Project Title: Evaluation of controls on density and behaviors of invasive carp in the lower UMR

Geographic Location: Pool 5A through Pool 26 of the Upper Mississippi River and open river sections extending to the confluence of the Ohio River

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Participating Agencies: Minnesota Department of Natural Resources (MNDNR), Missouri Department of Conservation (MDC), Iowa State University (ISU), U.S. Army Corps of Engineers (USACE), U.S. Coast Guard (USCG), U.S. Geological Survey – Upper Midwest Environmental Sciences Center (USGS), Illinois Natural History Survey (INHS)

Statement of Need: Populations of Silver Carp (*Hypophthalmichthys molitrix*) and Bighead Carp (*H. nobilis*) as well as hybrids (*H. molitrix x nobilis*) between these species, are advancing in the Upper Mississippi River (UMR) basin (Conover et al. 2007; Chapman and Hoff 2011; O'Connell et al. 2011). Three zones of relative abundance of Silver and Bighead Carp have been identified in the UMR; a robust core population (established) below Lock and Dam 19 (LD19), a transitional zone of moderately dense populations with occasional reproduction and recruitment from LD19 to LD15 (also referred to as the intensive management or IMZ zone), and a zone above LD15 where captures of adults occur but there is no evidence of population recruitment (USFWS 2016). Contracted removal efforts have been implemented in the transitional zone since 2016, but the impacts of those efforts are largely unknown. Furthermore, additional contract removal efforts in Pools 20-25 have recently been initiated.

A robust stock assessment program is needed to more directly evaluate how populations of Silver and Bighead Carp may be affected by current contract removals and to forecast their future response to alternative removal strategies. A robust stock assessment program should incorporate information from multiple fishery-dependent and independent sources, hydroacoustics, and telemetry, to provide the least-biased composite estimate of carp abundance, biomass, demographic distributions, recruitment, and migratory tendencies. Telemetry operations span all three management zones to help understand movement and habitat use within and among pools across these zones.

Project Objectives:

1. Establish a sampling protocol for hydroacoustic surveys in the UMR to estimate Silver and Bighead Carp relative density, size distribution, spatial distribution and biomass at the pool-scale, to inform and evaluate management actions in the UMR.

2. Conduct fishery-independent monitoring to quantify relative abundance, sex ratio, body condition, recruitment, growth, and mortality of invasive carp, support hydroacoustics surveys, and inform and evaluate management actions in the UMR.

3. Monitor spatial and temporal trends in Silver and Bighead Carp movements in response to contract removals and environmental changes using sonic telemetry in Pools 5A-26

4. Use light traps to establish an annual index of spawning activity by invasive carps in Pool 19.

5. Collect demographic information from invasive carp removed from the UMR by contracted fishers for assessment modeling and to inform and evaluate management actions in the UMR.

Project Highlights:

- A hydroacoustics sampling protocol has been successfully established for the Upper Mississippi River. A multi-year effort to conduct comprehensive surveys of select pools to produce data-driven estimates of optimum transect length and required sampling effort necessary to accurately characterize the large-bodied (>254 mm TL) fish population of a navigation pool has been completed (Johnson et al. *accepted*). A product of that effort is an equation that can be used to estimate necessary sampling effort for new navigation pools without conducting additional comprehensive surveys.
- Silver Carp pool-wide relative density estimates decreased from 2023 to 2024 in all pools with multiple years of comparable data. Among Pools 20-24, relative density of Silver Carp was highest in Pool 20.
- Pool-wide hydroacoustic surveys in FY24 covered UMR Pools 20-24 and included randomized sampling of 372 transects 0.5 nautical miles in length, counted 27,207 fish greater than 254 mm/10" TL, and ensonified nearly 9.3 million cubic meters of water.
- Fisheries-independent sampling occurred across the four spatial monitoring units that were defined through 2021-2023 sampling. Electrified dozer trawl collections showed that trends in length, age, and growth observed during 2021-2023 remained consistent during 2024 sampling. However, substantially reduced relative abundance in the Open River was observed in 2024. Additionally, body condition changed dramatically in the Open River and the Pooled Reach, where the Open River depicted an increase in body condition, while the Pooled Reach populations depicted reduced body condition.
- Age-frequency histograms suggest variable recruitment of Silver Carp during the last 12 years with strong and weak cohorts represented in each spatial monitoring unit. During 2024, large numbers of age-0 Silver carp were detected (n = 1,471) in sampling. Of these, only 3 came from the Pooled Reach, with the remainder coming from the Open River reach and Pool 26.
- Age-1 Silver Carp were collected by USFWS with an electrified dozer trawl during a spring tagging event in the Skunk River Bottoms (Pool 19). This was in the same area where age-0 Silver Carp (N=106) were collected during fall surveys in 2023, indicating that successful spawning and recruitment occurred above LD19 in 2023-2024. Additionally, in 2024 YOY Silver Carp were collected from culture ponds at the IA DNR Fairport Fish Hatchery (Pool 16) in the wake of receding flood waters. Nine of these fish were implanted with telemetry tags, as were the age-1 fish collected in Pool 19.

- Telemetry efforts by USFWS documented immense changes in the distribution of invasive carp in the UMR that occurred during spring floods in 2023 and 2024. Overall, invasive carp from Pools 16-19 made upstream migrations into Pools 5A-10 during periods of flooding that required the US Army Corps of Engineers to open all spillway gates on dams. These data highlight how invasive carp move freely among the jurisdictional boundaries of the UMR and underscore the need for cohesive management strategies among the UMRICT partnership.
- Telemetry efforts by MDC showed how some tagged invasive carp within the Open River and lower pooled portions of the UMR remained relatively close to their tagging origin, while others were highly mobile, moving upstream, downstream, and into adjacent major tributaries. Maximum distance traveled from tagging origin was 727 river miles from Pool 25 up the Missouri River to the vicinity of River Sioux, IA; maximum total distance traveled was 750.8 river miles from Pool 26, up the Missouri River to Kansas City, KS, then back to Pool 26.
- Telemetry work by ISU in Iowa tributaries showed that while some invasive carp move in and out of Iowa tributaries, functioning as subpopulations of the UMR metapopulation, other tagged individuals remained within their respective tributaries for the entire duration of the study, acting as resident populations. From 2022-2024 a Silver Carp moved out of the Des Moines River and up the Missouri River to Blaire, NE, a distance of 1,433 km (~890 miles). This individual then moved back down the Missouri River, returned to the Mississippi River, and was most recently detected back in the Des Moines River.
- Using larval light trap sampling, 833 bigheaded carp were collected in the 2024 field season from Pool 19 of the Mississippi River, with 813 (97.6%) of these bigheaded carp captured on 07/01/2024. Larval bigheaded carp were also caught in 2023 and 2022, but prior to that, were last collected in 2018.

Methods:
Hydroacoustics

Hydroacoustic surveys can provide data on the relative abundance, size distribution, and spatial distribution of fishes. When paired with physical capture data, hydroacoustics can also estimate biomass of fishes, and provide species specific estimates for these metrics. Hydroacoustics data were collected as described in Johnson et al. (*accepted*) and MacNamara et al. (2016). Surveys were conducted using two horizontally oriented split-beam transducers (200 kHz; BioSonics, Inc.) offset in angle to maximize water column coverage (Figure 1). Main channel / main channel border habitats have their sampling area divided into either nearshore or offshore transects along each bank (Figure 2). The nearshore main channel sampling area occurs at the 1.5 m depth contour with the transducers pointed out towards the thalweg. The offshore main channel sampling area is located farther from shore, picking up approximately where the beams from the first transect would have hit the bottom and viable data collection would have stopped. Side channel habitats have only nearshore transects available on each shoreline. Backwater lakes and other off-channel habitats are sampled when available, with one or more transects on each shoreline (depending on size). In the UMR, transducers are pointed towards the thalweg when sampling all habitat types. In areas where wing dams or closing structures bisected transect routes, transects went over the top if water depths were sufficient (Figure 2). If depths were insufficient to sample over the top of structures, data collection was paused, the boat routed around the structure, and then resumed data collection as close as possible for transect continuity.

In the fall of 2024, pool-wide population assessment surveys shifted slightly downstream to areas of higher invasive carp density to collect baseline information from navigation pools prior to the institution of subsidized removal programs. Pool-wide surveys were conducted in Pools 20, 21, 22 and 24 of the UMR. Sampling effort in these pools was determined through a re-sampling analysis and use of an equation derived from a multi-year comprehensive survey effort by the USFWS, used to determine the optimum transect length and amount of effort necessary to describe fish communities greater than 254 mm / 10 inches total length within navigation pools of large rivers (Johnson et al. *accepted*). Those results were used to inform stratified random sampling designs for all pools, with transects 0.5 nautical miles in length randomly selected from side channel, nearshore main channel border, and offshore main channel border sites (Figure 2). The fall period was selected for pool-wide surveys because water levels are typically lower, concentrating fish in main channel border and side channel habitats where they are more easily surveyed with hydroacoustic equipment. Secondly, fish are generally less motile at this period, reducing chances of double counting fish within or among pools, compared to the spring, when spawning cues can increase fish movement. Thirdly, the fall period aligns with other comparable hydroacoustic surveys in neighboring river basins (IL River, Ohio River).

Hydroacoustic data was analyzed following MacNamara et al. (2016) using Echoview 13.1. Single targets were detected using parameter values from Parker-Stetter et al. (2009). Multiple targets from a single fish were grouped using Echoview's fish tracking algorithm to reduce the potential of over counting fish targets. The size of fish targets (total length; cm) were estimated from mean acoustic target strength (dB) using a function specific to side-looking hydroacoustics (Love 1971). Hydroacoustic data were informed by pool/habitat-specific fish community data. Proportions of fish were determined for each 10 cm length groups for Silver Carp and other fish species. Length-specific proportions were used to categorize acoustically detected fish, and relative density was estimated. All analyses were conducted using the data analysis program "R" (R Core Team 2020).

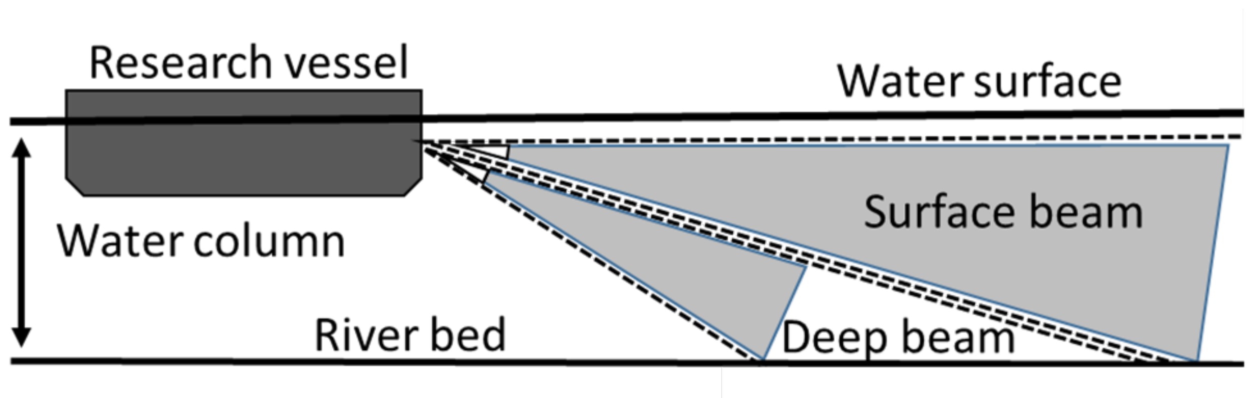

Figure 1. *Diagram showing the approximate orientation of the hydroacoustic beams during a mobile survey. The data that can be used in analysis is collected within the gray area.*

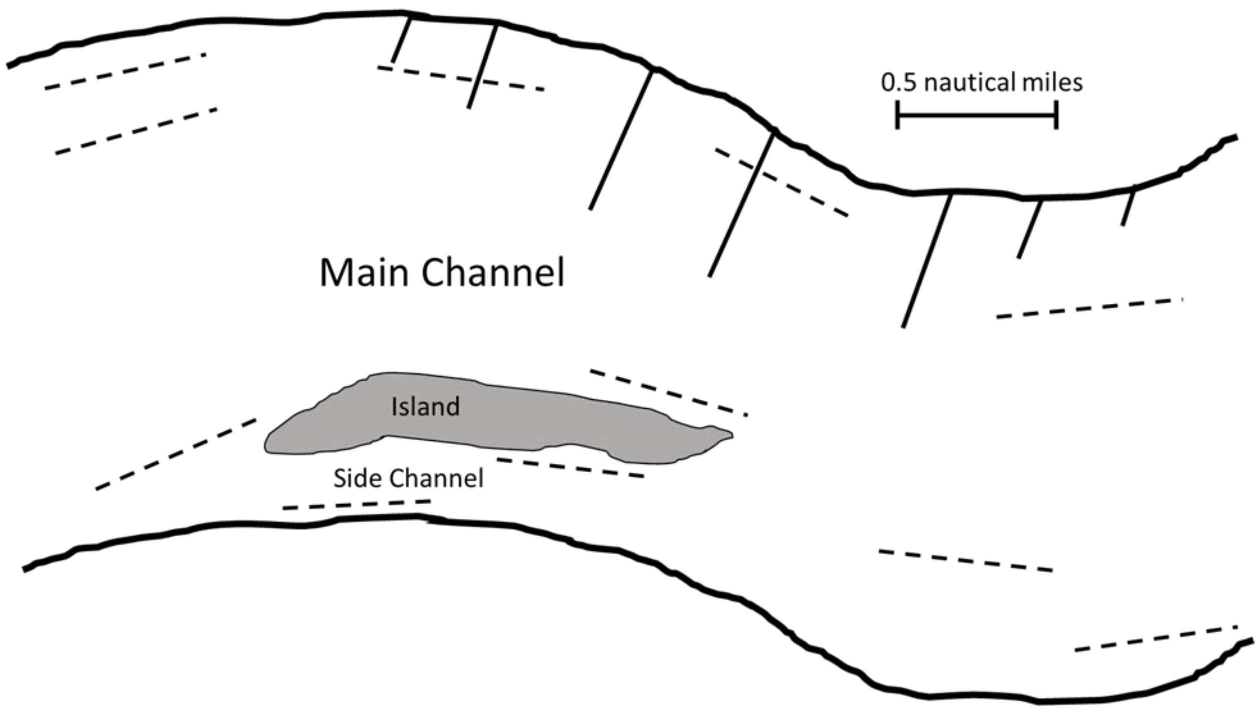

Figure 2. *Example of randomly selected survey transects 0.5 nautical miles in length (represented by dotted lines) in the Upper Mississippi River. Transects are randomly selected from available nearshore and offshore locations for each bank along the main channel; only nearshore transects are randomly sampled within island side-channels and can occur on each bank. Transducers point toward the thalweg. If wing dikes or closing structures bisect a transect, data collection will continue over the top of the structure if water depth allows. If the survey boat cannot safely collect data over the top of the structure, the transect will pause, the boat will relocate around the structure, then resume transecting.*

Fishery Sampling

Physical fish capture data can provide demographic information and relative abundance data that can help evaluate management actions. Physical fish capture data is also needed to inform hydroacoustic surveys to generate species specific estimates of relative abundance. Fall pool-wide surveys relied on fisheries-independent sampling conducted by the USFWS using an electrified dozer trawl (Hammen et al. 2019). Staff from the U.S. Fish and Wildlife Service's Carterville, Columbia, and La Crosse Fish and Wildlife Conservation Offices (FWCOs) coordinated to conduct fisheries-independent Silver Carp population demographic assessments in the Upper Mississippi River during 2021-2023. Standardized stratified-random electrified dozer trawl sampling occurred across a broad spatial gradient of more than 430 river miles between the confluence of the Ohio River and Pool 18. These assessments revealed trends in Silver Carp relative abundance, length, condition, and growth, helping to delineate four Meaningful Management Units (i.e., Open River, Pool 26, Pooled Reach (Pools 20-25), and Above L&D 19) where Silver Carp population demographics were similar within each management unit, but differed across units (Figure 3). In 2024 the electrified dozer trawl was used to monitor Silver Carp populations within these designated spatial units to inform and assess management across a broad area within the UMR. Site locations were randomly distributed and stratified by habitat (i.e., main channel, side channel, backwater, tributary). All Silver Carp were measured (TL mm), weighed (g), and enumerated. Additionally, crews removed lapilli otoliths from a subsample of Silver Carp (~100/management unit). The data collected during these sampling efforts were used to determine relative abundance (CPUE, fish/hr), length structure, condition (Wr), and growth.

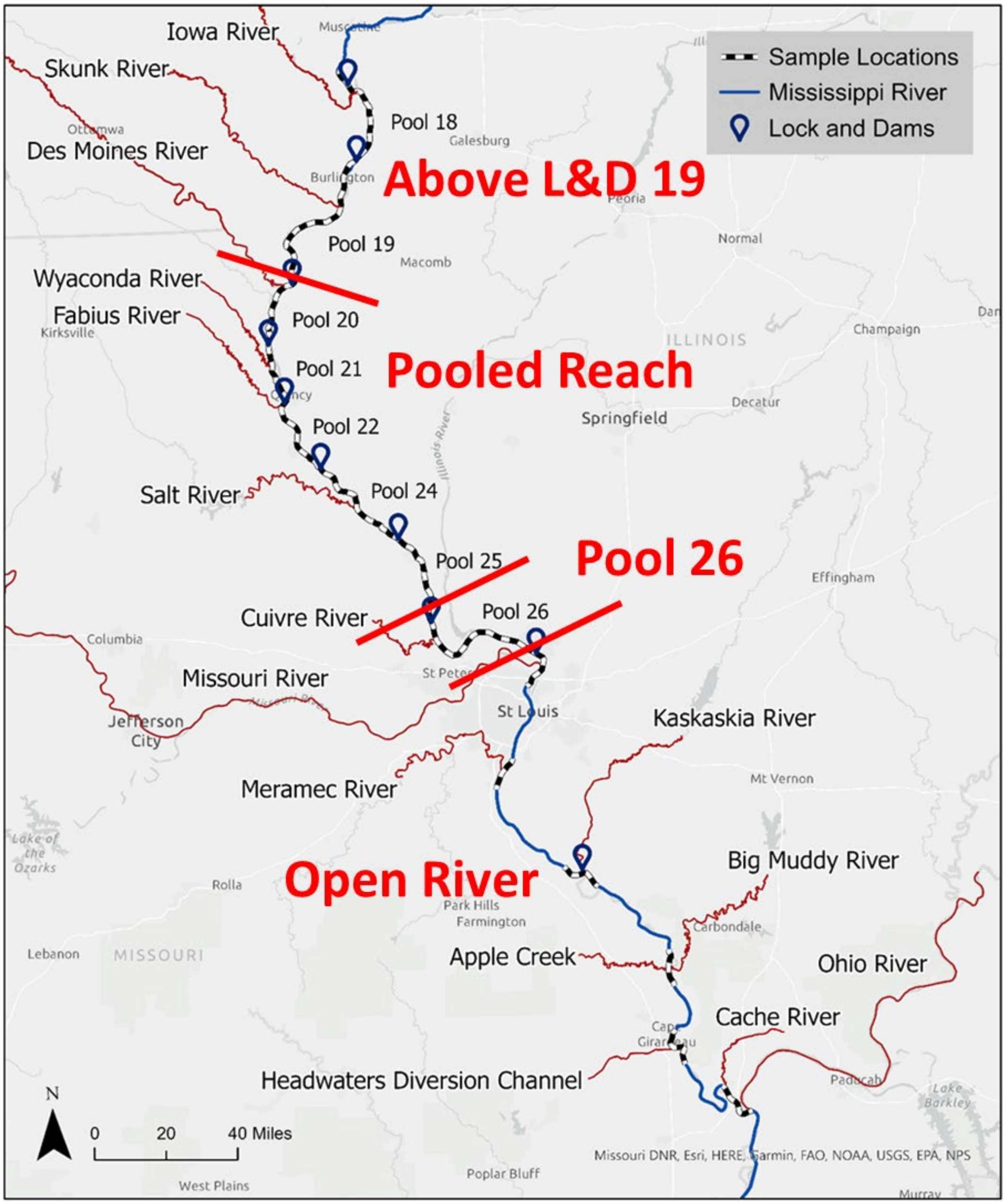

Figure 3. *Map depicting the spatial monitoring units wherein fall 2024 fishery-independent sampling locations occurred. Tributaries where sampling occurred are highlighted in red. The southernmost dam is in the Kaskaskia River, whereas all other dams are on the mainstem Mississippi River.*

Telemetry

Telemetry operations span the entire UMR to help understand movement and habitat use within and among pools and tributaries, and across spatial monitoring units. Telemetry infrastructure is maintained by a multi-agency cooperative with broad interests concerning the management and spatial ecology of Silver and Bighead Carp as well as native species who share those habitats.

Stationary Receiver Array

Stationary receivers (Innovasea, (formerly Vemco) Model VR2W and VR2-Tx) have been deployed in the UMR since 2013. During 2024, 98 receivers were deployed and maintained by USFWS-La Crosse staff (Pools 5-13) and Illinois Natural History Survey (Pools 14-19; Figure 4). This number includes 28 new stationary receivers deployed in Pools 5-12 to better monitor invasive carp that expanded into these pools during Spring 2023. USFWS crews built and deployed one new real-time telemetry receiver that was deployed at Carthage Lake in Pool 19 during April 2024. Four additional real-time receivers built during previous years were deployed in Pools 16-19 from March-November 2024. All receivers in Pools 5-13 were downloaded at least 4 times during the 2024 field season. Some receivers, such as those in Pools 5-8 were downloaded as many as 8 times during the field season to provide up to date movement information to contracted commercial fishing crews working with the MN DNR.

Data from these receivers were shared daily with partners at INHS leading contracted removal efforts. MDC maintains 36 receivers along sites in Pools 20-26 including above and below each of the locks and dams (Figure 4), utilizing platforms of opportunity. All 36 stationary telemetry receivers maintained by MDC were downloaded quarterly throughout the year; data was shared with the appropriate partners annually or upon request. MDC also manages receivers downstream of Pool 26 including the Open River portion of the UMR.

Crews from Iowa State University deployed an array of 31 Innovasea VR2W and VR2Tx acoustic receivers throughout the Des Moines (N=14), Cedar (N = 7), Iowa (N = 8), and Skunk (N=2) rivers (Figure 5). Receivers were hung inside PVC conduit using stainless steel cable and mounted them to bridge pilings with the exceptions of a receiver in a Des Moines River backwater, a receiver in a Cedar River backwater, and a receiver below Oakland Mills Dam in the Skunk River that were bottom sets. In 2024, ISU installed 16 additional receivers in the Wapsipinicon (n=3), Maquoketa (n=3), Yellow (n=2), Turkey (n=2), Paint (n=1), Bloody Run (n=1), and Upper Iowa (n=4) rivers. Iowa State University downloaded acoustic receivers throughout the UMR basin during fall 2023, spring 2024, and fall 2024 and performed regular maintenance as needed.

