Project Title: Bigheaded Carp Monitoring and Removal 2022

Geographic Location: Pools 14–19 of the Mississippi River

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Participating Agencies: Illinois Natural History Survey, Missouri Department of Conservation, Illinois Department of Natural Resources, United States Geological Survey-Upper Midwest Environmental Sciences Center, and United States Fish and Wildlife Services

Statement of Need: Adult silver carp (*Hypophthalmichthys molitrix*), bighead carp (*H. nobilis*), grass carp (*Ctenopharyngodon idella*), and black carp (*Mylopharyngodon piceus*), hereafter referred to as invasive carp, are present in varying abundances 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 invasive carp upstream as all upstream passage is restricted to the lock chamber, effectively slowing progression and establishment of invasive 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 Invasive Carp Team (UMRICT) 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 UMRICT, 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.

Illinois Natural History Survey

Project Objectives:

1. Targeted removal of 200,000-300,000 lbs of invasive carp species in UMR Pools 14-19 using commercial fishers and intensive netting protocols.
2. Acoustically tag and monitor, collectively, 200 bigmouth buffalo, paddlefish, lake sturgeon, flathead catfish, blue sucker, white bass, freshwater drum, walleye with acoustic tags in Pool 20 in the fall of 2022 to assess frequency and timing of fish passage at Lock and Dam 19

Project Highlights:

- Commercial removal efforts resulted in 138,963 lbs of invasive carp removed from 01/01/2022–12/31/2022
- Since the project started in 2015 a total of 1,064,415 lbs of invasive carp have been removed, with 878,857 lbs coming from 2018, 2019, 2020, 2021, and 2022
- 282 bighead carp (BHCP), 3,199 silver carp (SVCP), 51 hybrid silver carp x bighead carp (SCBC), and 2,535 grass carp (GSCP) were harvested and removed in 2022

Methods:

Study site

Data were collected from September 2015 through December 2022 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 a 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 10 g 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 both in all pools combined, and in each pool separately. A Tukey's Post Hoc test (α=0.05) determined between what years in each pool any difference in Wr existed.

Results and Discussion:

Contracted Commercial Removal

Low river conditions greatly impacted our fishing efforts in 2022. Our intensive harvest event occurred from April 5-April 29. 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 2022 began March 8 with ice-off and continued until December 15.

In 2022, we removed 6,067 invasive carp, weighing 63,022 kg (138,963 lbs), from Pools 14–19 of the Mississippi River (Table 1, Table 2, Table 3). An additional 452 invasive carp weighing 5,054 kg (10,907 lbs) were released after being tagged by USGS (Table 9). Silver carp were the most abundant invasive carp species removed from the UMR (3,199 fish; 30,490 kg; 67,231 lbs), followed by grass carp (2,535 fish; 27,449 kg; 60,525 lbs), bighead carp (282 fish; 4,407 kg; 9,717 lbs), and hybrid carp (51 fish; 719 kg; 1585 lbs). A total of 6,067 bycatch fish were captured in gill nets and released, with the highest amount of bycatch caught in Pool 19 (4,107 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, and further in 2022, potentially due to low water, which leads 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, Pool 17 and 18 in 2021, and Pools 17 and 16 in 2022. Pools 18 and 19 had the highest overall CPUE, and Pool 14 had the lowest CPUE, with only four invasive carp removed from Pool 14 from 2018 through 2022 (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 2+ fishing crews was analyzed using data from 2018 through 2022, which showed that CPUE generally increased with additional fishing crews (Fig. 3). Results from 2020 may be slightly biased because crews of 3 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, 2021, and 2022, a positive trend generally exists between the number of fishing crews and CPUE (Fig. 3).
Total removed weight was the lowest it has been since 2017 at 138,963 lbs. This year was likely affected by low water. The low water on the Mississippi River made it difficult to target areas where invasive carp tend to congregate. It was also difficult to pinpoint areas to target due to waning acoustic tags in the system. If more fish were tagged it may guide us to places to target more effectively. We also had the lowest number of invasive carp removed (6,067) in 2022 since 2017 (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).

Acoustic Monitoring

We monitored acoustically tagged fish through two methods in Pools 14–19: Vemco VR100 detections during harvest (Table 10), and recaptures of acoustically tagged individuals in nets during harvest (Table 11. These data were used to monitor movements of invasive carp to assist in contracted commercial harvest efforts.

Acoustic tag recaptures
We recaptured 9 unique telemetered individuals during our commercial removal efforts in 2022. one individual was a bighead carp, and eight individuals were silver carp (Table 10). Most fish were recaptured in Pool 17. All fish were released after capture in 2022.

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 2022, we had 85 detections among five different species: bighead carp, silver carp, bighead x silver hybrid carp, bigmouth buffalo, and paddlefish. There were 5 bighead carp individuals, 43 silver carp individuals, 1 bighead x silver hybrid carp individuals, 24 bigmouth buffalo individuals, and 4 paddlefish individuals captured from VR100 receiver (Table 11). Most of our bigheaded carp detections were captured in Pool 18.

