ASIAN CARP INVESTIGATION AT LOCK AND DAM 19 AND IN POOL 20 OF THE UPPER MISSISSIPPI RIVER: PASSAGE AND HABITAT OVERLAP OF NATIVE AND NON-NATIVE FISH

Geographic Location:
The Missouri Department of Conservation maintains and manages the telemetry receivers that span from Pool 20 downstream to Pool 26 on the Upper Mississippi River.

Lead Agency: Missouri Department of Conservation

Participating Agencies:
Southern Illinois University
U.S. Army Corps of Engineers
U.S. Coast Guard
USFWS – La Crosse Fish and Wildlife Conservation Office
USGS – Upper Midwest Environmental Sciences Center
Western Illinois University

Statement of Need:
When certain species are introduced into novel environments, the ecological characteristics may provide favorable environments and lack of natural biological controls. Without evolutionary time to adapt to the presence of the introduced species, they are able to reproduce and expand their range unchecked. Once established, removal and control requires massive resource inputs to have a significant impact. Therefore, the best method of control is prevention. Since the introduction of silver carp (Hypophthalmichthys molitrix), bighead carp (Hypophthalmichthys nobilis), grass carp (Ctenopharyngodon idella), and black carp (Mylopharyngodon piceus), their populations have expanded unconstrained, reaching tremendous densities. The upstream expansion from the Lower Mississippi River (LMR) to the Upper Mississippi River (UMR) reaches has been hindered by the extensive lock and dam network. However, previous acoustic telemetry studies have shown that invasive carps are capable of moving through many of the UMR locks during closed river conditions, with few exceptions. The fish that were able to move past the dams were also able to establish a reproductively successful population. This allowed these fish to not only expand their range, but to reach impressive densities. The current assessment of the invasion shows high densities of invasive carps below Lock and Dam 19, but above the dam exhibits drastically lower densities. It also appears that they have limited reproductive success above this critical point. Further investigation of both invasive carp movement and potential fish deterrents could provide a solution to the upward expansion of invasive Asian carps.

Lock and Dam 19 located in Keokuk, IA, is a major barrier to fish passage due to the perceived inability of fish to pass the gated portion of the dam during closed river conditions unlike other dams in the Upper Mississippi River (Tripp et al. 2013). Therefore, the only avenue of upstream movement is through the navigation lock chamber. With the observed population differences on either side of this barrier, it can be inferred that this barrier holds great importance in the control of these invasive carp species. As the abundance of invasive carp continues to increase in the lower portion of the Upper Mississippi River, it is vital that an evaluation of upstream passage through the lock chamber is conducted so future use of deterrent barriers and operational modifications at lock and dams may be utilized to limit upstream passage of invasive species, while maximizing native fish passage. Because of this the objectives of this study were:

Project Objectives:

1. Quantify native and non-native fish passage at Lock and Dam 19 in the Upper Mississippi River using acoustic telemetry.
2. Evaluate movement and habitat use in Pool 20 of the Upper Mississippi River using acoustic telemetry via manual boat tracking.
3. Determine conditions that show probability of highest passage using environmental variables paired with acoustic telemetry data. Recommend lock operation and deterrent barrier use protocols to minimize passage of non-natives.

Project Highlights:

- 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.

Methods:

In order to monitor fish movement in Pool 20 and potential dam passage, existing acoustic monitoring array of stationary receivers (Vemco VR2W) that were deployed and are maintained collaboratively by state and federal agencies within the Upper Mississippi River was utilized (Figure 1). The receivers within this array were deployed using many different methods such as, navigation buoys, bridge pier attachments, lock chamber wall attachment, bottom set stands, and along with barge-attached units to utilize a method of dynamic tracking by partnering with the commercial navigation industry (e.g., ADM). In order to more closely monitor the movement around Lock and Dam 19, two stationary receivers were placed on navigation buoys below the

lock chamber entrance (one unit just outside the chamber and the other approximately one mile downstream of the lock chamber approach). An additional stationary receiver was placed above the lock chamber to work in correspondence with the lock chamber receiver to determine if a fish that enters the lock chamber exits above the dam for a successful passage event (Figure 2). The USFWS also placed a stationary receiver array inside the downstream approach to the lock chamber to further investigate passage (Figure 2). The USFWS array will collect 2-dimensional data and use Vemco Positioning System (VPS; accuracy of position of fish within 5 meters) to pinpoint fish approaching the lock chamber and determine how fish use the lock approach to inform deterrent placement and evaluate a deterrent should one be deployed in the future. Manual boat tracking (Vemco VR100) will also be performed monthly to assess finer scale movement and habitat use within Pool 20.