Figure 4. *Map of telemetry receivers deployed by federal, state, and academic partners to track the movements of invasive carp in the Upper Mississippi River and its tributaries during 2024. Black dots indicate the approximate position of each receiver. Receivers are cooperatively maintained by US Fish and Wildlife Service, US Geological Survey, MN Department of Natural Resources, Iowa State University, MO Department of Conservation, and Illinois Natural History Survey.*

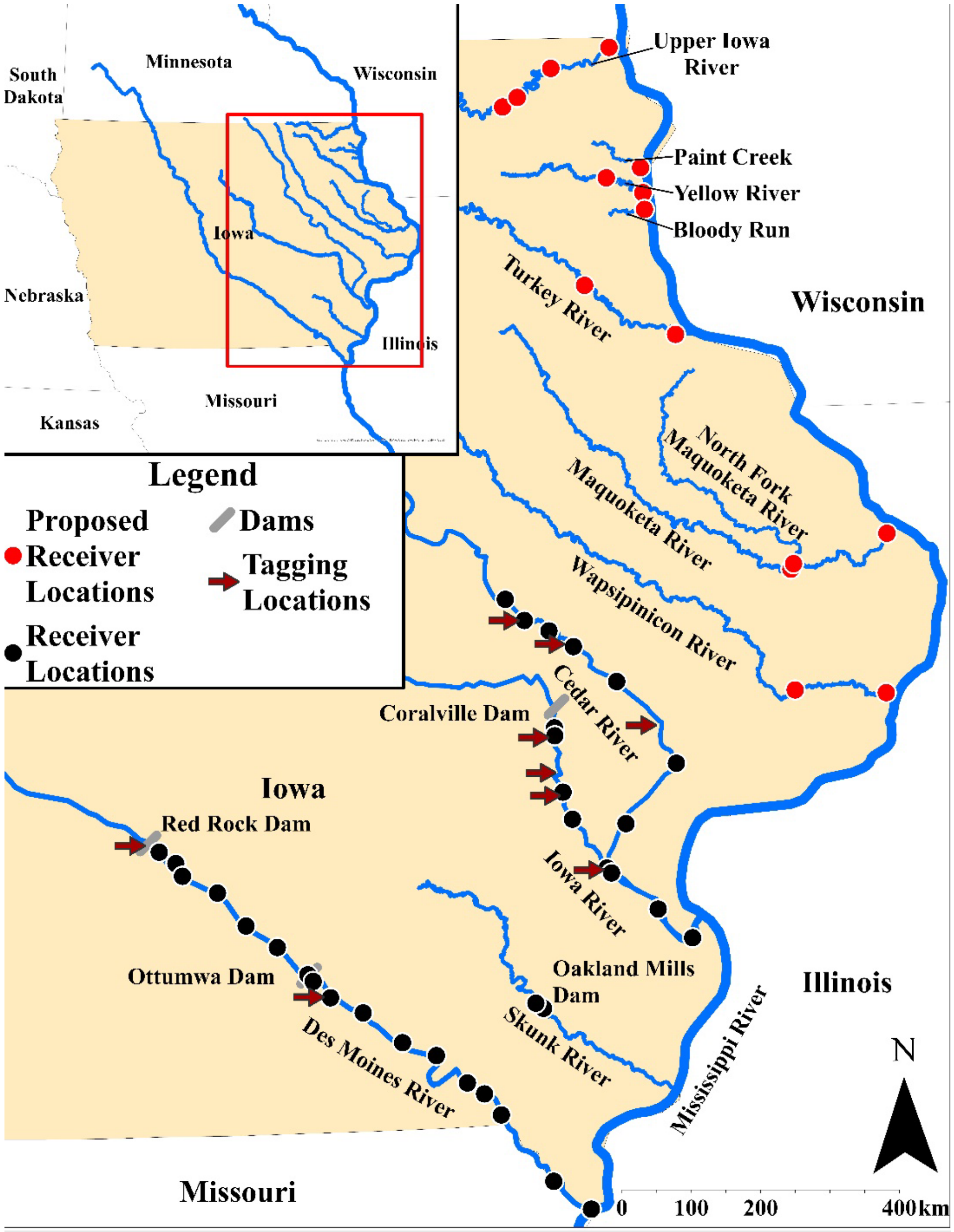

Figure 5. *Upper Mississippi River and its major tributaries throughout eastern Iowa. Red arrows indicate Silver Carp tagging locations, black dots represent existing receiver locations, and red dots represent new receivers installed in 2024.*

<u>Acoustic Transmitter Tagging</u>

During FY24 April-Nov, staff from the La Crosse FWCO tagged a total of 175 invasive carp, working alongside partners at WIDNR, MNDNR and INHS to capture many of these fish. A summary of these captures and releases is provided below (Table 1). Of particular interest is the tagging by USFWS of age-1 Silver Carp in the Skunk River bottoms of Pool 19 during targeted sampling in the Spring of 2024, and the tagging of young of year Silver Carp that were collected in 2024 from aquaculture ponds at the Iowa DNR Fairport Hatchery (Fairport, IA; Pool 16) in the wake of receding spring flood waters (Table 1). Seven additional invasive carp were captured and tagged in the Wisconsin River during April 2024, the largest number of invasive carp captured and tagged in one year in this system so far. Sixteen additional invasive carp were captured and tagged in lower Pool 10 during October 2025, the first invasive carp tagged in this pool by any agency.

Table 1. *Location, species, and number of invasive carp tagged by USFWS and partner agencies in the upper UMR in 2024. Invasive Carp captured and tagged in Pool 10 were the first from this pool. * Indicates that young of year fish were collected from Fairport Fish Hatchery ponds, tagged on site, then released into Pool 16.*

Capture Pools	Species	Fish Tagged
8	Grass Carp	3
	Silver Carp	11
10	Silver Carp	16
13	Bighead Carp	4
	Silver Carp	10
14	Silver Carp	12
16*	Silver Carp (YOY)	9
19	Bighead Carp	12
	Bighead x Silver Hybrid	2
	Silver Carp	85
	Silver Carp (Age-1)	4
Wisconsin River	Bighead Carp	3
	Bighead x Silver Hybrid	2
	Silver Carp	2
Total		175

In 2024, staff from MDC implanted additional invasive carp (n=34) with acoustic transmitters to bolster the number of tagged invasive carp in the Open River area of the lower UMR, also sometimes known as the Middle Mississippi River (MMR). Since 2021, MDC has tagged a total of 194 invasive carp within their project area.

Examination of tributary use by invasive carp has been a multi-year project lead by ISU. Teams initially tagged Silver Carp during Fall 2021 and early Spring 2022 when individuals from the UMR would not be migrating upstream for spawning. Silver Carp were collected using boat electrofishing (DC, 15 amps, 150V, 40 pulses per second) focusing on woody habitat, riffles, and shade. Thirty-four Silver Carp were implanted with acoustic transmitters (VEMCO V13-1x, V16-4x, V16A-6x, or V16T-4x, Vemco Inc., Halifax, Nova Scotia, Canada) by crews from ISU during spring 2024: 10 (8 males and 2 females [TL: 699-923 mm; mean TL = 868 mm]) in the CER and 24 (11 males and 13 females [TL: 826-1035 mm; mean TL = 935 mm]) in the Skunk River downstream of Oakland Mills Dam. An additional 48 Silver Carp were tagged during fall

2024: 1 (male [TL: 846 mm]) in the Skunk River, 20 (15 males and 5 females [TL: 757-941 mm; mean TL = 832 mm]) in the DSMR below Red Rock Dam, 8 (5 males and 3 females [TL: 635-863 mm; mean TL = 734 mm]) in the DSMR near Cliffland, IA, 5 (4 males and 1 female [TL: 613-791 mm; mean TL = 698 mm]) in the DSMR near St. Francisville, MO, 9 (6 males and 3 females [TL: 830-1079 mm; mean TL = 923 mm]) in the CER, and 5 (1 male and 4 females [TL: 747-859 mm; mean TL = 819 mm]) in the IAR. Iowa State University plans to tag additional fish in spring 2025.

Data Analyses

All USFWS telemetry detections data were completed in Program R (Campbell et al. 2012; R Core Team 2020). The package condensed detection records in situations where at least two detections for an individual fish within 12 hours at a fixed location (i.e., a receiver) constituted a residence event. The event was terminated/timed-out when 1) the individual was either not detected for 12 hours at a given receiver, or 2) it was detected at a new receiver. Residency events were filtered to determine the number of individual carp contributing to events in each pool. Data from both stationary and real-time receivers were incorporated into this analysis. Additionally, USGS detections data collected from receivers in their arrays at Locks and Dams 14, 15, and 19 were included in these analyses to increase spatial resolution. Residence events were summarized by UMR pools and tributaries to examine the geographic extent of Silver Carp and Bighead Carp dispersal using an extension to the V-Track package that allows the easy identification of dam passage events using data parsing and plotting functions.

Invasive carp movement within the MMR and surrounding tributaries was evaluated by MDC biologists. For each tagged fish within their purview, broad scale movement was analyzed to include detected locations, distance from tagging origin, and maximum distance traveled.

To quantify general, broad movements of Silver Carp in Iowa tributaries and the UMR, ISU staff calculated maximum displacement values for individual Silver Carp and estimated mean values based on tagging location. Maximum displacement value represents the distance (km) between most upstream and downstream detections. Individuals were classified as mobile, sedentary, or intermediate and frequency distributions of maximum displacement values at each study site were examined. Currently, individuals with a maximum displacement value less than 25 kilometers are classified as sedentary, individuals with displacement values greater than 100 km as mobile, and individuals with displacement values between those thresholds as intermediate. Also assessed were the frequency of transitions between the DSMR and UMR Pool 20 and transitions between IAR/CER and UMR Pool 18 to provide insights on population structure/connectivity of individuals located within the UMR tributaries and those within the mainstem UMR. Observations of both upstream and downstream passage through Ottumwa Dam were noted. Iowa State University also assessed water temperature and discharge from nearby USGS gauging stations well as HOBO temperature loggers (HOBO 64K Pendant data loggers; Onset Computer Corp., Bourne, Massachusetts) attached to the receivers to understand Silver Carp movements in relation to environmental conditions.

Larval Sampling

Evidence of Silver and Bighead Carp reproduction was detected as early as 2009 in Pool 19 of the Upper Mississippi River, indicating that areas of the UMR above LD19 can provide the hydrological requirements needed for successful Silver and Bighead Carp (collectively referred to as "bigheaded carp") spawning, egg maturation, and development. Monitoring for larval and juvenile bigheaded carp in Pool 19 is meant to detect and quantify bigheaded carp reproduction and any potential reproductive response to control strategies.

Quadrafoil larval light traps (250µm, Aquatic Research Instruments) that utilize green chemical light sticks were deployed approximately an hour after sunset and were fished for at least an hour one time per week. Deployment locations for each trap were selected based on proximity to shoreline, structure, and other traps. Traps were collected, and the sample filtered with the catch pan at the bottom of each trap and placed into a sample jar with a tag describing site information. Samples were preserved using 95% ethanol. Water quality measures such as dissolved oxygen, specific conductivity, conductivity, and temperature were taken using a YSI. Depth was measured at sampling locations using a secchi disk and turbidity was measured using a portable turbidity meter at night when available.

Fishery Dependent Population Assessment

Illinois Natural History Survey collected demographic information from invasive carp removed from the UMR by contracted fishers for assessment modeling and to inform and evaluate management actions in the UMR. Crews recorded all UMR contract fishing effort information from every fishing event. Removed invasive carp were identified to species (e.g. Silver, Bighead, Grass) and the number of individuals removed recorded for all removal events. Additionally, length, weight, sex, and age (otoliths) information were collected from a sub-sample of contractor-removed Silver and Bighead Carp. Fish were selected randomly from the contractor catch, demographic information was collected from no more than 10% of the overall catch on a given day, at a given sampling location. Up to 50% of demographic data collection could occur in the spring during the intensive removal period, with the remainder spread throughout the fishing season. Data from a minimum of 200 invasive carp will be collected per pool, per commercial fishing gear type (e.g. seine, gill net). These data will be collected from pools within the IMZ where contracted removals are occurring, a minimum of 1,000 fish (200/pool; P15-19). If more than one gear was regularly used by contracted fishers (e.g. seines and gill nets), or if low catch rates made obtaining collection goals difficult for some pools, the data collection effort could be concentrated to Pools 18-19 (e.g. 250 fish/gear/pool).

Lab processing

Otoliths collected from this sampling effort are deposited at the Illinois Natural History Survey aging lab. All otoliths are prepared by mounting in epoxy and sectioning each lapilli otolith on a transverse plane at the nucleus using a low speed Isomet saw with two 2- 5" Isomet 20 LC blades with a .3mm spacer and polished with lapping film. Prepared otoliths are then mounted on a slide, submerged in glycerol and analyzed using a dissecting scope. Three readers will analyze each otolith independently, then a final age is recorded using a 2/3 or consensus mutual agreement (Maceina and Sammons 2006; Seibert and Phelps 2013). If no agreement can be reached, the otolith will not be used for analyses.

Data analysis

Data will be collected, processed, entered, and subjected to QA/QC protocols by INHS, then provided to USFWS. USFWS biologists and data modelers will select data analyses as appropriate to meet study objectives. Data generated via fishery-dependent sampling will be available to other researchers studying elements of UMR fish communities.

Results:

Pool 20-24 pool-wide hydroacoustics

Pool-wide hydroacoustic surveys in FY24 included 372 transects 0.5 nautical miles in length, counted 27,207 fish greater than 254 mm/10” TL, and ensonified nearly 9.3 million cubic meters of water. (Table 2). Four years of survey data are now available for Pool 20, and two years for Pool 21. Pools 22 and 24 saw their first year of hydroacoustic surveys in 2024. Like 2021-2023, water levels in 2024 were too low to access any backwater habitats, only main channel border and side channel habitats were sampled. One large harbor at the lower end of Pool 24 (HOLCIM Harbor), could be considered a man-made backwater habitat, and did receive a nearshore survey along the entirety of each bank.

By pool, overall relative densities were greatest at Pool 20 and then decreased as we proceeded downstream through Pools 21 and 22 (Table 3). Then relative densities increased in Pool 24 (Table 3). Although overall fish densities had been increasing in Pool 20 from 2021-2023, overall densities declined in 2024 back to levels similar to 2022 (Table 3). Overall relative density also declined in Pool 21 between 2023 and 2024. Trends in overall relative densities among habitats were similar among pools and mirrored those observed in previous years. Relative densities of fish were greater at side channel habitats than main channel habitats in all pools and years except Pool 20 in 2023 (Table 3).

Community data from fall dozer trawl sampling was applied to the hydroacoustic data to produce estimates of Silver Carp relative density across pools, habitats, and years (Appendix Figure A.1). Silver Carp exhibited trends in relative density like those seen in the overall fish community estimates. Silver Carp relative density was greater in side channel habitats than main channel habitats for all pools and years except Pool 20 in 2023, when Silver Carp relative density was greater in the main channel. The highest relative densities of Silver Carp occurred in Pool 20, and then decreased as we proceeded downstream through Pools 21 and 22 (Table 4; Figure 6). Then relative density of Silver Carp increased in Pool 24 (Table 4; Figure 6). We also estimated the percentage of hydroacoustically detected fish that were likely to be Silver Carp (Table 5; Figure 7). This is a relative abundance estimate that does not rely on sampled volume, only the number of hydroacoustic targets and their estimated length, relative to physical capture data. When using this metric, the percentage of insonified targets estimated to be Silver Carp ranged from 2.06%-5.06% among sampled pools, and Pools 20, 21 and 24 had similar estimated percentage of targets identified as Silver Carp (~5%; Table 5; Figure 7). When examining Silver Carp abundance as a percentage of the overall hydroacoustic sample, we also saw habitat association trends change, with more Silver Carp generally being associated with the main channel instead of side channels (Table 5; Figure 7).

Table 2. *Effort by pool and habitat type for pool-wide hydroacoustic surveys in the UMR, fall 2024. All transects were 0.5 nautical miles in length and were randomly selected from available side channel and main channel habitats within each pool.*

Pool	Macrohabitat	0.5 mile transects (N)
20	MC	76
	SC	25
21	MC	57
	SC	16
22	MC	80
	SC	17
24	MC	86
	SC	13
	BW/Harbor	2
Total		372

Table 3. *Number of fish ≥ 254 mm/10", and relative density of fish/1,000 m^3 by pool and habitat type, pool-wide hydroacoustic surveys in the UMR, fall 2021-2024. Blank cells indicate years when no samples were taken within a navigation pool.*

Pool	Habitat	2021	2022	2023	2024
P20	MC	2.1010	4.6497	7.2952	3.8140
	SC	4.8261	5.0206	5.2756	8.2164
	All	2.8240	4.7387	6.8153	4.9037
P21	MC			2.3853	1.0660
	SC			5.5590	6.5601
	All			3.3102	2.2702
P22	MC				1.4067
	SC				3.5829
	All				1.7881
P24	MC				3.5509
	SC				4.3424
	All				3.6548

Table 4. *Relative density of Silver Carp/1,000 m^3 by year, pool and habitat type, derived from pool-wide hydroacoustic and dozer trawl surveys in the UMR, fall 2021-2024. Blank cells indicate years when no samples were taken within a navigation pool.*

Pool	Habitat	2021	2022	2023	2024
P20	MC	0.1410	0.1750	0.6434	0.2369
	SC	0.5739	0.2976	0.2756	0.2823
	All	0.2559	0.2044	0.5560	0.2481
P21	MC			0.1586	0.0463
	SC			0.4785	0.3531
	All			0.2518	0.1136
P22	MC				0.0428
	SC				0.0639
	All				0.0465
P24	MC				0.1699
	SC				0.1978
	All				0.1735

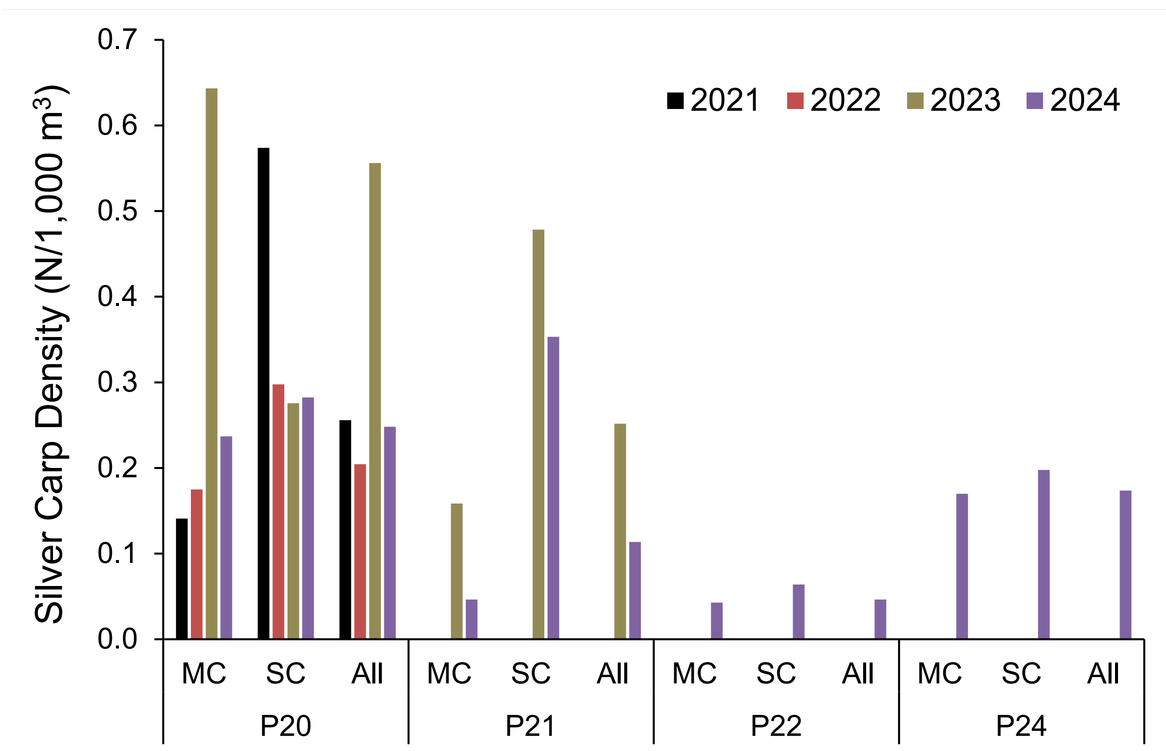

Figure 6. *Relative density of Silver Carp/1,000 m^3 by year, pool and habitat type, derived from pool-wide hydroacoustic and dozer trawl surveys in the UMR, fall 2021-2024.*

Table 5. *Percentage of hydroacoustic targets estimated to be Silver Carp by year, pool and habitat type, derived from pool-wide hydroacoustic and dozer trawl surveys in the UMR, fall 2021-2024. Blank cells indicate years when no samples were taken within a navigation pool.*

Pool	Habitat	2021	2022	2023	2024
P20	MC	6.71%	3.76%	8.82%	6.21%
	SC	11.89%	5.93%	5.22%	3.44%
	All	9.06%	4.31%	8.16%	5.06%
P21	MC			6.65%	4.35%
	SC			8.61%	5.38%
	All			7.61%	5.00%
P22	MC				3.04%
	SC				1.78%
	All				2.60%
P24	MC				4.78%
	SC				4.56%
	All				4.75%

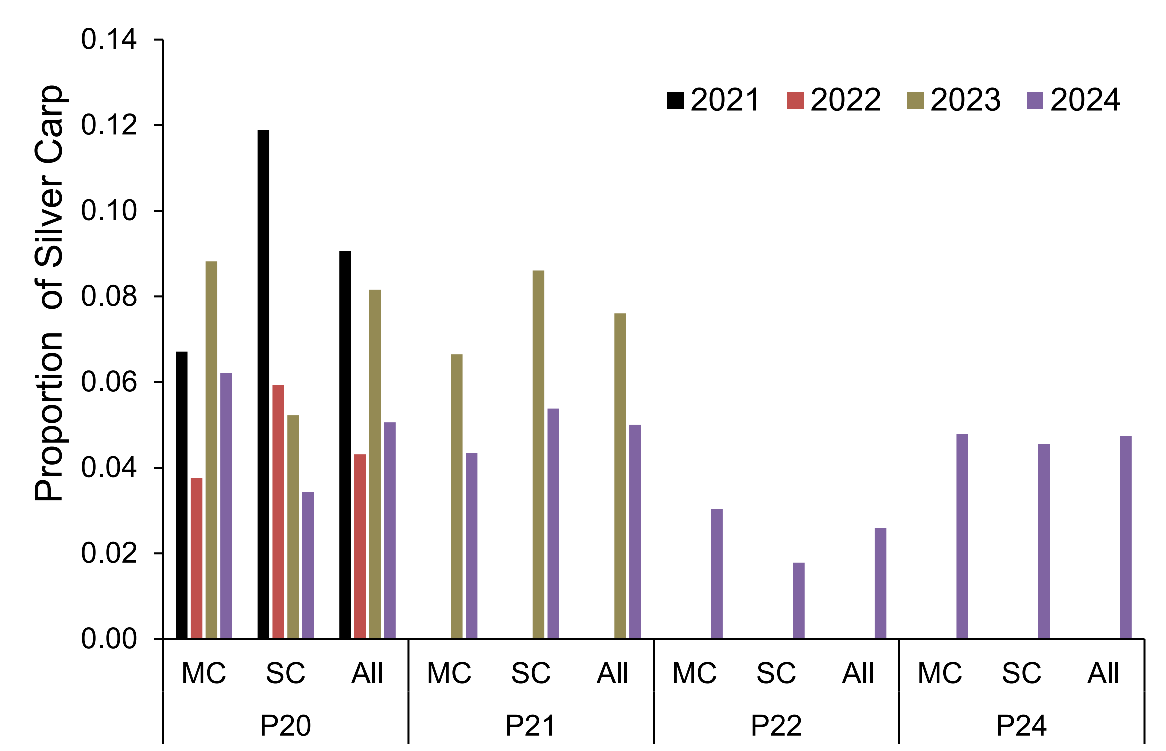

Figure 7. *Proportion of hydroacoustic targets estimated to be Silver Carp by year, pool and habitat type, derived from pool-wide hydroacoustic and dozer trawl surveys in the UMR, fall 2021-2024.*

Fishery-Independent Sampling

During 2024, FWCO staff conducted 380 electrified dozer trawl samples, collected 2,693 Silver Carp, and aged 447 individuals from the four spatial units of the Upper Mississippi River (Table 6). Variability in CPUE values across spatial units was expected due to the large spatial extent sampled and population fragmentation from dams. Throughout the first three years of sampling, there was a general trend in Silver Carp CPUE which decreased from the Open River and Pool 26 (~100/hr.) to the Pooled Reach (~50/hr.), and finally to Above LD 19 (~1/hr.; Figure 8; Appendix Figure A.1). Sampling during 2024 indicated similar trends with relative abundances staying consistent Above LD 19 and slightly higher than 50/hr. in the Pooled Reach whereas Pool 26 showed a decline consistent with declines observed between 2021-2023. The consistent decline in our relative abundance estimates from 2021 to 2024 in Pool 26 may be indicative of natural mortality from large 2018 and 2019 cohorts that are decreasing in magnitude through time. Data collected during 2024 also suggested a large reduction in relative abundance in the Open River which may be a product of reduced catchability coinciding with changes in river stage in the Open River reach, immigration into or out of the system (see MDC telemetry section below), or recent institution of incentivized harvest programs (Appendix Table B.1).

