FY19 Annual Progress Report

Project Title: Evaluation of fish passage for assessment of bigheaded carp deterrents at locks in the Upper Mississippi River

Geographic Location: Mississippi River Navigation Pools 14 to 20, with special emphasis on Lock and Dams 15 and 19

Participating Agencies: Illinois Department of Natural Resources (ILDNR), Missouri Department of Conservation (MDC), U.S. Geological Survey (USGS), US Fish and Wildlife Service (USFWS), US Army Corps of Engineers (USACE)

Introduction: Invasive carp 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 physical and operational characteristics of Lock and Dam (LD) 19 restrict upstream migration of fishes because the only upstream fish passage route is through the lock chamber. This possible restriction of emigration into pools above Lock 19 may make that segment of the population more susceptible to control measures, such as overfishing. Lock and Dam 15, located at the upstream end of the Intensive Management Zone (IMZ; LD 15 to LD 19), also serves a potential barrier as this system is rarely in open river condition.

Acoustic deterrents have been developed for limiting the range of fish, and those systems show promise in deterring bigheaded carps. To date, small scale acoustic deterrents have been tested on many native fish and Asian carps in labs, outdoor ponds, and small rivers, and there is a need to test these deterrents on a larger scale such as at lock and dam structures on the large rivers where bigheaded carps are abundant. As a result, the USGS with the support of many partner agencies and multiple funding sources are moving forward with testing deterrent systems at lock and dam facilities (i.e., Lake Barkley Dam, Cumberland River; Lock and Dam 19, Mississippi River). The results from this study are informing the design, installation, and operation of the experimental Acoustic Deterrent System (ADS) at Lock and Dam 19.

Project Objectives:

1. Assess fish passage rates at lock and dam structures in the IMZ on the Upper Mississippi River as an assessment tool for the future testing of Asian carp deterrents.
2. Support increasing receiver coverage in and around lock chambers to improve one-, two-, or 3-dimensional tracking of tagged fishes (native and invasive carps) in the lock approach and chamber
3. Increase receiver coverage in pools 19 and 20, and pools 14, 15, and 16 to enhance detection probabilities to ensure fish passages are documented
4. Analyze movement data to evaluate approach channel use, lock use, and dam passage by invasive carps and native species at LD 15 and 19

5. Use USACE Lock Queue Reports to inform the relationship between fish movements and behavior in relation to lock structures and operation
6. Determine suitability of depth sensitive transmitters for determining vertical position in the water column
7. Conduct planning or studies at strategic locations to better understand feasibility of and how to deploy deterrents at lock chambers to deter bigheaded carp while minimizing effects to native species

Project Highlights:

Agency: Missouri Department of Conservation

- To date, 647 native and invasive fish have been tagged in Pool 20 and 587 were active during the year of 2019. By spring of 2021 the majority of the transmitters implanted in fall of 2015 and spring 2016 will expire (N = 255)
- During the four years of the study (2016-2019), 152 individual fish that were tagged in Pool 20 were detected in the lock chamber (for a total of 277 entrances), and 25 of those fish were detected on the receiver upstream of the chamber for a total of 31 passage events for fishes that originated from Pool 20.
- Of the 150 Asian carp (Bighead, Silver, Hybrid Asian Carp, and Grass) that were tagged in Pool 20, 57% approached the lock chamber, 32 (13%) entered the lock chamber, and only 2 (1%) passed upstream into Pool 19.
- Although 90 of 120 Lake Sturgeon (75%) were detected in or approaching the lock chamber, none were detected moving into Pool 19.
- During 2019, transmitters were implanted into an additional 29 Flathead Catfish, 44 Bigmouth Buffalo, 67 Lake Sturgeon, and 29 Paddlefish below LD 19, and 18 bigheaded carps in Pools 14-16.

