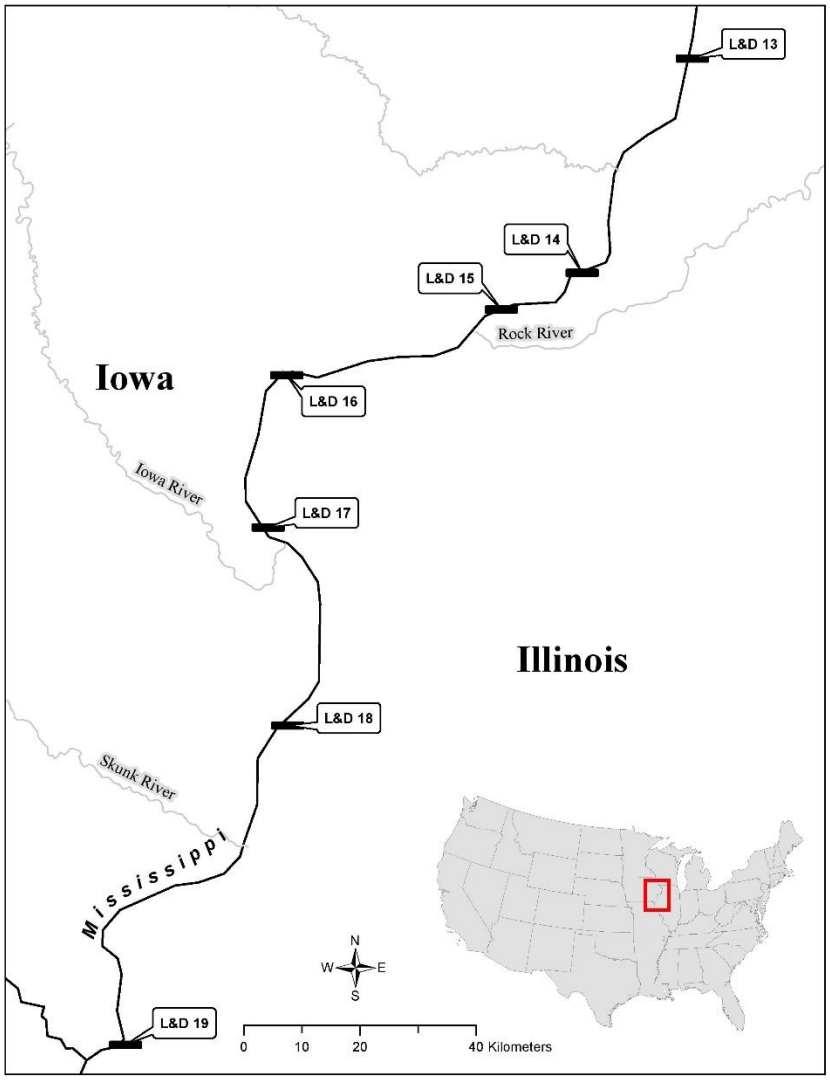

Figure 1. Locations of Lock and Dams 14-19 on the upper Mississippi River.