The length structure of the Silver Carp population during 2024 was consistent with trends during 2021-2023. Length distributions indicated smaller Silver Carp in the Open River (mean = 618mm) relative to Pool 26 (mean = 648mm) and the Pooled Reach (mean = 730mm; Figure 8). However, condition indices depicted a stark increase in relative weight in the Open River (2021-2023 mean: 0.93, 2024 mean: 1.004) relative to previous years, and a decrease in relative weight in the Pooled Reach (2021-2023 mean: 1.08, 2024 mean: 0.99) compared to previous years. Pool 26 somewhat declined and Above LD 19, Silver Carp populations remained similar to the previous years (Figure 9; Appendix Figure A.2). Overall, Silver Carp length structures remained consistent with past surveys, but condition varied dramatically in some spatial units.

Age-frequency histograms suggest variable recruitment of Silver Carp during the last 12 years with strong and weak cohorts represented in each population (Figure 10). Although inconsistent among spatial units, we were able to detect strong year classes from age-frequency histograms (Figure 10). Specifically, we identified strong 2018 and 2019 cohorts in the Open River and Pool 26. These strong cohorts coincide with other studies that have documented a large 2018 cohort in the lower Illinois River, which intersects the UMR in Pool 26 (ICRCC 2021; Figure 3), and a large 2019 cohort in the Missouri River which intersects the UMR south of Pool 26 (MICRA 2021; Figure 3). Except for the 2018- and 2019-year classes, the population appears to be dominated by older Silver Carp (about 8-11 years; 2011–2016-year classes) in all spatial units. Furthermore, larger numbers of young Silver Carp were captured in the Open River and Pool 26 compared to the pooled reaches (Figure 11). Additionally, during 2024, large numbers of age-0 Silver carp were detected (n = 1,471) in sampling. Of these, only 3 came from the Pooled Reach. We suspect that spawning and/or recruitment is hindered in pooled reaches. Insufficient flow or distance for egg drift can result in ineffective spawning and recruitment of Silver Carp (George and Chapman 2013) and may explain why few age-0 Silver Carp are detected in the pooled reaches. Growth metrics during 2024 depicted increased growth potential in the Pooled Reach and Pool 26 relative to the Open River, as well as lower overall mortality estimates in the pooled reaches relative to the Open River (Table 7). Overall, age and growth metrics indicate similar trends of source populations in the Open River and Pool 26. On the other hand, sink populations in the Pooled Reach and Above L&D 19 are consistent with 2021-2023 baselines.

Although the pooled reaches may be primarily a migrant population, infrequent spawning and recruitment events appear to occur. Age data from Above L&D 19 depicted a relatively large 2016 cohort (age-8 in 2024; Figure 10). Those fish likely spawned Above L&D 19 and recruited to the population. Additionally, 106 age-0 Silver Carp were collected in Pool 19 in 2023 (some of these were from targeted sampling efforts and were not reported in CPUE), and age-1 Silver Carp were collected in the same area of Pool 19 (Skunk River bottoms) during targeted sampling in the Spring of 2024. Furthermore, age-0 Silver Carp were collected in 2024 from aquaculture ponds at the Iowa DNR Fairport Hatchery (Fairport, IA; Pool 16) in the wake of receding spring flood waters. These captures indicate that Silver Carp can intermittently spawn and recruit in the pooled reaches when conditions are ideal.

Table 6. *Summary of sample effort (number of dozer-trawl survey sites; N), Silver Carp catch, and range of Silver Carp total length (TL) of dozer-trawl surveys across the 4 Meaningful Management Units (Management Unit) in the Upper Mississippi River during fall 2024. Note that river mile was set to 0 at the confluence of the Ohio River.*

Management Unit	River Miles	N	Total Catch	Stock-sized	TL Range (mm)
Above L&D 19	365–437	63	14	14	463–953
Pooled Reach	242–365	142	498	492	60–841
Pool 26	203–242	50	372	368	66–790
Open River	0–198	125	1,785	318	24–862
Summary	0–437	380	2,693	1,833	24–953

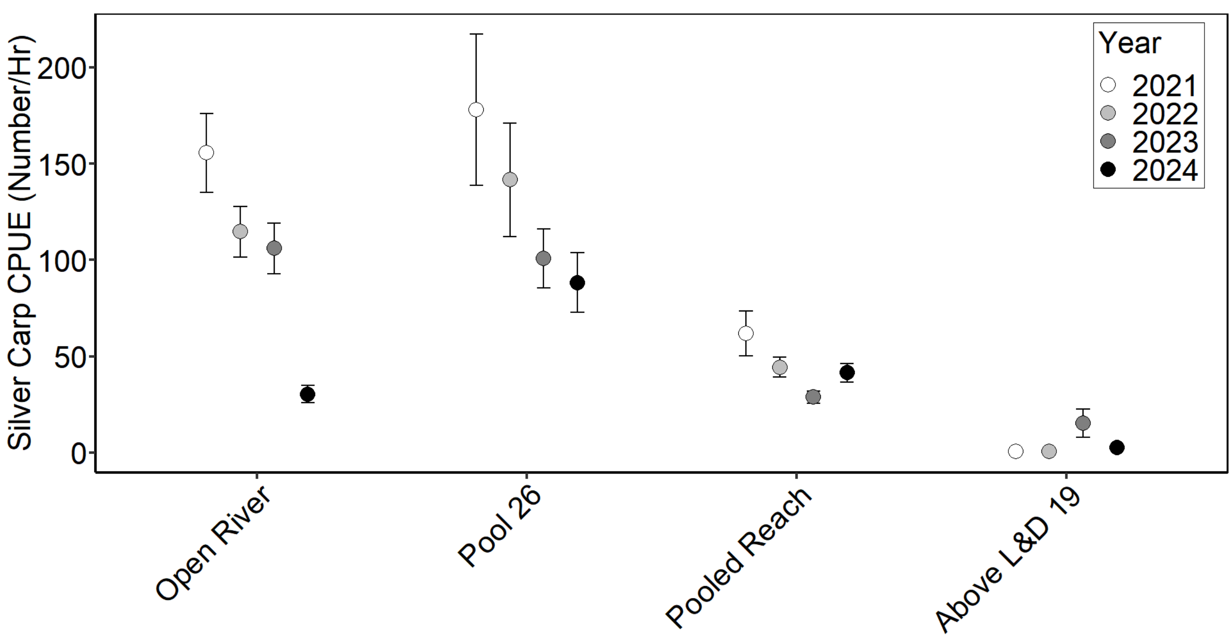

Figure 8. *Management unit-specific mean stock-sized catch-per-unit-effort of Silver Carp (number/hr) in the Upper Mississippi River during 2021–2024. Error bars represent one standard error. All fish were sampled using an electrified dozer trawl.*

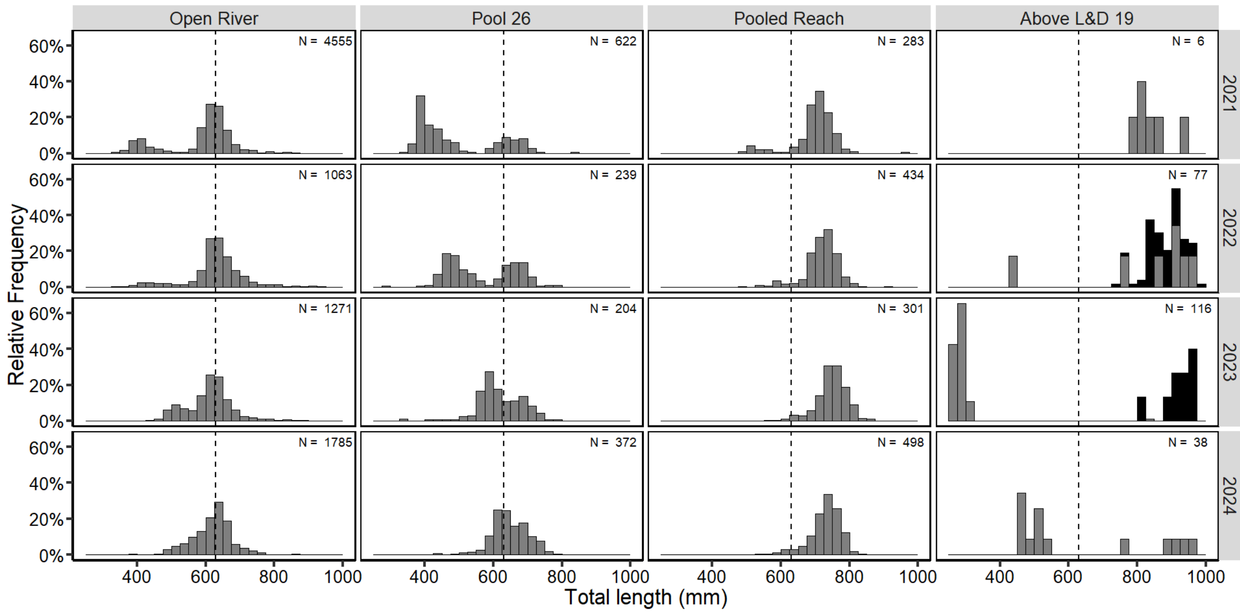

Figure 9. *Management unit-specific relative length-frequency histograms of stock-sized (total length > 250 mm) Silver Carp from electrified dozer trawl surveys (DT, with a sample size of N) in the Upper Mississippi River during 2021–2024. Supplementary data from sampling commercial gill net were included for low-density locations Above L&D 19 during 2022–2023 (black bars).*

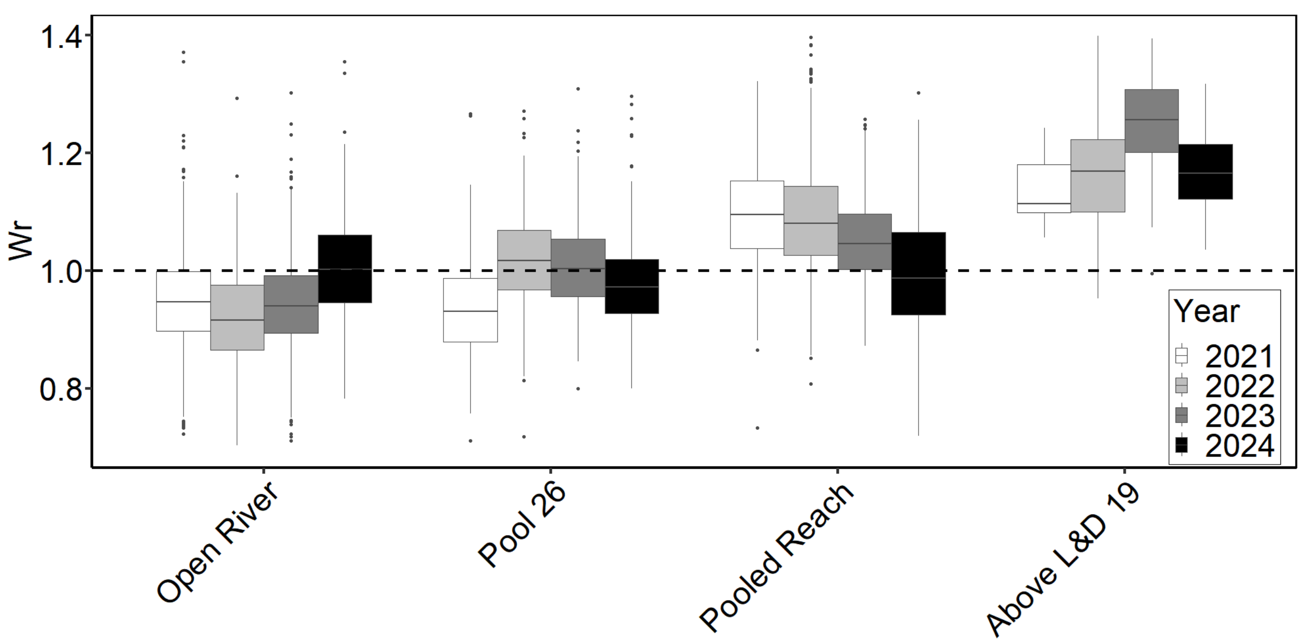

Figure 10. *Management unit-specific relative weights (Wr) of stock-sized Silver Carp in the Upper Mississippi River during 2021–2024. The horizontal line represents the median Wr, the box is the interquartile range (25th -75th percentile), the error bars represent 1.5 times the interquartile range, and the points above or below the error bars represent potential outliers. The majority of fish were from electrified dozer trawl surveys, with complemented fish from fisheries-dependent sampling (N = 79) at locations Above L&D 19.*

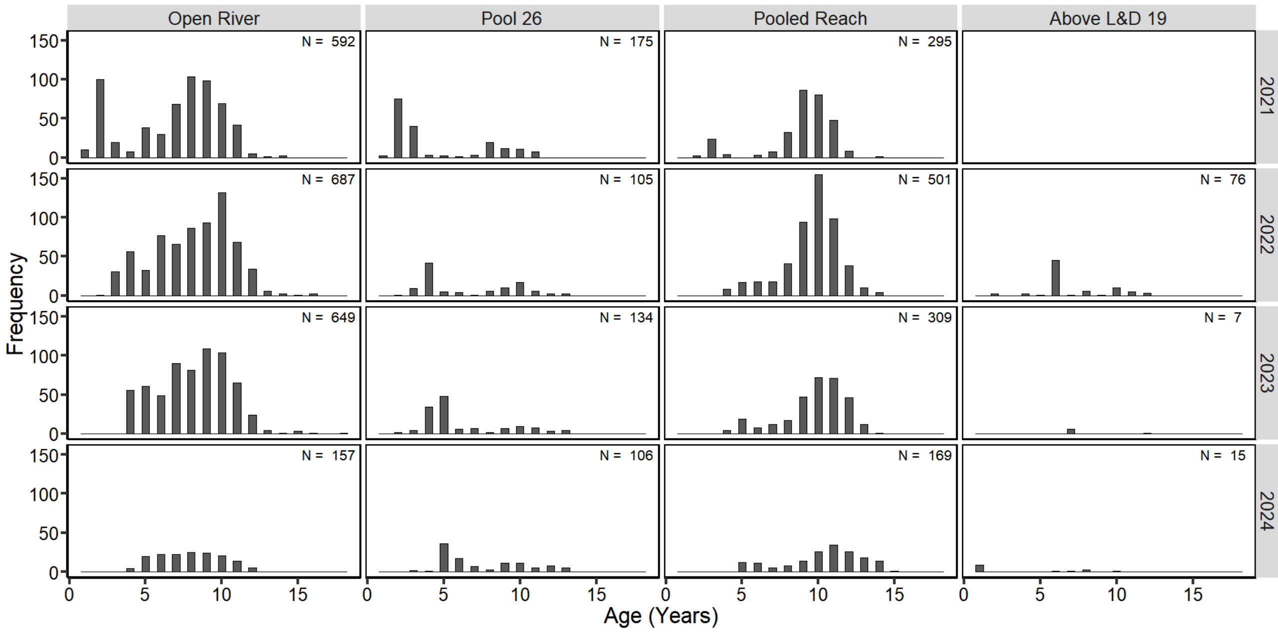

Figure 11. *Management unit-specific age-frequency histograms of Silver Carp from electrified dozer-trawl surveys (DT, with a sample size of N) in the Upper Mississippi River during 2021– 2024.*

Table 7. *The estimates of life history parameters of Silver Carp across management units of the Upper Mississippi River.*

Spatial Unit	N	L∞ (mm)	K (Year^{-1})	t_0 (Year)	M (Year^{-1})
Above L&D 19	79	941.3	0.387	-0.784	0.453
Pooled Reach	827	762.6	0.300	-0.996	0.404
Pool 26	357	720.5	0.277	-0.896	0.388
Open river	1,618	678.0	0.362	-0.557	0.481

Telemetry

A peer reviewed manuscript detailing UMR movement information was published in *Scientific Reports* during 2024 (Fritts et al. 2024). In summary, the study compared invasive carp and paddlefish movements during 2022 and 2023, years characterized by the absence and presence of spring floods in the UMR. The analyses of these data indicated both invasive carp and paddlefish upstream migration is closely related to dam gate operations in relationship to flooding. During 2022, a year without a substantial spring flood, spillway gates on Lock and Dams 5, 14, 15 remained closed throughout the year and limited upstream fish movement to the shipping lock. Less than 1% of all available tagged invasive carp made passage at LD 14 and 15 during 2022. In contrast, 46% of all tagged invasive carp and 25% of all tagged paddlefish made upstream passage through the spillway gates at LD 14 and 15 during open-river conditions when flood waters forced the opening of all spillway gates (Figure 12 and 13).

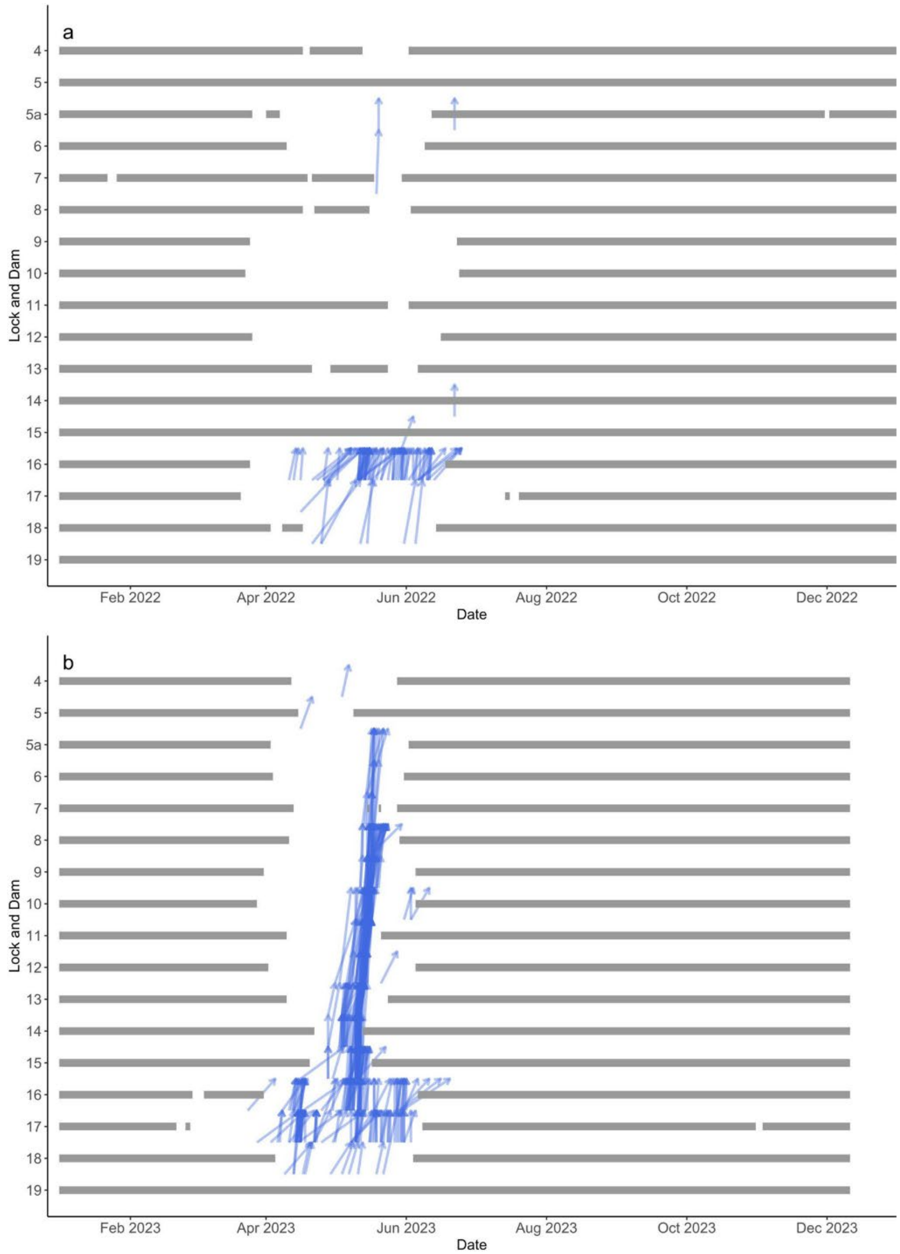

Figure 12. *Upstream passages by implanted bigheaded carp from Lock and Dam 4 to Lock and Dam 18 in 2022 (a) and 2023 (b). Gray bars indicate dates of putative controlled river conditions for each lock and dam, based on a threshold hydraulic head value of 0.46 m, with white spaces between indicating dates of putative open-river conditions. The bottom of each blue arrow indicates the last date a fish was detected in the downstream pool, and the point of each arrow indicates the first date it was detected in the upstream pool. Upstream passages with a detection interval between upper Mississippi River pools of 21 days or less are depicted to align the river conditions most precisely with the timing of upstream passage.*