Methods:

Agency: Missouri Department of Conservation

Receiver Array: The collaborative stationary receiver array maintained by many state and federal agencies within the UMR was utilized to monitor fish movement around Lock and Dam 19, quantify passage events, and gain knowledge of pre-deterrent movement within Pool 20. 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). To more closely monitor the movement around Lock and Dam 19, one stationary receiver was placed on the mooring station at the USCG station (as we were losing the receiver on the navigation buoy) approximately one mile downstream of the lock

chamber approach. Two stationary receivers were 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. The USFWS also placed a stationary receiver array inside the downstream approach to the lock chamber to further investigate passage. This array collects 2-dimensional data and uses 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) was also utilized to assess finer scale movement and habitat use within Pool 20.

Tagging: During 2019, transmitters were implanted into 29 Flathead Catfish, 44 Bigmouth Buffalo, 67 Lake Sturgeon, and 29 Paddlefish. 4 Bighead Carp and 9 Silver Carp were also added but were implanted with depth sensor transmitters to better understand positioning in the water column when inside the lock approach and lock chamber. This brings the total number of fish tagged to 647 over the four-year study (Table 1). Asian carp and Lake Sturgeon were also tagged in 2012 in the same location, so detections from these fish were also used in this study, but these transmitters are starting to expire and were not active during the entire 2019 season (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 were 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. After surgery fish were returned 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 had been activated. Acoustic signals began transmitting upon release of the specimen. The date, time, and location of release was recorded for each specimen.

Analysis: Stationary receivers were uploaded seasonally, and the detection data was 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.

Agency: Illinois Natural History Survey/Illinois DNR

During fall of 2019, 18 bigheaded carps were tagged with acoustic transmitters in Pools 14-16, following the methods described in the MDC section. Additional bigheaded carps and bigmouth buffalo will be tagged in Pool 16 during 2020.

Results

Agency: Missouri Department of Conservation

During the four-year period, a total of 152 individual fish that were tagged in Pool 20 (some of those with multiple entrances for a total of 277 entrances), have been detected on the Vemco receiver in the lock chamber. Species detected in the lock chamber were; 1 American Eel, 7 Bighead Carp, 27 Bigmouth Buffalo, 1 Blue Sucker, 2 Channel Catfish, 12 Flathead Catfish, 5 Grass Carp, 45 Lake Sturgeon, 27 Paddlefish, 20 Silver Carp, and 5 Walleye (Table 1). Of these, 25 have been detected on the Vemco receiver above the lock chamber. Species that have passed into pool 19 are as follows; 1 Bighead Carp, 11 Bigmouth Buffalo, 3 Walleye, 3 Flathead Catfish, 1 Grass Carp, and 6 Paddlefish (Table 1). Twenty-five of those fish detected in the lock chamber were detected on multiple receivers upstream of the chamber for a total of 31 passage events (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). Unlike previous years, the percent of individuals within each species group were similar between the primary native (Flathead Catfish, Bigmouth Buffalo, Lake Sturgeon, and Paddlefish) and invasive groups, with Flathead Catfish being the least likely to approach at 22% and Grass Carp the most likely at 79%. Bigmouth Buffalo, Paddlefish, Walleye, and Flathead Catfish were still more likely to approach the lock chamber, enter, and pass upstream than all the invasive species that were tagged in Pool 20. While 150 Bighead, Grass, and Silver carp (57%) approached the lock chamber, only 2 (1%) of the invasive species originally tagged in Pool 20 successfully passed through Lock and Dam 19 into Pool 19 (Table 1). The Bighead Carp that successfully passed upstream into Pool 19 made 10 attempts or entered the lock chamber on 10 separate occasions before successfully passing upriver. The Vemco receiver array below Pool 20 detected 25 fish that have made long-range downstream movements. Native fish species that made downstream movements were Paddlefish, Lake Sturgeon, and Flathead Catfish. Each of the invasive species implanted with transmitters were also 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. In 2019 several species with tags made their way up to Red Rock Dam on the Des Moines River, including 2 Bighead Carp, 2 Bigmouth Buffalo, 8 Lake Sturgeon, 4 Paddlefish, and 1 Silver Carp. Invasive fish were also detected making long-range movements downstream with Bighead Carp, Silver Carp, Grass Carp, and hybrid bigheaded carp all being detected in Pool 24 (105 kilometers downstream). Bighead, Silver, and Grass Carp were also detected in the Kaskaskia River (190 kilometers downstream), Cape Girardeau, MO (500 kilometers downstream), the Ohio River at Cairo, IL (588 kilometers downstream), and Caruthersville, MO (775 kilometers downstream). The VR2W array above Pool 19 also detected long-range upstream movements by native species. A Bigmouth Buffalo and Paddlefish were detected as far upstream as Pool 17 and a Walleye was detected in Pool 15.