SEIcarP

From 10/3/2022 to 12/14/2022 we captured fish for the SEIcarP model. This year we worked in conjunction with Iowa State University. Iowa State was interested in capturing 1000 silver carp above Lock and Dam 19, which corresponded with our SEIcarP goals. For SEIcarP a total of 187 SVCP, BHCP, and SCBC were captured in Pools 16-19 for the SEIcarP model with the use of gillnets. In Pool 16, 14 SVCP were captured for the model. In Pool 17, 22 SVCP were captured. 30 SVCP, and 1 BHCP were captured in Pool 18. In Pool 19 a total of 100 SVCP were captured,

along with 5 SCBC and 15 BHCP. Fish were then brought to Kibbe field station 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 slightly increased from 2016 to 2017, slightly increased from 2017 to 2018, held steady from 2018 to 2019, and slightly increased from 2019 through 2022 (Fig. 3). 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 12).

In Pool 16, Wr appeared to increase from 2016 to 2017 (Fig. 5). Relative weight held steady in 2017–2019. There were no data available for 2015, 2020, and limited data in 2021, in 2022 Wr seemed slightly higher than other years, however, there were no statistically significant differences detected. In Pool 17, Wr dropped from 2016 to 2018, and increased again in 2019 through 2022; there were limited data for 2020 (Fig. 5). There was a significant difference found in the data for Pool 17(Table 13). In Pool 18, Wr was relatively steady throughout the years (Fig. 5). There was no significant difference detected between years (Table 13). In Pool 19, Wr was variable across time but there were significant differences found in the data (Table 13).

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 and 2022. 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 14).

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 15). In Pool 17, silver carp Wr remained steady throughout all years with a slight raise in 2021 and 2022, and a significant difference was found in the data (Table 15). 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 15). 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 2022. The ANOVA revealed a significant difference. A Post Hoc Tukey's test showed a significant difference between many of the years (Table 15).

Data are lacking in several areas of this data set. Raised Wr in 2020, 2021, and 2022 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. 8). 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, and 2022 and 2017 (Table 16).

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, there was significant difference shown in the ANOVA. In Pool 17, the Wr of bigmouth buffalo appeared variable throughout the years (Fig. 9). 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 17). 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. 9). 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 18). In Pool 19, Wr was variable (Fig. 9). The ANOVA ($p\leq0.001$) and Post Hoc Tukey's test ($p=0.001$) indicated a difference between the years of data (Table 17).

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. 10). The ANOVA showed significant differences ($p<0.001$, $\alpha = 0.05$) between the years (Table 18).

In Pool 16, paddlefish Wr was variable throughout the years (Fig. 14). An ANOVA indicated one significant difference between years in Pool 16 (Table 19). 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 20). 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 years (Table 19). In Pool 19, a significant difference was detected between many of the years (Table 19).

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.

Missouri Department of Conservation

Contract/commercial removal efforts are still being pursued; however, no removals have been completed at the time of this report. MDC staff will continue working internally and with interested vendors to pursue removal actions.

References:

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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 2022. 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	1,168.1	192.4	0	0	1,566.4
2016	18,800.3	38,274.4	12,488.9	1509.5	0	7,1073.1
2017	15,361.5	32,726.2	19,621.1	405.0	28472.1	95,220.7
2018	26,029.1	98,798.9	49,887.6	482.0	13071.1	188,271.7
2019	24,308.0	90,280.1	53,739.3	613.8	1786.1	170,727.2
2020	13,092.6	120,461.3	35,223.8	421.8	0	169,199.4
2021	15,655.5	116,516.0	75,537.2	915.05	0	208,623.7
2022	9,716.7	67,231.3	60,525.2	1,585.5	0	138,963.5
Totals	12,8070.5	57,7873.8	30,9862.4	6,116.78	43,332.3	**1,064,415**

Table 2. *Total weight (kgs) of invasive carp removed from Pools 14–19 on the Upper Mississippi River from 2015 through 2022. 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	93.4	529.8	87.3	0.0	0.0	710.4
2016	8,526.2	17,358.0	5,663.9	684.6	0.0	32,232.7
2017	6,966.7	14,841.8	8,898.5	183.7	12,912.5	43,184.0
2018	11,804.6	44,806.8	22,624.8	218.6	5,927.9	85,384.0
2019	11,024.0	40,943.4	24,371.6	278.4	810.0	77,427.3
2020	5,937.7	54,631.0	15,974.5	191.3	0.0	76,734.4
2021	7,100.0	52,841.7	34,257.2	415.0	0.0	94,613.9
2022	4,406.7	30,490.4	27,449.1	719.0	0.0	63,022.0
Total	58,081.9	262,074.3	140,527.2	2,774.0	19,651.8	**482,727.9**

Table 3. *Total number of invasive carp captured and removed using gill nets in Pools 14–20 of the Upper Mississippi River from 2015 through 2022.*

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	1,781	18	450	2,429
	20	57	255	1	44	357
Total		**354**	**2,238**	**23**	**675**	**3,290**
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**	**1,495**
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	1,061	2	690	2,019
	19	305	3,078	22	1,275	4,680
	20	0	0	0	0	0
Total		**756**	**5,000**	**30**	**2,249**	**8,035**
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	1,556	5	379	2,313
	19	302	3,637	19	2,113	6,056
	20	0	0	0	0	0
Total		**836**	**5,843**	**27**	**2,638**	**9,318**

