Project Title: Bigheaded Carp Monitoring and Removal 2021

Geographic Location: Pools 14–19 of the Mississippi River

Lead Agency: Illinois Natural History Survey

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

Statement of Need:

Adult silver carp (*Hypophthalmichthys molitrix*), bighead carp (*H. nobilis*), and grass carp (*Ctenopharyngodon idella*), hereafter referred to as invasive carp, are present in varying abundances in the Upper Mississippi River (UMR) in Pools 14 through 19; however black carp have not been collected above Lock and Dam (LD) 19. Bighead and silver carp, collectively referred to as bigheaded carp, have increased in range and abundance throughout the Mississippi River basin, thus increasing their potential for causing ecological and economic damage. Lock and Dam 19 has limited movements of bigheaded carp upstream as all upstream passage is restricted to the lock chamber, effectively slowing progression and establishment of bigheaded carp in the UMR. A combination of containment and control measures are thought to be the most effective tools for managing invasive carp in the UMR. The Upper Mississippi River Asian Carp Team (UMRACT) is an interagency group across five states that is concerned with minimizing the impacts of bigheaded carp in the UMR. Commercial harvest effort programs, funded through the UMRACT, are aimed at capturing and removing bigheaded carp in the UMR to prevent establishment of incipient populations. We propose that targeted commercial harvest at the established and invasion front (Pool 16) will be effective in reducing populations and help alleviate the pressure invasive species elicit at dams.

Project Objectives

1) Targeted removal of 300,000-400,000 lbs of invasive carp species in UMR Pools 14-19 using commercial fishers and intensive netting protocols.
2) Acoustically tag and monitor invasive carp within the study area to inform contracted removals

Project Highlights

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- Commercial removal efforts resulted in 208,623 lbs of invasive carp removed from 01/01/2021–12/31/2021, an additional 10,907 lbs were captured and released after being tagged by USGS
- Since the project started in 2015 a total of 904,682 lbs of invasive carp have been removed, with 736,822 lbs coming from 2018, 2019, 2020, and 2021
- 527 bighead carp (BHCP), 5,990 silver carp (SVCP), 43 hybrid silver carp x bighead carp (SCBC), and 3,555 grass carp (GSCP) were harvested and removed in 2021, and additional 64 BHCP, 304 SVCP, and 105 GSCP were caught and released after being tagged by USGS
- The use of multiple crews (more than one fisherman) tended to increase catch per unit effort

- During sampling to support the SEAcarP model 381 SVCP, 16 BHCP, and 6 SCBC were captured and are being processed

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- 124 invasive carp transmitters implanted
- 542 Silver Carp weighing 13,014 pounds were removed from 9/19/2021-10/12/2021

Methods:

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Study site

Data were collected from September 2015 through December 2021 on Pools 14–20 of the UMR. The UMR is classified as the portion of the river above Cairo, Illinois to St. Anthony Falls near Minneapolis, Minnesota. The UMR consists of 29 locks and dams that vary in size and passage capability. The UMR has a drainage basin of 490,000 km^2 and at the mouth has a discharge of 5,796 m^3/s. Pools 14–19 of the Mississippi River are the border waters between Illinois and Iowa, while Pool 20 is the border water between Illinois and Missouri. Pool 14 is 47.0 km long and has an area of 41.6 km^2. It extends from Lock and Dam 13 near Clinton, IA to Lock and Dam 14 in Le Claire, IA. Pool 15 is 16.7 km long and covers an area of 14.7 km^2, extending from Lock and Dam 14 in Le Claire, IA to Lock and Dam 15 in Rock Island, IL. Pool 16 is 41.4 km long and occupies an area of 52.6 km^2. It extends from Lock and Dam 15 in Rock Island, IL to Lock and Dam 16 in Muscatine, IA. Pool 17 is 32.3 km long and covers 30.7 km^2 between Lock and Dam 16 in Muscatine, IA and Lock and Dam 17 near New Boston, IL. Pool 18 is 42.8 km long and covers 53.8 km^2. It is located between Lock and Dam 17 near New Boston, IL and Lock and Dam 18 in Gladstone, IL. Pool 19 extends 74.5 km and covers 123.3 km^2 from Lock and Dam 18 in Gladstone, IL to Lock and Dam 19 in Keokuk, IA. Pool 20 is approximately 34 km long and has an area of approximately 28.3 km^2 (Jahn and Anderson 1986). It extends from Lock and Dam 19 in Keokuk, IA to Lock and Dam 20 near Canton, MO. Pools 14–18 and 20 have similar aquatic habitats, while Pool 19 shows more similarities to pools further upriver (Pools 4–13), characterized by a higher average size of contiguous impounded and shallow aquatic areas than downstream pools (Koel 2001). Pools can be split into three distinct groups based on dominant aquatic habitat types: Pools 14, 18, and 20, Pools 15 and 17, and Pool 16. Pools 14, 18, and 20 have no contiguous impounded area, contiguous floodplain shallow aquatic area, or tertiary channel. Pools 15 and 17 have a small portion of the tertiary channel and contain a larger floodplain area than other pools. Pool 16 has more secondary channels than other pools (Koel 2001). Tributaries that contribute to Pools 14–19 of the Mississippi River include Wapsipinicon River (converges at Pool 14), Rock River (converges at Pool 16), Iowa River (converges at Pool 18), and Skunk River (converges at Pool 19).

Sample Collection

Fish were collected using nylon filament gillnets provided by Illinois Natural History Survey (INHS) biologists and contracted removal effort personnel. Net mesh sizes used were 3, 3.5, 4, 4.25, 4.5, 4.75, 5, 5.25, and 6-inch bar gillnets. Gillnets were set in a range of habitat areas (backwater, side channel, main channel border, and tributaries) to target bigheaded carp. Bigheaded carp were located using side-scan sonar, acoustic receivers (manual, stationary, and real-time), visual cues, and fishing areas that

have had historically high catch rates. The time nets were set and removed was recorded, along with mesh size, net height, length, color, and twine size. Dissolved oxygen, specific conductivity, and water temperature were measured at net locations using an YSI Pro 2030 meter (Yellow Springs, Ohio, USA), and GPS coordinates were taken using a Vemco VR-100 receiver (Bedford, Nova Scotia, Canada). Once set, the nets were either left overnight to fish ("dead set") or a method called "pounding" was employed which included driving fish towards the nets to scare them into the nets (Butler et al. 2019). Nets were then removed from the water, and fish were removed from the net. Fish collected from nets were identified to species, the number of fish per species was recorded, and the bulk weight of invasive carp by species was measured and recorded. To collect additional bycatch data, on certain days all collected fish were weighed to the nearest 10g and measured to the nearest mm. Invasive carp were removed from the system and bycatch were released back into the water at the capture location.

Statistical analyses

Relative weight (Wr) was calculated based on the available standard weight equation for each species. Grass carp could not be included in these analyses because standard weight equations do not exist for this species. Relative weight for a species was compared between years, and between pools per year. Box plots were constructed to display the Wr for each species between years, and between pools per year. Analysis of Variance (ANOVA) tests were performed to determine if Wr of species were statistically, significantly different (α=0.05) between years in all pools combined and in each pool separately. A Tukey's Post Hoc test (α=0.05) determined what years in each pool any difference in Wr existed.

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Study Site

Pools 20-26 of the Upper Mississippi River

Telemetry

Standardized electrofishing utilizing Long Term Resource Monitoring power goal settings was conducted to capture invasive carps for surgical insertion of transmitters. Up to 10 individual fish were captured at a time during electrofishing runs and placed into stock tanks with aeration, until the total goal for implanted transmitters at that location was met. Innovasea, (formerly Vemco), standardized acoustic telemetry equipment continues to be used including long-term V16-6H coded transmitters and Vr2Tx style receivers. Transmitter specifications were: Innovasea V16-6H Power H; Random Delay: 30 to 60 seconds, Loop back to step 1. Estimated tag life 1460 days. Both transmitter and receiver operate at the acoustic signal of 69 kHz. Transmitters were surgically implanted into the abdominal cavity of invasive carp by 1) removing scales near the incision then 2) with surgical scalpel, completing a lateral incision just above the pelvic fins large enough (i.e., 1.5-2 cm in length) to accept the transmitter. Three interrupted external surgical sutures were completed on the incision to improve healing and reduce transmitter expulsion. All transmitters were checked for ping rate and coded ID prior to inserting into the fish. Vr2Tx receivers were placed along sites utilizing platforms of opportunity. Suitable sites included locations of protected bankline (e.g., inside bend), large rock areas, and notable landmarks that improved chances of future retrieval. The receivers are further protected from damage by PVC encasement but allowing the end of the omni-directional hydrophone to be exposed. Cable (1/8-3/16-inch diameter) was used to anchor receivers to platforms of opportunity. The receiver was placed away

from the bankline in water depths that accounted for record drought cycles and anchored using a rock bag. Each receiver was labeled with MDC logo/property control number and has a visible tag on the bankline and anchor ends engraved with "MDC Equip".

Contracted harvest

Harvest was implemented using Silverfin Solutions, a not-for profit company who has completed contracted removal efforts in other states.

Text from Silverfin Solutions (SFS) below:

To conduct the work outlined in this agreement, SFS used a modified, electrified "dozer trawl" and accompanying tender boat to harvest invasive carp from MDC-designated target areas in upper Mississippi River pools (20, 21, 22) upstream from St. Louis, MO, and in lower Mississippi River areas downstream of St. Louis in the vicinity of New Madrid, MO (i.e., in waters along the state's eastern margin). Given that a few agencies have used smaller versions of the electrified dozer trawl to sample fish in other rivers and tributaries, we had reason to anticipate that our larger dozer trawl/tender boat system would enable us to remove appreciable numbers of invasive carp under big-river conditions.

In anticipation of future projects, and to acquire the equipment necessary to conduct several previously-funded Kentucky Lake projects scheduled for winter, 2021-22, SFS had ordered motors and make-specific machinery parts well in advance of being contacted and eventually contracted by the MDC in June, 2021. Our understanding was that most or all the parts and equipment would be received before or during August 2021. However, lingering COVID-19-related supply chain issues delayed the delivery of many items, including trucks, boat motors, and an assortment of parts. In fact, many of these orders went unfilled for the project's entire duration. Despite persistent communication with vendors and national searches for alternative suppliers, we never obtained the boat motors, trucks, and services we required to make our removal system fully operational and capable of maximizing harvest yields with optimal efficiency.

The modified dozer boat was equipped with electro-fishing equipment capable of delivering a wide range of AC and DC outputs. Electrical discharges were produced using a 7,000i Honda generator that fed power to an ETS electro-fishing box; this directed the AC or DC current to a multi-dropper electrode array, the specifications of which were dependent on water conductivity and depth. The droppers were mounted on fiberglass poles that extended a few meters in front of the net frame of the dozer trawl and consisted of several steel, detachable antennae mounted on a "T" fitting attached to the distal end of each dropper pole. The amount of current tested to assess effectiveness of the electrical field for stunning fish and keeping them from escaping the front opening of the net ranged from 1.3 to 24.0 in conjunction with 35 to 320 volts. Eventually, the electrical dropper arrays were adjusted to provide 40 volts at 7.0 amps, the most effective combination for the Dozer.

Two catch nets were attached side-by-side to a 2-m high x 4-m wide frame affixed to a lift system at the bow of the boat and raised or lowered using an electric hoist system. An elongated, cinchable mesh bag approximately 4 to 8 feet long was attached to each catch net. Stunned fish were collected in the catch nets and pushed into the bags by water flow as the dozer boat was operated at 2.5 – 4.0 mph. Full bags could either be removed from the catch nets or exchanged for empty ones or the bags were lifted with a hoist and emptied into mesh bags or tubs in either the Dozer boat or the tender boat.

All invasive carp were dispatched. Most invasive carp harvested in the lower Mississippi River sites were transferred to trailers and taken to farm fields for unloading. Two local farmers had enthusiastically offered to allow us to deposit our fish in their fields for fertilizer. On two dates, invasive carp collected were taken to the nearest boat ramp area soon after being harvested. The cinched bags of fish were tethered to floats and moored in the river for at least 12 hours. The bags were weighed the following day and transported to Two Rivers Fisheries in Wickliffe, Kentucky. The purpose was to determine if leaving fish in bags in the river would allow most to remain alive, giving time for transport trucks to arrive and for fish to accumulate to yield full loads. In exchange for our donation, Two Rivers Fisheries agreed to give us a report concerning the flesh quality of the fish when they were processed.

Results and Discussion:

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Contracted Commercial Removal

Low river conditions impacted our fishing efforts in 2021. Fortunately, COVID-19 restrictions did not affect fishing efforts as much as they did in 2020, and we were able to conduct our intensive harvest event from March 29-April 30. During intensive harvest, we contracted 3-4 fishermen crews during the peak period when bigheaded carp occupy backwater areas, which past data indicate can account for 1/3 of our yearly catch. Fishing efforts for 2021 began March 9 with ice-off and continued until December 17.