There is one important note for the total number of fish and the number of species implanted with transmitters. The fish implanted with transmitters the first year of the study in fall of 2015 and spring 2016 will all expire by the spring of 2021(N = 255). This will leave active transmitters in the species deemed important for study by area managers (i.e., Bigmouth

Buffalo, Flathead Catfish, Lake Sturgeon, Paddlefish, Bighead Carp and Silver Carp); however only 50 to 75 of each of these species will have functional transmitters.

Kernel density estimates were developed for the native and invasive species within Pool 20 using the manual tracking detections. The LD 19 tailwater area and the mouth of the Des Moines River had a more frequent presence of tagged fishes, whereas wing dike and channel border habitats were not used (Figure 1 and 2). The core use areas are more spread out for native fish, with the native species 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 (Figure 1 and 2). When we quantified the overlap of detections within the fishnet grid, 90% of the grids contained both native and invasive fish detections, so 90% of the areas used by native fishes were also being used by invasive carps.

To further investigate the passage events, the number of passage attempts and successful passage events for native and invasive species were plotted against the river stage based on the gauge for the Mississippi River at Keokuk, IA (Figure 3). Due to the low number of passages statistical analysis were not run on these data, but visual observation of the data show that the invasive fish passages occurred during June and August with a rise in river. Native passage attempts and successful passages were more frequent in the spring and other periods when water levels were high (April through October). Native and invasive species had few attempts and no passages during the winter of 2018 and 2019, even though winter 2018 was a low water period and winter 2019 had a substantial rise in water river levels.

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. **Note: this table only reports fishes that were originally tagged in Pool 20 and does not include any carps that were originally tagged upstream of Lock and Dam 19.

Species	Total Tagged	# Active in 2019	# of Tags Detected in Downstream Approach	Lock Chamber Detections		# Detected Above L&D 19		% Approached	% Passed
				# Tags	# Entrances	# Tags	# Passages		
Native									
American Eel	2	0	1	1	1	0	0	50	0
Sauger	3	0	2	0	0	0	0	67	0
Walleye	17	0	5	5	6	3	3	29	18
Blue Catfish	1	1	0	0	0	0	0	0	0
Channel Catfish	20	20	7	2	2	0	0	35	0
Flathead Catfish	54	54	14	12	19	3	3	26	6
Bigmouth Buffalo	68	68	45	27	56	11	15	66	16
Blue Sucker	23	23	6	1	2	0	0	26	0
Lake Sturgeon	120	100	90	45	72	0	0	75	0
Paddlefish	78	78	34	27	63	6	8	44	8
Non-Native									
Bighead Carp	97	91	45	7	17	1	1	46	1
Grass Carp	47	47	37	5	5	1	1	79	2
Hybrid Carp	3	3	1	0	0	0	0	33	0
Silver Carp	114	102	67	20	34	0	0	59	0
	647	587	354	152	277	25	31		