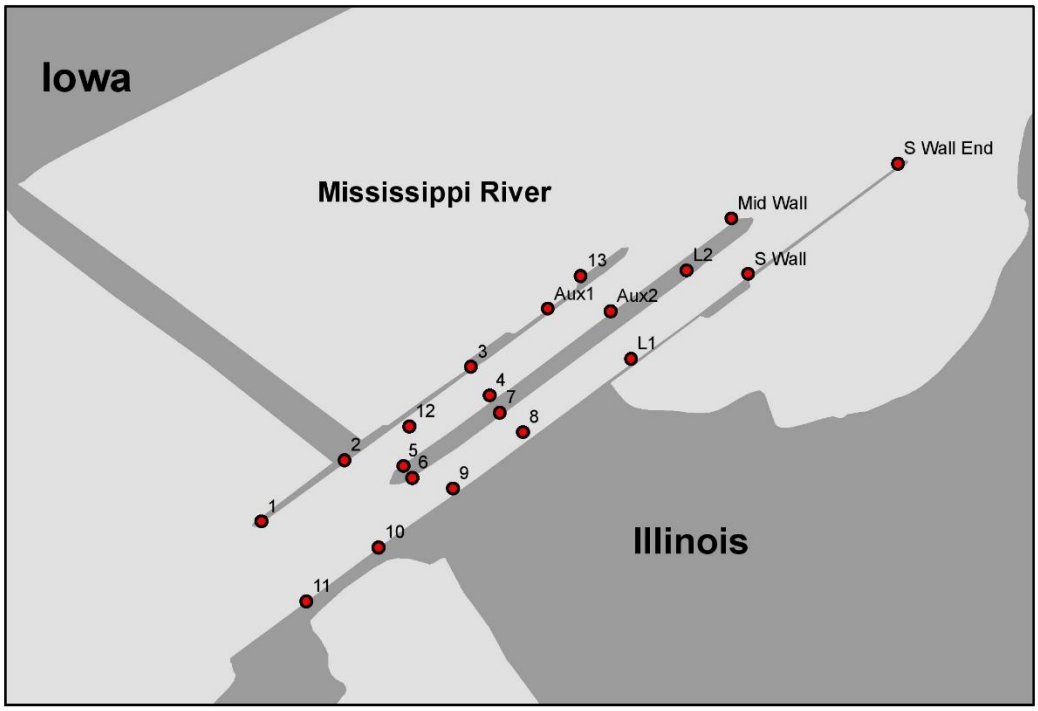

Figure 2. Location of the VPS array at LD 15 located in Davenport, IA. The VPS array arrays, denoted by the red dots, are dispersed throughout the main and auxiliary locks. There are 12 receivers in the downstream approach, 2 receivers in the main lock, 2 receivers in the auxiliary lock, and 4 receivers positioned above LD 15.