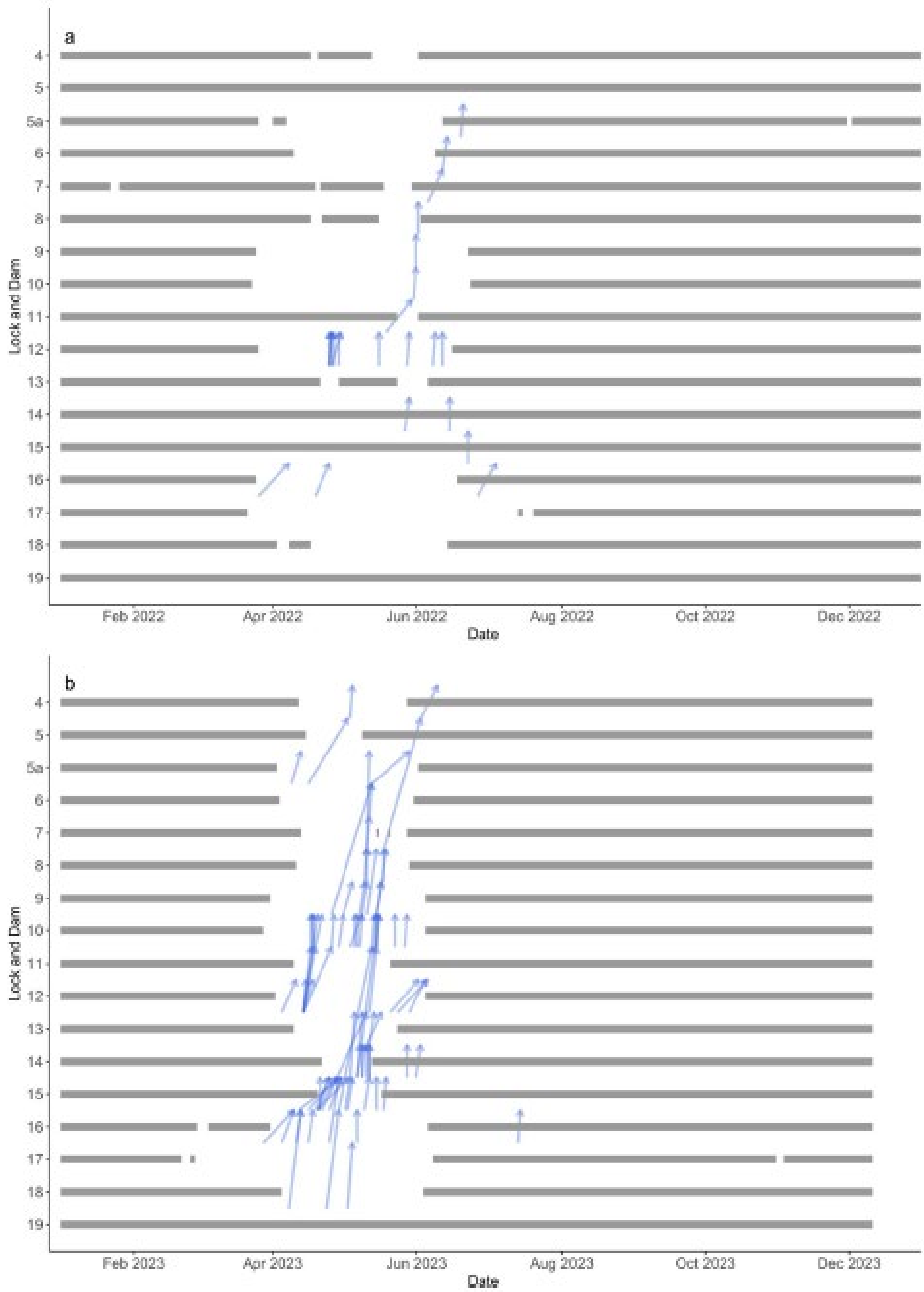

Figure 13. *Upstream passages by implanted paddlefish between Lock and Dam 4 and Lock and Dam 18 in 2022 (a) and 2023 (b). Gray bars indicate dates of putative controlled river conditions for each lock and dam, based on a threshold hydraulic head value of 0.46 m, with white spaces between indicating dates of putative open-river conditions. The bottom of each blue arrow indicates the last date a fish was detected in the downstream pool, and the point of each arrow indicates the first date it was detected in the upstream pool. Upstream passages with a detection interval between upper Mississippi River pools of 21 days or less are depicted to align the river conditions most precisely with the timing of upstream passage.*

Staff from the La Crosse FWCO continued fish tracking operations throughout 2024. Another period of spring flooding occurred during May-July 2024. During this period, 751 Silver, Bighead, and Grass Carp were observed making either upstream or downstream transitions. Initial analyses of invasive carp movements indicate that 38% (283) of invasive carp transitions were upstream while 62% (468) transitions were downstream. Some individuals made both downstream and upstream passages. Of note, is a male bighead carp (A69-1602-18661) that was originally captured and tagged by USGS in Pool 16 during 2020. This individual migrated to Pool 6 near Trempealeau, WI during May 2023. On 6 May 2024, this bighead carp left Pool 6 and moved downstream to Pool 10 before entering the Wisconsin River and moving upstream until it was detected near Muscoda, WI on 26 May 2024. As flood waters continued to rise throughout June, this individual left the Wisconsin River and began an upstream migration back up the UMR. It arrived back in Pool 6 on 10 June then was detected making passage through the spillway gates at LD5 on 23 June. This bighead carp was next detected on WI DNR receivers in the Chippewa River on 21 July. Overall, the complexity of upstream and downstream movements in newly invaded pools highlights the need for more in-depth and careful analyses of these data. Additionally, these observations provide indications of how individuals can move freely among jurisdictions and potentially contribute to spawning events in different river segments.

Tracking of young of year and age-1 Silver Carp in Pools 16-19 has been largely unsuccessful to date. USFWS failed to relocate all of these individuals > 6 months post-tagging. This could be attributable to post-tagging mortality or predation. However, these fish could still be at large and occupying zones outside our current receiver coverage.

In 2024, for telemetry operations under the purview of MDC, of the 194 invasive carp tagged, 113 were detected at least a single day since being tagged in late fall 2024. Of the 124 invasive carp tagged in the pooled UMR system, 65 were not detected outside the pooled reaches of the UMR, while nine invasive carp made it to the MMR and were detected at Maple Island and Cape Girardeau (Figure 12), four invasive carp were detected in the Des Moines River (Figure 13), three invasive carp were detected in the Missouri River (Figure 14), and 12 invasive carp were detected in the Illinois River system at Peoria Lake (Figure 15). Eighteen invasive carp were not detected outside of their respective pools, meaning they were only detected within the pool they were originally tagged in. Eleven invasive carp tagged in Pool 21 left that pool and traveled 1.9 to 102.0 river miles (total distance from tagging origin, not accounting for total distance actually traveled) from Pool 21 within the pooled UMR system (Table 8). Ten invasive carp tagged in Pool 22 left that pool and traveled 15.4 to 84.9 river miles from Pool 22 within the pooled UMR system (Table 8). Eight invasive carp tagged in Pool 24 left that pool and traveled 23.9 to 62.5 river miles from Pool 24 within the UMR system (Table 8). Fifteen invasive carp tagged in Pool 25 left that pool and traveled 12.0 to 91.9 river miles from Pool 25 within the pooled UMR system (Table 8). Two invasive carp tagged in Pool 26 left that pool and traveled 37.0 to 38.0 river miles from Pool 26 within the UMR system (Table 8).

Of the 70 invasive carp tagged in the MMR, eight were not detected outside the MMR, while two were detected in the Lower Mississippi River (LMR; Figure 16) and ten were detected in the Ohio River system (Figure 17). Eight invasive carp tagged near Cape Girardeau traveled 4.0 to

4.6 river miles (total distance from tagging origin, not accounting for total distance actually traveled) from Cape Girardeau within the MMR (Table 8).

Table 8. *Origin (U21 = upper pool 21, L21 = lower pool 21, U22 = upper pool 22, U24 = upper pool 24, L25 = lower pool 25, U26 = upper pool 26, L26 = lower pool 26, HDC = Headwaters Diversion Channel, Cairo = Angelo Island), transmitter ID, detected locations, distance from origin (DFO), and maximum distance traveled (MDT) for each fish tagged in the Upper Mississippi River (UMR) system. A69-1602-58316 was the only Bighead Carp tagged in the UMR, all other fish were Silver Carp.*

+	Transmitter ID	Detected Locations	DFO	MDT
U21	A69-1602-58313	L20 - U21 (x2)	1.9	4.3
U21	A69-1602-58314	U22 - L24	68.0	68.0
U21	A69-1602-58315	U21	1.1	1.1
U21	A69-1602-58316	L20 - Eldon - Douds - Kilbourn - L20 - U21	91.0	190.8
U21	A69-1602-58317	(L20 - Farmington (x1.5)) - U21	51.8	102.5
U21	A69-1602-58318	(L20 - U20 (x1.5)) - U21 - L20	21.5	42.7
U21	A69-1602-58320	(L20 - U21 (x1.5)) - U20 - L20 - U21	21.5	43.5
U21	A69-1602-58321	L20 - L24 - U25 - L25 - U26	102.0	105.8
L21	A69-1602-58340	U21 - L20 - U20	36.2	36.2
L21	A69-1602-58342	U21 - (L20 - U20 (x1.5)) - U21	36.2	56.6
L21	A69-1602-58343	U21 - (L20 - U20 (x1.5))	36.2	55.8
L21	A69-1602-58344	U21 - L20 (x1.5)	16.6	17.4
L21	A69-1602-58345	U21	15.8	15.8
L21	A69-1602-58347	U21	15.8	15.8
L21	A69-1602-58348	U26 - Peoria Lake - U26 - L24 - L21	332.3	662.3
L21	A69-1602-58349	U26	87.3	87.3
L21	A69-1602-58350	U21 - (L20 - U20 (x1.5)) - U21 - L21	36.2	74.7
U22	A69-1602-58351	L24 - U25 - L25 - U26 - Peoria Lake - U26 - L24 - L22 - U22 - L22	329.9	675.2
U22	A69-1602-58355	U21 - L20	19.0	19.0
U22	A69-1602-58356	U21 - L20 - DSM	36.6	36.6
U22	A69-1602-58357	(L21 - U22 (x1.5)) - (U21 - L20 (x2))	19.0	20.8
U22	A69-1602-58358	L21 - U21 - L20 - U20 - L21 - U22	38.6	77.2
U22	A69-1602-58359	L20 - U20	38.6	38.6
U22	A69-1602-58360	U21 - L20 (x1.5)	19.0	19.8
U22	A69-1602-58361	U20 -(L20 - U21 (x1.5)) - DSM - U20	38.6	79.4
U22	A69-1602-58362	U22	0.0	0.0
U22	A69-1602-58363	U26 - L24 - U22	84.9	169.8
U22	A69-1602-58364	(U21- L20 (x1.5)) - (L21 - U22 (x3.5)) - (U21 - L20 (x1.5))	19.0	58.2
U22	A69-1602-58365	U22	0.0	0.0
U22	A69-1602-58366	L22 - (U22 - L21 (x1.5))	15.4	31.0
U22	A69-1602-58367	U26 - U25 - L24	84.9	118.9
U22	A69-1602-58368	Cape - STL 255 - Maple Island - L26 - U26	273.4	461.9
U22	A69-1602-58369	U26	84.9	84.9

U24	A69-1602-58371	L22 - U22 (x1.5)	23.9	39.3
U24	A69-1602-58373	L21 - L24 - L25 - U26	61.0	109.0
U24	A69-1602-58374	(L20 - U20 (x1.5)) - U21 - L21 - L22	62.5	116.5
U24	A69-1602-58376	Peoria Lake - U26 - L24 - U21 - L20	316.0	664.9
U24	A69-1602-58377	L24 - (U25 - U26 (x1.5)) - L24 - U22 - L22	61.0	161.3
U24	A69-1602-58378	L22 - U22	23.9	23.9
U24	A69-1602-58379	L24	27.0	27.0
U24	A69-1602-58381	U26 - L25 - U25 - L24 - U22 - L21 - U21 - L20 - L21 - U22	61.0	183.9
U24	A69-1602-58383	U20 - L20 - U21 - L21 - U25 - U26 - Peoria Lake	306.0	431.0
U24	A69-1602-58386	U25 - L25 - U26 - Maple Island - MOR RM2 - U26 - (U25 - L24 (x1.5)) - L25	108.0	206.0
U24	A69-1602-58389	U26 - L24 - U22	61.0	145.9
U24	A69-1602-58390	U20 - L20 - U21 - L21 - L22	62.5	116.5
L25	A69-1602-48913	U26 - L25	12.0	29.0
L25	A69-1602-48914	U25 - L25	21.0	42.0
L25	A69-1602-48915	U26 - U25 - L25	21.0	61.0
L25	A69-1602-48916	U25 - L24 - L25	22.0	39.0
L25	A69-1602-48918	Peoria Lake - U26	200.6	392.8
L25	A69-1602-48919	U25 - L25 (x2.5)	21.0	85.0
L25	A69-1602-48920	Maple Island - L26 - U26 - U25 - L24 - L21	73.0	166.0
L25	A69-1602-48921	U26	12.0	12.0
L25	A69-1602-48922	L26 - U26	49.4	86.8
L25	A69-1602-48923	Peoria Lake - U26	257.0	518.6
L25	A69-1602-58392	U26 - L25	12.0	24.0
L25	A69-1602-58394	Peoria Lake	257.0	257.0
L25	A69-1602-58395	U25 - L24 - U22 - L21 - (U21 - L20 (x1.5)) - L21 - L24 - U25	91.9	162.8
L25	A69-1602-58396	U26 - (U25 - L24 (x1.5))	22.0	47.0
L25	A69-1602-58397	U26 - L25 - (U25 - U26 (x1.5)) - L25	21.0	127.0
L25	A69-1602-58398	U26 - MOR RM250 - MOR RM452 - Nishnabotna - Platte - MOR RM641.5 - MOR RM670	727.0	727.0
L25	A69-1602-58399	U26	12.0	12.0
L25	A69-1602-58401	U25 - L24 - L25	22.0	39.0
L25	A69-1602-58402	U26	12.0	12.0
L25	A69-1602-58403	U26 - U25 - L25	21.0	61.0
L25	A69-1602-58406	Peoria Lake	253.8	311.6
L25	A69-1602-58408	L21 - U21 - L20	91.9	91.9
L25	A69-1602-58409	U25 - L25 (x1.5)	21.0	53.0
L25	A69-1602-58411	U26 - L25 - U25	21.0	45.0
L25	A69-1602-58412	U26 - Peoria Lake	257.0	257.0
U26	A69-1602-48925	L24	38.0	38.0
U26	A69-1602-48926	U26	4.0	4.0
U26	A69-1602-48928	U26	4.0	4.0
U26	A69-1602-48929	U26	4.0	4.0
U26	A69-1602-48930	Maple Island	35.5	35.5

U26	A69-1602-48931	U25 - U26	37.0	70.0
U26	A69-1602-48932	Maple Island - U26 - Cape	184.5	263.5
U26	A69-1602-48933	Maple Island	35.5	35.5
U26	A69-1602-48934	Maple Island	35.5	35.5
L26	A69-1602-58322	U26 - L26	38.0	75.4
L26	A69-1602-58323	L26	0.6	0.6
L26	A69-1602-58325	Maple Island - L26	1.5	3.6
L26	A69-1602-58328	Maple Island - L26	1.5	3.6
L26	A69-1602-58329	LPL - L26	180.8	361.0
L26	A69-1602-58330	L26	0.6	0.6
L26	A69-1602-58331	L26	0.6	0.6
L26	A69-1602-58332	L26	0.6	0.6
L26	A69-1602-58333	Maple Island - L26	1.5	3.6
L26	A69-1602-58335	Peoria Lake	189.0	197.2
L26	A69-1602-58336	Maple Island - MOR RM2 - MOR RM368 - Grand Mouth - Lamine Mouth - Osage Mouth - Maple Island - L26	375.0	750.8
L26	A69-1602-58337	Peoria Lake	239.0	259.3
L26	A69-1602-58338	L26	0.6	0.6
L26	A69-1602-58339	L26	0.6	0.6
HDC	A69-1604-27619	Ohio Cairo	52.0	52.0
HDC	A69-1604-27623	Cape	4.0	4.0
HDC	A69-1604-27625	HDC	4.6	4.6
HDC	A69-1604-27626	HDC	4.6	4.6
HDC	A69-1604-27627	Cape - Ohio Cairo	52.0	57.0
HDC	A69-1604-27629	HDC	4.6	4.6
HDC	A69-1604-27635	Cape	4.0	4.0
HDC	A69-1604-27638	Cape	4.0	4.0
HDC	A69-1604-27645	HDC	4.6	4.6
HDC	A69-1604-27646	Cape	4.0	4.0
Cairo	A69-1604-27460	Cape - Ohio Cairo	46.3	99.3
Cairo	A69-1604-27469	MS Cairo - Ohio Cairo	6.7	6.7
Cairo	A69-1604-27470	Ohio Cairo	6.7	6.7
Cairo	A69-1604-27472	Cape - Ohio Cairo	46.3	99.3
Cairo	A69-1604-27473	Ohio Brookport - (Kentucky Dam - Tennessee River (x2)) - Ohio Brookport - Cumberland River - Barkley Dam	93.9	175.9
Cairo	A69-1604-27475	Ohio Cairo	6.7	6.7
Cairo	A69-1604-27476	MS Cairo - New Madrid	70.2	70.2
Cairo	A69-1604-27479	7 Island Closer	43.2	43.2
Cairo	A69-1604-27480	MS Cairo - Ohio Cairo	6.7	6.7
Cairo	A69-1604-27481	Cape - Ohio Cairo - Ohio Brookport - (Tennessee River - Kentucky Dam (x1.5)) - Ohio Brookport	73.8	190.9

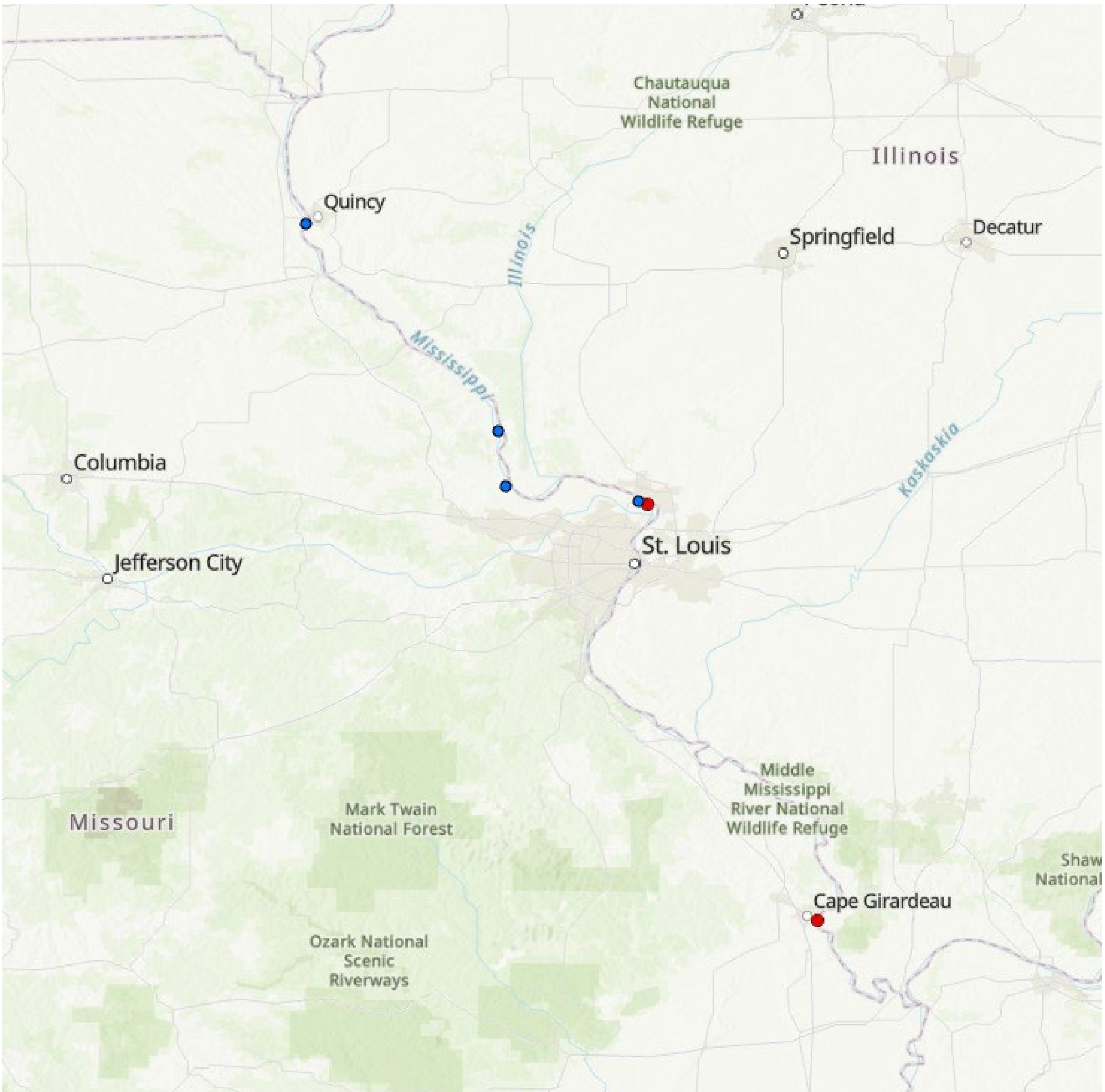

Figure 12. *Relative locations of invasive Silver Carp (blue dots) tagged in the pooled UMR (one from lower pool 25, three from upper pool 26, three from lower pool 26) that made it to the MMR and were detected at Maple Island (upper red dot) and Cape Girardeau (lower red dot), approximately 1.5 to 273.4 river miles from the original tagging locations.*