During the spring of 2016, invasive carp and native fishes were captured using a wide range of gears (e.g., electrofishing, trotlines, experimental gill nets, three and five inch bar mesh gill nets, trammel nets, and hoop nets) that provided a broad size and age distribution to provide a representative sample of each target species. All fish of the target species list were weighed, measured, and sex was determined internally during transmitter implantation. Ultrasonic transmitters (Vemco V16-5H; 69kHz) were allotted for implantation into each of the representative invasive carp groups (silver, bighead, and grass carp), using the methods described in Tripp et al. (2013). Transmitters were implanted into 46 bighead carp, 48 grass carp, 49 silver carp, and 3 hybrid carp. An additional 150 transmitters allotted to be implanted into certain species chosen to represent the native fish community. Transmitter implantation of these species included; 24 bigmouth buffalo, 23 blue sucker, 1 blue catfish, 20 channel catfish, and 25 flathead catfish. A total of 20 walleye and sauger and 2 American eel were implanted with the smaller Vemco V13 transmitters. Opportunistic tagging of 8 paddlefish and 50 lake sturgeon was also completed. Asian carp were also tagged in 2012 in the same location, so detections from these fish were also used in this study (Table 1.) All fish were placed onto a clean surgery board where a low flow bilge pump circulated water over the gills. Incision site and all surgical tools were disinfected at the beginning and end of each surgery. The incision site was located ventral to the lateral line and anterior to the cloacal opening. A scalpel and hemostat was used to carefully make the incision to avoid damaging internal organs. Three or four Ethicon 3-0 monofilament sutures closed the incision site after the transmitter has been inserted into the abdominal cavity. While the incision is open, a quick examination of the gonadal structure for gender determination was be performed and recorded. After disinfection of the suture site the fish were returned gently to the water where they were released upon regaining strength and orientation. The transmitters were all tested prior to implantation with a VR100 unit to ensure they have been activated. Acoustic signals began transmitting upon release of the specimen. The date, time, and location of release were recorded for each specimen.

Stationary receivers will be uploaded seasonally and the detection data will be analyzed to summarize movements and passage of the implanted fish over the four to five year lifespan of the transmitter. This summary will be paired with the manual tracking data to generate finer scale habitat use and movements of fish within Pool 20. In order to investigate the potential overlap of native and invasive species habitat use, daily detections were represented as the GPS location and kernel density estimates were calculated for each group using PROC KDE state with Statistical Analysis System (SAS). This analysis allowed us to visualize location utilization for each of the groups (native and invasive). In order to quantify the overlap of areas used, we developed a grid system using the fishnet analysis in ArcMap and overlaid native and invasive fish detections. From this we determine the number of grids in which both native and invasive fish were utilizing each area. The number and date of passage events will be used to determine river conditions that yield high potential for passage. This summary will be combined with the USFWS 2-D data processed by Vemco to discuss the potential alteration of lock operation during such periods along with the addition of deterrent barriers to minimize upstream movement of invasive carps.

Results:

During the two year period, a total of 55 fish have been detected on the VR2W in the lock chamber. Species detected in the lock chamber were; 1 American Eel, 4 Bighead Carp, 12 Bigmouth Buffalo, 1 Blue Sucker, 2 Channel Catfish, 1 Flathead Catfish, 4 Grass Carp, 16 Lake Sturgeon, 4 Paddlefish, 11 Silver Carp, and 5 Walleye (Table 1). Of these, 21 have been detected on the VR2W above the lock chamber. Species that have passed into pool 19 are as follows; 1 Bighead Carp,10 Bigmouth Buffalo, 3 Walleye, 2 Flathead Catfish, 2 Grass Carp, 2 Paddlefish, and 1 Silver Carp (Table 1). To look at this data another way we determined the percent of individuals within each species that approached the lock chamber and then the percent that successfully passed upstream into Pool 19 (Table 1). This demonstrated that while fewer individuals within each of the native species were implanted with transmitters, the native species (Bigmouth Buffalo, Paddlefish, and Walleye) were more likely to approach the lock chamber, enter, and pass upstream. Despite the invasive species having many more individuals implanted and 27 – 49% approaching the lock chamber, only 2 – 4% of the invasive species actually successfully passed through Lock and Dam 19 into Pool 19 (Table 1). The VR2W array below pool 20 detected 25 fish that have made downstream movements. Native fish species that made downstream movements were Paddlefish, Lake Sturgeon, and Flathead Catfish. All of the invasive species implanted were documented making downstream movements. For the native fish 2 Paddlefish and 4 Lake Sturgeon were documented moving down into Pool 24, and one Paddlefish was documented moving down to Caruthersville, MO which is about 775 kilometers downstream. The invasive fish were also detected making some long range movements downstream, with Bighead, Silver, Grass, and hybrid Carp all being detected in Pool 24 (105 kilometers downstream). Bighead Carp were also detected in the Kaskaskia River (190 kilometers downstream), Cape Girardeau, MO (500 kilometers downstream), and the Ohio River