In 2021, we removed 10,115 invasive carp, weighing 208,623 lbs, from Pools 14–19 of the Mississippi River (Table 1, Table 2). An additional 458 Invasive carp weighing 10,907 lbs were released after being tagged by USGS (table 7). Silver carp were the most abundant invasive carp species removed from the UMR (5,990 fish; 116,516 lbs), followed by grass carp (3,555 fish; 75,537 lbs), bighead carp (527 fish; 15,655 lbs), and hybrid carp (43 fish; 915 lbs). A total of 17,504 bycatch fish were captured in gill nets and released, with the highest amount of bycatch caught in Pool 19 (7,374 fish; Table 3).

Contracted commercial efforts have been successful in removing large quantities of biomass annually from the UMR. Catch per unit effort (CPUE) has steadily risen from 2018 to 2020, but dropped in 2021, potentially due to a decrease in accessibility to backwaters where high abundances of fish are historically caught (Fig. 1). As contracted fishing moved upstream, the total CPUE generally decreased. The exception for this was Pools 16 and 17 in 2019, and Pool 18 in 2021. Pools 18 and 19 had the highest overall CPUE, and Pool 14 had the lowest CPUE, with only three invasive carp removed from Pool 14 from 2018 through 2021 (Fig. 2). These results suggest that Pools 18 and 19 are the key focal points for removing pressure from upstream movement and contain the highest densities.

The effectiveness of using one versus two or more fishing crews was analyzed using data from 2018 through 2021, which showed that CPUE generally increased with additional fishing crews (Fig. 3). Results from 2020 may be slightly biased because crews of three fishermen were generally used when the harvest was the lowest for the year. Comparison of CPUE between crews of 1-4 fishermen across years showed that in 2018, 2019, 2020, and 2021, a positive trend generally exists between the number of fishing crews and CPUE (Fig. 3).

Total removed weight was the highest it has ever been at 208,623 lbs. Due to our ability to have intensive harvest this year, and having more fishermen working for us, we were able to harvest the most fish we have in a year. We had the highest number of invasive carp removed (10,115) in 2021 compared to 2015–2021 data (Table 1, Table 2). The total removed invasive carp and CPUE calculations show the benefits of using additional fishermen to increase harvest efforts (Fig. 3). This effort is further supported by better prediction tools, such as real-time receivers deployed by our federal partners, and using telemetry data to help guide our efforts.

Acoustic Monitoring

We monitored acoustically tagged fish through three methods in Pools 14–19: Vemco VR100 detections during harvest (Table 10), recaptures of acoustically tagged individuals in nets during harvest (Table 9), and active tracking (Table 8). These data were used to monitor movements of invasive carp to assist in contracted commercial harvest efforts.

Active Tracking

We acoustically-tagged 150 bigmouth buffalo and 132 bigheaded carp from 6/10/2020 – 6/23/2020 in Pools 14, 15, and 19. In Pool 15, we tagged 18 bigmouth buffalo and 38 silver carp. In Pool 16, we tagged 132 bigmouth buffalo, 87 silver carp, 6 bighead carp, and 1 bighead x silver hybrid carp. In Pool 19, we tagged 30 bigmouth buffalo. In 2021, 30 silver carp were tagged in pool 19. We actively tracked in Pools 14–16 from May to July resulting in 314 detections (Table 8).

The combination of extended efforts of commercial removal crews along with acoustic telemetry data can provide great opportunities at removing congregated schools of bigheaded carp. Increasing acoustically transmitted bigheaded carp and stationary real-time receivers could benefit during increased removal events and help establish better population estimates in the UMR.

Acoustic tag recaptures

We recaptured 10 unique telemetered individuals during our commercial removal efforts in 2021. Five individuals were bighead carp, three individuals were silver carp, one individual was a bigmouth buffalo, and one individual was unknown (Table 9). Most fish were recaptured in Pool 16, primarily in Sunset Marina. All fish were released after capture in 2021.

Commercial fishing VR 100 detections

Our Vemco VR100 receiver was equipped with a portable omni-directional hydrophone (Vemco Model VH165) to detect the presence of acoustically tagged fish in areas where commercial removal efforts occurred. In 2021, we had 98 detections among five different species: bighead carp, silver carp, bighead x silver hybrid carp, bigmouth buffalo, and paddlefish. There were 7 bighead carp individuals, 27 silver carp individuals, 2 bighead x silver hybrid carp individual, 39 bigmouth buffalo individuals, and 7 paddlefish individuals captured from VR100 receiver (Table 10). Most of our bigheaded carp detections were captured in Pools 19.

SEAcarP

From 10/19/2021 to 12/8/2021 a total of 403 SVCP, BHCP, and SCBC were captured with the use of gillnets in Pools 16-19 to gather more information in support of the SEAcarP model. In Pool 16, 100 SVCP

were captured and 4 BHCP were captured for the model. In Pool 17, 80 SVCP, 1 SCBC, and 4 BHCP were captured. Ninty-four SVCP, and 1 BHCP were captured in Pool 18. In Pool 19 a total of 107 SVCP were captured, along with 5 SCBC and 7 BHCP. Fish were then brought to IRBS to be processed. Processing involved taking lengths and weights of fish, checking sex, weighing gonads, and removing aging structures. Aging structures are currently being processed.

Relative Weight of 4 Common Species Caught During Commercial Efforts

Bighead Carp

Bighead carp Wr decreased from 2015 to 2016, slightly increased from 2016 to 2017, slightly increased from 2017 to 2018, held steady from 2018 to 2019, and slightly increased from 2019 to 2020 and 2021 (Fig. 7). There was a statistical difference among years shown using an ANOVA (($p \leq 0.001$), $\alpha = 0.05$). A Tukey's test showed a difference between several years (Table 11).

In Pool 16, Wr appeared to increase from 2016 to 2017 (Fig. 8). Relative weight held steady in 2017–2019. There were no data available for 2015, and there were no statistically significant differences detected. In Pool 17, Wr dropped from 2015 to 2017, and increased again in 2018, then dropped in 2019; there was limited data for 2020 (Fig. 8). There was a significant difference found in the data (Table 12). In Pool 18, there were limited data for 2015. Wr was relatively steady in Pool 18 throughout the years (Fig. 8). There was no significant difference detected between years (Table 12). In Pool 19, Wr remained relatively stable across time but there were significant differences found in the data (Table 12). We have discontinued fishing in Pool 20 for bighead and silver carp.

There were low amounts of data associated with bighead carp due to low capture success using gill nets or abundance in these pools. More data are needed to analyze the effects of bighead carp in the UMR.

Silver Carp

Silver carp Wr (Fig. 9) has a steady trend throughout the years with little interannual variability, except for a slightly higher Wr in 2021. However, an ANOVA indicated significant differences in the data ($p \leq 0.001$, $\alpha = 0.05$). A Tukey's test revealed a significant difference between multiple years (Table 13).

In Pool 16, there were no data available for 2015, but a steady trend exists in silver carp Wr from 2017 to 2019 with a slight increase in 2021 (Fig. 10). An ANOVA indicated there was significant difference in the data. A Tukey's test revealed a significant difference between years (Table 14). In Pool 17, silver carp Wr remained steady throughout all years with a slight raise in 2021, a significant difference was found in the data (Table 14). In Pool 18, silver carp Wr was variable throughout the years. An ANOVA revealed significant differences in the data and a Tukey's test showed a difference between several of the years (Table 14). In Pool 19, silver carp Wr was variable between 2015 and 2019 with no apparent trend in the data, but there was a raise in Wr between 2019 and 2021. The ANOVA revealed a significant difference. A Post Hoc Tukey's test showed a significant difference between many of the years (Table 14).

Data are lacking in several areas of this data set. Raised Wr in 2020 and 2021 may be a symptom of low sample numbers focused mostly in the spring of the year when fish are plump and preparing to spawn. To continue to monitor Wr, data must be taken diligently and at appropriate times. Continued collections are needed to continue to monitor silver carp Wr and the effects they have on other species.

Bigmouth Buffalo

Bigmouth buffalo show relatively stable Wr throughout all years of sampling (Fig. 11). There was a significant difference found in the data with an ANOVA ($p=0.005$, $\alpha = 0.05$), a Tukey's test showed a significant difference between 2021 and 2017 (Table 15).

When examining the data between pools and years, Wr appeared variable. In Pool 16, there were no data from 2015 or 2020. A slight upward trend in Wr existed from 2016 to 2019 in Pool 16, but there was no significant difference shown in the ANOVA. In Pool 17, the Wr of bigmouth buffalo appeared variable throughout the years (Fig. 12). The ANOVA indicated a significant difference in the data ($p\leq0.001$), and the Post Hoc Tukey's test showed a significant difference between several years (Table 16). There were no data available for 2020. In Pool 18, there were no data available for 2015. Throughout 2016, 2017, and 2018, Wr appeared to be stable (Fig. 12). The ANOVA showed no significant difference between any of the years in Pool 18 ($p=0.005$). Post Hoc Tukey's test showed a significant difference between 2019 and 2021 ($p=.004$) (Table 16). In Pool 19, Wr was variable (Fig. 12). The ANOVA ($p\leq0.001$) and Post Hoc Tukey's test ($p=0.001$) indicated a difference between the years of data (Table 16).

Paddlefish

For paddlefish, there were no data in 2015 for Pools 16, 18, and 19 and limited data for 2020 due to COVID restrictions. Paddlefish showed a slightly decreasing trend in Wr from 2015 to 2017 and an increasing trend from 2017 to 2019 when all the Pools were combined (Fig. 13). The ANOVA showed significant differences ($p<0.001$, $\alpha = 0.05$) between the years (Table 17).

In Pool 16, paddlefish Wr was variable throughout the years (Fig. 14). An ANOVA indicated no significant difference between years in Pool 16. In Pool 17, paddlefish Wr appeared steady. However, an ANOVA showed a significant difference in the data ($p<0.001$). A Tukey's test revealed a significant difference between many of the years in pool 17 (Table 18. In Pool 18, there were no data for 2015 and limited data for 2018 and 2021. An ANOVA ($p<0.001$) showed a significant difference in the data, and a Tukey's test revealed a difference between 2016 and 2019 ($p<0.001$), and between 2017 and 2019 ($p=0.01$) (Table 18). In Pool 19, a significant difference was detected between 2016 and 2018 ($p=0.004$) (Table x).

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Transmitter(s), receiver(s), and detection(s) data were shared with multi-basin partners to improve coordination, control, and management of large river fish species (including invasive carps) through movement pattern and habitat utilization.

Additional telemetry receivers were deployed above and below each of the locks and dams (Figure 12; Table 19). Existing receiver stations on bridge piers (e.g., Chester, Hannibal), lock chamber (e.g., LD19) and within tributaries (e.g., Des Moines, Meramec) were maintained and data shared with sub-basin partners. One-hundred-twenty-four transmitters were implanted in invasive carp (123 silver; 1 bighead carp) within the Upper Mississippi River (Table 20). All fish were measured, weighed, sexed, and a t-bar inserted in the dorsal fin for external ID. These captures and implants were dispersed across each pool: Pool 20-Pool 26. Mean length of implanted silver carp was 698 mm with mean weight of 3948 grams. The single bighead carp was 782 mm and 4600 grams and was female. Silver carp sex demographic was 68 female and 55 male.

Contracted Harvest (Silverfin solutions text below)

Silverfin Solutions harvest efforts in the Upper Mississippi River were conducted from September 19 through October 12, 2021 (Table 21). Transects were run on 14 days and 1 night. A total of 123 transects were completed; Pool 20 (n=30), Pool 21 (n=29), Pool 22 (n=64). A total of 13,014 pounds of invasive carp were harvested in 982 minutes of pedal time.

Samples of invasive carp were taken in each pool to determine if size and weight differences exist among the areas harvested. In general, the carp were larger in Pool 21 than the other pools (Table 22).

A considerable amount of each day's effort was spent searching for aggregations of fish. Finding aggregations in Pool 21 was particularly more difficult than pools 20 and 22, and sonar fish surveillance scans indicated it contained fewer and smaller aggregations of invasive carp. In Pools 20 and 22, fish aggregations were more prevalent in some areas, but were usually smaller and more distant from other aggregations. Invasive carp aggregations in the upper pools were most often associated with side channel habitats. Occasionally, however, in all pools invasive carp were found within 100 feet of the shore in deeper water associated with either the main channel or outside bends of side channels with water current. Although most of the carp were often deeper than the Dozer's effective electrical field, we experienced a few transect runs that yielded fairly high amounts of carp. It is unclear whether the fish were compelled to rise to the field or if there were enough fish located in the effective field range to provide the decent yields.

The Dozer typically pushed carp from aggregation areas while running transects and harvesting fish. Therefore, areas were rarely successfully worked twice in a particular day, a significant factor in daily harvests. This meant we had to locate several carp aggregation areas each day to be able to stay in fish. This was true regardless of where we worked. In the upper pools, it was more difficult to locate several large aggregations daily, most evident in Pool 21 where daily harvest rates (487 lbs/hr) averaged lowest of all pools/areas worked. In pools 20 and 22, carp were more numerous, but locating more than one aggregation in a day was also challenging. Habitats in the pools were not limiting fish to the same areas, or at least they were not as compelled to return to the same areas as routinely.