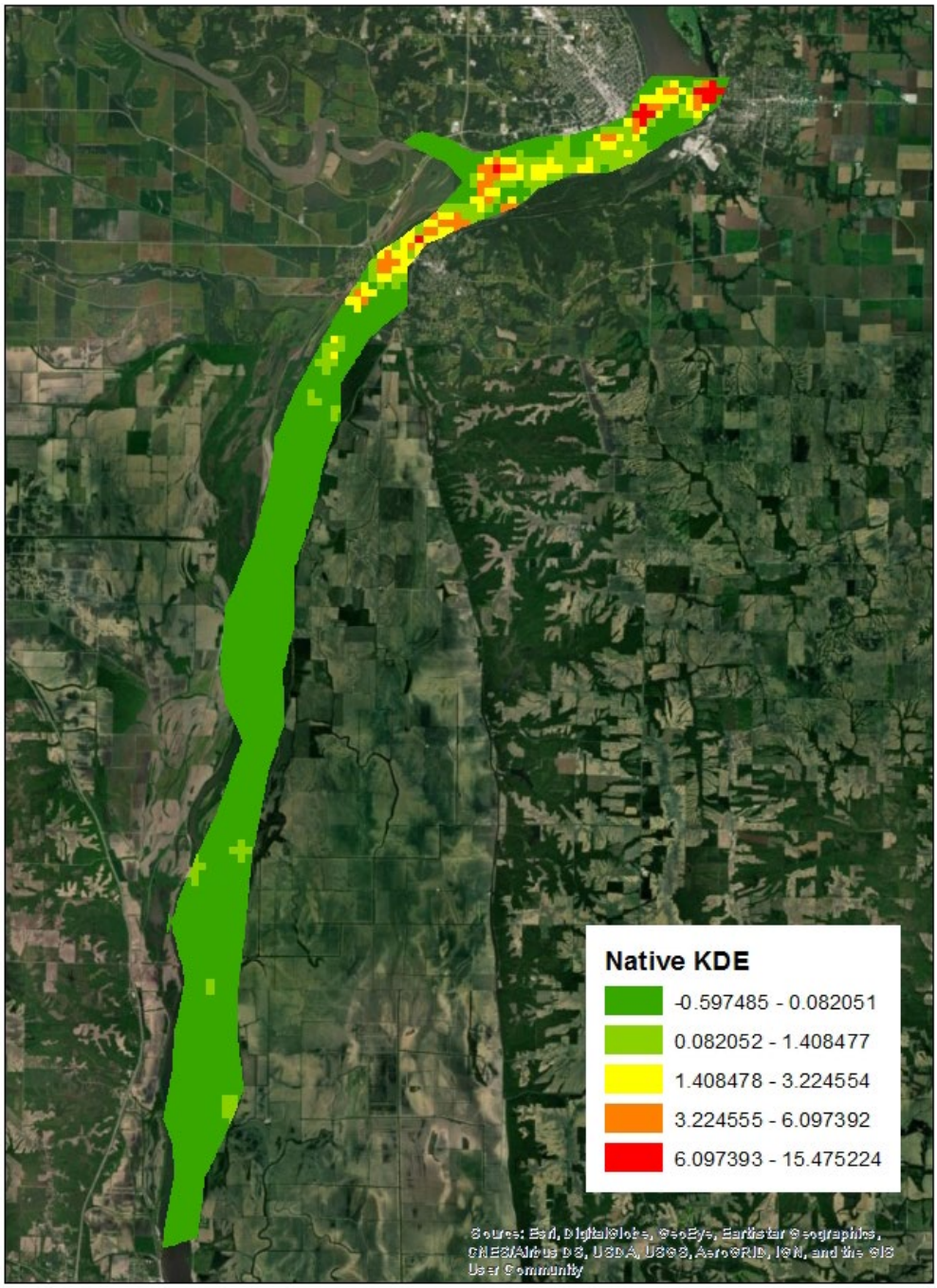

Figure 1. Kernel density estimates for native fish species in Pool 20.