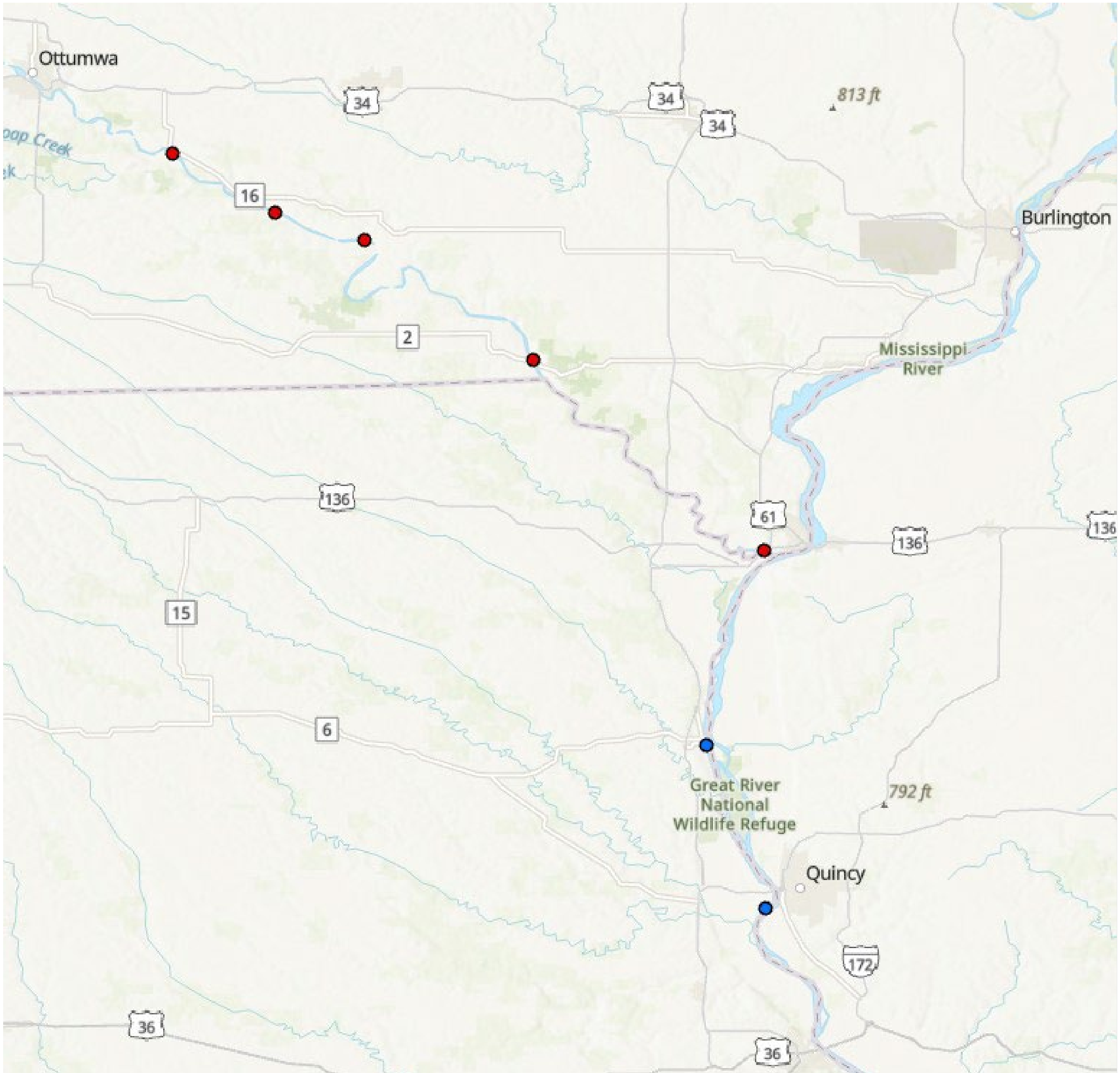

Figure 13. *Relative locations of invasive Silver and Bighead Carp (blue dots) tagged in the pooled UMR (two from upper pool 21, two from upper pool 22; the single Bighead Carp was tagged in upper pool 21) that were detected in the Des Moines River at five locations (red dots), approximately 36.6 to 91.0 river miles from the original tagging locations.*

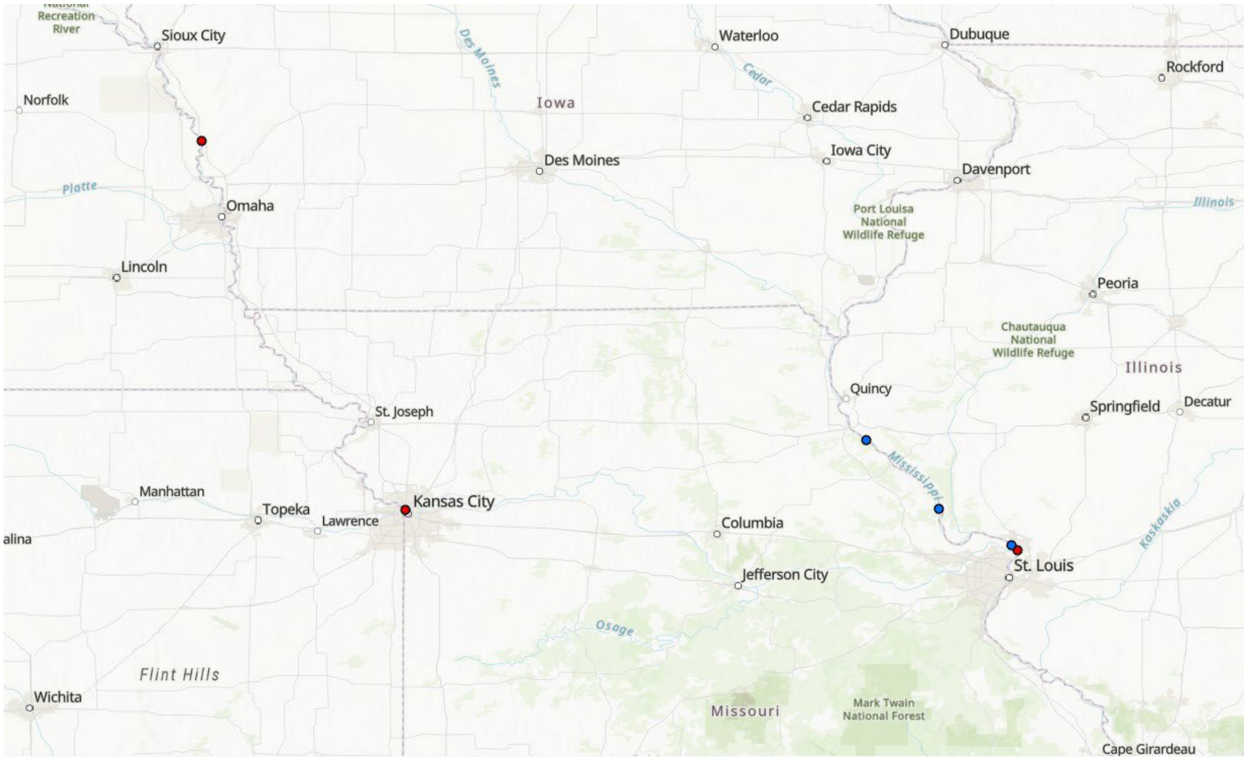

Figure 14. *Relative locations of invasive Silver Carp (blue dots) tagged in the pooled UMR (one each from upper pool 24, lower pool 25, lower pool 26) that made it to the Missouri River and were detected across three main locations (red dots), approximately 108.0 to 727.0 river miles from the original tagging locations.*

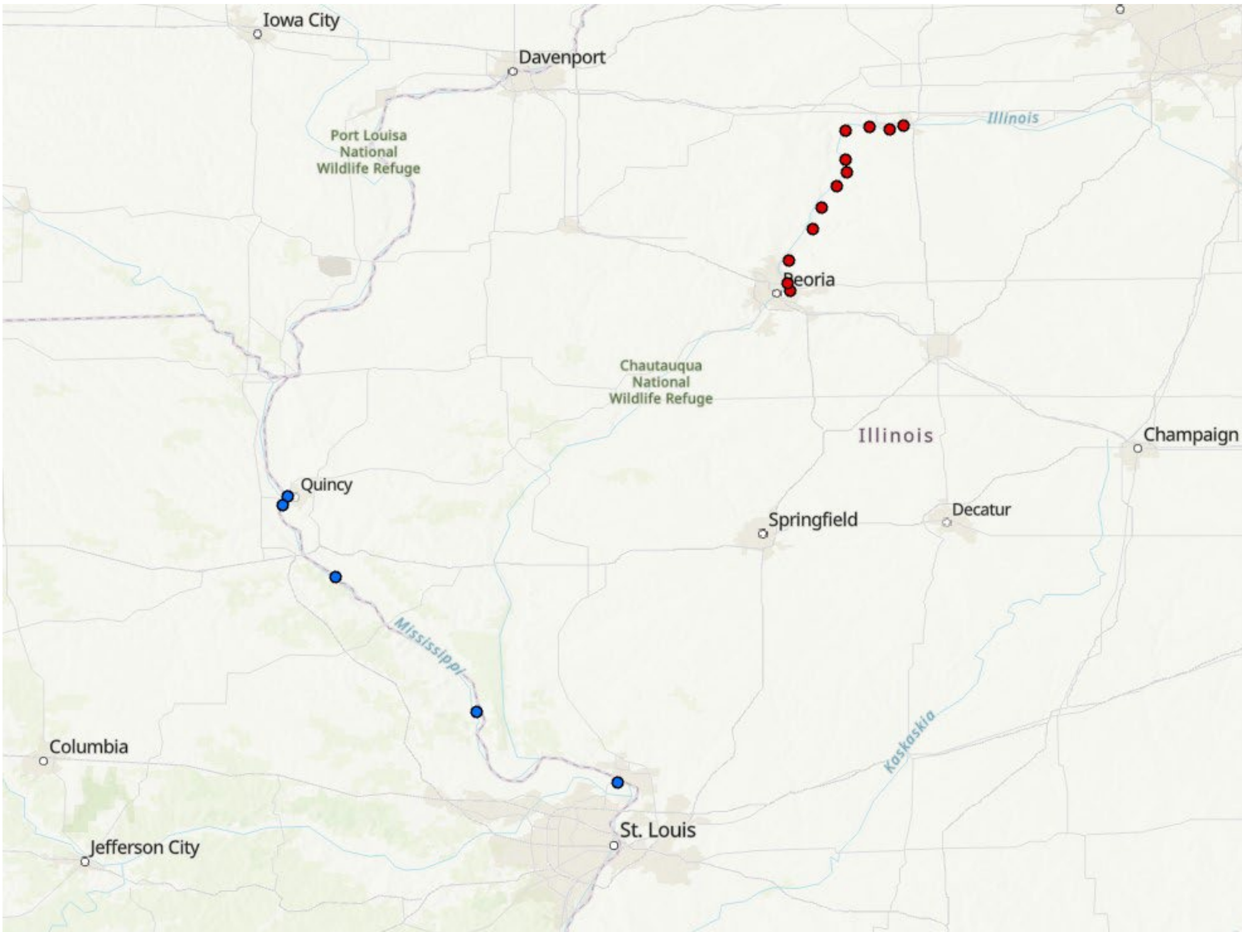

Figure 15. *Relative locations of invasive Silver Carp (blue dots) tagged in the pooled UMR (one from lower pool 21, one from upper pool 22, two from upper pool 24, five from lower pool 25, three from lower pool 26) that made it to Peoria Lake on the Illinois River and were detected across twelve locations (red dots), approximately 180.8 to 332.3 river miles from the original tagging locations.*

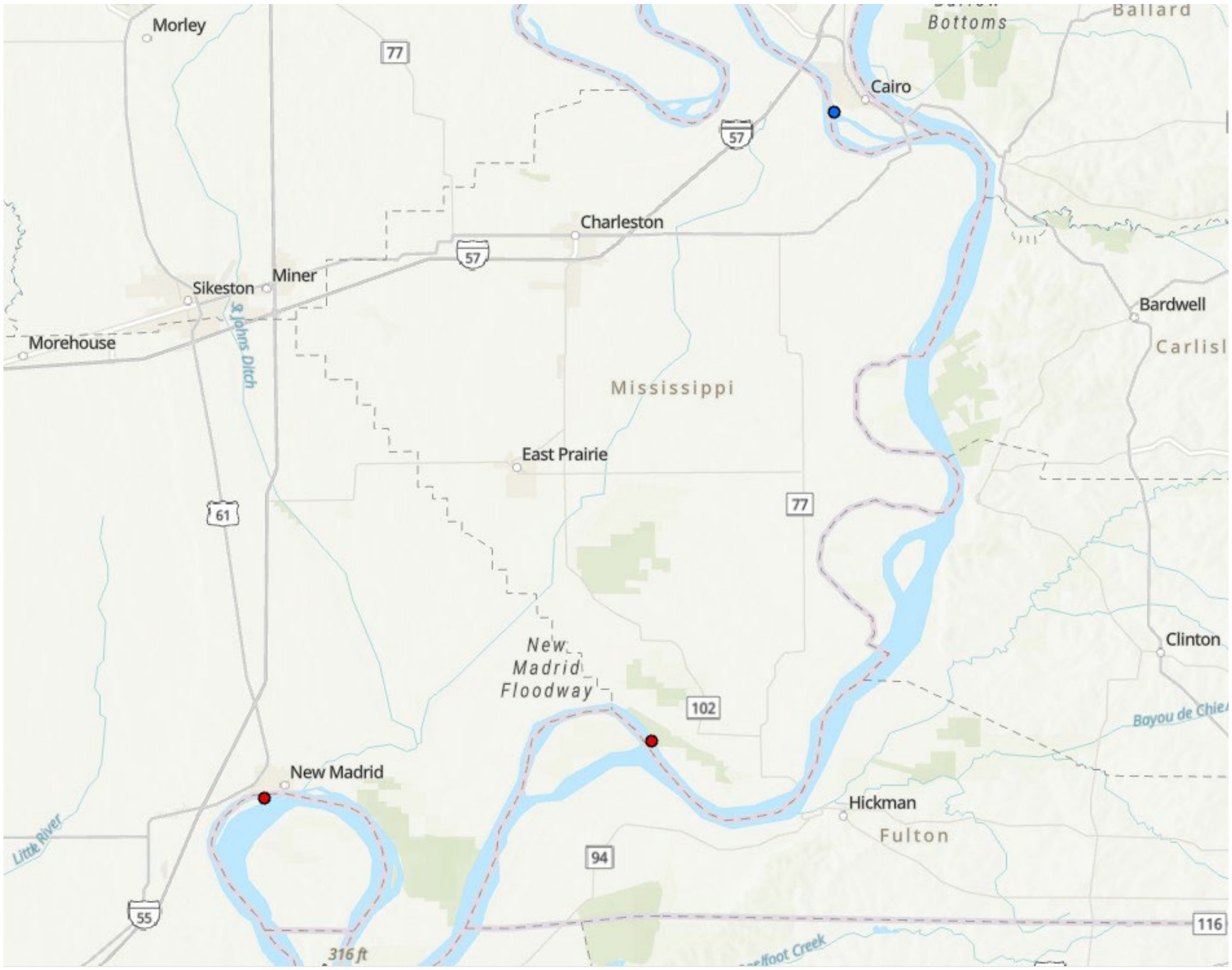

Figure 16. *Relative locations of invasive Silver Carp (blue dots) tagged in the MMR (two from Angelo Island) that made it to the LMR and were detected at New Madrid (left red dot) and Seven Island (right red dot), approximately 43.2 to 70.2 river miles from the original tagging location.*

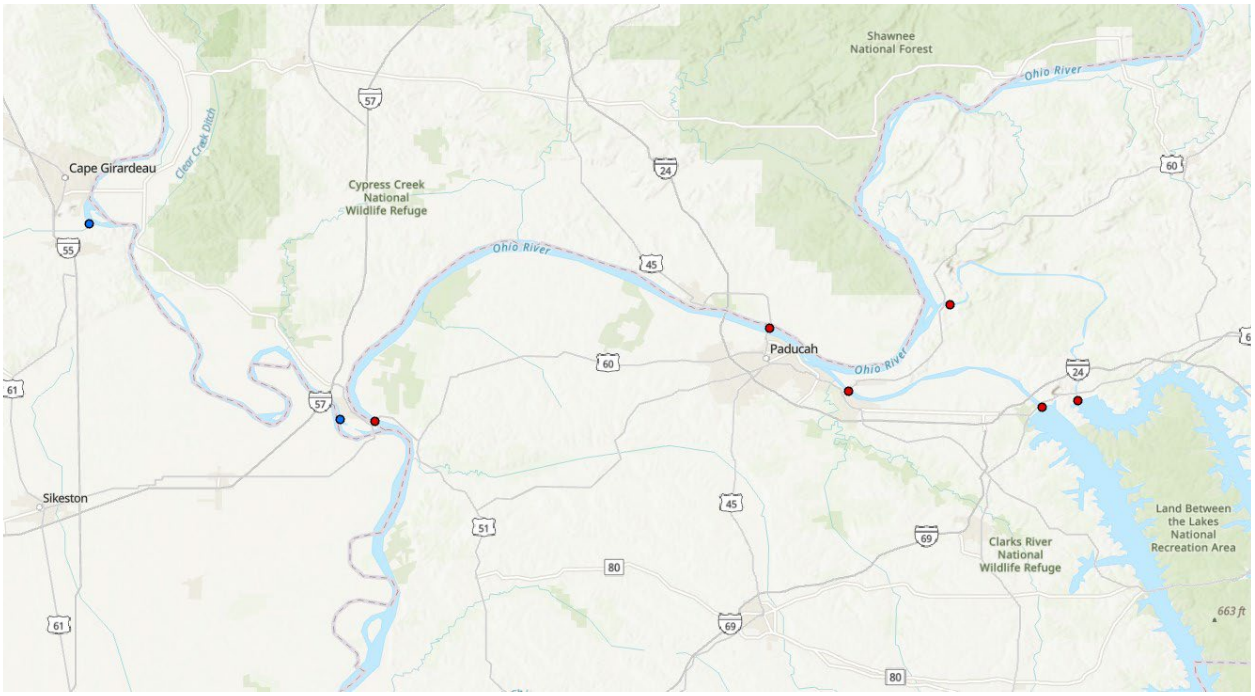

Figure 17. *Relative locations of invasive Silver Carp (blue dots) tagged in the MMR (eight from Angelo Island, two from Headwaters Diversion Channel) that made it to the Ohio River system and were detected across six main locations (red dots), approximately 6.7 to 93.9 river miles from the original tagging locations.*

Iowa State University is using acoustic telemetry to assess residency and metapopulation dynamics of Silver Carp in UMR tributaries. Receivers were most recently downloaded during fall 2024 and data through July 2024 was used to estimate maximum displacement and transition frequency. Preliminary observations are based on individuals tagged in the Des Moines, Cedar, and Iowa rivers from fall 2021 - fall 2023.

Of the Silver Carp tagged downstream of Red Rock Dam, 23 individuals were classified as sedentary, 17 individuals were classified as mobile, and 24 individuals were classified as intermediate (Figure 18). Four individuals have not yet been detected. A Silver Carp (765 mm TL, male) moved out of the Des Moines River into the UMR during Spring 2022 and was detected at a Missouri Department of Conservation receiver near Jefferson City, MO in the Missouri River during July 2022 and in the Missouri River near Blaire, NE during June 2023, resulting in the longest maximum displacement of 1,433 km that we observed. This individual moved back down the Missouri River, returned to the Mississippi River, and was most recently detected back in the Des Moines River above Ottumwa Dam. Of the Silver Carp we tagged below Ottumwa Dam, we classified 21 individuals as sedentary, 33 individuals as mobile, and 16 individuals as intermediate (Figure 18). The longest confirmed maximum displacement of individuals tagged below Ottumwa Dam was approximately 606 km where a Silver Carp (709 mm TL) was detected at a Southern Illinois University receiver in the Illinois River near Starved Rock Dam. Of the Silver Carp we tagged in the Iowa River, we classified 25 individuals as sedentary, 18 individuals as mobile, and 15 individuals as intermediate (Figure 18). Four individuals have not yet been detected. The longest confirmed maximum displacement of individuals tagged in the Iowa River was approximately 811 km where a Silver Carp (893 mm TL) was detected at a Missouri Department of Conservation receiver near the mouth of the Ohio River. Of the Silver Carp we tagged in the Cedar River, we classified 20 individuals as sedentary, 21 individuals as mobile, and 7 individuals as intermediate (Figure 18). Four individuals have not yet been detected. The longest confirmed maximum displacement of individuals tagged in the Cedar River was approximately 338 km where a Silver Carp (791 mm TL) was detected at Lock 15 in the UMR.

Twenty-two Silver Carp tagged below Red Rock Dam transitioned downstream and successfully passed through Ottumwa Dam between October 2021 and October 2024 (Figure 19). Five of those individuals (A69-1602-49707, A69-1602-49718, A69-1604-21967, A69-9002-4686, A69-9004-14226) appear to have successfully transitioned back upstream through Ottumwa Dam (Figure 19) and 14 individuals have moved downstream to the mouth of the Des Moines River. We did not observe any individuals tagged below Ottumwa Dam transitioning upstream through Ottumwa Dam from 2021 – 2023; however, seven individuals transitioned upstream through Ottumwa Dam between 05/2024 – 08/2024 (Figure 20**)**. Thirty individuals tagged below Ottumwa Dam have transitioned downstream to the mouth of the Des Moines River as of October 2024. Of those 30, 16 have since migrated back upstream to their tagging location at some point in time. Nine individuals repeated this movement at least twice, showcasing highly mobile behavior (Figure 21). We observed a large movement event between late October and early November 2021, with 13 of the 39 individuals tagged below Ottumwa Dam moving downstream to the mouth of the Des Moines River. The movement event coincided with a two-week, ~350 m^3/s increase in discharge and water temperatures declining to approximately 10°C (Figure 21). Smaller upstream movement events were also observed during spring 2022 as both water temperature and discharge increased (Figure 21). Another large downstream movement event was observed during July 2022 when 15 individuals moved downstream to the mouth of the Des Moines River, followed by a smaller downstream movement between late October and early November 2022 (Figure 21). A second series of smaller upstream movement events occurred between late March and early June 2023 where individuals moved back up into the Des Moines River, followed by a small downstream movement between late May and early June 2023 (Figure 21). During 2024, we observed upstream movement event between April and May, followed by a downstream movement event between August and September (Figure 21**)**. These movements typically coincided with fluctuations of discharge and temperature (Figure 22); however, we have observed movements even during periods of low flow.

Seventeen Silver Carp tagged in the Iowa River moved downstream to the mouth of the Iowa River between April 2022 and October 2024 (Figure 23). Of those 17 individuals, 10 have made this movement two to three times (Figure 23). During Spring 2023, two individuals moved downstream in the Iowa River into UMR Pool 18 and then moved upstream to Lock 15 (Figure 23). Six individuals moved from the Iowa into the Cedar River, showing some connectivity with the Cedar River cohort. Of the cohort tagged in the Cedar River, 21 individuals have moved downstream to the mouth of the Iowa River between April 2022 and October 2024 (Figure 24). Nineteen of those individuals have since moved back upstream into the Cedar River at some point and 16 of the 19 moved back downstream a second time, showcasing some mobility. During Spring 2023, two individuals moved from the Cedar River downstream to the Iowa River and then into UMR Pool 18 where they began moving upstream and were detected as far as Lock 15 (Figure 24). One individual (A69-1602-49655) returned to the lower portion of the Iowa River during July 2023 (Figure 24). A single individual moved downstream from the Cedar River to UMR Pool 19 during June 2022 but has since moved back upstream into the Cedar River. These movements generally occurred during periods of increased discharge and changing temperature (Figure 25). A movement event was observed between mid-June and mid-July 2022 where 10 individuals between the Iowa and Cedar rivers moved downstream to the mouth of the Iowa River (Figure 25). A second downstream movement event was observed between early August and early September 2022 during increased discharge but still relatively low water levels (Figure 25). We observed a large upstream movement between late March and mid-May 2023 as water temperature began to increase from 5 - 20°C, followed by a smaller downstream movement from mid-May through early June 2023 (Figure 25). Nine individuals moved downstream during October 2023 as water temperature was decreasing (Figure 25). During 2024, a large upstream movement occurred again between late March and mid-May, followed by a smaller downstream movement from late-Mate through mid-June (Figure 25).

In the Des Moines River, maximum displacement analysis suggests a more sedentary population of Silver Carp above Ottumwa Dam with most individuals displacing less than 25 km between October 2021 and May 2024 (Figure 19). Comparatively, individuals tagged below Ottumwa Dam appear to be more mobile (Figure 19), suggesting partially migratory behavior. In the Iowa River, individuals appear to be relatively sedentary (Figure 19), with most individuals displacing less than 25 km between April 2022 and May 2024. Individuals in the Cedar River appear to be more mobile (Figure 19), suggesting partially migratory behavior similar to individuals below Ottumwa Dam in the Des Moines River.