at Cairo, IL (588 kilometers downstream). A Grass Carp was also detected down at the Ohio River.

When kernel density estimates were developed for the native and invasive species within Pool 20 using the manual tracking detections, it became evident that specific habitats were not being using such as wing dike or channel borders, it was more like the tailwater area or the mouth of the Des Moines River (Figure 3 and Figure 4). While the core use areas are more spread out for native fish, with the natives also using areas below the mouth of the Des Moines River as well as the Mouth of the Des Moines and the tailwater area where invasives congregated (Figrue 3 and 4). When we quantified the overlap of detections within the fishnet grid, 80% of the grids contained both native and invasive fish detections, so 80% of the areas used by native fishes were also being used by invasive carp.

To further investigate the passage events, the number of successful passages was plotted against the river stage based on the gauge for the Mississippi River at Keokuk, IA (Figure 5). Due to the low number of passages statistical analysis were not run of this data, but visual observation of the data show that the majority of the passages occur between June and September when the river was low. When the USFWS approach data is processed we may be able to further investigate the passages and approaches to determine what factors maybe influencing the number of fish that approach and the number that successfully pass.

Discussion:

Asian carp expansion has been slightly slowed by a few of the UMR lock and dams, specifically Lock and Dam 19, 15, and 14 because of the lack of or infrequent open river conditions at this pinch point areas making them the ideal candidate for areas where deterrent systems may be a potential to impede further upstream establishment. With the continued expansion of all Asian carp species including Black Carp, determining the movement and passage rates at areas that may be pinch points will be critical. From this this study we were able to quantify native and invasive fish species entering and passing the lock chamber at Lock and Dam 19; however this data set would benefit from increased sample size and a longer time period to allow more passage events occur so that the environment factors influencing passage and movement can be further investigated.

Since the transmitters used for this study have a battery life of 5 years, they will still provide data for another 3 years. In addition, we have already begun tagging an additional 100 Asian carp and 50 Paddlefish in collaboration with other agencies throughout the UMR which will also be adding both invasive and native fish implanted with transmitters. Additional transmitters and temporal data will also allow the group to investigate seasonal and specific habitat use of native and invasive species and determine the level of overlap occurring. This will provide the UMR Asian Carp Workgroup with the evidence needed to determine the potential impact a deterrence

system may have on native and invasive species ability to pass upstream into Pool 19. This pre-deterrent data will inform the partnership of how both native and invasive fish approach the lock chamber in these pinch point areas, the frequency that native fish are able to make successful passage, and identify the abiotic and biotic factors that contribute or hinder successful passage.

As the option of deterrence becomes more likely, understanding how deterrence will be utilized to limit passage of invasive species but maximize native fish passage will be critical. Such additions to the navigational structure and operations of the Upper Mississippi River may be the key to reducing passage of invasive carps and effectively reducing future upstream expansion. The emergence of a reproductively successful population of black carp adds extra stress on the need to prevent the further upstream expansion of invasive carps.

Table 1. Species detected downstream, within, and above Lock and Dam 19 with the percent of each species that approached the lock chamber and the percent that successfully passed through into Pool 19.