The experiment with Two Rivers Fisheries for which carp were held in mesh bags for at least 12 hours prior to deliver to the processor had very positive results. Most of the fish remained alive during holding, and Two Rivers Fisheries indicated the quality of the fish at delivery as excellent. This was even though the fish were transferred from bags to totes with ice at Two Rivers and not examined until the following day. Therefore, there is great utility in using detachable mesh bags on the Dozer in conjunction with a tender boat operation to pick up bags, quickly transport the fish to holding areas near the truck pickup points and place the bags in the water until being transported. Fish quality is important for most processors, whether the fish are to be processed into fish meal or used for it or food.

Telemetry efforts continue to improve given the addition of receivers allows for better detection of transmitter fishes in the UMR. Maintenance through download and data archival is critical to ensure project success. Allowing a receiver station to go unchecked longer than three months is not advised.

We did not collect age data from the UMR. The researcher in charge of these projects suffered severe injury during November 2020; did not return to work until March 2021; then departed employment with the agency in June 2021. We did acknowledge this short-fall with UMR basin partners who agreed that

we could forego this sampling. We remain hopeful that we will be able to recruit an employee by March 2022 to assist in completing these and other efforts.

Information to improve contracted harvest measures is needed. Programs to engage commercial fishers or other entities has largely fallen short of harvest goals. Market instability decreases commercial fishing likelihood for participation because of return on investment. Existing contracted removal efforts through SFS was largely experimental and a learning process. Innovative methods, participation, and monetary incentive will all be important to improving contracted harvest for control and management of invasive carp.

Leveraged telemetry projects (e.g., Towboat telemetry, Pallid sturgeon), ongoing partner data collection (e.g., LTRM, MOPSPAP), and basin wide coordination (e.g., MICRA) are all needed to contribute to our data gap conversations for improving our large river resources.

Combining limited resources in coordinated standards will be the most effective tools against our changing landscapes with invasive species encroachment.

Recommendation:

It is recommended that commercial removal efforts continue to reduce the number of bigheaded carp in Pools 16–19 of the Upper Mississippi River (low-density management zone). It is also recommended that efforts continue to determine the relationship between bigheaded carp and commonly encountered bycatch. This information is important to collect to target bigheaded carp more effectively and efficiently while trying to avoid harming other ecologically and commercially important species.

It is recommended to continue contracting commercial fishermen and increase the number of fishermen per sampling event to increase the total likelihood of bigheaded carp captured. Having additional acoustically tagged bigheaded carp and real-time receivers can offer greater capture success by identifying where schools of bigheaded carp are daily and provide better population estimates.

References:

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Jahn, L. A., and R. V. Anderson. 1986. The Ecology of Pools 19 and 20, Upper Mississippi River: A Community Profile. Biological Report 85(7.6):142.

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Tables and Figures:

Table 1. *Total weight (lbs) of invasive carp removed from Pools 14–19 on the Upper Mississippi River from 2015 through 2021. Invasive carp are broken down by bighead carp (BHCP), silver carp (SVCP), grass carp (GSCP), and bighead x silver carp (Hybrid). Unsorted weight is an accumulated weight of all species weight when there was no ability to sort by species.*

Year	BHCP	SVCP	GSCP	Hybrid	Unsorted	Total
2015	205.9	1168.1	192.4	0	0	1566.4
2016	18800.3	38274.4	12488.9	1509.5	0	71073.1
2017	15361.5	32726.2	19621.1	405.0	27106.9	95220.7
2018	26029.1	98798.9	49887.6	482.0	13071.1	188271.7
2019	24308.0	90280.1	53739.3	613.8	1786.1	170727.2
2020	13092.6	120461.3	35223.8	421.8	0	169199.4
2021	15655.5	116516.0	75537.2	915.05	0	208623.7
Totals	113452.8	498225.1	246690.2	4347.1	41967.1	**904,682.3**

Table 2. *Total number of invasive carp captured and removed using gill nets in Pools 14–20 of the Upper Mississippi River from 2015 through 2021.*

Year	Pool	Bighead Carp	Silver Carp	Hybrid Carp	Grass Carp	Total
2015	14	0	0	0	0	0
	15	0	0	0	0	0
	16	0	0	0	0	0
	17	1	3	0	0	4
	18	0	6	0	0	6
	19	6	56	0	9	71
	20	3	4	0	0	7
Total		**10**	**69**	**0**	**9**	**88**
2016	14	0	0	0	0	0
	15	0	0	0	0	0
	16	0	0	0	8	8
	17	22	66	1	54	143
	18	95	136	3	119	353
	19	180	1781	18	450	2429
	20	57	255	1	44	357
Total		**354**	**2238**	**23**	**675**	**3290**
2017	14	0	0	0	0	0
	15	0	0	0	0	0
	16	13	33	1	51	98
	17	106	342	3	37	488
	18	19	64	0	14	97
	19	70	395	0	347	812
	20	0	0	0	0	0
Total		**208**	**834**	**4**	**449**	**1495**
2018	14	2	0	0	0	2
	15	0	0	0	0	0
	16	64	330	2	127	523
	17	119	531	4	157	811
	18	266	1061	2	690	2019
	19	305	3078	22	1275	4680
	20	0	0	0	0	0
Total		**756**	**5000**	**30**	**2249**	**8035**
2019	14	0	0	0	0	0
	15	2	36	0	4	46
	16	116	364	2	115	597
	17	44	240	1	27	306
	18	372	1556	5	379	2313
	19	302	3637	19	2113	6056
	20	0	0	0	0	0
Total		**836**	**5843**	**27**	**2638**	**9318**
2020	14	0	1	0	0	1

	15	2	8	0	2	12
	16	77	626	2	92	797
	17	83	819	2	75	979
	18	65	1139	4	161	1369
	19	246	4582	19	1546	6393
	20	0	0	0	0	0
Total		**473**	**7175**	**27**	**1876**	**9551**
2021	14	0	0	0	0	0
	15	0	4	0	6	10
	16	26	628	3	268	925
	17	91	660	7	97	855
	18	60	356	5	147	568
	19	350	4342	28	3037	7757
	20	0	0	0	0	0
Total		**527**	**5990**	**43**	**3555**	**10115**
Total		**3164**	**27149**	**154**	**11451**	**41918**

Table 3. *Total number of bycatch species captured using gill nets during contracted commercial removal of invasive carp in Pools 14–20 of the Upper Mississippi River from 2015 through 2021.*

Family/Species	2015	2016	2017	2018	2019	2020	2021	Total
Acipenseridae								
Lake Sturgeon			1	1		2	4	8
Shovelnose Sturgeon				1	2		2	5
Amiidae								
Bowfin		7	3	16	6	15	5	52
Catostomidae								
Bigmouth Buffalo	79	822	2134	2417	1985	2470	4274	14181
Black Buffalo		226	1019	953	859	1247	1379	5683
Golden Redhorse				1				1
Quillback		6	2		7	3		18
River Carpsucker	16	89	64	143	82	43	125	562
River Redhorse				1				1
Shorthead Redhorse		2			2			4
Smallmouth Buffalo	19	321	3237	1183	974	2502	2959	11195
Centrarchidae								
Black Crappie				1	4	2		7
Bluegill					2		1	3
Largemouth Bass	1	5	1	7	11	7	2	34
Smallmouth Bass					1	2	1	4
White Crappie		1	6	3	2		2	14
Clupeidae								
Gizzard Shad	4	8	11	11	8	5	9	56
Cyprinidae								
Common Carp	83	1460	2273	3819	3964	3457	3012	18068
Goldfish			1		2	2	1	6
Hiodontidae								
Mooneye			3	13	13	1	9	39
Ictaluridae								
Brown Bullhead						1		1
Channel Catfish	1	55	34	102	91	72	149	504
Flathead Catfish		4	37	145	90	87	58	421
Lepisosteidae								
Longnose Gar	21	33	27	124	111	138	135	589
Shortnose Gar	37	33	28	109	179	267	151	804
Moronidae								
Striped x White Bass	1		2	24	52	31	5	110
White Bass	1	5	3	7	3	1		20
Sciaenidae								
Freshwater Drum	68	350	806	1847	3108	2009	2396	10584
Esocidae								
Northern Pike		17	28	64	67	28	67	271
Polyodontidae								

Paddlefish	5	1010	2077	2989	2087	1319	2671	12158
Percidae								
Sauger			1	3	7		6	17
Walleye	3	1	1	21	14	10	80	130
Total	339	4455	11799	14005	13733	13721	17504	**75556**

Table 4. *Total invasive carp gill netting effort in Pools 14–19 of the Upper Mississippi River in 2019. Invasive carp are broken down by bighead carp (BHCP), silver carp (SVCP), grass carp (GSCP), and bighead x silver carp (HYBRID). Unsorted weight is an accumulated weight of all species weight when there was not an ability to sort by species.*

2019	Pool 19	Pool 18	Pool 17	Pool 16	Pool 15	Pool 14	Total
Netting Effort							
Total Yards of Net	190,610	83,025	34,200	40,560	4,400	3,950	356,745
Catch Effort (Removed)							
Total IC (N)	6,071	2,322	312	597	42	0	9,344
Total IC Weight (kg)	48,131	19,605	2,794	5,763	323	0	76,617
Average IC Weight (kg)	7.9	8.4	9.0	9.7	7.7	0	8.2
Total Unsorted IC Weight (kg)	0	810	0	0	0	0	810
Total BHCP (N)	302	372	44	116	2	0	836
Total BHCP Weight (kg)	3,129	5,794	639	1,424	38	0	11,024
Average BHCP Weight (kg)	10.4	15.6	14.5	12.3	19.0	0	13.2
Total SVCP (N)	3,637	1,566	240	364	36	0	5,843
Total SVCP Weight (kg)	25,254	10,831	1,836	2,771	253	0	40,943
Average SVCP Weight (kg)	6.9	6.9	7.7	7.6	7.0	0	7.0
Total HYBRID (N)	19	5	1	2	0	0	27
Total HYBRID Weight (kg)	198	55	17	8	0	0	278
Average HYBRID Weight (kg)	10.4	11.0	17.0	4.0	0	0	10.3
Total GSCP (N)	2,113	379	27	115	4	0	2,638
Total GSCP Weight (kg)	19,551	2,926	303	1,561	32	0	24,372
Average GSCP Weight (kg)	9.3	7.7	11.2	13.6	8.0	0	9.2
Catch per unit of effort							
CPUE (BHCP/100 yds of net)	0.16	0.45	0.13	0.29	0.05	0	0.23
CPUE (SVCP/100 yds of net)	1.91	1.89	0.70	0.90	0.82	0	1.64
CPUE (HYBRID/100 yds of net)	0.01	0.006	0.003	0.005	0	0	0.008
CPUE (GSCP/100 yds of net)	1.11	0.46	0.08	0.28	0.09	0	0.74
CPUE (Total IC/100 yds of net)	3.19	2.80	0.91	1.47	0.95	0	2.62

Table 5. *Total invasive carp gill netting effort in Pools 14–19 of the Upper Mississippi River in 2020. Invasive carp are broken down by bighead carp (BHCP), silver carp (SVCP), grass carp (GSCP), and bighead x silver carp (HYBRID). Unsorted weight is an accumulated weight of all species weight when there was not an ability to sort by species.*

2020	Pool 19	Pool 18	Pool 17	Pool 16	Pool 15	Pool 14	Total
Netting Effort							
Total Yards of Net	164680	39830	41130	34590	8050	5060	293340
Catch Effort (Removed)							
Total IC (N)	6393	1369	979	797	12	1	9551
Total IC Weight (kg)	52569	10578	8339	6126	80	8	77700
Average IC Weight (kg)	8.5	7.7	8.5	7.7	6.7	8.0	8.3
Total Unsorted IC Weight (kg)	0	0	0	0	0	0	0
Total BHCP (N)	246	65	83	77	2	0	473
Total BHCP Weight (kg)	2908	852	1272	906	25	0	5964
Average BHCP Weight (kg)	11.8	13.1	15.3	11.8	12.5	0	12.7
Total SVCP (N)	4582	1139	819	626	8	1	7175
Total SVCP Weight (kg)	36180	8257	6447	4271	43	8	55206
Average SVCP Weight (kg)	7.9	7.2	7.9	6.8	5.4	8.0	7.8
Total HYBRID (N)	19	4	2	2	0	0	27
Total HYBRID Weight (kg)	137	30	25	0	0	0	191
Average HYBRID Weight (kg)	7.2	7.5	12.5	0	0	0	7.1
Total GSCP (N)	1546	161	75	92	2	0	1876
Total GSCP Weight (kg)	13344	1439	596	949	11	0	16339
Average GSCP Weight (kg)	8.6	8.9	7.9	10.3	5.5	0	9.0
Catch per unit of effort							
CPUE (BHCP/100 yds of net)	0.15	0.16	0.20	0.22	0.025	0	0.16
CPUE (SVCP/100 yds of net)	2.78	2.86	2.00	1.81	0.10	0.02	2.45
CPUE (HYBRID/100 yds of net)	0.01	0.01	0.01	0.01	0	0	0.01
CPUE (GSCP/100 yds of net)	0.94	0.40	0.18	0.27	0.025	0	0.64
CPUE (Total IC/100 yds of net)	3.88	3.44	2.40	2.30	0.15	0.020	3.26