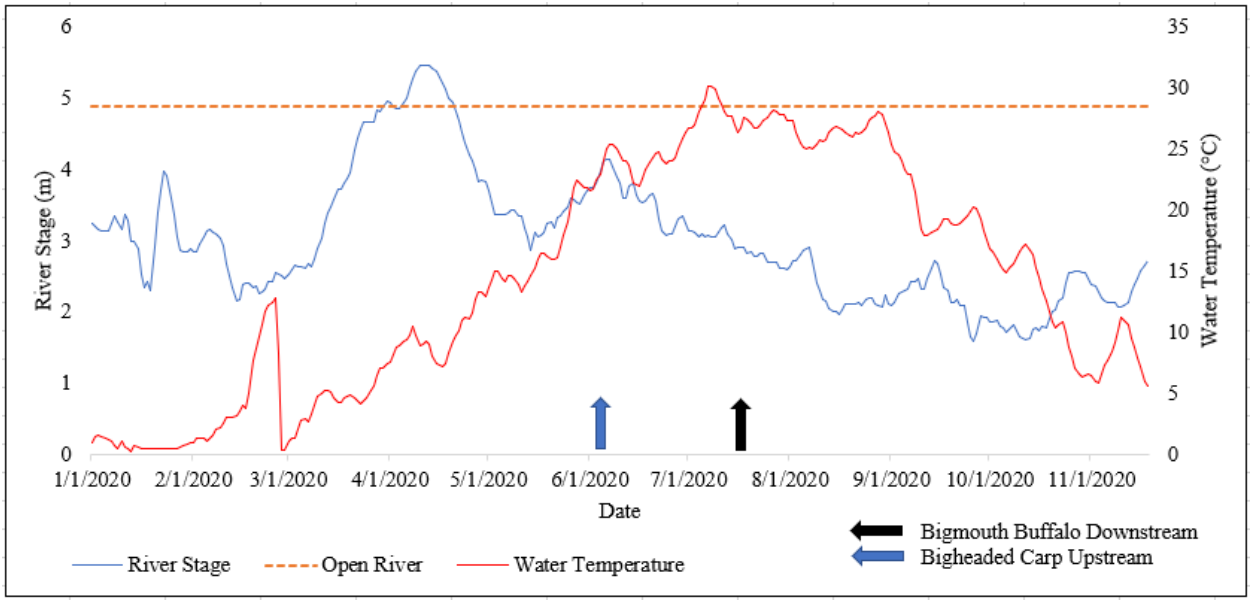

Figure 3. The relationship between average water temperature, river stage, and successful passage events at LD15. The solid red line is average water temperature (°C) at LD15. The solid blue line represents the river stage (m) at LD15. The dashed orange line represents the river stage where LD15 experience open river conditions. The black arrow represents the bigmouth buffalo downstream passage. The blue arrow represents the bigheaded carp upstream passage.

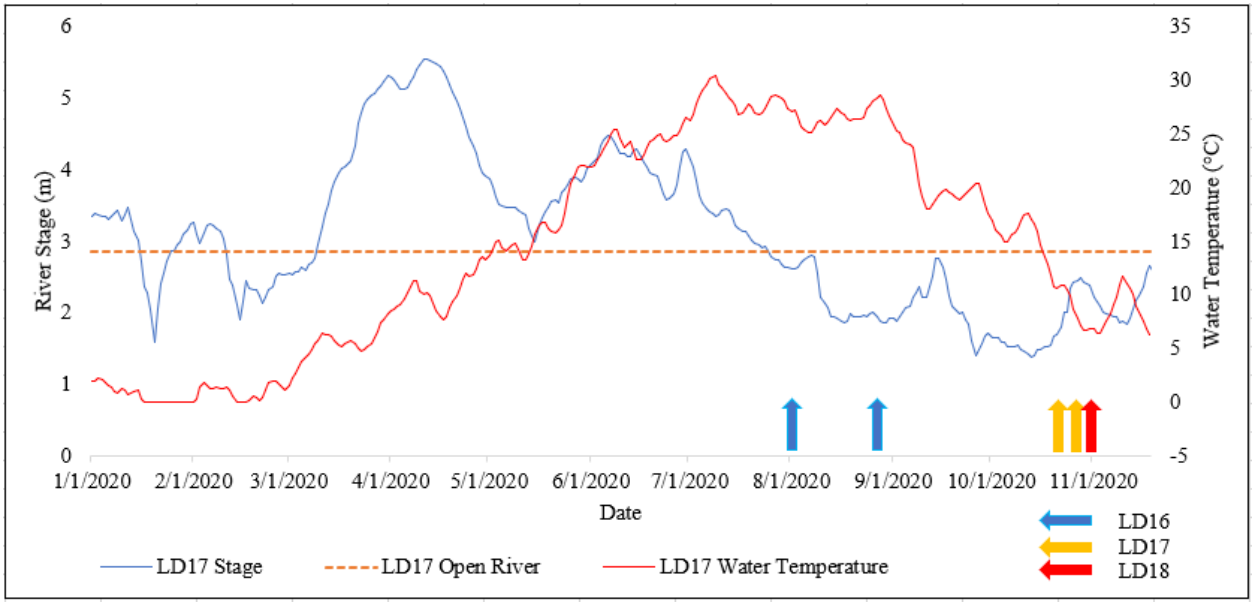

Figure 4. The relationship between average water temperature, river stage, and successful downstream passage events at LD16-18. The solid red line is average water temperature (°C) at LD17. The solid blue line represents the river stage (m) at LD17. The dashed orange line represents the river stage where LD17 experience open river conditions.