Species		# Tagged	# Detected in Downstream Approach L&D 19	# Detected in Lock Chamber	# Detected Above L&D 19	% Approached	% Passed
Native							
	American Eel	2	1	1	0	50	0
	Sauger	3	2	0	0	67	0
	Walleye	17	5	5	3	29	18
	Blue Catfish	1	0	0	0	0	0
	Channel Catfish	20	6	2	0	30	0
	Flathead Catfish	25	2	1	2	8	8
	Bigmouth Buffalo	24	15	12	10	63	42
	Blue Sucker	23	3	1	0	13	0
	Lake Sturgeon	50	22	16	0	44	0
	Paddlefish	8	4	4	2	50	25
Non-Native							
	Bighead Carp	49	24	4	1	49	2
	Grass Carp	48	13	4	2	27	4
	Hybrid Carp	3	1	0	0	33	0
	Silver Carp	58	20	11	1	34	2
		331	112	55	21		

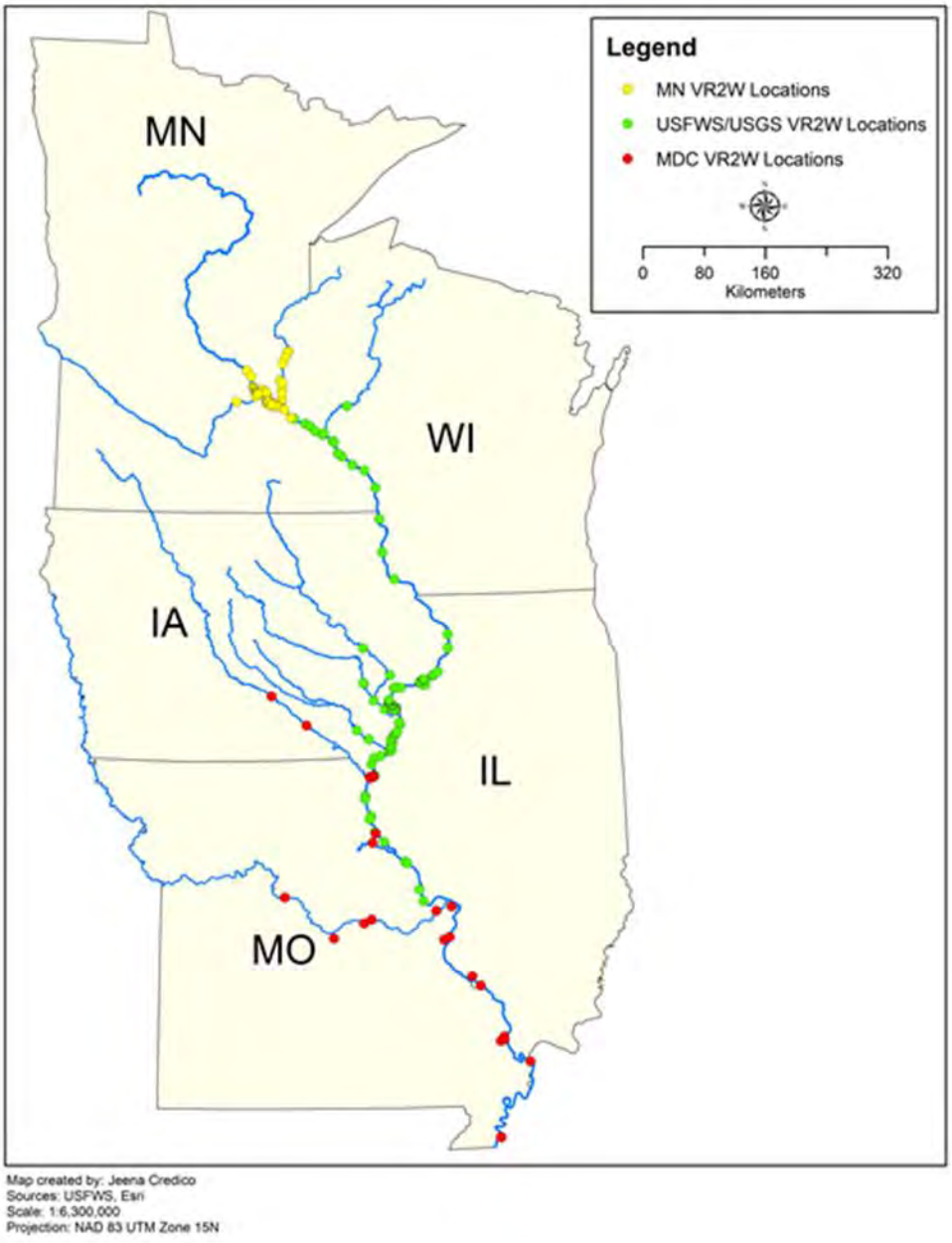

Figure 1. Collaborative stationary receiver array in the Mississippi River and its major tributaries.