Year	Pool	Bighead Carp	Silver Carp	Hybrid Carp	Grass Carp	Total
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	1,139	4	161	1,369
	19	246	4,582	19	1,546	6,393
	20	0	0	0	0	0
Total		**473**	**7,175**	**27**	**1,876**	**9,551**
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	4,342	28	3,037	7,757
	20	0	0	0	0	0
Total		**527**	**5,990**	**43**	**3,555**	**10,115**
2022	14	0	0	0	1	1
	15	5	25	0	2	32
	16	29	306	4	245	584
	17	11	341	0	38	390
	18	49	793	12	99	953
	19	188	1,734	35	2,150	4,107
	20	0	0	0	0	0
Total		**282**	**3,199**	**51**	**2,535**	**6,067**
Total		**3,446**	**30,348**	**205**	**13,986**	**47,985**

Table 4. *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 2022.*

Family/Species	2015	2016	2017	2018	2019	2020	2021	2022	Total
Acipenseridae									
Lake Sturgeon			1	1		3	4	3	12
Shovelnose Sturgeon				1	2		2		5
Amiidae									
Bowfin		7	3	16	6	15	5	9	61
Catostomidae									
Bigmouth Buffalo	79	868	2,151	2,443	1,986	2,473	4,274	4,195	18,469
Black Buffalo		262	1,023	959	859	1,310	1,380	822	6,615
Golden Redhorse				1					1
Quillback		23	2		7	3		1	21
River Carpsucker	16	95	67	144	82	50	125	179	758
River Redhorse				1					1
Shorthead Redhorse		2			2				4
Smallmouth Buffalo	19	312	3,249	1,186	974	2,512	2,959	3,425	14,636
Centrarchidae									
Black Crappie				1	4	2		2	9
Bluegill					2		1		3
Largemouth Bass	1	5	1	7	11	7	2	8	42
Smallmouth Bass					1	2	1	1	5
White Crappie		1	6	3	2		2	1	15
Clupeidae									
Gizzard Shad	4	8	11	12	8	6	9	17	75
Cyprinidae									
Common Carp	83	1,602	2,279	3,822	3,965	3,460	3,012	4,600	22,823
Goldfish			1		2	2	1	7	13
Hiodontidae									
Mooneye			3	13	13	1	9	4	43
Ictaluridae									
Brown Bullhead						1			1
Channel Catfish	1	61	34	102	92	72	149	175	686
Flathead Catfish		4	48	145	90	89	58	57	491
Lepisosteidae									
Longnose Gar	21	32	29	124	111	138	135	102	692
Shortnose Gar	37	35	29	109	179	267	151	305	1,112
Moronidae									
Striped x White Bass	1		2	24	52	26	1		106
White Bass	1	5	3	7	3	1			20
Sciaenidae									
Freshwater Drum	68	328	814	1,847	3,108	2,613	2,396	2,950	14,124
Esocidae									
Northern Pike		18	28	65	67	29	67	24	298
Polyodontidae									
Paddlefish	5	1,064	2,078	2,993	2,088	1313	2,671	1,769	13,981
Percidae									

Family/Species	2015	2016	2017	2018	2019	2020	2021	2022	Total
Sauger			1	3	7		6	1	18
Walleye	3	1	1	21	14	14	80	7	141
Total	339	4,718	11,864	14,050	13,737	14,414	17,505	18,664	**95,291**

Table 5. *Total gill netting effort for removed invasive carp (IC) 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 (SCBC). 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 SCBC (N)	19	5	1	2	0	0	27
Total SCBC Weight (kg)	198	55	17	8	0	0	278
Average SCBC 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 (SCBC /100 yds of net)	0.01	0.006	0.003	0.005	0	0	0.008

2019	Pool 19	Pool 18	Pool 17	Pool 16	Pool 15	Pool 14	Total
CPUE (GSCP/100 yds of net)	1.11	0.46	0.08	0.28	0.09	0	0.74
CPUE (Total/100 yds of net)	3.19	2.80	0.91	1.47	0.95	0	2.62

Table 6. *Total gill netting effort for removed invasive carp (IC) 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 (*SCBC*). 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	164,680	39,830	41,130	34,590	8,050	5,060	293,340
Catch Effort (Removed)							
Total IC (N)	6,393	1,369	979	797	12	1	9,551
Total IC Weight (kg)	52,569	10,578	8,339	6,126	80	8	77,700
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)	2,908	852	1,272	906	25	0	5,964
Average BHCP Weight (kg)	11.8	13.1	15.3	11.8	12.5	0	12.7
Total SVCP (N)	4,582	1,139	819	626	8	1	7,175
Total SVCP Weight (kg)	36,180	8,257	6,447	4,271	43	8	55,206
Average SVCP Weight (kg)	7.9	7.2	7.9	6.8	5.4	8.0	7.8
Total SCBC (N)	19	4	2	2	0	0	27
Total SCBC Weight (kg)	137	30	25	0	0	0	191
Average SCBC Weight (kg)	7.2	7.5	12.5	0	0	0	7.1
Total GSCP (N)	1,546	161	75	92	2	0	1,876
Total GSCP Weight (kg)	13,344	1,439	596	949	11	0	16,339
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 (SCBC /100 yds of net)	0.01	0.01	0.01	0.01	0	0	0.01