Table 6. *Total invasive carp gill netting effort in Pools 14–19 of the Upper Mississippi River in 2021. Invasive carp are broken down by bighead carp (BHCP), silver carp (SVCP), grass carp (GSCP), and bighead x silver carp (HYBRID). Unsorted weight is an accumulated weight of all species weight when there was not an ability to sort by species.*

2021	Pool 19	Pool 18	Pool 17	Pool 16	Pool 15	Pool 14	Total
Netting Effort							
Total Yards of Net	242290	49610	52970	68500	7240	10830	431440
Catch Effort (Removed)							
Total IC (N)	7757	568	855	925	10	0	10115
Total IC Weight (kg)	74490	3714	8261	8057	90	0	94613
Average IC Weight (kg)	9.6	6.5	9.7	8.7	9	0	9.3
Total Unsorted IC Weight (kg)	0	0	0	0	0	0	0
Total BHCP (N)	350	60	91	26	0	0	527
Total BHCP Weight (kg)	4510	735	1512	343	0	0	8000
Average BHCP Weight (kg)	12.9	12.3	16.6	13.2	0	0	15.2
Total SVCP (N)	4342	356	660	628	4	0	5990
Total SVCP Weight (kg)	39523	2182	5804	5305	28	0	52842
Average SVCP Weight (kg)	9.1	6.1	8.8	8.4	7	0	8.8
Total HYBRID (N)	28	5	7	3	0	0	27
Total HYBRID Weight (kg)	322	51	72	17	0	0	415
Average HYBRID Weight (kg)	11.5	10.2	10.3	5.6	0	0	10.5
Total GSCP (N)	3037	147	97	268	6	0	3555
Total GSCP Weight (kg)	30135	747	909	2404	62	0	34257
Average GSCP Weight (kg)	9.9	5.1	9.4	9.0	10.3	0	9.6
Catch per unit of effort							
CPUE (BHCP/100 yds of net)	0.14	.12	0.17	0.04	0	0	0.12
CPUE (SVCP/100 yds of net)	1.8	.71	1.26	.92	0.05	0	1.4
CPUE (HYBRID/100 yds of net)	0.01	0.01	0.01	0.013	.004	0	.01
CPUE (GSCP/100 yds of net)	1.25	.3	.2	.4	.08	0	.82
CPUE (Total IC/100 yds of net)	3.2	1.1	1.6	1.3	0.14	0	2.34

Table 7. *Fish captured, tagged, and released in Pools 16-19 of the Mississippi River in 2021*

Year	Species	Number	Weight
2021	Silver Carp	304	6441 lbs
	Bighead Carp	64	2001lbs
	Grass Carp	105	2465 lbs
	Total	473	10907 lbs
Total		473	10907 Lbs

Table 8. *Detections of fish species from active tracking in Pools 14–16 in the Upper Mississippi between May through July 2021 using a VR100.*

Active Tracking Detections	
Species	Detections
BMBF	132
SVCP+BHCP +SCBC	94
PDFH	88
Total	314

Table 9. *Number of tagged bigheaded carp captured (release/killed) from commercial removal efforts in Pools 16–19 in the Upper Mississippi River from 2018 through 2021.*

USFWS/USGS Acoustically Tagged Fish Recaptures																					
	2018					2019					2020					2021					Total Removed
Pool	**15**	**16**	**17**	**18**	**19**	**15**	**16**	**17**	**18**	**19**	**15**	**16**	**17**	**18**	**19**	**15**	**16**	**17**	**18**	**19**	
BHCP	0	1	8	6	2	0	1	1	3	0	0	3	1	0	1	0	2	1	0	2	10
BMBF	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3	0	0	0	0
SCBC	0	0	1	4	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
SVCP	0	1	12	7	4	0	0	0	2	1	0	2	1	0	0	0	1	0	0	0	6
Unknown	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Total Detections	0	2	21	17	6	0	1	1	5	2	2	5	2	0	1	0	7	1	0	2	15

Table 10. *Number of fish detections from the VR100 receiver during commercial removal efforts in Pools 16–19 in the Upper Mississippi River from 2018 through 2021.*

VR100 Detections																			
	2018					**2019**					**2020**					**2021**			
Pool	**15**	**16**	**17**	**18**	**19**	**15**	**16**	**17**	**18**	**19**	**15**	**16**	**17**	**18**	**19**	**15**	**16**	**17**	**18**	**19**
BHCP	0	1	2	3	7	0	1	3	6	2	0	3	1	0	0	0	1	1	2	5
BMBF	0	0	0	0	0	0	0	0	0	0	0	4	1	0	0	3	36	2	0	3
GSCP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PDFH	0	15	0	0	1	0	3	3	0	1	0	2	0	0	1	0	7	0	0	0
SCBC	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	1	0
SVCP	0	4	4	5	8	0	0	3	4	10	0	2	2	0	1	1	13	4	8	9
Total Detections	0	20	7	8	16	0	4	9	10	13	0	12	4	0	2	4	59	7	22	17

Table 11. *Bighead Carp Wr comparison by year in pools 16-19 of the Mississippi River from 2015-2021*

Year	diff	lwr	upr	p.adj
2016-2015	-6.04002	-15.9137	3.833674	0.543111
2017-2015	-5.47562	-15.5453	4.594065	0.677929
2018-2015	-4.17324	-14.2429	5.896445	0.884565
2019-2015	-4.12604	-14.4355	6.183469	0.900692
2020-2015	-1.66005	-20.8217	17.50163	0.999977
2021-2015	0.88982	-9.39011	11.16975	0.999977
2017-2016	0.5644	-3.34759	4.476388	0.999541
2018-2016	1.86678	-2.04521	5.778768	0.796433
2019-2016	1.913983	-2.57946	6.407424	0.870434
2020-2016	4.379978	-12.3853	21.14526	0.987532
2021-2016	6.929843	2.504684	11.355	8.66E-05
2018-2017	1.30238	-3.08081	5.685572	0.975776
2019-2017	1.349583	-3.55956	6.258731	0.98373
2020-2017	3.815578	-13.0659	20.69703	0.99426
2021-2017	6.365443	1.518717	11.21217	0.002143
2019-2018	0.047203	-4.86194	4.956351	1
2020-2018	2.513198	-14.3683	19.39465	0.99945
2021-2018	5.063063	0.216337	9.909789	0.033938
2020-2019	2.465994	-14.5596	19.49159	0.99953
2021-2019	5.01586	-0.31125	10.34297	0.080336
2021-2020	2.549865	-14.4578	19.55757	0.999427

Table 12. *Bighead carp Wr comparison between years within pools in pools 16-19 of the Mississippi river from 2015 to 2021.*

Pool	Year	diff	lwr	upr	p.adj
Pool 16	2018-2017	0.192561	-8.62916	9.014283	0.999933
	2019-2017	-3.57548	-13.9309	6.779902	0.802922
	2021-2017	-5.478	-43.2323	32.27628	0.981241
	2019-2018	-3.76804	-14.9781	7.442028	0.815364
	2021-2018	-5.67056	-43.6682	32.32703	0.979654
	2021-2019	-1.90253	-40.2852	36.48013	0.999215
Pool 17	2016-2015	-12.96328645	-30.23909645	4.312523556	0.256687829
	2017-2015	-19.10162026	-37.05813692	-1.145103594	0.03012969
	2018-2015	-13.64265724	-39.26682444	11.98150996	0.635778485
	2019-2015	-22.22748981	-49.83405813	5.37907851	0.188659674
	2021-2015	-5.259925267	-22.38079214	11.86094161	0.947682684
	2017-2016	-6.138333812	-18.46276362	6.186095992	0.69898281
	2018-2016	-0.67937079	-22.72598105	21.36723947	0.999999173
	2019-2016	-9.264203364	-33.5865736	15.05816687	0.878004549
	2021-2016	7.70336118	-3.368186218	18.77490858	0.338237922
	2018-2017	5.458963022	-17.12501146	28.04293751	0.981360684
	2019-2017	-3.125869552	-27.93636276	21.68462366	0.999121322
	2021-2017	13.84169499	1.735413926	25.94797606	0.015313459
	2019-2018	-8.584832574	-39.40239295	22.2327278	0.965353941
	2021-2018	8.38273197	-13.54267556	30.3081395	0.876285848
	2021-2019	16.96756454	-7.244997588	41.18012667	0.330240617
Pool 18	2016-2015	-9.48369896	-46.83558021	27.86818229	0.988892281
	2017-2015	-5.090158045	-42.59072522	32.41040913	0.999663921
	2018-2015	-12.9606524	-51.96786223	26.04655743	0.956596759
	2019-2015	-5.108260931	-42.55062965	32.33410779	0.999653846
	2020-2015	1.156869986	-41.78865461	44.10239458	0.999999977
	2021-2015	-5.303595447	-43.15382582	32.54663493	0.999596087
	2017-2016	4.393540915	-1.520716976	10.30779881	0.295536118
	2018-2016	-3.476953439	-15.73453585	8.780628973	0.98022765
	2019-2016	4.375438028	-1.157814484	9.908690541	0.225045389
	2020-2016	10.64056895	-11.10808598	32.38922387	0.772296282
	2021-2016	4.180103512	-3.650978634	12.01118566	0.692023939
	2018-2017	-7.870494353	-20.57395185	4.832963139	0.522290656
	2019-2017	-0.018102886	-6.479247448	6.443041675	1
	2020-2017	6.247028031	-15.75600578	28.25006184	0.980135006
	2021-2017	-0.213437402	-8.725508435	8.29863363	0.999999985
	2019-2018	7.852391467	-4.678221815	20.38300475	0.50811415
	2020-2018	14.11752238	-10.3651935	38.60023827	0.608357998
	2021-2018	7.657056951	-6.044228881	21.35834278	0.643572969

	2020-2019	6.265130918	-15.63856589	28.16882772	0.979367672
	2021-2019	-0.195334516	-8.447230675	8.056561644	0.99999999
	2021-2020	-6.460465433	-29.05428977	16.1333589	0.979401262
Pool 19	2016-2015	4.299717679	-9.912453244	18.5118886	0.972942013
	2017-2015	-1.697962539	-16.81208566	13.41616058	0.999890094
	2018-2015	7.201465919	-7.04940195	21.45233379	0.74611113
	2019-2015	-1.382700889	-17.99873081	15.23332903	0.999981248
	2020-2015	2.979494515	-23.49407846	29.45306749	0.999888925
	2021-2015	11.25286665	-3.561251662	26.06698497	0.270768754
	2017-2016	-5.997680219	-12.93602771	0.940667275	0.14074016
	2018-2016	2.901748239	-1.872262992	7.675759471	0.547797033
	2019-2016	-5.682418569	-15.46998203	4.105144889	0.602480557
	2020-2016	-1.320223164	-24.135876	21.49542967	0.999997836
	2021-2016	6.953148974	0.695190067	13.21110788	0.018499424
	2018-2017	8.899428458	1.882157009	15.91669991	0.003691069
	2019-2017	0.31526165	-10.74128907	11.37181237	0.999999969
	2020-2017	4.677457055	-18.71067946	28.06559357	0.997002396
	2021-2017	12.95082919	4.850646168	21.05101222	6.17E-05
	2019-2018	-8.584166808	-18.4278364	1.259502786	0.133515463
	2020-2018	-4.221971403	-27.06174913	18.61780633	0.998068899
	2021-2018	4.051400734	-2.293950503	10.39675197	0.48657079
	2020-2019	4.362195405	-20.02346969	28.7478605	0.998394604
	2021-2019	12.63556754	1.992790766	23.27834432	0.008718194
	2021-2020	8.273372138	-14.92202209	31.46876636	0.939957888

Table 13. *Silver Carp Wr comparison by year in pools 16-19 of the Mississippi River from 2015-2021*

Year	diff	lwr	upr	p.adj
2016-2015	-5.07075	-7.87134	-2.27015	2.01E-06
2017-2015	-3.90117	-6.76179	-1.04056	0.001143
2018-2015	0.961118	-1.85472	3.77695	0.952653
2019-2015	-4.38534	-7.37364	-1.39704	0.000307
2020-2015	0.592935	-3.96066	5.146529	0.999751
2021-2015	8.733039	5.755014	11.71106	0
2017-2016	1.169573	-0.48806	2.827209	0.364134
2018-2016	6.031865	4.45277	7.61096	0
2019-2016	0.685408	-1.18397	2.554782	0.933717
2020-2016	5.663683	1.752181	9.575184	0.000396
2021-2016	13.80379	11.95088	15.65669	0
2018-2017	4.862292	3.179041	6.545543	0
2019-2017	-0.48416	-2.44232	1.473986	0.990822
2020-2017	4.49411	0.539412	8.448808	0.014209
2021-2017	12.63421	10.69178	14.57665	0
2019-2018	-5.34646	-7.23858	-3.45433	0
2020-2018	-0.36818	-4.29061	3.554243	0.999963
2021-2018	7.771921	5.896066	9.647776	0
2020-2019	4.978275	0.930258	9.026292	0.005366
2021-2019	13.11838	10.99238	15.24437	0
2021-2020	8.140103	4.099666	12.18054	6.23E-08