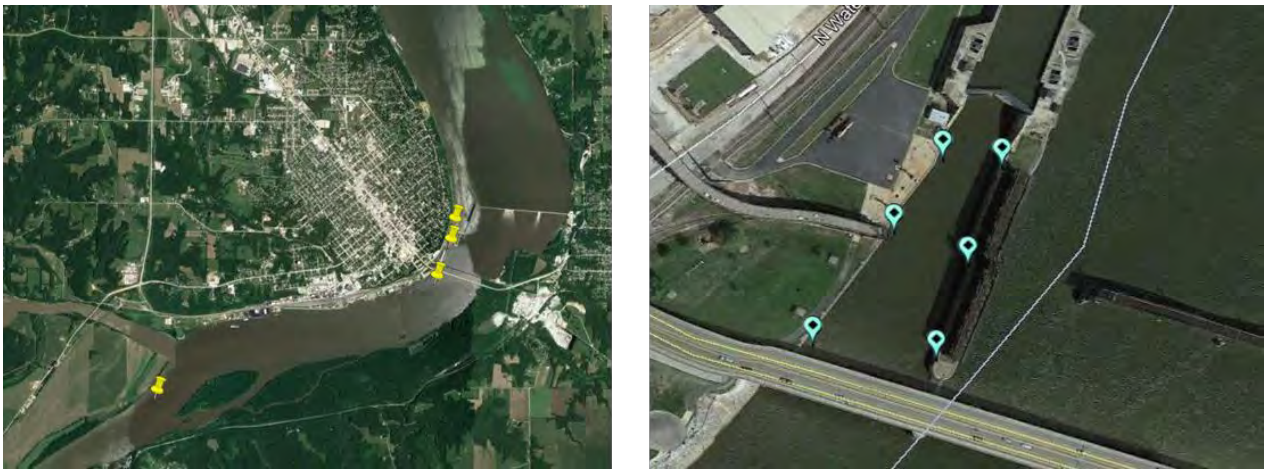

Figure 2. Stationary receiver array around Lock and Dam 19 and the USFWS VPS array in the downstream approach of the lock chamber.