2020	Pool 19	Pool 18	Pool 17	Pool 16	Pool 15	Pool 14	Total
CPUE (GSCP/100 yds of net)	0.94	0.40	0.18	0.27	0.025	0	0.64
CPUE (Total/100 yds of net)	3.88	3.44	2.40	2.30	0.15	0.020	3.26

Table 7. *Total gill netting effort for removed invasive carp (IC) 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 (*SCBC*). 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	242,290	49,610	52,970	68,500	7,240	10,830	431,440
Catch Effort (Removed)							
Total IC (N)	7,757	568	855	925	10	0	10,115
Total IC Weight (kg)	74,490	3,714	8,261	8,057	90	0	94,613
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)	4,510	735	1,512	343	0	0	8,000
Average BHCP Weight (kg)	12.9	12.3	16.6	13.2	0	0	15.2
Total SVCP (N)	4,342	356	660	628	4	0	5,990
Total SVCP Weight (kg)	39,523	2,182	5,804	5,305	28	0	52,842
Average SVCP Weight (kg)	9.1	6.1	8.8	8.4	7	0	8.8
Total SCBC (N)	28	5	7	3	0	0	27
Total SCBC Weight (kg)	322	51	72	17	0	0	415
Average SCBC Weight (kg)	11.5	10.2	10.3	5.6	0	0	10.5
Total GSCP (N)	3,037	147	97	268	6	0	3,555
Total GSCP Weight (kg)	30,135	747	909	2,404	62	0	34,257
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

2021	Pool 19	Pool 18	Pool 17	Pool 16	Pool 15	Pool 14	Total
CPUE (SCBC/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/100 yds of net)	3.2	1.1	1.6	1.3	0.14	0	2.34

Table 8. *Total gill netting effort for removed invasive carp (IC) in Pools 14–19 of the Upper Mississippi River in 2022. Invasive carp are broken down by bighead carp (BHCP), silver carp (SVCP), grass carp (GSCP), and bighead x silver carp (*SCBC*). Unsorted weight is an accumulated weight of all species weight when there was not an ability to sort by species.*

2022	Pool 19	Pool 18	Pool 17	Pool 16	Pool 15	Pool 14	Total
Netting Effort							
Total Yards of Net	324,050	44,300	43,200	49,400	5,900	10,350	324,050
Catch Effort (Removed)							
Total IC (N)	4,107	953	390	584	32	1	6,067
Total IC Weight (kg)	43,260	9,923	4,150	5,409	313	8.2	63,063
Average IC Weight (kg)	10.5	10.4	10.6	9.3	9.8	0	10.4
Total Unsorted IC Weight (kg)	0	0	0	0	0	0	0
Total BHCP (N)	188	49	11	29	5	0	282
Total BHCP Weight (kg)	2,887	847	182	408	82	0	4,407
Average BHCP Weight (kg)	16.6	15.4	17.3	16.5	16.4	0	15.6
Total SVCP (N)	1,734	793	341	306	25	0	3,199
Total SVCP Weight (kg)	15,935	7,989	3,557	2,788	212	0	30,482
Average SVCP Weight (kg)	9.2	10.1	10.4	9.1	8.5	0	9.5
Total SCBC (N)	35	12	2	4	0	0	53
Total SCBC Weight (kg)	506	130	37	47	0	0	719
Average SCBC Weight (kg)	35	12	18.5	14.4	0	0	14.1
Total GSCP (N)	2,150	99	38	245	1	1	2,535
Total GSCP Weight (kg)	23,931	957	374	2,166	18	8.2	27,455
Average GSCP Weight (kg)	11.1	9.6	9.8	8.8	9	8.2	10.8
Catch per unit of effort							
CPUE (BHCP/100 yds of net)	.11	.11	.02	.06	.08	0	.09
CPUE (SVCP/100 yds of net)	1.04	1.80	.79	.62	.42	0	.99
CPUE (SCBC/100 yds of net)	.02	.03	0	.01	0	0	.02
CPUE (GSCP/100 yds of net)	1.28	.22	.09	.50	.03	.01	.78
CPUE (Total/100 yds of net)	2.45	2.15	.90	1.18	.54	.01	1.9

Table 9. *Invasive carp tagged, translocated, and released from Pools 16-19 of the Mississippi River in 2021 -2022*

Year	Species	Number Tagged	Number Translocated	Weight (kg)
2021	Silver Carp	274	274	2,629
	Bighead Carp	63	63	882
	Grass Carp	55	55	533
	2021 Total	392	392	4,044
2022	Silver Carp	304	84	3,160
	Bighead Carp	41	5	682
	Grass Carp	96	96	1,102
	Hybrid Carp	11	0	110
	2022 Total	452	185	5,054
Total		**844**	**577**	**9,098**

Table 10. *Number of tagged bigheaded carp captured from commercial removal efforts in Pools 16–19 in the Upper Mississippi River from 2018 through 2022.*