Table 14. *Silver carp Wr comparison between years within pools in pools 16-19 of the Mississippi river from 2015 to 2021.*

Pool	Year	diff	lwr	upr	p.adj
Pool 16	2018-2017	3.856282	-1.38824	9.100805	0.230913
	2019-2017	1.687535	-3.5329	6.907972	0.838247
	2021-2017	7.883505	2.270954	13.49606	0.001858
	2019-2018	-2.16875	-7.33778	3.000284	0.700423
	2021-2018	4.027223	-1.53755	9.591991	0.243931
	2021-2019	6.19597	0.653896	11.73804	0.021451
Pool 17	2016-2015	-0.01741	-9.37691	9.342084	1
	2017-2015	-1.59048	-10.1822	7.001224	0.995026
	2018-2015	-0.98225	-10.4708	8.506264	0.999698
	2019-2015	1.147871	-12.0903	14.38601	0.999873
	2021-2015	9.299597	0.771463	17.82773	0.023316
	2017-2016	-1.57307	-6.53677	3.390633	0.94525
	2018-2016	-0.96484	-7.35646	5.426786	0.998112
	2019-2016	1.165285	-10.0628	12.39335	0.999694
	2021-2016	9.31701	4.464175	14.16985	8.08E-07
	2018-2017	0.608229	-4.59466	5.811116	0.999452
	2019-2017	2.738352	-7.85818	13.33489	0.977161
	2021-2017	10.89008	7.764827	14.01533	7.07E-13
	2019-2018	2.130123	-9.20571	13.46595	0.994664
	2021-2018	10.28185	5.184621	15.37908	1.71E-07
	2021-2019	8.151726	-2.39333	18.69678	0.235118
Pool 18	2016-2015	-5.60021	-18.8503	7.64989	0.874037
	2017-2015	-8.03435	-19.7095	3.640773	0.393268
	2018-2015	-1.2035	-13.3836	10.9766	0.999949
	2019-2015	-2.38423	-14.1895	9.421009	0.996887
	2020-2015	0.824893	-13.0787	14.72852	0.999998
	2021-2015	7.058665	-4.66569	18.78302	0.561643
	2017-2016	-2.43415	-10.1879	5.31956	0.967919
	2018-2016	4.396704	-4.09837	12.89177	0.726151
	2019-2016	3.215978	-4.73229	11.16425	0.89539
	2020-2016	6.425099	-4.3972	17.2474	0.578449
	2021-2016	12.65887	4.831229	20.48651	4.39E-05
	2018-2017	6.830853	1.094148	12.56756	0.008301
	2019-2017	5.650127	0.759464	10.54079	0.011915
	2020-2017	8.859248	0.035088	17.68341	0.048349
	2021-2017	15.09302	10.40095	19.78509	0
	2019-2018	-1.18073	-7.17779	4.81634	0.997298
	2020-2018	2.028395	-7.4538	11.51059	0.995723
	2021-2018	8.262166	2.425921	14.09841	0.000637
	2020-2019	3.209121	-5.78648	12.20472	0.94065
	2021-2019	9.442893	4.435842	14.44994	7.49E-07

	2021-2020	6.233772	-2.65542	15.12297	0.369368
Pool 19	2016-2015	-5.32822	-8.32217	-2.33426	3.37E-06
	2017-2015	-4.18464	-7.46083	-0.90845	0.003169
	2018-2015	1.252685	-1.78639	4.291762	0.88825
	2019-2015	-6.09027	-9.41234	-2.76821	1.44E-06
	2020-2015	-0.01184	-5.05222	5.028541	1
	2021-2015	10.50273	6.319408	14.68604	3.55E-08
	2017-2016	1.143575	-0.94538	3.232527	0.672761
	2018-2016	6.580903	4.887895	8.273912	3.55E-08
	2019-2016	-0.76206	-2.92224	1.398126	0.944575
	2020-2016	5.316377	0.95338	9.679373	0.006072
	2021-2016	15.83094	12.49471	19.16718	3.55E-08
	2018-2017	5.437328	3.284203	7.590453	3.55E-08
	2019-2017	-1.90563	-4.44257	0.631307	0.28708
	2020-2017	4.172801	-0.38849	8.734096	0.098798
	2021-2017	14.68737	11.0957	18.27904	3.55E-08
	2019-2018	-7.34296	-9.56526	-5.12066	3.55E-08
	2020-2018	-1.26453	-5.65861	3.129557	0.979666
	2021-2018	9.250041	5.873256	12.62682	3.55E-08
	2020-2019	6.078433	1.48408	10.67279	0.001867
	2021-2019	16.593	12.95944	20.22656	3.55E-08
	2021-2020	10.51457	5.26365	15.76548	1.14E-07

Table 15. *Bigmouth Buffalo Wr comparison by year in pools 16-19 of the Mississippi River from 2015-2021*

Year	diff	lwr	upr	p.adj
2016-2015	0.560873	-3.91784	5.039585	0.9998
2017-2015	-0.30032	-4.8642	4.263552	0.999996
2018-2015	0.425576	-4.03073	4.881878	0.999959
2019-2015	0.711076	-3.7643	5.186451	0.999208
2020-2015	-0.19011	-8.02445	7.644232	1
2021-2015	2.819932	-1.46887	7.108732	0.453283
2017-2016	-0.8612	-3.83862	2.11623	0.979018
2018-2016	-0.1353	-2.94506	2.674461	0.999999
2019-2016	0.150203	-2.68971	2.990114	0.999999
2020-2016	-0.75098	-7.78043	6.278457	0.999921
2021-2016	2.259059	-0.27667	4.794788	0.117682
2018-2017	0.725899	-2.21771	3.669509	0.990887
2019-2017	1.011399	-1.96101	3.983805	0.953081
2020-2017	0.110212	-6.97379	7.194218	1
2021-2017	3.120255	0.43697	5.80354	0.010936
2019-2018	0.2855	-2.51894	3.089937	0.99994
2020-2018	-0.61569	-7.63087	6.399498	0.999975
2021-2018	2.394356	-0.10158	4.890291	0.069906
2020-2019	-0.90119	-7.9285	6.126129	0.99977
2021-2019	2.108856	-0.42098	4.638688	0.174476
2021-2020	3.010043	-3.89995	9.920035	0.858543

Table 16. *Bigmouth buffalo Wr comparison between years within pools in pools 16-19 of the Mississippi river from 2015 to 2021.*

Pool	Year	diff	lwr	upr	p.adj
Pool 16	2017-2016	2.182593	-5.93935	10.30454	0.947049
	2018-2016	6.488194	-2.63838	15.61477	0.291482
	2019-2016	6.883916	-0.47256	14.2404	0.078799
	2021-2016	3.784218	-7.05397	14.62241	0.872477
	2018-2017	4.305601	-3.22507	11.83627	0.516513
	2019-2017	4.701323	-0.54601	9.948655	0.102653
	2021-2017	1.601625	-7.93164	11.13489	0.99057
	2019-2018	0.395722	-6.30225	7.093696	0.999842
	2021-2018	-2.70398	-13.1064	7.698497	0.952898
	2021-2019	-3.0997	-11.9899	5.79046	0.873046
Pool 17	2016-2015	9.188332574	1.083688845	17.2929763	0.015809767
	2017-2015	8.761358996	0.712777576	16.80994042	0.023766276
	2018-2015	2.473131168	-5.523981625	10.47024396	0.950275713
	2019-2015	7.701869886	-8.611371923	24.0151117	0.756932318
	2021-2015	11.04537088	3.379663855	18.71107791	0.000614946
	2017-2016	-0.426973577	-4.718081136	3.864133982	0.999749197
	2018-2016	-6.715201406	-10.90897706	-2.521425753	8.32E-05
	2019-2016	-1.486462688	-16.31062538	13.3377	0.999739511
	2021-2016	1.857038307	-1.663899836	5.37797645	0.659379576
	2018-2017	-6.288227829	-10.3726087	-2.203846953	0.000183856
	2019-2017	-1.05948911	-15.85307598	13.73409776	0.999950485
	2021-2017	2.284011884	-1.105887572	5.67391134	0.387053376
	2019-2018	5.228738718	-9.53690934	19.99438678	0.913825391
	2021-2018	8.572239713	5.306421521	11.8380579	3.78E-10
	2021-2019	3.343500994	-11.24531711	17.9323191	0.986575584
Pool 18	2017-2016	-0.591787811	-6.746451968	5.562876346	0.999781872
	2018-2016	0.659131739	-5.636885077	6.955148554	0.999668884
	2019-2016	-3.132388222	-9.287052379	3.022275935	0.689266704
	2020-2016	1.211582865	-7.968734457	10.39190019	0.998976818
	2021-2016	4.129326625	-0.364379725	8.623032975	0.091862178
	2018-2017	1.25091955	-6.015310947	8.517150046	0.996346821
	2019-2017	-2.540600411	-9.684700688	4.603499866	0.910629161
	2020-2017	1.803370677	-8.067622385	11.67436374	0.995166529
	2021-2017	4.721114436	-1.053976441	10.49620531	0.179291893
	2019-2018	-3.791519961	-11.05775046	3.474710536	0.665812297
	2020-2018	0.552451127	-9.407289878	10.51219213	0.999985659
	2021-2018	3.470194886	-2.455310282	9.395700054	0.545352628
	2020-2019	4.343971088	-5.527021974	14.21496415	0.804569497
	2021-2019	7.261714847	1.48662397	13.03680572	0.004888578
	2021-2020	2.91774376	-6.012542344	11.84802986	0.936281696
Pool 19	2016-2015	-0.951947827	-7.168510954	5.2646153	0.999343029

2017-2015	-2.780949447	-9.897472983	4.33557409	0.909672554
2018-2015	2.851330474	-3.139384959	8.842045908	0.796833539
2019-2015	-2.400239732	-8.429054823	3.628575359	0.901961547
2020-2015	-3.680949179	-14.96526426	7.6033659	0.961026
2021-2015	-4.160593439	-12.03501507	3.713828195	0.705191497
2017-2016	-1.82900162	-8.084238591	4.426235351	0.977382682
2018-2016	3.803278301	-1.133497338	8.740053941	0.255355827
2019-2016	-1.448291905	-6.431232174	3.534648363	0.978060299
2020-2016	-2.729001352	-13.49091796	8.032915258	0.989200979
2021-2016	-3.208645612	-10.31424892	3.896957697	0.83423114
2018-2017	5.632279921	-0.398557819	11.66311766	0.085055299
2019-2017	0.380709714	-5.687975798	6.449395227	0.999996532
2020-2017	-0.899999732	-12.20566642	10.40566696	0.999985716
2021-2017	-1.379643992	-9.28463283	6.525344845	0.998615528
2019-2018	-5.251570207	-9.949730272	-0.553410141	0.017290418
2020-2018	-6.532279653	-17.16533488	4.100775571	0.535866323
2021-2018	-7.011923913	-13.92080318	-0.10304465	0.044060552
2020-2019	-1.280709446	-11.9352767	9.373857809	0.999838305
2021-2019	-1.760353706	-8.70229527	5.181587857	0.989200339
2021-2020	-0.47964426	-12.27708924	11.31780072	0.99999974

Table 17. *Paddlefish Wr comparison by year in pools 16-19 of the Mississippi River from 2015-2021*

Year	diff	lwr	upr	p.adj
2016-2015	2.808818585	-19.72490786	25.34254503	0.999804692
2017-2015	-3.689986657	-26.43921519	19.05924187	0.999106869
2018-2015	10.07847362	-12.45940078	32.61634801	0.842497018
2019-2015	13.28695912	-9.192575343	35.76649358	0.585506952
2020-2015	10.37000104	-21.22253851	41.96254058	0.960502957
2021-2015	10.27226362	-12.2841376	32.82866483	0.830643524
2017-2016	-6.498805242	-11.7149026	-1.282707881	0.004545848
2018-2016	7.269655033	3.070124672	11.46918539	7.58E-06
2019-2016	10.47814054	6.603899615	14.35238146	0
2020-2016	7.56118245	-14.972544	30.0949089	0.956060587
2021-2016	7.463445032	3.165595704	11.76129436	6.97E-06
2018-2017	13.76846028	8.534472663	19.00244789	0
2019-2017	16.97694578	12.00016833	21.95372323	0
2020-2017	14.05998769	-8.689240837	36.80921622	0.5312825
2021-2017	13.96225027	8.649051622	19.27544893	0
2019-2018	3.208485502	-0.689808658	7.106779663	0.186690503
2020-2018	0.291527417	-22.24634698	22.82940181	1
2021-2018	0.193789999	-4.125754363	4.513334361	0.999999542
2020-2019	-2.916958085	-25.39649255	19.56257638	0.999753235
2021-2019	-3.014695503	-7.018712355	0.989321349	0.283605259
2021-2020	-0.097737418	-22.65413863	22.4586638	1

Table 18. *Paddlefish Wr comparison between years within pools in pools 16-19 of the Mississippi river from 2015 to 2021.*