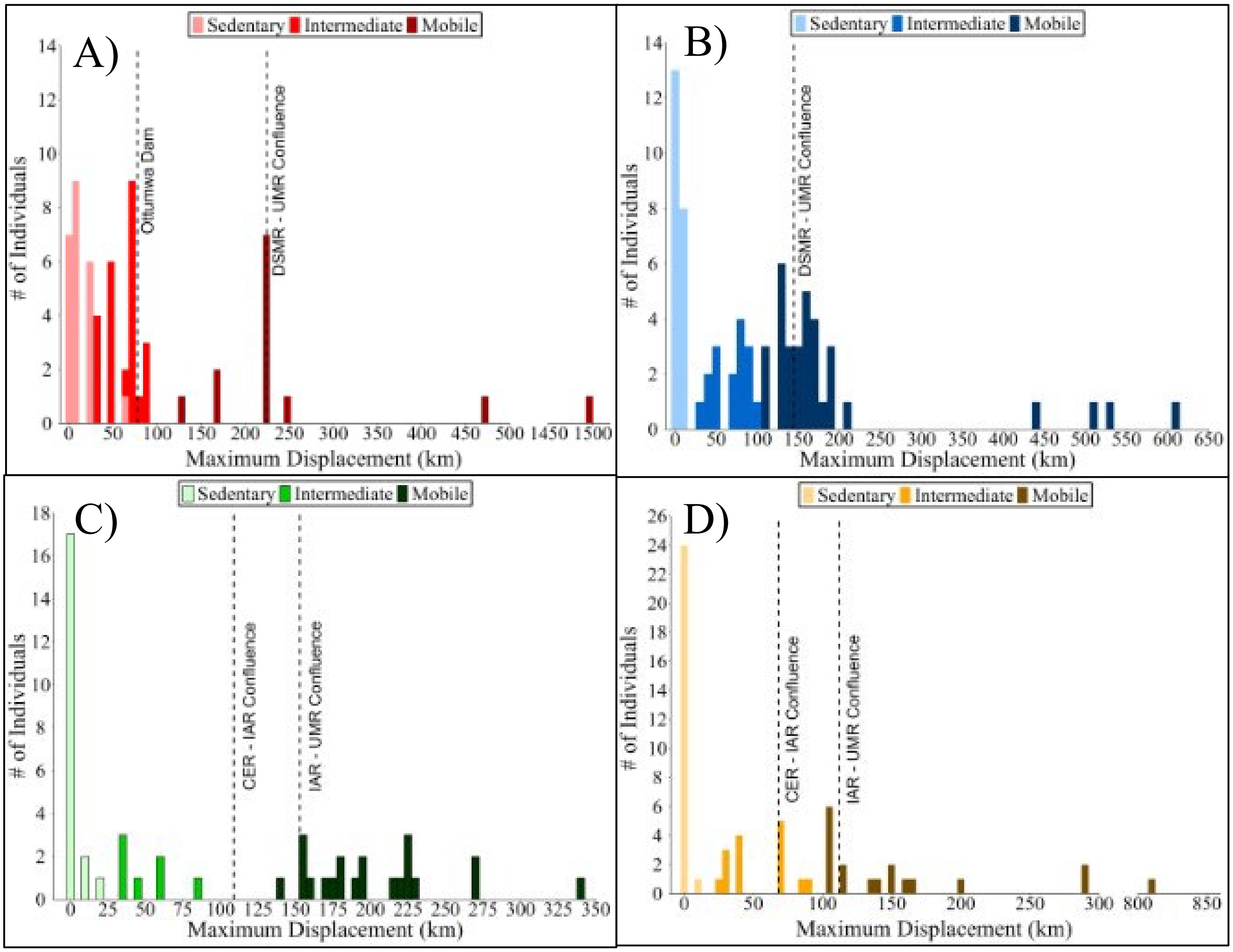

Figure 18. *Movement-frequency of maximum displacement distances (kilometers) for Silver Carp tagged A) below Red Rock Dam in the Des Moines River (DSMR), B) below Ottumwa Dam in the Des Moines River, C) in the Iowa River (IAR), and D) in the Cedar River (CER).*

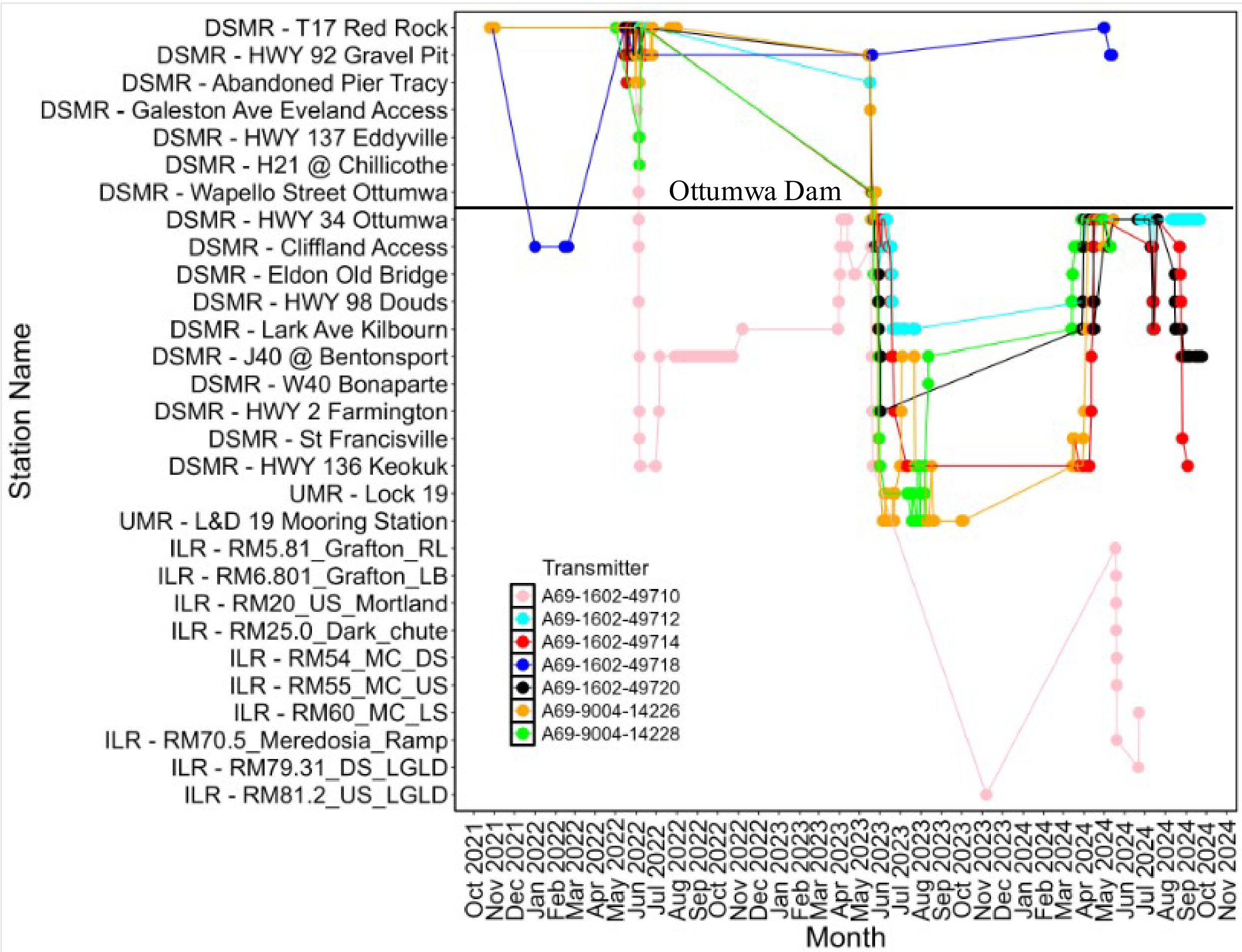

Figure 19. *Abacus plot showing detection histories of seven Silver Carp that transitioned downstream through Ottumwa Dam. Transmitter IDs A69-1602-49718 (blue) and A69-9004-14226 (orange) successfully transitioned both downstream and upstream through Ottumwa Dam. Transmitter IDs A69-1602-49710 (pink), A69-1602-49714 (red), A69-1602-49720 (black), and A69-9004-14228 (green) transitioned downstream through Ottumwa Dam to the mouth of the Des Moines River (DSMR). Transmitter ID A69-1602-49710 (pink) transitioned to the Illinois River (ILR).*

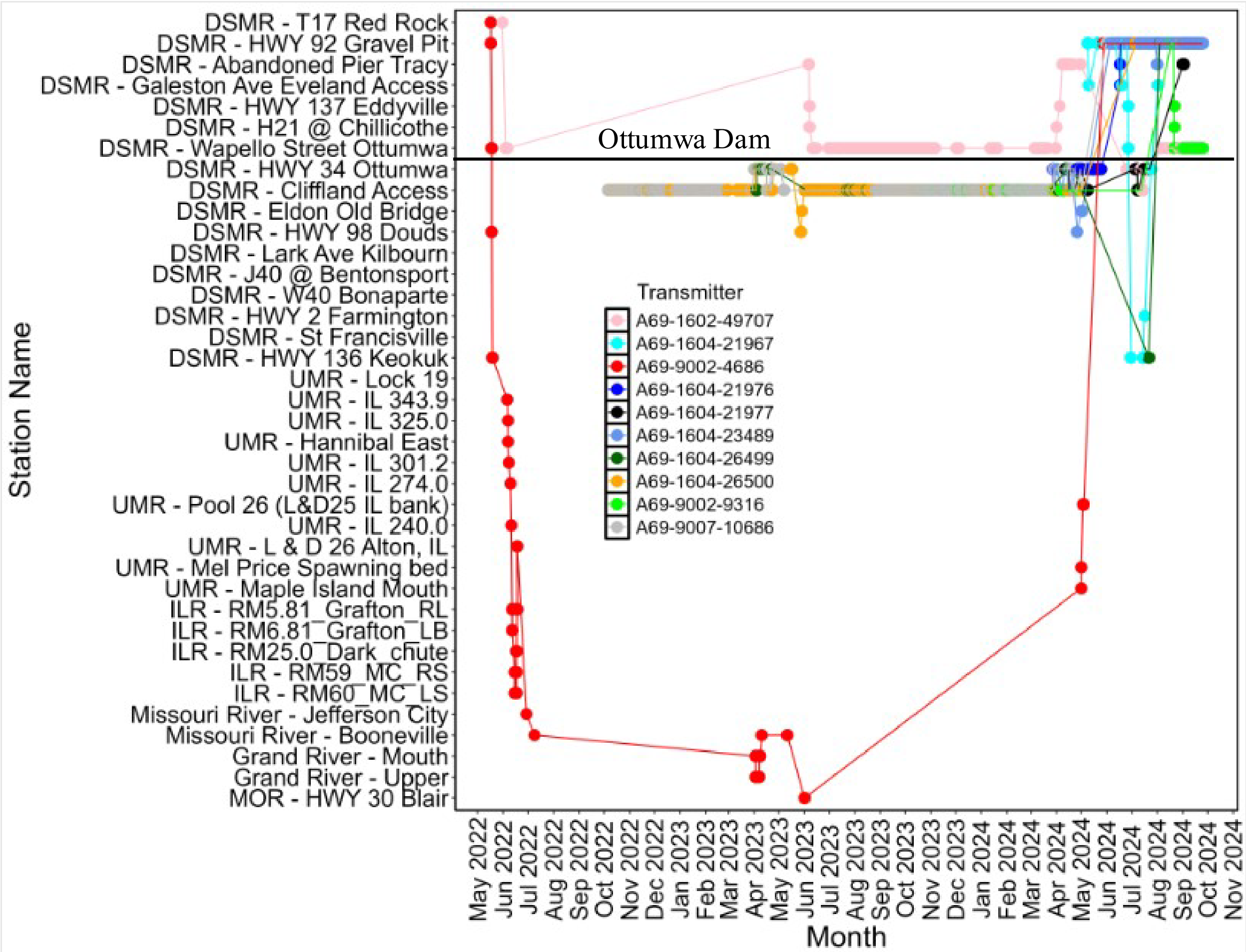

Figure 20. *Abacus plot showing detection histories of ten Silver Carp that transitioned upstream through Ottumwa Dam during 2024. Transmitter ID A69-9002-4686 (red) transitioned downstream through Ottumwa Dam to the mouth of the Des Moines (DSMR) and then moved down to the Illinois (ILR) and Missouri rivers before returning back to the Des Moines River and passing upstream through Ottumwa Dam during May 2024.*

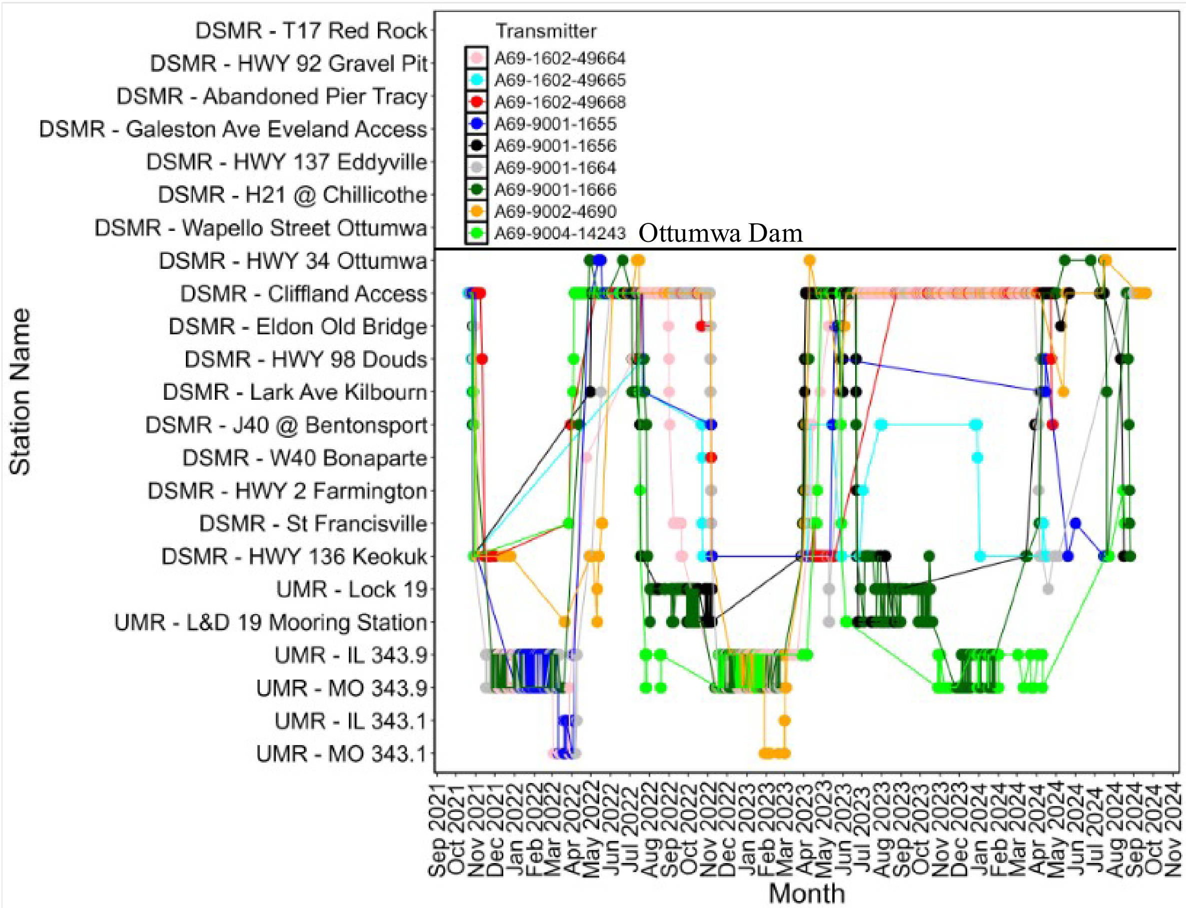

Figure 21. *Abacus plot showing detections histories of nine Silver Carp that made multiple movements between receivers near Cliffland, IA and the last receiver near the mouth of the Des Moines River (DSMR). Each movement from DSMR - Cliffland Access to DSMR - HWY 136 Keokuk is ~133 km. These nine individuals each migrated at least twice between November 2021 and September 2024.*

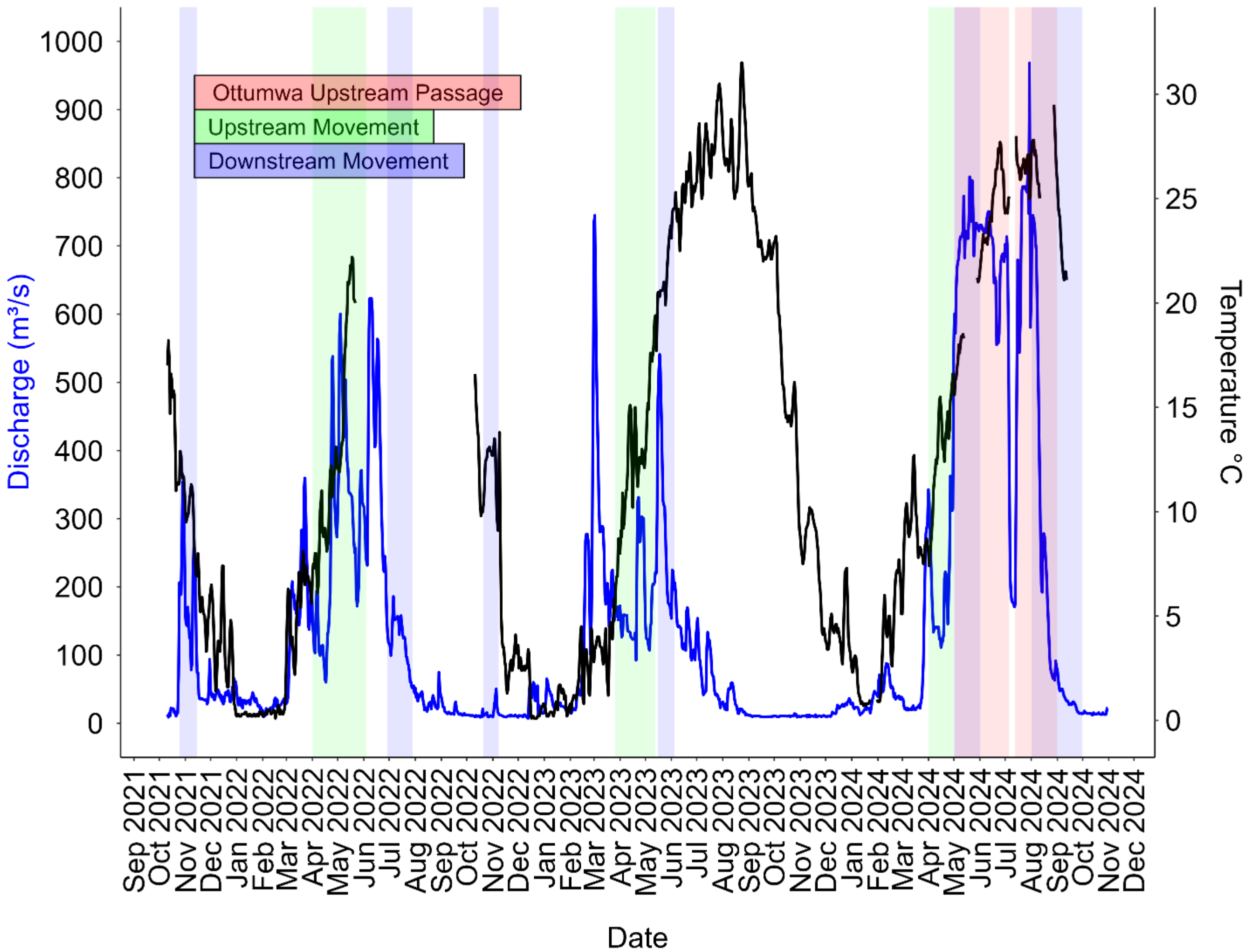

Figure 22. *Discharge (m³/s; blue) and water temperature (°C; green) from the USGS gauging station at Ottumwa, IA (station number 05489500) between October 12, 2021 and November 1, 2024 (https://waterdata.usgs.gov). Downstream movements occurred between late October and early November 2021, late June and late July 2022, late October and late November 2022, mid-May and early June 2023, May 2024, and between August and September 2024 (blue). Upstream movements were observed between early April and early May 2022, between late March and early June 2023, and during April 2024 (green). An upstream passage event through Ottumwa Dam also occurring between May 2024 and August 2024 (red). A movement event was considered a short period of time when at least five individuals made a unidirectional movement greater than 100 m within the Des Moines River.*

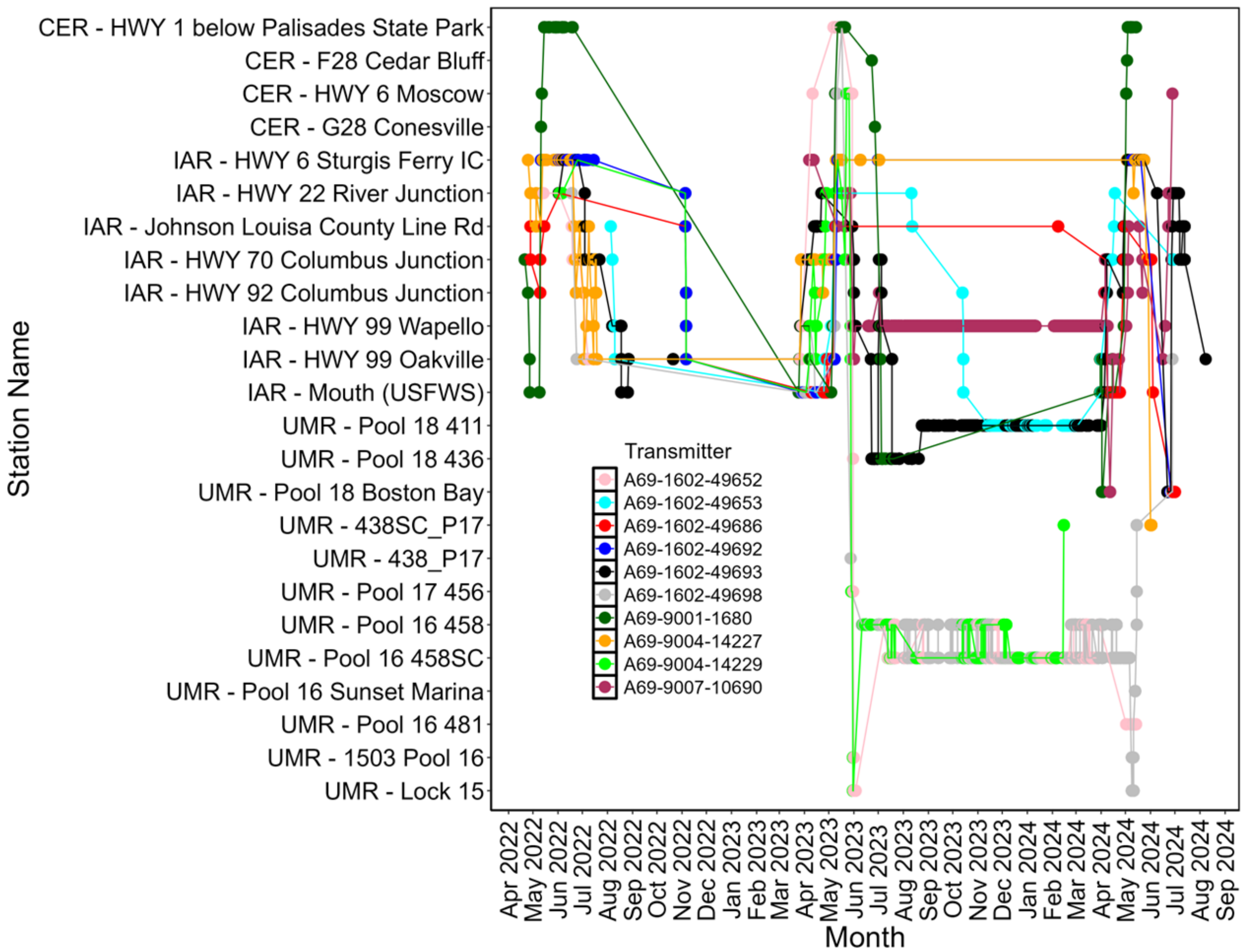

Figure 23. *Abacus plot showing detections histories of ten Silver Carp that moved from their tagging location in the Iowa River (IAR) to the mouth of the Iowa River. Transmitter IDs A69-1602-49652 (pink), A69-1602-49698 (grey), A69-9001-1680 (dark green), and A69-9004-14229 (light green) moved downstream to the mouth of the Iowa River and then back upstream into the Cedar River (CER). Transmitter IDs A69-1602-49652 (pink) and A69-9004-14229 (light green) then moved back downstream to the mouth of the Iowa River and upstream to Lock 15 on the Mississippi River.*