USFWS/USGS Acoustically Tagged Fish Recaptures																		
	2018				2019				2020				2021			2022		Total Removed
Pool	16	17	18	19	16	17	18	19	15	16	17	19	16	17	19	16	17	
BHCP	1	8	6	2	1	1	3	0	0	3	1	1	2	1	2	1	0	10
BMBF	0	0	0	0	0	0	0	0	1	0	0	0	3	0	0	0	0	0
SCBC	0	1	4	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
SVCP	1	12	7	4	0	0	2	1	0	2	1	0	1	0	0	1	7	10
Unknown	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Total Captures	2	21	17	6	1	1	5	2	2	5	2	1	7	1	2	2	7	15

Table 11. *Number of fish detections from the VR100 receiver during commercial removal efforts in Pools 15–19 in the Upper Mississippi River from 2018 through 2022.*

VR100 Detections																					
	2018				2019				2020			2021					2022				
Pool	16	17	18	19	16	17	18	19	16	17	19	15	16	17	18	19	15	16	17	18	19
BHCP	1	2	3	7	1	3	6	2	3	1	0	0	1	1	2	5	0	1	2	2	1
BMBF	0	0	0	0	0	0	0	0	4	1	0	3	36	2	0	3	3	19	1	0	3
PDFH	15	0	0	1	3	3	0	1	2	0	1	0	7	0	0	0	0	4	1	0	1
SCBC	0	1	0	0	0	0	0	0	1	0	0	0	2	0	1	0	0	0	0	1	0
SVCP	4	4	5	8	0	3	4	10	2	2	1	1	13	4	8	9	4	14	4	19	5
Total Detections	20	7	8	16	4	9	10	13	12	4	2	4	59	7	22	17	7	39	8	22	10

Table 12. *Bighead Carp Wr comparison by year in pools 16-19 of the Mississippi River from 2016-2022*

Year	diff	lwr	upr	p.adj
2017-2016	0.328351	-3.9642	4.620902	0.999989
2018-2016	1.997967	-2.58428	6.58022	0.857188
2019-2016	2.265618	-2.80113	7.332365	0.841836
2020-2016	4.220006	-13.0096	21.44957	0.991135
2021-2016	7.30967	2.51056	12.10878	0.000156
2022-2016	10.22142	5.046794	15.39606	1.59E-07
2018-2017	1.669616	-3.09469	6.433925	0.945639
2019-2017	1.937267	-3.29471	7.169239	0.929797
2020-2017	3.891655	-13.3872	21.17053	0.994362
2021-2017	6.981318	2.008083	11.95455	0.000727
2022-2017	9.893073	4.556556	15.22959	1.18E-06
2019-2018	0.267651	-5.20451	5.739815	0.999999
2020-2018	2.222039	-15.1311	19.57515	0.99977
2021-2018	5.311702	0.086369	10.53704	0.043428
2022-2018	8.223457	2.651253	13.79566	0.000292
2020-2019	1.954388	-15.5329	19.44168	0.999896
2021-2019	5.044051	-0.61095	10.69905	0.116538
2022-2019	7.955806	1.978821	13.93279	0.001747
2021-2020	3.089663	-14.322	20.50129	0.998501
2022-2020	6.001418	-11.5174	23.52027	0.951189
2022-2021	2.911755	-2.8401	8.663614	0.747178

Table 13. *Bighead carp Wr comparison between years within pools in pools 16-19 of the Mississippi river from 2015 to 2022.*

Pool	Year	diff	lwr	upr	p.adj
Pool 16	2018-2017	0.283538	-9.01456	9.581633	0.999988
	2019-2017	-3.4845	-14.4111	7.442057	0.901532
	2021-2017	-5.38703	-45.3305	34.55643	0.995747
	2022-2017	2.609276	-11.1331	16.35164	0.984356
	2019-2018	-3.76804	-15.6307	8.094617	0.90281
	2021-2018	-5.67056	-45.8802	34.53904	0.994948
	2022-2018	2.325738	-12.172	16.82352	0.991721
	2021-2019	-1.90253	-42.5196	38.71456	0.999934
	2022-2019	6.093776	-9.49855	21.6861	0.813577
	2022-2021	7.996302	-33.4671	49.45967	0.983419
Pool 17	2017-2016	-6.317757702	-20.25417319	7.618657791	0.772000412
	2018-2016	-26.06786857	-60.20497537	8.069238232	0.236537512
	2019-2016	-9.443627253	-34.6555515	15.76829699	0.883090645
	2021-2016	9.446426279	-3.456187303	22.34903986	0.279597171
	2022-2016	28.18276782	5.167535115	51.19800053	0.007543674
	2018-2017	-19.75011087	-53.62761613	14.1273944	0.535476875
	2019-2017	-3.125869552	-27.9851621	21.733423	0.999102852
	2021-2017	15.76418398	3.564973377	27.96339458	0.003994117
	2022-2017	34.50052553	11.872131	57.12892005	0.000372016
	2019-2018	16.62424132	-23.23931109	56.48779372	0.827751207
	2021-2018	35.51429485	2.048803318	68.97978638	0.030948485
	2022-2018	54.25063639	15.73878597	92.76248681	0.001258674
	2021-2019	18.89005353	-5.40476457	43.18487163	0.218992766
	2022-2019	37.62639508	6.748220163	68.50456999	0.00796901
	2022-2021	18.73634155	-3.270430123	40.74311321	0.140938302
Pool 18	2017-2016	4.790056	-1.50845	11.08856	0.267846
	2018-2016	-2.97792	-15.4667	9.510834	0.992018
	2019-2016	5.473432	-0.5106	11.45746	0.097891
	2020-2016	11.1396	-10.8573	33.13651	0.741915
	2021-2016	4.679138	-3.42213	12.7804	0.60589
	2022-2016	11.80414	0.689295	22.91898	0.029258
	2018-2017	-7.76798	-20.6037	5.067724	0.550532
	2019-2017	0.683375	-5.99456	7.361314	0.999935
	2020-2017	6.349547	-15.8462	28.54527	0.979277
	2021-2017	-0.11092	-8.73743	8.515595	1
	2022-2017	7.014083	-4.48922	18.51739	0.541378
	2019-2018	8.451351	-4.233	21.1357	0.430115
	2020-2018	14.11752	-10.5594	38.7944	0.616821
	2021-2018	7.657057	-6.15289	21.467	0.651626