Pool	Year	diff	lwr	upr	p.adj
Pool 16	2017-2016	-9.069626687	-34.81121829	16.67196492	0.86651617
	2018-2016	11.64732475	-9.677443981	32.97209349	0.557939466
	2019-2016	1.95550343	-14.42152909	18.33253595	0.997410737
	2021-2016	-9.199727475	-31.24350955	12.8440546	0.777543435
	2018-2017	20.71695144	-5.275783589	46.70968647	0.184711601
	2019-2017	11.02513012	-11.09010687	33.1403671	0.642731257
	2021-2017	-0.130100788	-26.71590228	26.4557007	0.999999992
	2019-2018	-9.691821323	-26.46083829	7.077195646	0.501488343
	2021-2018	-20.84705223	-43.18359323	1.489488778	0.079753605
	2021-2019	-11.15523091	-28.82957662	6.519114814	0.410324832
Pool 17	2016-2015	2.216833773	-15.8960992	20.32976675	0.9993086
	2017-2015	-4.594458426	-22.84138211	13.65246526	0.979485393
	2018-2015	5.42422542	-12.74927741	23.59772825	0.957095956
	2019-2015	7.858548447	-11.05431819	26.77141509	0.842487453
	2021-2015	13.24902056	-4.932553286	31.43059441	0.297217687
	2017-2016	-6.8112922	-11.82364021	-1.798944191	0.001587629
	2018-2016	3.207391647	-1.530710686	7.94549398	0.381334351
	2019-2016	5.641714674	-1.420150022	12.70357937	0.202056591
	2021-2016	11.03218679	6.263220854	15.80115272	1.75E-09
	2018-2017	10.01868385	4.791686923	15.24568077	9.56E-07
	2019-2017	12.45300687	5.054235617	19.85177813	2.82E-05
	2021-2017	17.84347899	12.58848905	23.09846892	4.49E-10
	2019-2018	2.434323027	-4.781478887	9.650124942	0.928849905
	2021-2018	7.824795141	2.830708602	12.81888168	0.000131309
	2021-2019	5.390472114	-1.845633167	12.62657739	0.273164666
Pool 18	2017-2016	4.145556628	-10.53587933	18.82699258	0.965528147
	2018-2016	-6.93249946	-51.2948209	37.42982198	0.997704037
	2019-2016	18.41725514	10.40508981	26.42942048	3.06E-09
	2020-2016	14.18016105	-6.76229166	35.12261376	0.378381762
	2021-2016	-4.720408678	-49.08273012	39.64191276	0.999643065
	2018-2017	-11.07805609	-56.58741878	34.43130661	0.982018707
	2019-2017	14.27169852	1.337970404	27.20542663	0.021012347
	2020-2017	10.03460442	-13.23926193	33.30847078	0.818302521
	2021-2017	-8.865965306	-54.375328	36.64339739	0.993500316
	2019-2018	25.3497546	-18.46522371	69.16473292	0.559469906
	2020-2018	21.11266051	-26.7845613	69.00988232	0.803969982
	2021-2018	2.212090782	-59.62295668	64.04713824	0.999998394
	2020-2019	-4.237094093	-23.99369012	15.51950194	0.989867532
	2021-2019	-23.13766382	-66.95264214	20.67731449	0.65484096
	2021-2020	-18.90056973	-66.79779154	28.99665208	0.867660974
Pool 19	2017-2016	-7.399462796	-26.4585945	11.65966891	0.82463395

2018-2016	7.918038576	0.570828314	15.26524884	0.027429326
2019-2016	10.47186705	-0.203381971	21.14711606	0.057485563
2021-2016	3.044258547	-4.524120936	10.61263803	0.805034138
2018-2017	15.31750137	-3.360170724	33.99517347	0.164501648
2019-2017	17.87132984	-2.348335781	38.09099546	0.111466432
2021-2017	10.44372134	-8.322053469	29.20949616	0.546337643
2019-2018	2.553828469	-7.424441685	12.53209862	0.956025532
2021-2018	-4.873780029	-11.42246705	1.674906992	0.248887618
2021-2019	-7.427608498	-17.56983432	2.714617324	0.264274436

Table 19. *VR2Tx telemetry receivers in the Upper Mississippi River (UMR). Location describes state-side of the river and the river mile.*

Location	Date	Latitude	Longitude
IL325	10/25/2021	39.90712	-91.42213
MO325	10/25/2021	39.90888	-91.43408
MO343.1	10/25/2021	40.14065	-91.51545
IL343.1	10/25/2021	40.14379	-91.50684
IL343.9	10/25/2021	40.14920	-91.50557
MO343.9	10/25/2021	40.14702	-91.51626
IL324.9	10/26/2021	39.90621	-91.43231
MO324.9	10/26/2021	39.90678	-91.43272
MO301	10/26/2021	39.63343	-91.24716
IL301.2	10/26/2021	39.63833	-91.24499
MO273.8	10/26/2021	39.37848	-90.91422
IL274.0	12/2/2021	39.38648	-90.90818
IL273.5	12/2/2021	39.37745	-90.90247
MO272.7	12/2/2021	39.36602	-90.89721
MO257.8	12/2/2021	39.21764	-90.72237
IL256.7	12/2/2021	39.20487	-90.71304
MO239.7	12/14/2021	38.98219	-90.68031
IL240.0	12/14/2021	38.98604	-90.67342
MO202.6	12/14/2021	38.88087	-90.1852
IL202.6	12/14/2021	38.88504	-90.17982

Table 20. *Invasive carp species with transmitters implanted during calendar year 2021.*

DATE	RIVER MILE	LAT	LONG	FISH CODE	LENGTH	SEX	WEIGHT	LBS	TRANS	FLOY
10/5/2021	342	40.12526	-85.51398	SVCP	571	F	1340	2.95	58318	ORFS44446
10/5/2021	342	40.12526	-85.51398	BHCP	782	F	4600	10.14	58316	ORFS44444
10/5/2021	342	40.12526	-85.51398	SVCP	722	F	3620	7.98	58315	ORFS44443
10/5/2021	342	40.12526	-85.51398	SVCP	749	F	3800	8.38	58314	ORFS44442
10/5/2021	342	40.12526	-85.51398	SVCP	740	F	4550	10.03	58320	ORFS44448
10/5/2021	342	40.12526	-85.51398	SVCP	745	F	4800	10.58	58313	ORFS44441
10/5/2021	342	40.12526	-85.51398	SVCP	764	F	5120	11.29	58317	ORFS44445
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10/5/2021	342	40.12526	-85.51398	SVCP	675	M	3540	7.80	58319	ORFS44447
10/18/2021	202	38.87094	-84.18484	SVCP	481	F	1200	2.65	58325	ORFS44928
10/18/2021	202	38.87094	-84.18484	SVCP	701	F	3500	7.72	58331	ORFS44934
10/18/2021	202	38.87094	-84.18484	SVCP	681	F	3520	7.76	58330	ORFS44933
10/18/2021	202	38.87094	-84.18484	SVCP	712	F	3560	7.85	58328	ORFS44931
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10/18/2021	202	38.87094	-84.18484	SVCP	680	M	3460	7.63	58332	ORFS44935
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10/25/2021	327	39.93698	-85.41742	SVCP	765	F	5520	12.17	58342	ORFS44946
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10/27/2021	252	39.13263	-84.71269	SVCP	738	M	4720	10.41	58394	ORFS43097

Table 21. *Invasive carp harvest effort and weight totals by pool and date. Harvests were conducted in three pools of the Upper Mississippi River. An electrified Dozer trawl was used to collect fish.*

Pool	Date	Time (min)	Distance (meters)	Weight (pounds)	Harvest/min	Harvest/hr
20	8-Oct	30	2,414	253	8.4	506.2
	9-Oct	62	4,656	1,126	18.2	1,089.5
	12-Oct***	141	10,622	2,520	17.9	1,075.0
	Total	233	17,692	3,899	16.8	1,005.6
21	3-Oct	28	1,971	249	8.9	532.7
	4-Oct	81	6,399	880	10.9	654.5
	5-Oct	27	2,092	120	4.4	266.7
	6-Oct	35	2,836	139	4.0	237.3
	Total	171	13,299	1,388	8.1	487.3
22	19-Sep	35	2,179	199	5.7	341.1
	20-Sep	39	2,830	533	13.7	819.6
	21-Sep	25	2,347	469	18.8	1,125.2
	27-Sep	90	6,974	1,104	12.3	737.1
	28-Sep	61	4,970	597	9.8	587.2
	29-Sep	91	7,622	1,235	13.6	815.6
	30-Sep	66	4,632	1,043	15.8	948.3
	1-Oct	172	11,869	2,548	14.9	891.4
	Total	578	43,424	7,727	13.4	801.9
All Pools	Grand Total	982	74,415	13,014	12.8	764.9

*** Included night fishing

Table 22. *Mean lengths of silver carp obtained from dozer trawl sampling of upper Mississippi River Pools 20, 21, and 22. Within each site, the data are divided amongst males, females, and *unsexed individuals.*

Site and Gender	#	Mean Length (mm)	Standard Deviation	95% CI
Pool 20 Males	54	696.67	51.30	(683.62, 709.71)
Pool 20 Females	74	717.53	50.25	(706.38, 728.67)
Pool 20 *Unsexed	31	716.68	43.15	(699.46, 733.90)
Pool 21 Males	31	716.68	43.15	(699.46, 733.90)
Pool 21 Females	54	727.59	46.74	(714.55, 740.64)
No *Unsexed Lengths from Pool 21	1	-	-	-
Pool 22 Males	137	712.20	43.93	(704.01, 720.39)
Pool 22 Females	136	726.67	50.59	(718.45, 734.89)
Pool 22 *Unsexed	24	722.5	59.6	(702.9, 742.1)

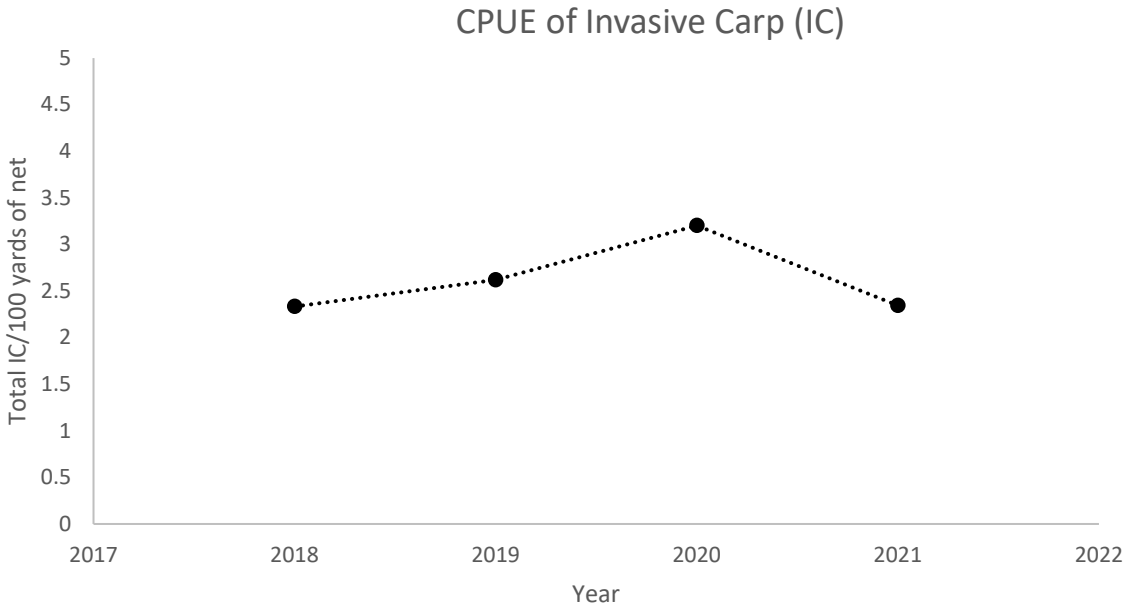

Figure 1. *Total catch per unit effort by year for invasive carp contracted removal from the Upper Mississippi River Pools 14–19 using gill nets from 2018 through 2021.*