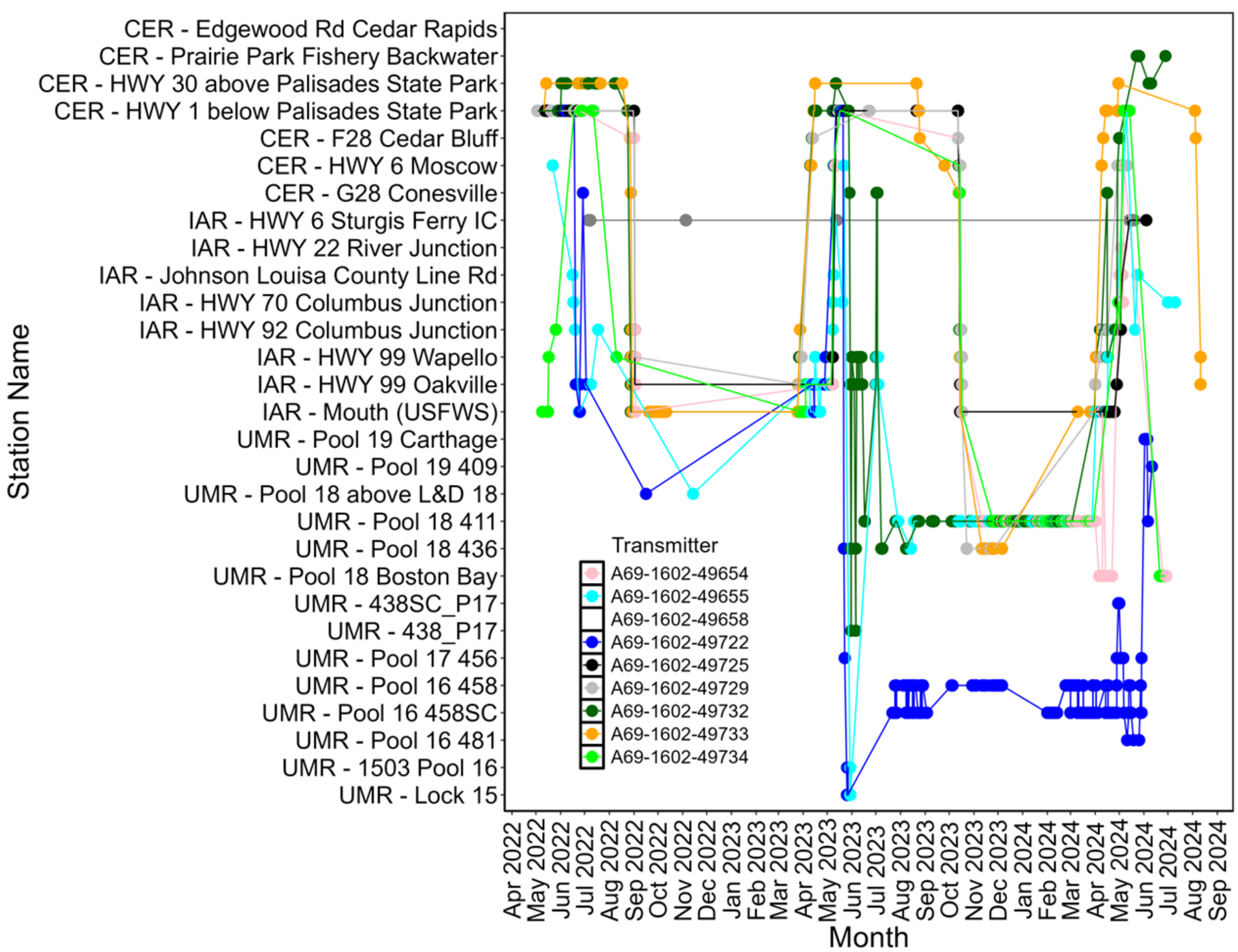

Figure 24. *Abacus plot showing detections histories of ten Silver Carp that moved from their tagging location in the Cedar River (CER) to the Cedar River/Iowa River confluence and then downstream to the mouth of the Iowa River (IAR). Transmitter IDs A69-1602-49655 (cyan) and A69-1602-49729 (grey) have also moved into the Iowa River upstream from its confluence with the Cedar River. Transmitter IDs A69-1602-49655 (cyan) and A69-1602-49722 (blue) moved downstream into the Mississippi River and then upstream to Lock 15.*

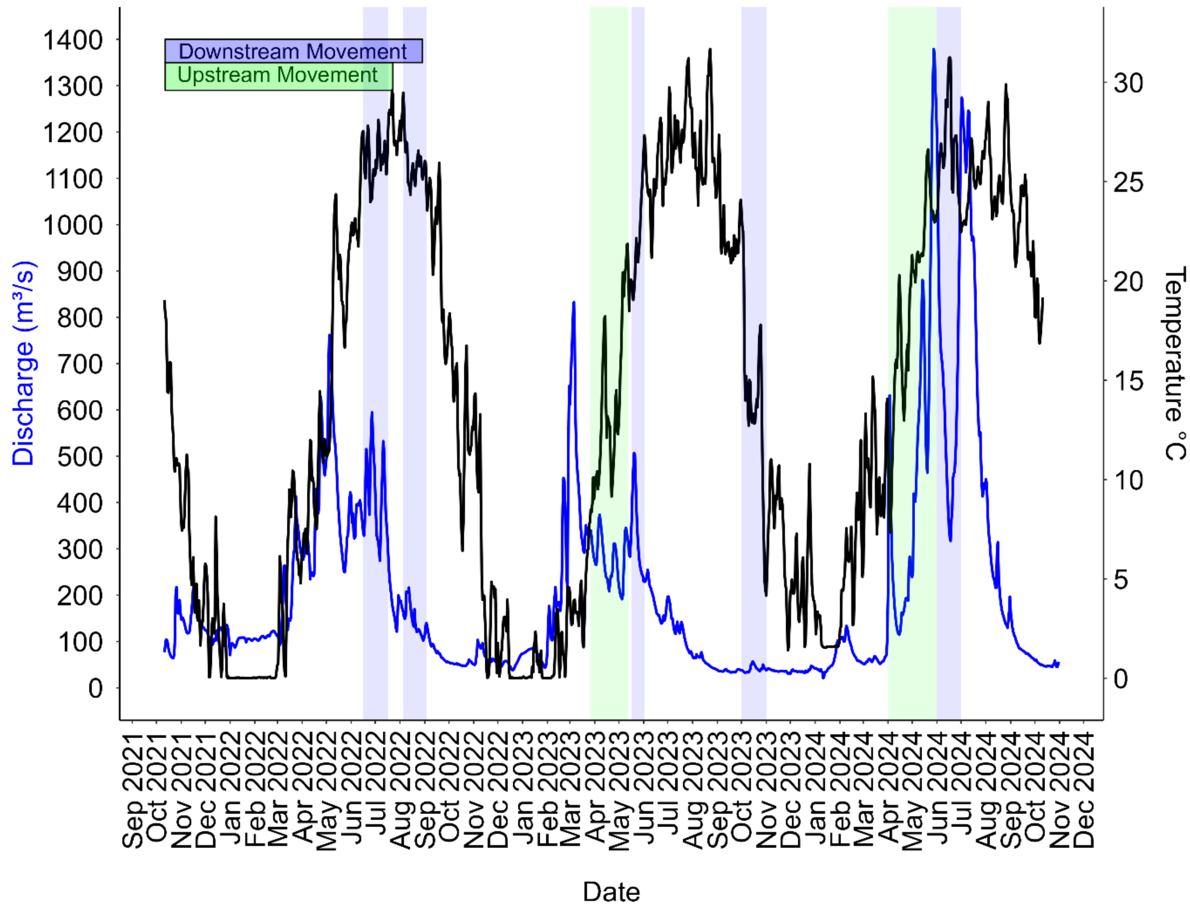

Figure 25. *Discharge (m^3/s; blue) from the USGS gauging station at Oakville, IA (station number 05465700) and water temperature (°C; black) from a HOBO Temperature logger near Conesville, IA between October 12, 2021 and November 1, 2024 (https://waterdata.usgs.gov). Downstream movement events of Silver Carp tagged in the Iowa and Cedar rivers occurred between mid-May and mid-June 2022, early August and early September 2022, mid-May and early-June 2023, mid to late October 2023, and throughout June 2024. An upstream movement event was observed between late-March and mid-May 2023 and between April and May 2024. A movement event was considered a short period of time when at least five individuals made a movement between upper portions of the Iowa and Cedar rivers and the mouth of the Iowa River in the same direction.*

Larval Sampling

In 2024, sampling occurred once a week from 05/20/2024 to 10/10/2024, and a total of 108 samples were collected from 15 nights of sampling. Following the 2023 sampling method, only larval light traps were used in 2024 to sample three streams in Pool 19 of the Upper Mississippi River where larval bigheaded carp have historically been detected: Chaney Creek, Larry Creek, Waggoner Creek (Figure 26, Figure 27). All 2024 samples have been sorted and identified. From the 2024 light trap samples, there were 33,154 larval fishes from nine different families, and Cyprinidae were the most abundant (72.5%) followed by Centrarchidae (25.0%, Figure 28). In 2024, there were a total of 859 confirmed invasive carp (833 larval bigheaded carp and 26 larval Grass Carp) collected from Chaney Creek, Waggoner Creek, and Larry Creek on 06/10, 06/24, 07/01, 07/08, 07/22, and 08/05/2024 (Figure 29). Examination of the hydrograph in the Skunk River and at Lock and Dam 19 may help determine what hydrological conditions are most conducive to spawning events and the detection of invasive carp larvae (Figure 30).

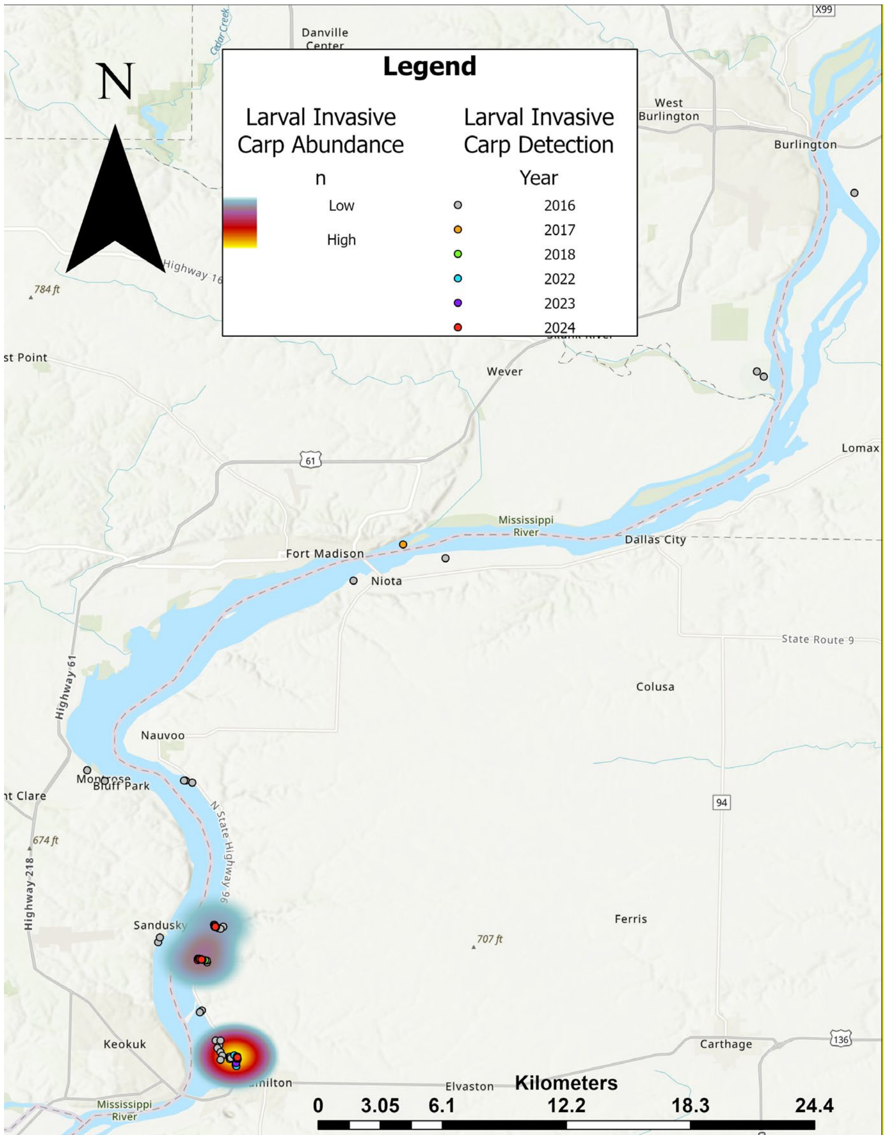

Figure 26. *Occurrences of individual larval bigheaded carp (n) collected using larval light traps from 2016–2024 in Pool 19 of the Upper Mississippi River. The grey circles represent areas where larval bigheaded carp were detected in 2016, the orange circles represent areas where larval bigheaded carp were detected in 2017, the green circles represent areas where larval bigheaded carp were detected in 2018, the blue circles represent areas where bigheaded carp were detected in 2022, the purple circles represent areas where bigheaded carp were detected in 2023, and the red circles represent areas where bigheaded carp were detected in 2024.*

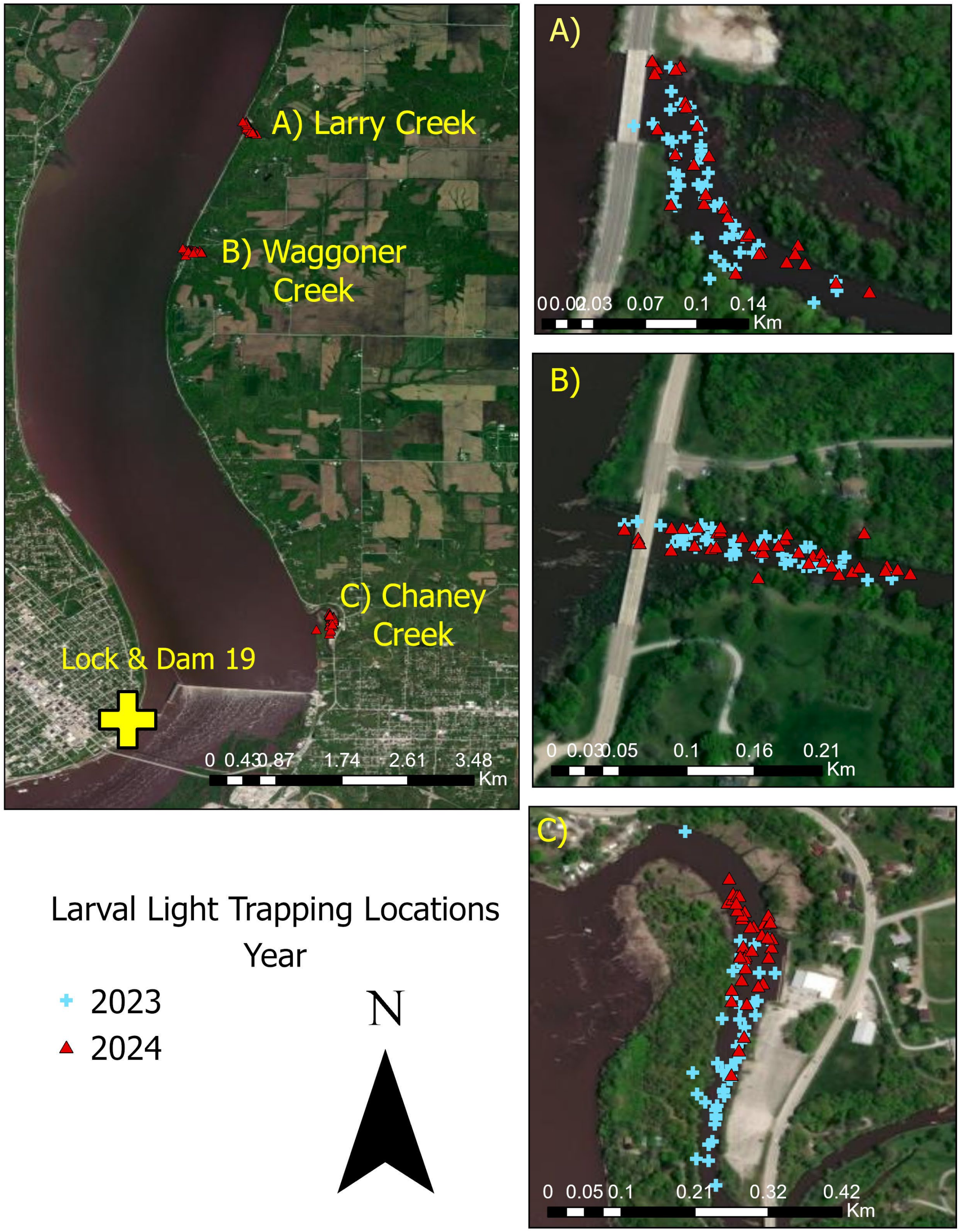

Figure 27. *Larval light trapping locations from 2023-2024 sampling seasons in lower Pool 19 of the Upper Mississippi River (left). For each creek sampled with light traps, blue crosses represent 2023 sites and red triangles represent 2024 sites (right).*

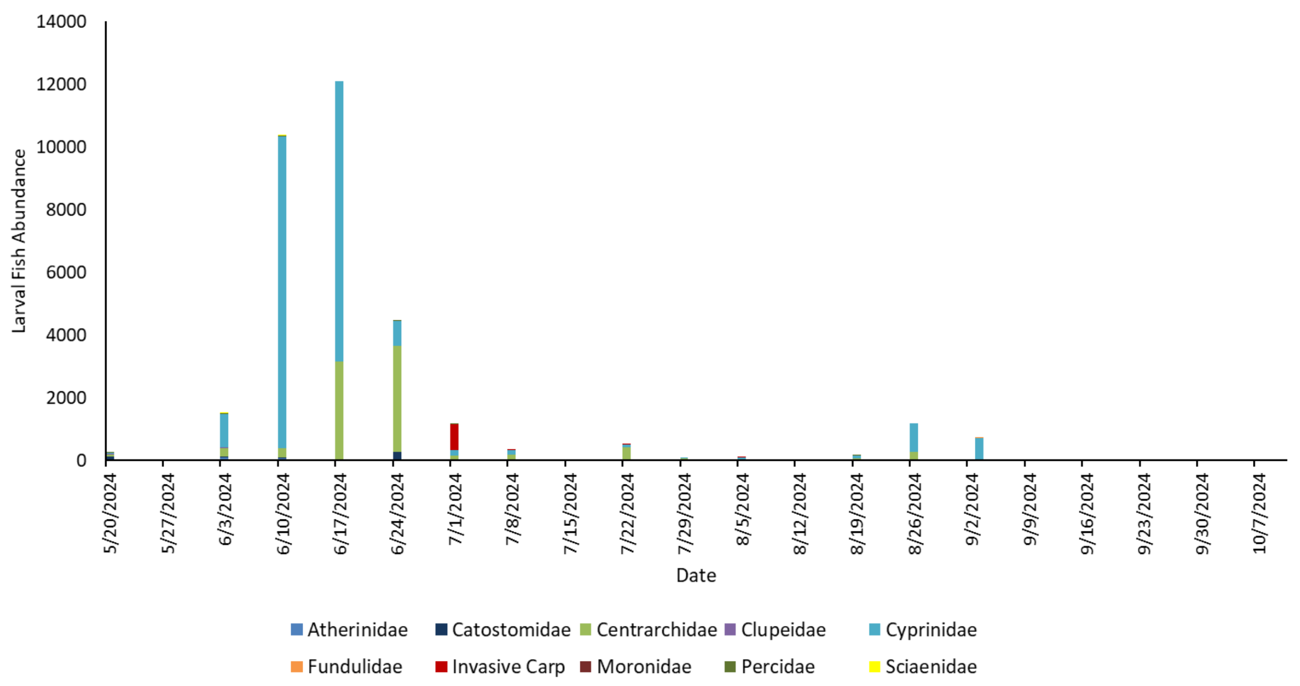

Figure 28. *Larval fish abundances throughout the 2024 sampling season using light traps deployed in Pool 19 on the Upper Mississippi River.*

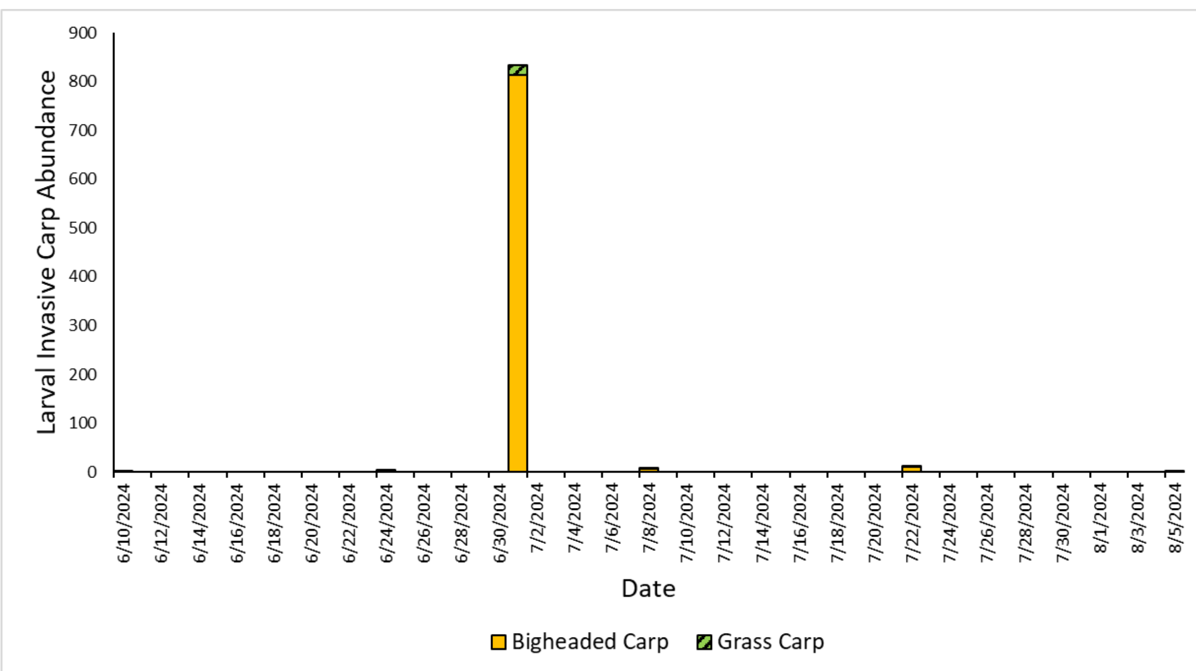

Figure 29. *Larval invasive carp abundances throughout the 2024 sampling season using light traps deployed in Pool 19 on the Upper Mississippi River.*