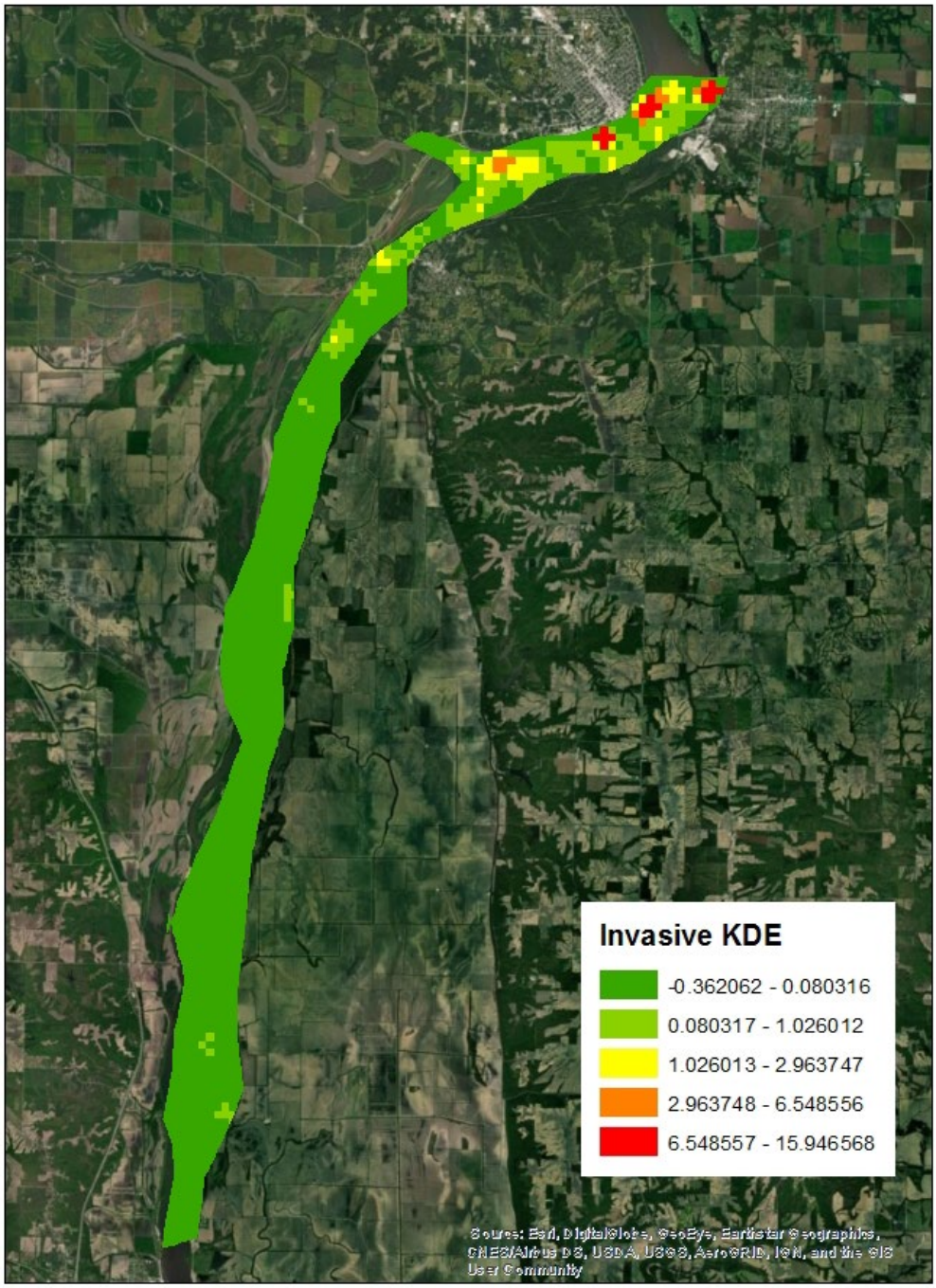

Figure 2. Kernel density estimates for invasive fish species in Pool 20.