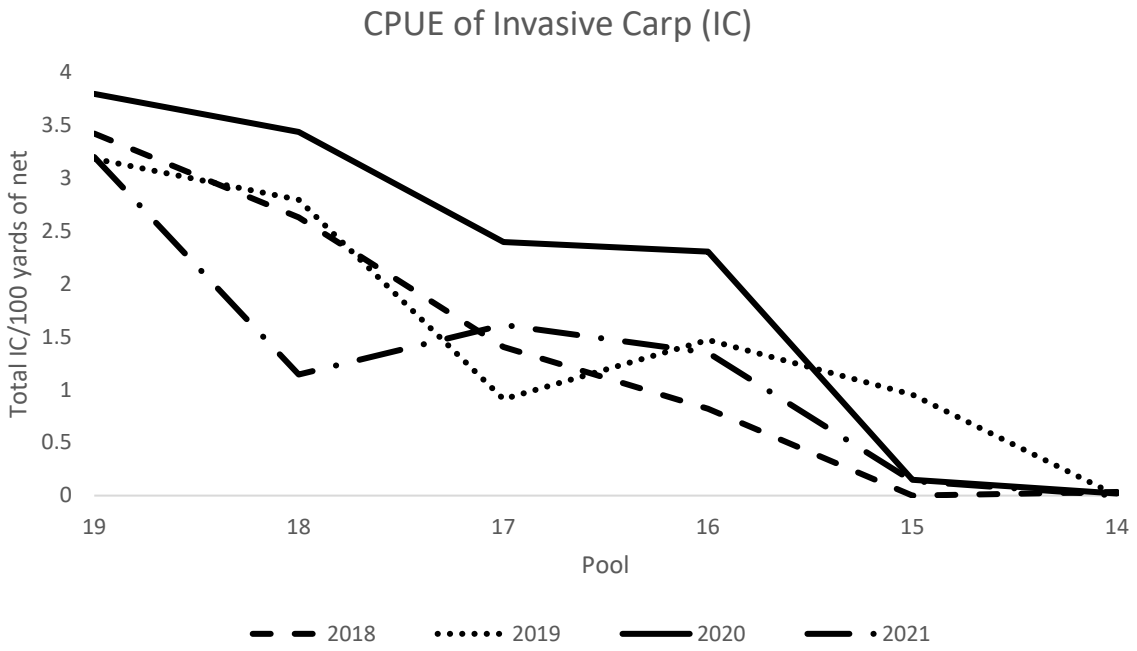

Figure 2. *Catch per unit effort by Upper Mississippi River reach for invasive carp contracted commercial removal using gill nets from 2018 through 2021. The dashed line represents 2018, the dotted line represents 2019, and the black line represents 2020, and the dot and dashed line represents 2021.*

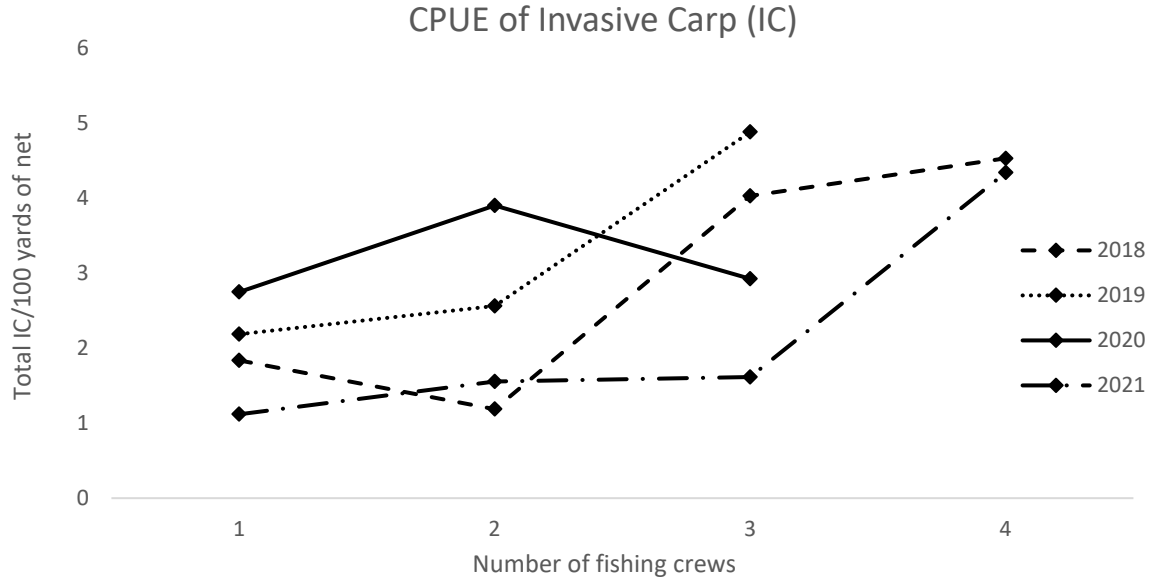

Figure 3. *Total catch per unit effort (CPUE) by number of fishing crews for Pools 14–19 invasive carp contracted removal using gill nets from 2018 through 2021. The dashed line represents 2018, the dotted line represents 2019, and the black line represents 2020, and the dot and dashed line represents 2021.*

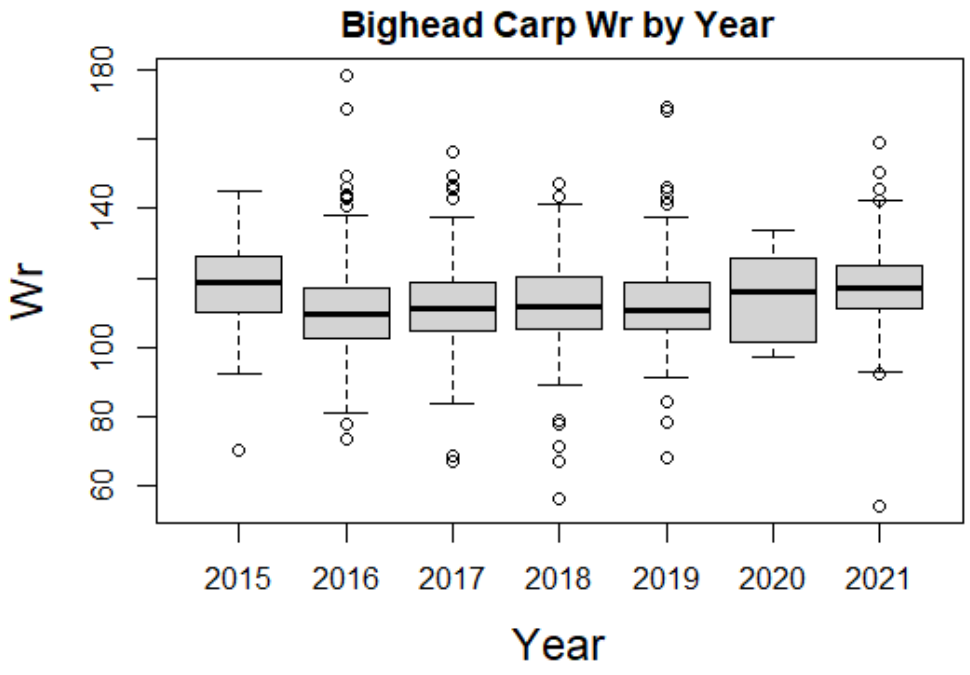

Figure 4. *Bighead Carp Wr by year in Pools 16–20 of the Upper Mississippi River from 2015 through 2021.*

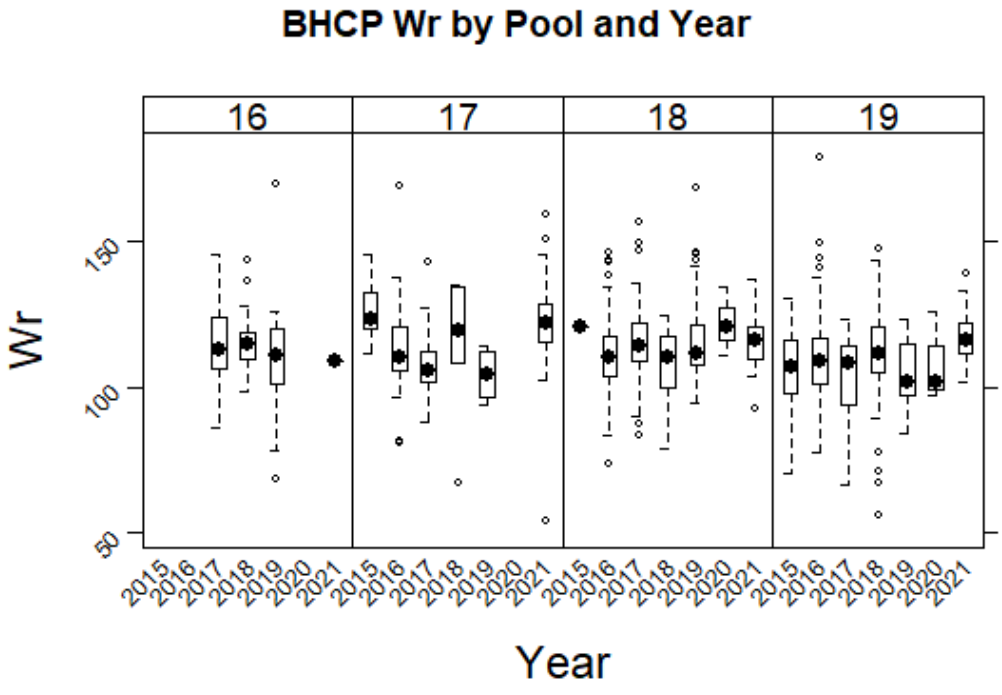

Figure 5. *Bighead Carp Wr by year and by pool in Pools 16–20 of the Upper Mississippi River from 2015 through 2021.*

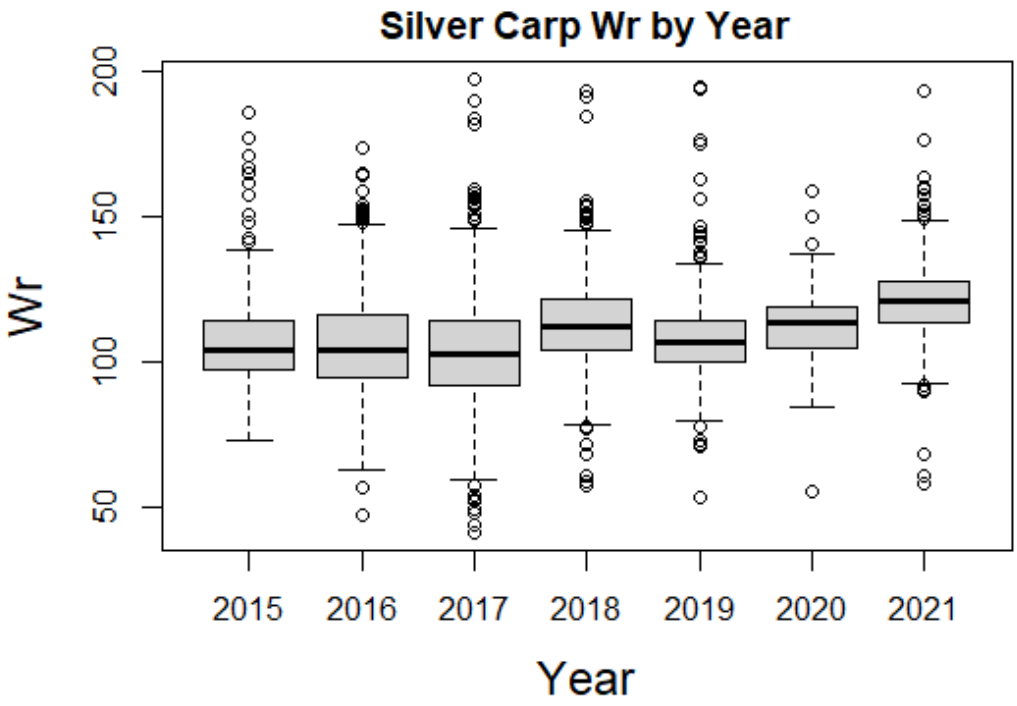

Figure 6. *Silver Carp Wr by year in Pools 16–20 of the Upper Mississippi River from 2015 through 2021.*

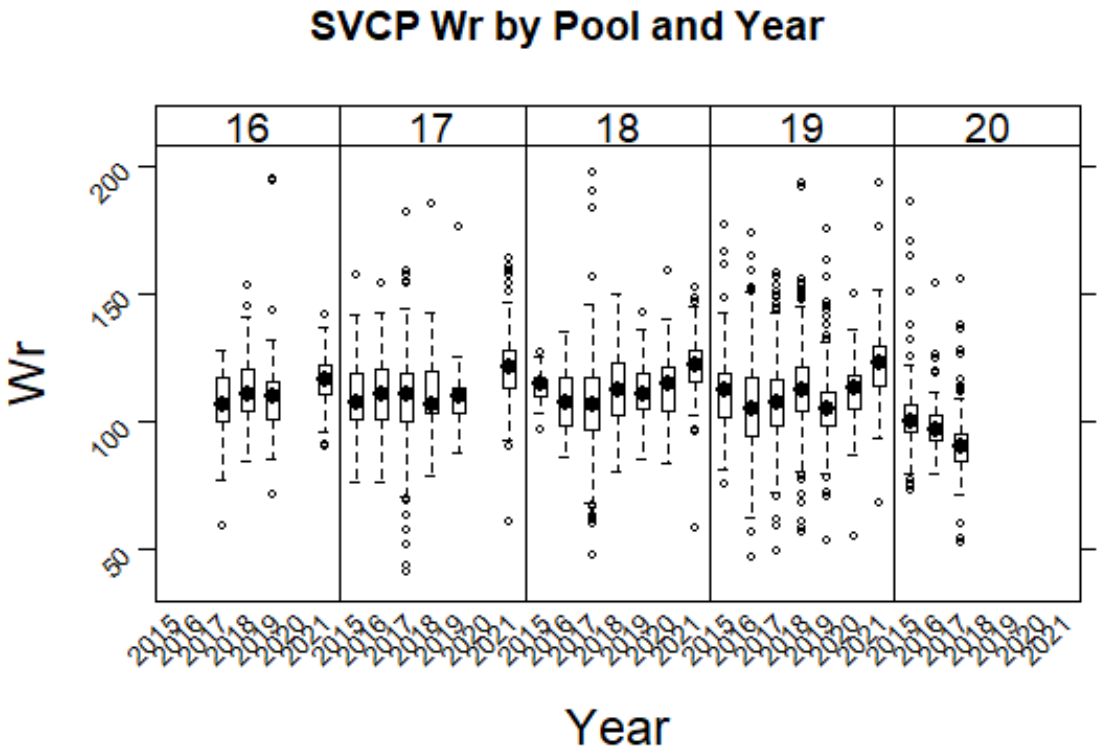

Figure 7. *Silver Carp Wr by year and by pool in Pools 16–20 of the Upper Mississippi River from 2015 through 2021.*