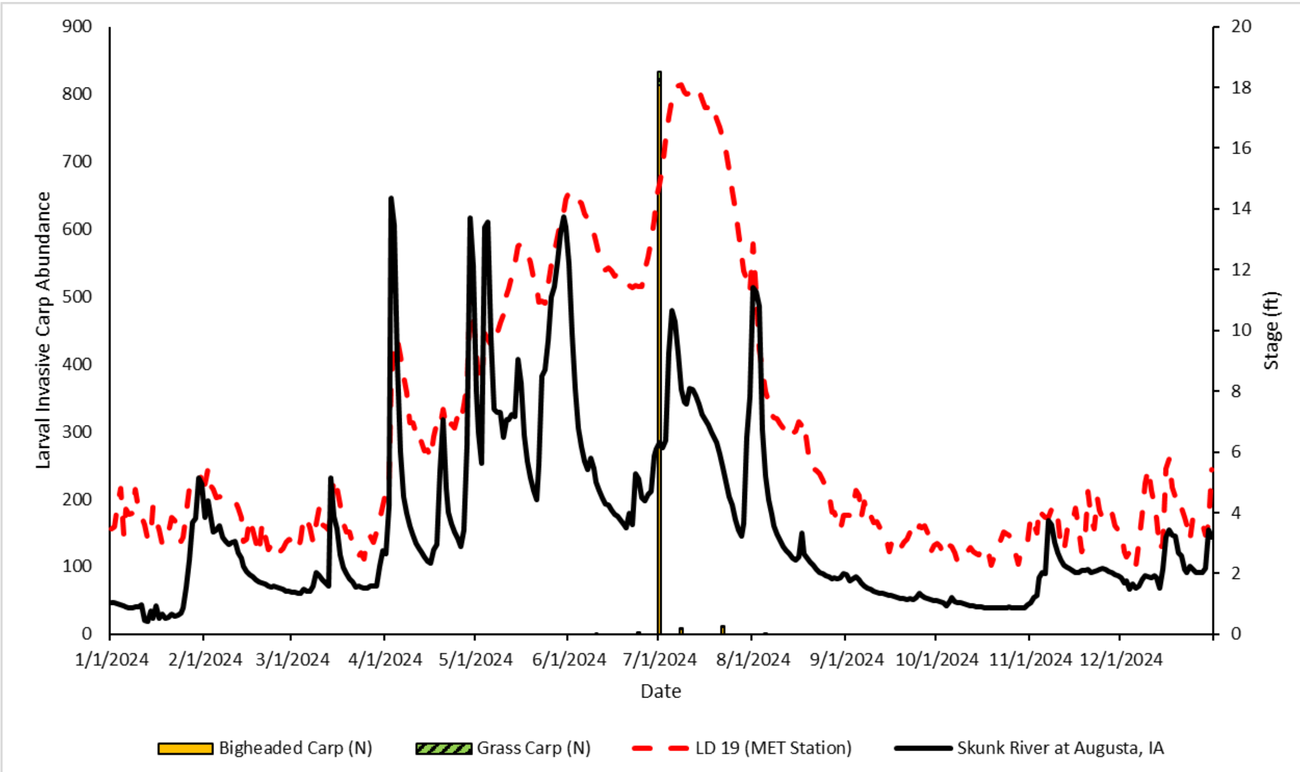

Figure 30. *Hydrological conditions in Pool 19 (P19) of the Upper Mississippi River from 01/01/2024 through 12/31/2024. Black line represents river stage (ft) of Skunk River at Augusta, Iowa. Dashed line represents river stage (ft) at Lock and Dam 19 (MET Station). Orange and green bars represent abundance of larval invasive carp (bigheaded carp and grass carp) collected in larval light traps in creeks of lower P19.*

Fishery Dependent Population Assessment

Due to staff turnover and reduced staff numbers, demographic sampling by INHS was not completed as planned. A number of fish from the IMZ contracted removals did have aging structures removed as part of another projects. From 10/15/2024 to 12/18/2024 INHS staff captured fish and removed otoliths for aging. A total of 174 Silver Carp, Bighead Carp, and hybrids were captured in Pools 16-19 with the use of gillnets. In Pool 16, two Bighead Carp and 21 Silver Carp were captured. In Pool 17, two Bighead Carp, one hybrid, and 52 Silver Carp were captured. In Pool 18, 16 Silver Carp were captured. In Pool 19, two Bighead Carp and 78 Silver Carp were captured. Fish were brought to Lee County Conservation Area or the Illinois River Biological Station to be processed. Processing involved taking lengths and weights of fish, checking sex, weighing gonads, taking a fin clip, and removing otoliths. Otoliths have been mounted and sectioned, these fish will be aged later in 2025.

Discussion:

A hydroacoustics sampling protocol has now been established for the Upper Mississippi River and was fully implemented in 2024. A multi-year effort to conduct comprehensive surveys of select pools to produce data-driven estimates of required sampling effort and optimum transect length necessary to accurately characterize the large-bodied (>254 mm TL) fish population of a navigation pool has been completed (Johnson et al. *accepted*). A product of that effort is an equation that can be used to estimate necessary sampling effort for new navigation pools that are looking to establish a hydroacoustics monitoring program without conducting additional comprehensive surveys. While questions regarding sampling design have now largely been answered, the Service will continue investigating ways to improve the automation and efficiency of data processing, and the accuracy of density estimates. While current, standardized processing methods can provide relative density estimates that can show trends over time, these methods likely under-estimate Silver Carp densities, especially when encountering very dense schools where it is hard to separate and identify individual fish targets in the echogram. The Service is exploring additional options such as moving from single target detection (counting individual fish), to echo integration (evaluating dense schools of fish as a whole), which may improve survey estimates.

Pool-wide estimates of Silver Carp relative density were reported (SVCP/1,000 m^3), and as the percentage of hydroacoustic targets estimated to be Silver Carp regardless of water volume sampled. When examining either metric, Silver Carp appeared to have a greater population in Pool 20 relative to the other sampled pools. Silver Carp pool-wide relative density estimates, and percent of targets suspected to be Silver Carp both decreased from 2023 to 2024 in all pools with multiple years of comparable data. However, we did see some difference among pool rankings (which pools had the most Silver Carp) and preferred habitats of Silver Carp, dependent on which metric was examined. More consideration may need to be given regarding which of these metrics may be more appropriate for characterizing riverine fish populations. The hydrograph and the seasonal stability of water levels during survey season may be important factors to consider as relative density estimates (fish/1,000 m^3) are likely affected by water levels (for example, a high water event in a pool may result in more water sampled, but not necessarily more fish targets, potentially reducing relative density estimates). The estimated decrease in Silver Carp from 2023 to 2024 in Pools 20 and 21 could be related to a variety of factors, but did coincide with incentivized fishing removals that totaled over 736,000 pounds during this same time period (Appendix Table B.1). For Pools 20 and 21 hydroacoustic data collection began prior to the implementation of these programs. The first hydroacoustic surveys of Pools 22 and 24 occurred midway through the first year of program implementation. Over time we hope to be able more fully evaluate the success of this removal program at reducing densities and abundance of Silver Carp.

Overall, trends in length, age, and growth observed during 2021-2023 remained consistent during 2024 sampling. However, two unique population characteristics were observed during 2024. The first was substantially reduced relative abundance in the Open River compared to previous years. This could be attributed to a change in catchability, potentially produced by a large pulse and change in river stage prior to 2024 sampling. Additionally, body condition changed dramatically in the Open River and the Pooled Reach. The Open River depicted an increase in body condition, while the Pooled Reach populations depicted reduced body condition. In previous years, we hypothesized that higher body conditions in more upstream areas were a product of lower fish densities. The trends we observed in 2024 could also be partially a product of density, as reduced abundances were observed in the Open River and slightly increased abundances in the Pooled Reach. However, it is unlikely that density-dependent interactions had such a dramatic effect after a single year. Another potential explanation for changes in abundance and body condition is largescale migrations of fish. Large upstream movements were documented in the UMR in the winter of 2023-2024 (Fritts et al. 2024). These upstream movements showed that ~50% of telemetered Silver Carp moved great distances upstream during open river conditions in the winter. Additionally, it is possible downstream migrations occurred by fish with relatively better body condition (movements in both directions were documented by MDC in 2024). Thus, the trends in 2024 could be partially explained by largescale population movements. It is noteworthy that in 2023 sampling, numerous emaciated Silver Carp were encountered in the Open River reach. It is also possible that many of the fish in poor condition had an increased mortality between 2023-2024, contributing to reduced abundances and increased body condition.

The analyses and publication of 2022-23 upstream fish movement results provides greater understanding of these broad-scale migration patterns. This new information can help managers better understand the movements of species that routinely traverse jurisdictional boundaries. Furthermore, increasing the understanding of how fishes move through lock and dam structures is critical for developing deterrent strategies that effectively limit the spread of aquatic invasive species while protecting migration corridors for native fishes.

Efforts to expand telemetry receiver arrays into newly invaded habitats and to capture and tag invasive carp in novel areas like Pools 10, 13, and 14 also contribute to managers ability to recognize and respond to shifts in invasive carp populations within the UMR. The addition of the new real-time receiver at Carthage Lake in Pool 19 will add further efficiency to removal efforts in that region. Although young of year and age-1 tagging efforts appear to be unsuccessful to date, USFWS will continue attempts to monitor the presence of the young fishes and will investigate ways to improve the chances of successful telemetry tracking for these individuals throughout FY25.

Telemetry efforts by MDC yielded interesting information showing how some tagged invasive carp within the MMR and lower pooled portions of the UMR remained relatively close to their tagging origin, while others were highly mobile. Most invasive carp that were tagged in the pooled UMR system remained within the pooled UMR system, while 28 of those invasive carp were detected outside the pooled UMR system. Invasive carp that stayed within the pooled UMR system traveled up to 102 river miles from their tagging origin. Three invasive carp were detected in the Missouri River system, nine were detected in the Open River Reach of the UMR system (Middle Mississippi River, MMR), four were detected in the Des Moines River, and 12 were detected in the Illinois River system. Approximately half of the invasive carp that were tagged in the MMR remained within the MMR, while the other half were detected outside of the MMR. Invasive carp that stayed within the MMR traveled up to 4.6 river miles from their tagging origin. Two invasive carp were detected in the Lower Mississippi River (LMR) system, while ten were detected in the Ohio River system. The maximum distance traveled from tagging origin was 727 river miles from Pool 25 to the Missouri River near River Sioux, IA. The maximum total distance traveled was 750.8 river miles from Pool 26 to the Missouri River near Kansas City, KS and back to Pool 26.

Telemetry efforts in UMR tributaries showed differences in transition frequency between Silver Carp tagged above Ottumwa Dam and those tagged below Ottumwa Dam. Transition observations suggest Silver Carp above Ottumwa Dam may be relatively independent from those below Ottumwa Dam during low water conditions. Downstream movements of individuals above Ottumwa Dam have been observed; however, upstream movement through Ottumwa Dam appears to be limited. Prior to late Spring – Summer 2024, we had observed only two upstream passages through Ottumwa Dam, both of which were individuals originally tagged above the dam; however, when water levels were above 550 m^3/s during late spring – summer 2024, we had ten individuals successfully pass upstream, seven of which were originally tagged below the dam. The frequent transitions of individuals tagged below Ottumwa Dam suggest more potential for metapopulation interactions. Observations suggest the cohort tagged below Ottumwa Dam may be functioning as a subpopulation of a UMR metapopulation due to the frequent transitions individuals have made between the receiver at the mouth of the Des Moines River and more upstream receivers. Overall, some individuals remained in the upstream portions of the study stretch below Ottumwa Dam and above Ottumwa Dam throughout the entire study period thus far, suggesting a portion of individuals throughout the Des Moines River may be residents. Differences in transition frequency were also observed between Silver Carp tagged in the Iowa River and those tagged in the Cedar River. The relatively low transition rates of Silver Carp in the Iowa River may suggest this population may be more isolated; however, there does appear to be some mixing of Silver Carp tagged in the Iowa and Cedar rivers and UMR, suggesting the possibility of metapopulation interactions. The high frequency of transitions shown by Cedar River individuals suggest this cohort may be functioning as a subpopulation of a UMR metapopulation as well. Similar to the Des Moines River, there appears to be some individuals that have remained within the Iowa and Cedar rivers during the entire study period suggesting a portion of the population may be residents.

Larval sampling has shown that bigheaded carp are capable of successfully spawning in areas of the IMZ above LD19, but that the success of these spawning events exhibits high interannual variability. Continuous larval sampling can identify potential nursery environments for bigheaded carp, as well as any future recruitment events within Pools 17–19 in the Mississippi River. Larval identification also determines what native fish families are reproducing yearly and establishes their recruitment success to the larval stage. Sampling allows managers to diagnose if bigheaded carp are reproducing yearly, under what hydrological conditions, and what size their recruitment potential is at the northern forefront of their reproductive range in the Mississippi River.

Collectively, hydroacoustic, fishery-independent and dependent sampling, telemetry, and larval sampling efforts, are developing into components of a robust stock assessment program. We hope that we will soon be able to directly evaluate how populations of Silver and Bighead Carp may be affected by current contract removals and to forecast their future response to alternative removal strategies.

Recommendation:

Management recommendations to increase harvest and removal programs in the source populations (i.e., Open River and Pool 26) have been implemented via an incentivized harvest program in the UMR, that became fully operational in September 2024 (Appendix Table B.1). Pool-wide hydroacoustic surveys in the UMR should continue and possibly expand downstream to evaluate more pools that have recently initiated incentivized removal programs. Silver Carp estimates reported herein were informed using only fisheries community data derived from standard electrified dozer trawl sampling. As more years of data are collected, the relationship between hydroacoustic estimates, physical sampling, the hydrograph, and the commercial harvest should be more throroughly investigated.

Fishery-independent surveys should continue in the UMR as a tool to monitor the demographic parameters and relative abundance of Silver and Bighead Carp, and to inform hydroacoustics estimates, both of which can help evaluate the effectiveness of management actions. Varying demographic rates are expected within a dynamic system like the UMR and across years with varying conditions. We observed similar trends in demographic rates from previous years with some unique observations. Overall, additional data collection and comprehensive studies are needed to identify the underlying drivers of the observed changes in Silver Carp relative abundance and condition. Continued monitoring will help to inform improved management strategies, as well as assess long term effects of the newly established incentivized harvest programs throughout the entire UMR. In FY25, site locations will focus on meaningful management units and areas with on-going management activity such as subsidized or contracted removal operations. Results from the broader USFWS demographics study (2021-2023) are being prepared as a manuscript for submission to a peer-reviewed journal.

Telemetry continues to be a useful tool for evaluating movements and habitat use by Silver and Bighead Carp, and for informing management actions. Maintenance of receiver arrays in the UMR should continue, with array expansion into any new locations identified by the partnership as areas of interest. Real-time receiver deployment and maintenance should also continue, and possibly expand if needed, as time and funding become available. Additional years of data collection under various flow conditions may be insightful to evaluate of how environmental conditions affect tributary movement dynamics. Movement patterns should be assessed in depth to elucidate patterns and further assist with harvest efforts. Additional telemetry efforts including active-tracking of tagged fish should be considered in low-density areas at the edge of their range, to inform and improve contracted fishing efforts in Minnesota waters.

Continued larval sampling will help further identify the nursery environments of bigheaded carp, and document spawning events within Pools 17–19 in the Mississippi River. Future sampling should continue to refine which habitats and larval sampling gears are most appropriate to determine spawning success and recruitment potential of Silver and Bighead Carp in the IMZ.

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Appendix A: Supplemental Material – Fishery Independent Sampling

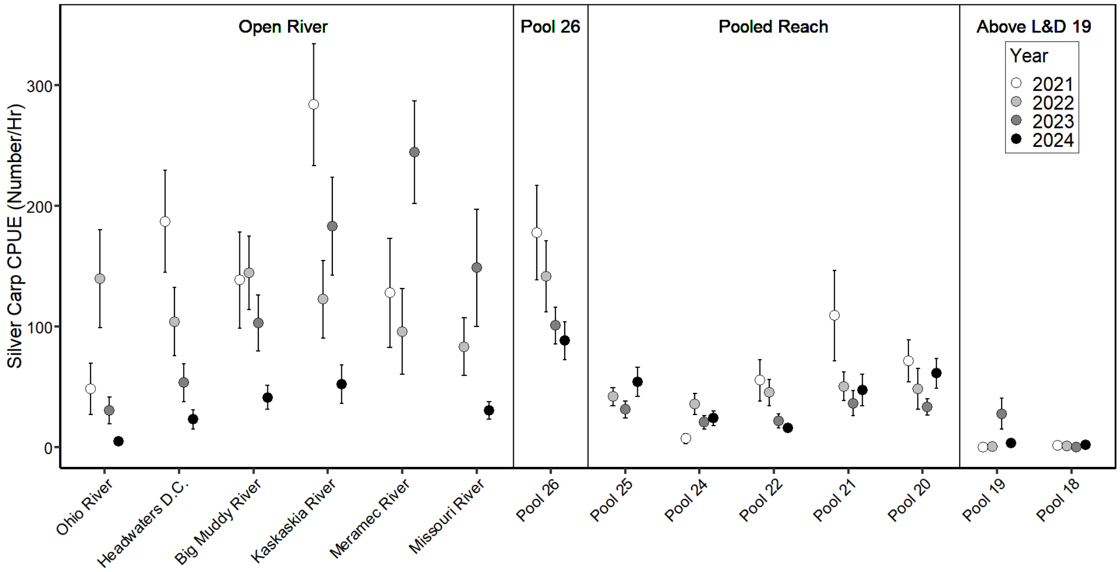

Figure A.1. *Location-specific mean stock-sized catch-per-unit-effort of Silver Carp (number/hr) in the Upper Mississippi River during 2021–2024. Error bars represent one standard error. All fish were sampled using an electrified dozer trawl.*

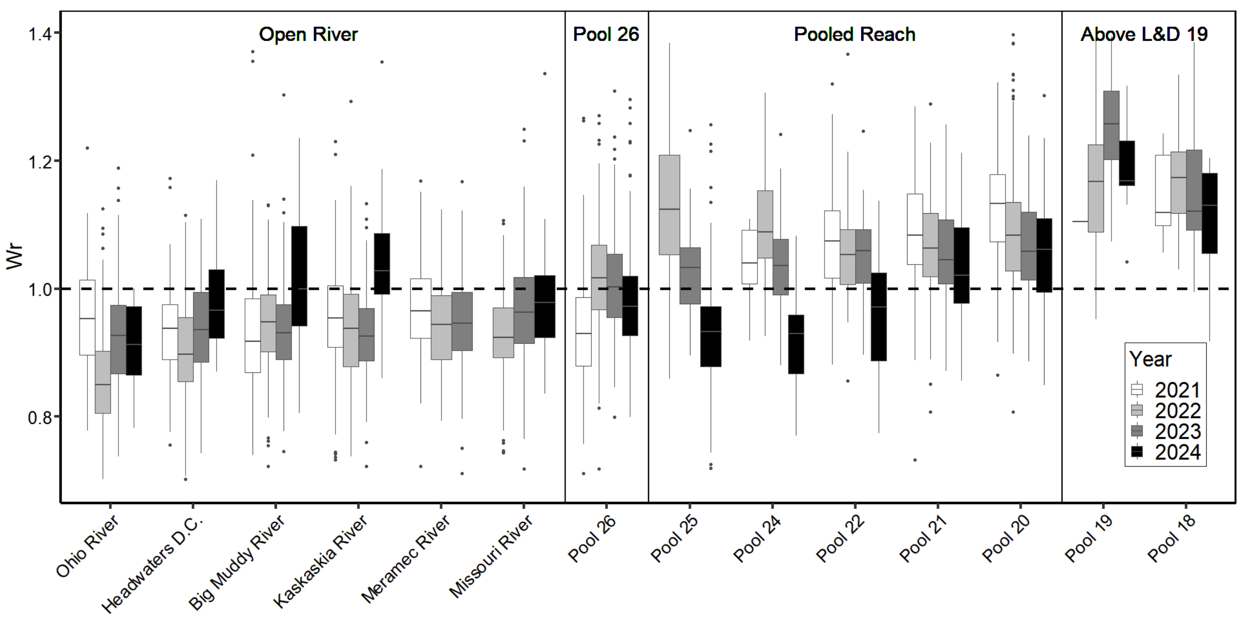

Figure A.2. *Management unit-specific relative weights (Wr) of stock-sized Silver Carp in the Upper Mississippi River during 2021–2024. The horizontal line represents the median Wr, the box is the interquartile range (25th -75th percentile), the error bars represent 1.5 times the interquartile range, and the points above or below the error bars represent potential outliers. The majority of fish were from electrified dozer trawl surveys, with complemented fish from fisheries-dependent sampling (N = 79) at locations Above L&D 19.*

Appendix B: Supplemental Material – Incentivized Removals

Month	Year	Pool 20	Pool 21	Pool 22	Pool 24	Pool 25	Pool 26	Open River
October	2023	3476	0	3632	0	0	0	0
November	2023	22343	0	16462	0	0	0	0
December	2023	28889	0	0	6624	39783	0	0
2023 Total		**54708**	**0**	**20094**	**6624**	**39783**	**0**	**0**
January	2024	8376	0	0	10760	3776	0	0
February	2024	77922	19874	20665	143287	0	0	0
March	2024	33610	0	5015	83063	9344	0	0
April	2024	0	6647	7665	55371	17646	0	0
May	2024	14571	2918	7643	26689	0	0	0
June	2024	12897	16954	0	26144	12155	0	0
July	2024	5405	7981	0	23525	0	0	0
August	2024	8542	12748	8101	70273	55065	23827	0
September	2024	88222	66267	51251	93491	94803	23317	19043
October	2024	67149	43102	31050	49060	35119	9435	0
November	2024	79326	20346	20301	53569	21855	0	0
December	2024	25519	118021	131418	126934	55336	26078	6239
2024 Total		**421539**	**314858**	**283109**	**762166**	**305099**	**82657**	**25282**
Grand Total		**476247**	**314858**	**303203**	**768790**	**344882**	**82657**	**25282**

Table B.1. *Removal data from an incentivized fishing program for invasive carp in the UMR, provided by Joe McMullen, Missouri Department of Conservation. More detailed information is within the report specific to contracted and incentivized fishing.*