	2022-2018	14.78206	-0.98575	30.54987	0.082427
	2020-2019	5.666171	-16.4424	27.77472	0.988284
Pool	Year	diff	lwr	upr	p.adj
	2021-2019	-0.79429	-9.19395	7.60536	0.999959
	2022-2019	6.330708	-5.00346	17.66488	0.643607
	2021-2020	-6.46047	-29.2335	16.31254	0.980143
	2022-2020	0.664537	-23.3463	24.67535	1
	2022-2021	7.125002	-5.45615	19.70615	0.628275
Pool 19	2017-2016	-6.528396844	-14.02782083	0.971027138	0.134839755
	2018-2016	3.039867185	-2.811104644	8.890839013	0.720066772
	2019-2016	-12.41053945	-26.54197896	1.720900072	0.127782919
	2020-2016	-2.103333152	-25.87009307	21.66342677	0.999972915
	2021-2016	6.170038986	-0.725397442	13.06547541	0.113558368
	2022-2016	9.488246332	3.006402718	15.97008995	0.000369014
	2018-2017	9.568264028	2.068840047	17.06768801	0.003407204
	2019-2017	-5.882142601	-20.77190659	9.007621384	0.904489448
	2020-2017	4.425063692	-19.80026119	28.65038858	0.998188199
	2021-2017	12.69843583	4.358499844	21.03837182	0.000173553
	2022-2017	16.01664318	8.015281707	24.01800465	1.44E-07
	2019-2018	-15.45040663	-29.58184615	-1.318967113	0.021889614
	2020-2018	-5.143200337	-28.90996026	18.62355958	0.995354419
	2021-2018	3.130171801	-3.765264627	10.02560823	0.829625435
	2022-2018	6.448379147	-0.033464467	12.93022276	0.052199922
	2020-2019	10.30720629	-16.71727499	37.33168758	0.918262175
	2021-2019	18.58057843	3.985690456	33.17546641	0.003513082
	2022-2019	21.89878578	7.494688856	36.3028827	0.000178818
	2021-2020	8.273372138	-15.77183631	32.31858059	0.949176681
	2022-2020	11.59157948	-12.33830356	35.52146253	0.781749857
	2022-2021	3.318207346	-4.120036319	10.75645101	0.841004033

Table 14. *Silver Carp Wr comparison by year in pools 16-19 of the Mississippi River from 2016-2022*

Year	diff	lwr	upr	p.adj
2017-2016	-3.55868	-5.15015	-1.96722	9.75E-10
2018-2016	4.447322	2.64293	6.251714	1.41E-11
2019-2016	1.023062	-1.11236	3.158485	0.795034
2020-2016	5.811738	1.815494	9.807981	0.000365
2021-2016	13.82543	11.89978	15.75108	5.43E-12
2022-2016	13.39596	10.52084	16.27108	5.43E-12
2018-2017	8.006003	6.247831	9.764176	5.43E-12
2019-2017	4.581743	2.485228	6.678259	2.61E-09
2020-2017	9.370419	5.394831	13.34601	8.95E-11
2021-2017	17.38411	15.5017	19.26652	5.43E-12
2022-2017	16.95464	14.10831	19.80098	5.43E-12
2019-2018	-3.42426	-5.68666	-1.16186	0.000166
2020-2018	1.364416	-2.70109	5.429926	0.956339
2021-2018	9.378105	7.312545	11.44367	5.43E-12
2022-2018	8.948638	5.977999	11.91928	5.48E-12
2020-2019	4.788676	0.565813	9.011539	0.014554
2021-2019	12.80236	10.44212	15.16261	5.43E-12
2022-2019	12.3729	9.190304	15.55549	5.43E-12
2021-2020	8.013689	3.892928	12.13445	2.13E-07
2022-2020	7.584223	2.943228	12.22522	3.03E-05
2022-2021	-0.42947	-3.47528	2.616351	0.999604