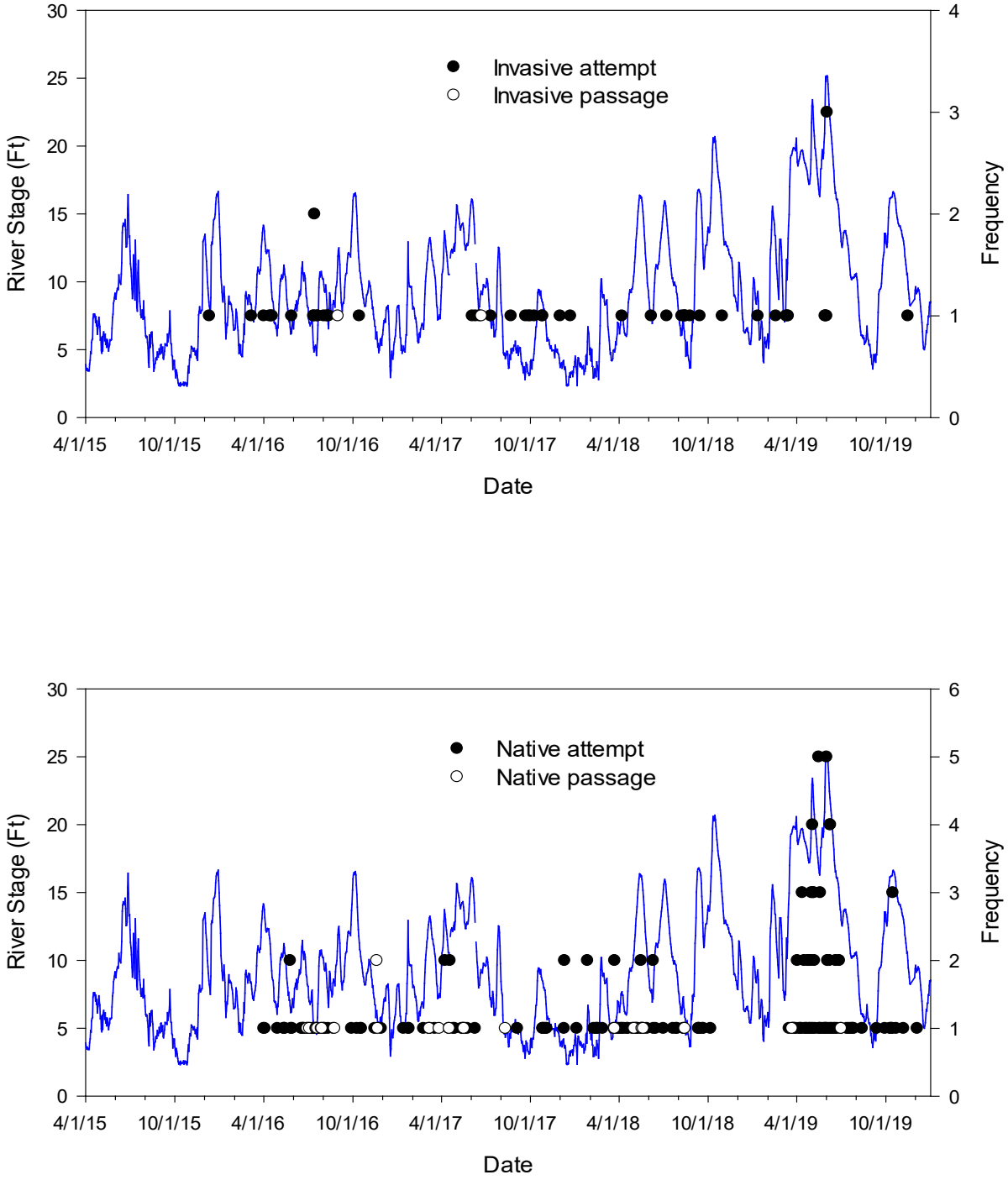

Figure 3. River stage at Keokuk, Iowa gauge associated with the dates of passage attempts and successful passage events of fishes tagged in Pool 20. The top graph depicts invasive species attempts in black circles and invasive species passage in open circles and the bottom shows native species attempts (black) and passages (open). **Note: this figure only reports fishes that were originally tagged in Pool 20 and does not include any carps that were originally tagged upstream of Lock and Dam 19.