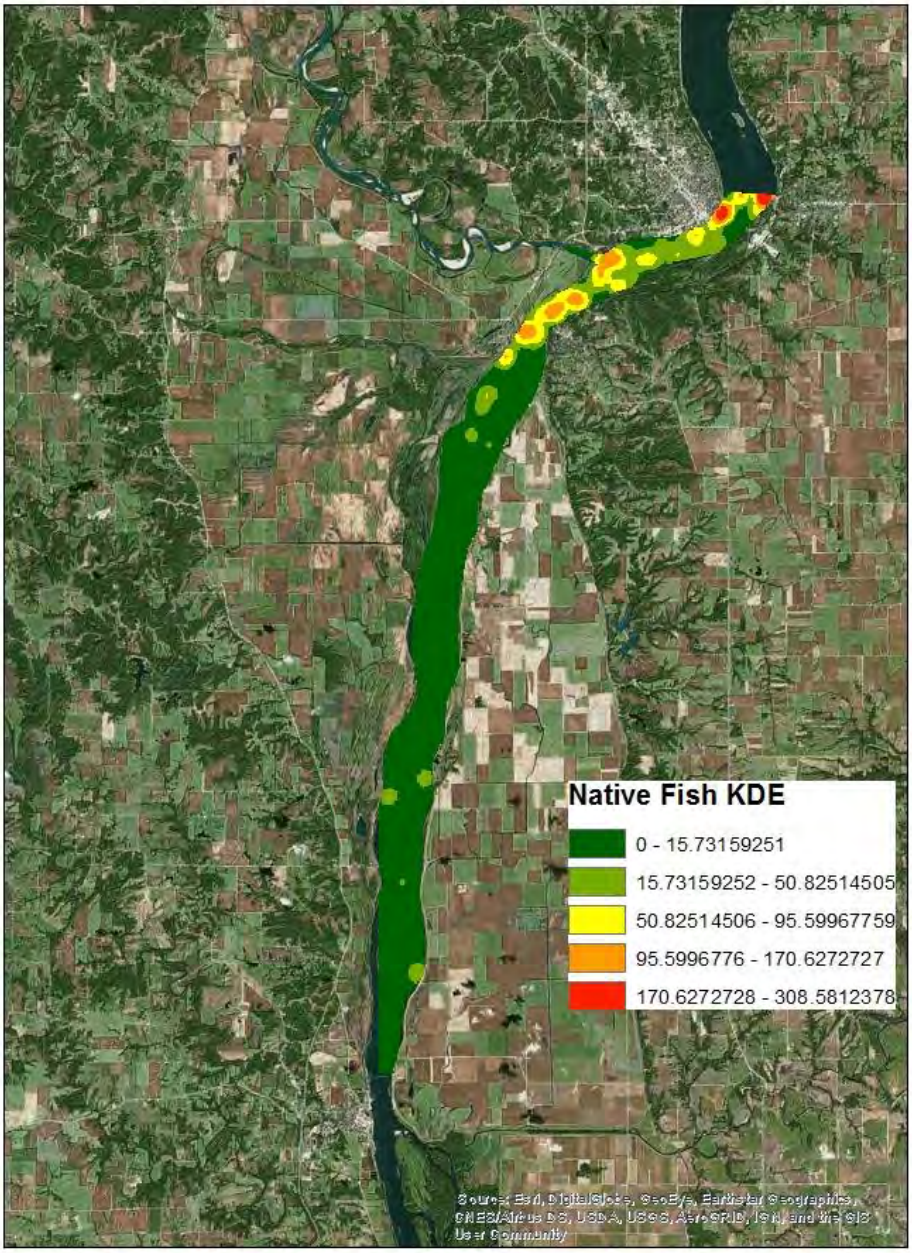

Figure 3. Kernel density estimates for native fish species in Pool 20.