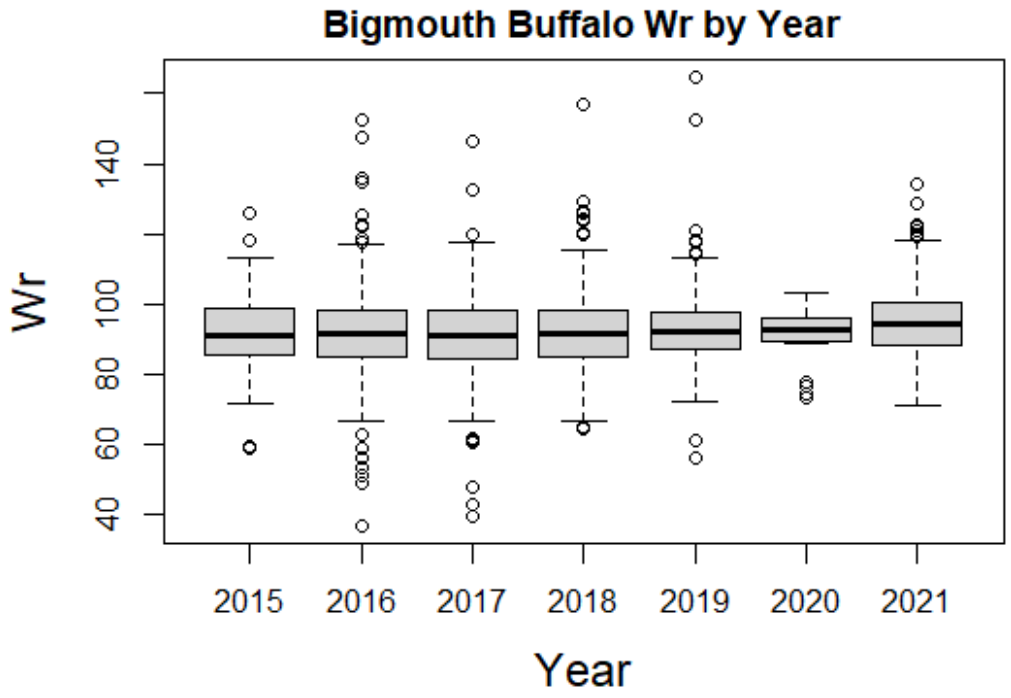

Figure 8. *Bigmouth buffalo Wr by year in Pools 16–19 of the Upper Mississippi River from 2015 through 2021.*

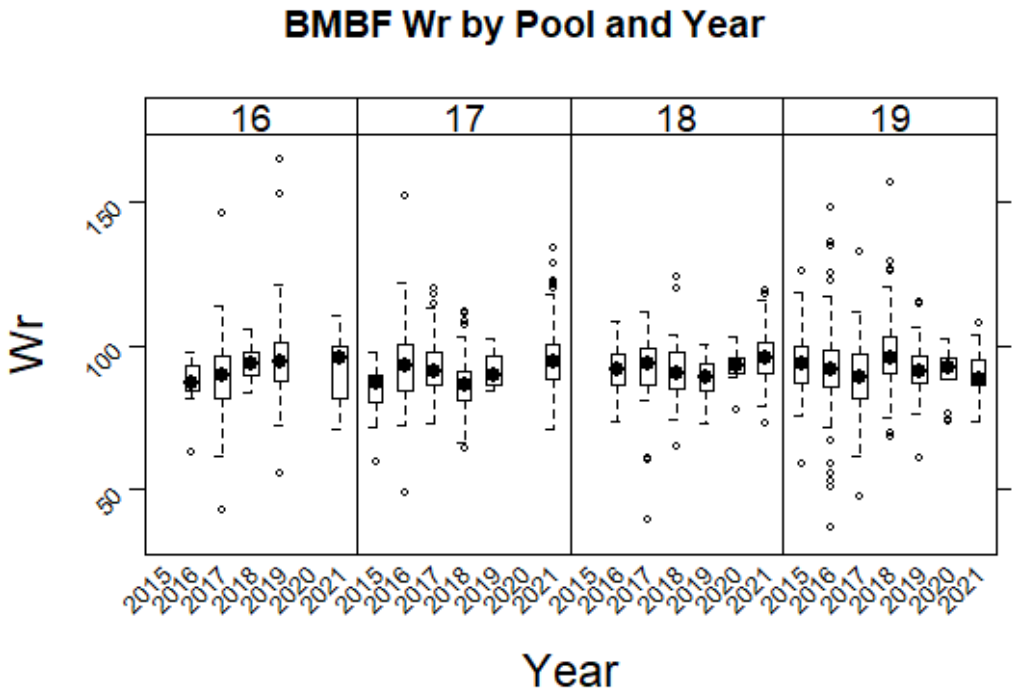

Figure 9. *Bigmouth buffalo Wr by year and by pool in Pools 16–19 of the Upper Mississippi River from 2015 through 2021.*

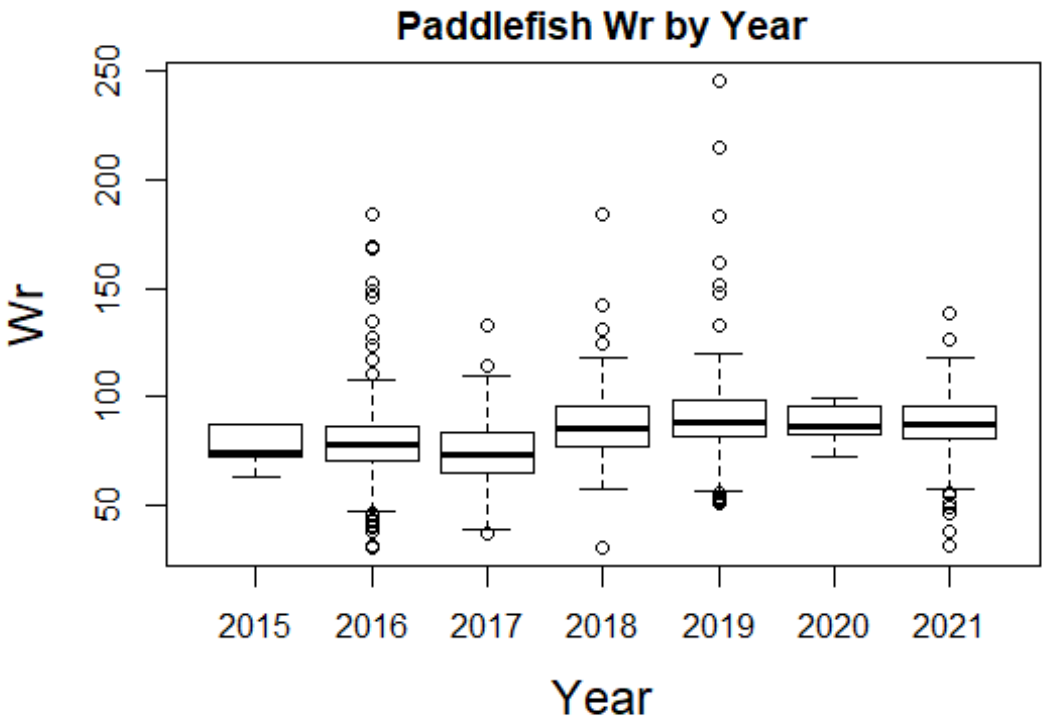

Figure 10. *Paddlefish Wr by year in Pools 16–19 of the Upper Mississippi River from 2015 through 2021.*

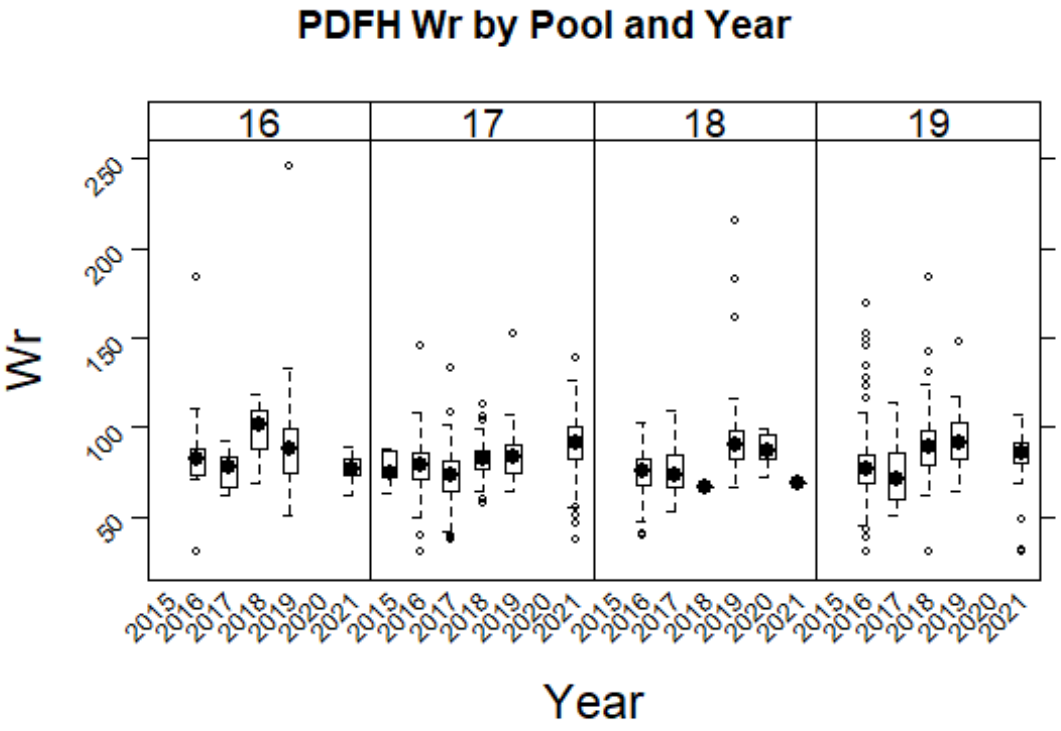

Figure 11. *Paddlefish Wr by year and by pool in Pools 16–19 of the Upper Mississippi River from 2015 through 2021.*

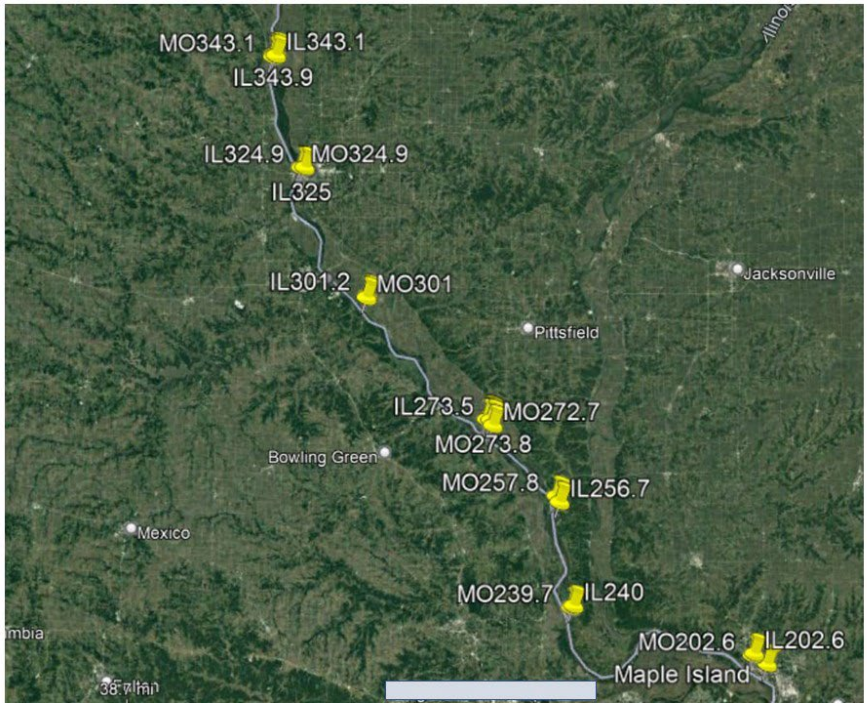

Figure 12. *Installation locations for VR2Tx receivers in the Upper Mississippi River.*