Table 15. *Silver carp Wr comparison between years within pools in pools 16-19 of the Mississippi river from 2016 to 2022.*

Pool	Year	diff	lwr	upr	p.adj
Pool 16	2018-2017	4.540099	-1.3807	10.4609	0.22156
	2019-2017	1.244395	-4.59851	7.087303	0.977466
	2021-2017	6.367669	-0.14789	12.88322	0.059033
	2022-2017	8.330932	-1.88125	18.54311	0.168856
	2019-2018	-3.2957	-9.0657	2.474288	0.520781
	2021-2018	1.82757	-4.62268	8.277818	0.93734
	2022-2018	3.790833	-6.37981	13.96147	0.845513
	2021-2019	5.123275	-1.25555	11.5021	0.181482
	2022-2019	7.086538	-3.03895	17.21203	0.309543
	2022-2021	1.963263	-8.56472	12.49125	0.986262
Pool 17	2017-2016	-3.105050262	-8.750701428	2.540600904	0.618023401
	2018-2016	-9.991692209	-17.97428005	-2.009104371	0.004959746
	2019-2016	-0.354333587	-11.69035783	10.98169066	0.999999206
	2021-2016	7.782178084	2.231923803	13.33243236	0.000952305
	2022-2016	13.35525245	-1.056047592	27.76655248	0.08739797
	2018-2017	-6.886641947	-13.38204225	-0.391241641	0.030359692
	2019-2017	2.750716675	-7.592105098	13.09353845	0.974055872
	2021-2017	10.88722835	7.841930475	13.93252622	0
	2022-2017	16.46030271	2.816473138	30.10413228	0.00784307
	2019-2018	9.637358622	-2.144928666	21.41964591	0.180703974
	2021-2018	17.77387029	11.36121323	24.18652736	1.18E-13
	2022-2018	23.34694465	8.58203975	38.11184956	0.000104762
	2021-2019	8.136511671	-2.15454793	18.42757127	0.21258045
	2022-2019	13.70958603	-3.106660693	30.52583276	0.183690224
	2022-2021	5.573074361	-8.031558336	19.17770706	0.851042241
Pool 18	2017-2016	-2.644339051	-10.75280837	5.464130268	0.961295107
	2018-2016	-3.202016497	-13.77421212	7.370179126	0.973149945
	2019-2016	3.167939729	-5.179192273	11.51507173	0.921107305
	2020-2016	6.3685725	-4.672254074	17.40939907	0.612104525
	2021-2016	12.61629138	4.459411442	20.77317132	0.0001167
	2022-2016	10.22794858	1.094962589	19.36093456	0.016892404
	2018-2017	-0.557677446	-8.768371897	7.653017006	0.999994479
	2019-2017	5.812278781	0.780500193	10.84405737	0.011942744
	2020-2017	9.012911551	0.207002482	17.81882062	0.040900998
	2021-2017	15.26063043	10.5511853	19.97007556	2.39E-10
	2022-2017	12.87228763	6.622838361	19.12173689	4.10E-08
	2019-2018	6.369956226	-2.076512937	14.81642539	0.280456874
	2020-2018	9.570588997	-1.545529035	20.68670703	0.144687286
	2021-2018	15.81830788	7.55980202	24.07681373	4.68E-07
	2022-2018	13.42996507	4.206101365	22.65382878	0.00038422
	2020-2019	3.20063277	-5.825516602	12.22678214	0.942263286

Pool	Year	diff	lwr	upr	p.adj
	2021-2019	9.448351651	4.338927869	14.55777543	1.36E-06
	2022-2019	7.060008847	0.50387019	13.6161475	0.025370149
	2021-2020	6.247718881	-2.602786763	15.09822452	0.360974879
	2022-2020	3.859376077	-5.898092492	13.61684465	0.905189061
	2022-2021	-2.388342804	-8.700476497	3.923790889	0.922180812
Pool 19	2017-2016	0.999213301	-1.119167597	3.1175942	0.806627683
	2018-2016	5.011641012	3.112466745	6.91081528	4.07E-09
	2019-2016	-1.245329216	-3.83594915	1.345290718	0.792222794
	2020-2016	5.322445885	0.959739989	9.685151781	0.00598069
	2021-2016	15.76531299	12.39426332	19.13636267	4.07E-09
	2022-2016	14.08697559	10.70785488	17.4660963	4.07E-09
	2018-2017	4.012427711	1.708856909	6.315998513	6.07E-06
	2019-2017	-2.244542517	-5.144695476	0.655610441	0.252379934
	2020-2017	4.323232583	-0.230093484	8.876558651	0.075643043
	2021-2017	14.76609969	11.15174616	18.38045322	4.07E-09
	2022-2017	13.08776229	9.465879864	16.70964471	4.07E-09
	2019-2018	-6.256970228	-9.001093485	-3.512846971	4.49E-09
	2020-2018	0.310804872	-4.144765074	4.766374818	0.999993684
	2021-2018	10.75367198	7.263274192	14.24406977	4.07E-09
	2022-2018	9.075334578	5.577141106	12.57352805	4.07E-09
	2020-2019	6.5677751	1.776475456	11.35907475	0.001053586
	2021-2019	17.01064221	13.10074125	20.92054316	4.07E-09
	2022-2019	15.33230481	11.41544301	19.2491666	4.07E-09
	2021-2020	10.44286711	5.188419795	15.69731442	1.08E-07
	2022-2020	8.764529705	3.504900688	14.02415872	1.91E-05
	2022-2021	-1.678337402	-6.149855107	2.793180302	0.926105275