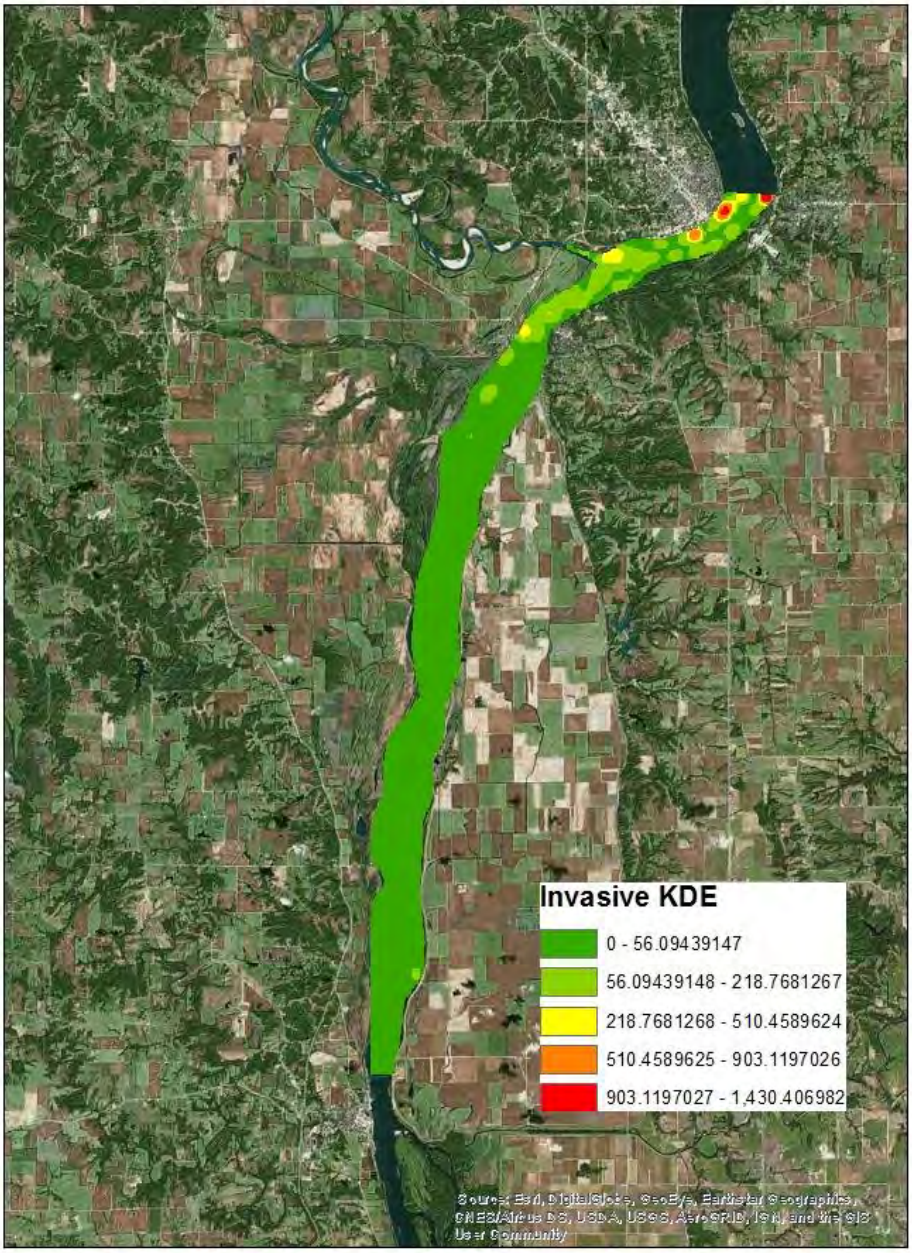

Figure 4. Kernel density estimates for invasive species in Pool 20.

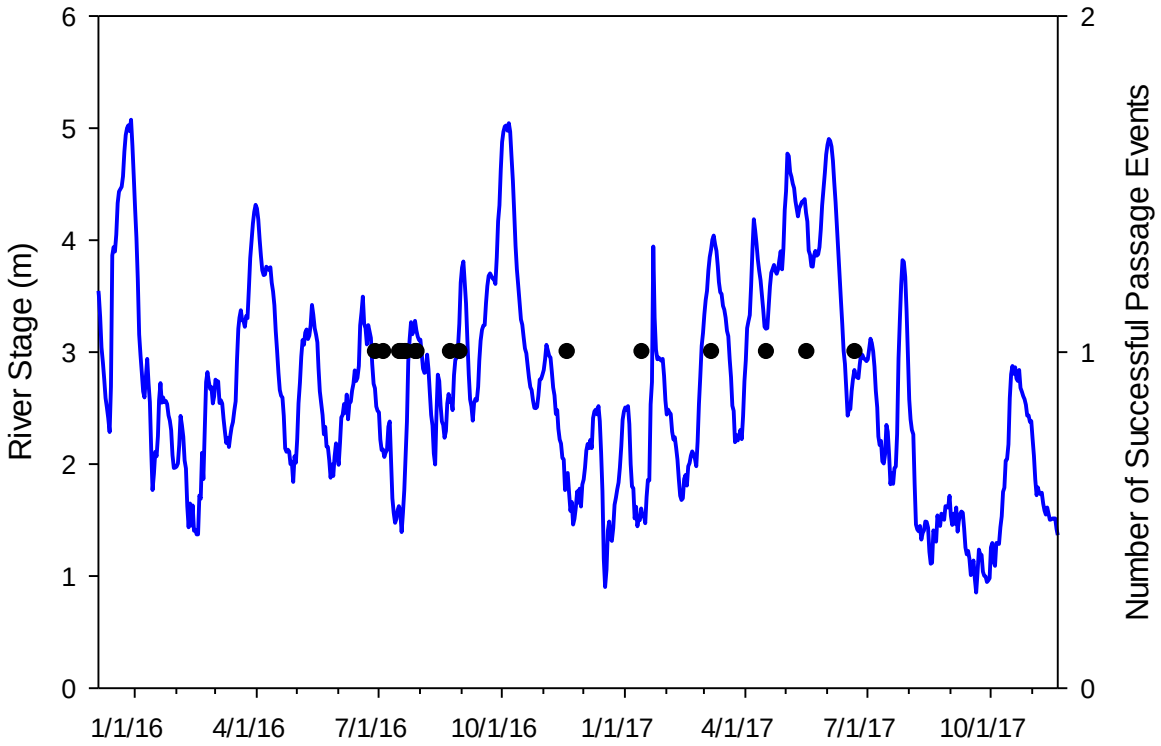

Figure 5. River stage at Keokuk, Iowa gauge associated with the date of successful passage events.

References

Tripp, S., R. Brooks, D. Herzog, and J. Garvey. 2013. Patterns of fish passage in the Upper Mississippi River. River Research and Applications. 30(8):1056-1064