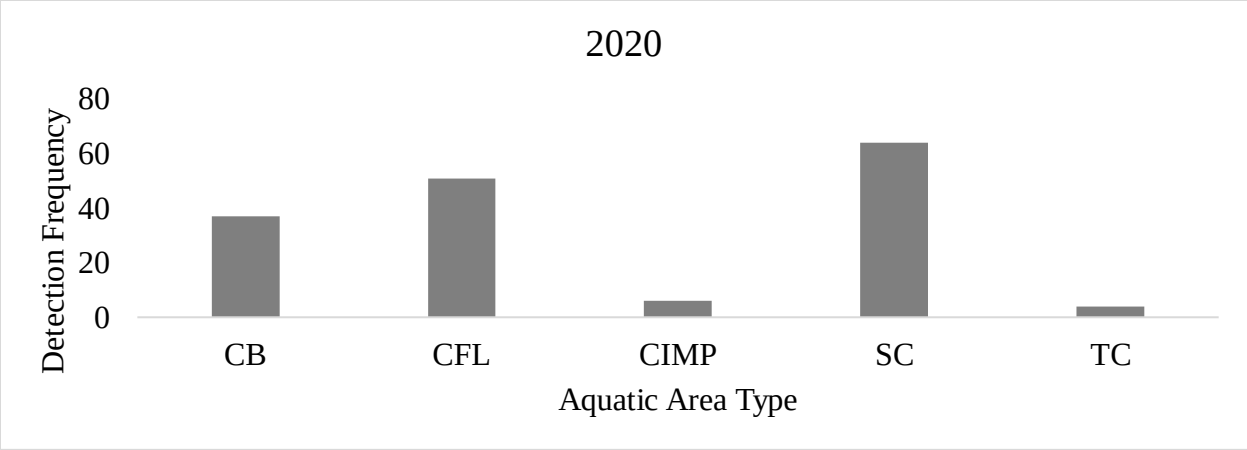

Figure 5. Bigmouth buffalo detections (N=162) from July-August 2020 manual tracking efforts. CB=Channel Border, CFL=Contiguous Floodplain Lake, CIMP=Contiguous Impounded, SC=Side Channel, and TC=Tributary Channel.

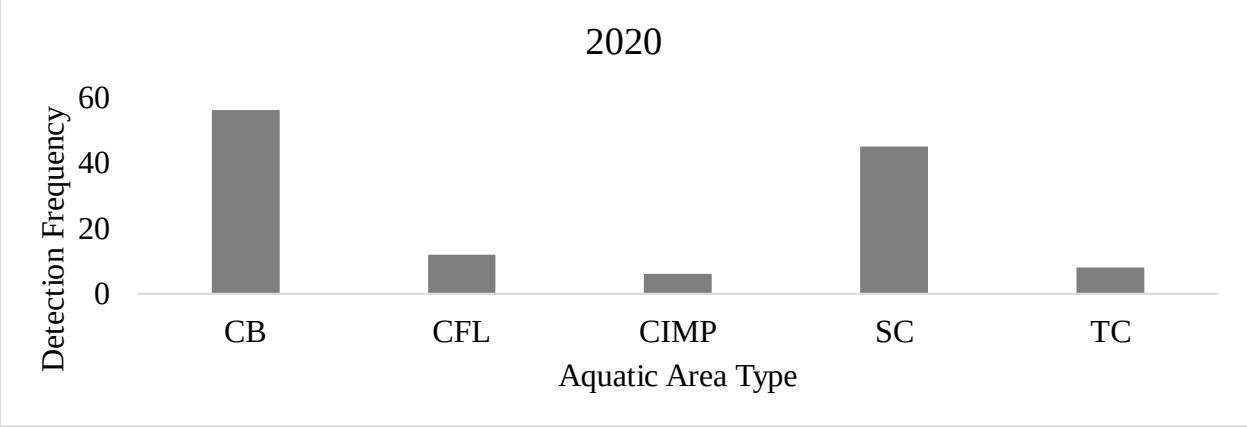

Figure 6. Asian Carp detections (N=127) from July-August 2020 manual tracking efforts. CB= Channel Border, CFL=Contiguous Floodplain Lake, CIMP=Contiguous Impounded, SC=Side Channel, and TC=Tributary Channel.

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