Table 16. *Bigmouth Buffalo Wr comparison by year in pools 16-19 of the Mississippi River from 2016-2022*

Year	diff	lwr	upr	p.adj
2017-2016	-1.036516199	-4.231415359	2.158382962	0.976667614
2018-2016	0.610934229	-2.3941808	3.616049257	0.998663996
2019-2016	1.441053842	-1.587887115	4.469994799	0.836705451
2020-2016	-0.23218314	-7.756826037	7.292459756	0.999999997
2021-2016	3.348236133	0.587353579	6.109118686	0.005864163
2022-2016	3.441270013	0.15743987	6.725100157	0.032261441
2018-2017	1.647450427	-1.508880434	4.803781289	0.760136738
2019-2017	2.477570041	-0.701453629	5.65659371	0.259406755
2020-2017	0.804333058	-6.78196768	8.390633797	0.999982885
2021-2017	4.384752331	1.45999924	7.309505423	0.000155014
2022-2017	4.477786212	1.05503168	7.900540744	0.001911768
2019-2018	0.830119614	-2.158111833	3.81835106	0.990584504
2020-2018	-0.843117369	-8.351465695	6.665230957	0.99997465
2021-2018	2.737301904	0.021143526	5.453460282	0.046652949
2022-2018	2.830335785	-0.415982787	6.076654357	0.14048774
2020-2019	-1.673236982	-9.191153021	5.844679056	0.997613614
2021-2019	1.907182291	-0.835313529	4.64967811	0.408528052
2022-2019	2.000216171	-1.268170473	5.268602816	0.580804556
2021-2020	3.580419273	-3.833557442	10.99439599	0.825781234
2022-2020	3.673453154	-3.950726714	11.29763302	0.827500933
2022-2021	0.093033881	-2.928611435	3.114679197	0.999999997

Table 17. *Bigmouth buffalo Wr comparison between years within pools in pools 16-19 of the Mississippi river from 2016 to 2022.*

Pool	Year	diff	lwr	upr	p.adj
Pool 16	2017-2016	0.954667699	-9.202374341	11.11170974	0.999803525
	2018-2016	6.488194163	-4.888352451	17.86474078	0.573504556
	2019-2016	8.634046881	-0.519534967	17.78762873	0.076973261
	2021-2016	5.890100144	-11.76154739	23.54174768	0.930237574
	2022-2016	0.352976825	-12.36638896	13.07234261	0.999999542
	2018-2017	5.533526464	-3.889045219	14.95609815	0.541228253
	2019-2017	7.679379182	1.110733589	14.24802478	0.011632063
	2021-2017	4.935432444	-11.52481375	21.39567864	0.955093057
	2022-2017	-0.601690874	-11.6081122	10.40473045	0.999986561
	2019-2018	2.145852718	-6.18525854	10.47696398	0.976665478
	2021-2018	-0.59809402	-17.837584	16.64139596	0.999998605
	2022-2018	-6.135217339	-18.27612423	6.005689555	0.694807233
	2021-2019	-2.743946738	-18.60466118	13.1167677	0.996235533
	2022-2019	-8.281070057	-18.36887795	1.806737832	0.175228915
	2022-2021	-5.537123319	-23.69081352	12.61656688	0.951754702
Pool 17	2017-2016	0.262220373	-4.228302359	4.752743105	0.999997751
	2018-2016	-6.026007455	-10.41529976	-1.636715152	0.0010812
	2019-2016	-0.797268737	-16.2671892	14.67265173	0.999998933
	2021-2016	3.412251843	-0.348211032	7.172714718	0.103941017
	2022-2016	-0.812592763	-8.479402236	6.854216711	0.999923067
	2018-2017	-6.288227829	-10.54944024	-2.027015421	0.000300182
	2019-2017	-1.05948911	-16.49355803	14.37457981	0.999994108
	2021-2017	3.150031469	-0.460110536	6.760173474	0.13349644
	2022-2017	-1.074813136	-8.66902223	6.519395958	0.999584903
	2019-2018	5.228738718	-10.17618179	20.63365923	0.952993028
	2021-2018	9.438259298	5.954838879	12.92167972	5.06E-10
	2022-2018	5.213414693	-2.321378223	12.74820761	0.386058773
	2021-2019	4.209520579	-11.02815542	19.44719658	0.983171701
	2022-2019	-0.015324026	-16.65340253	16.62275448	1
	2022-2021	-4.224844605	-11.41151966	2.961830453	0.589762893
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

Pool	Year	diff	lwr	upr	p.adj
	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	2017-2016	-0.591787811	-6.958820219	5.775244597	0.999963279
	2018-2016	0.659131739	-5.854130737	7.172394214	0.999939386
	2019-2016	-3.132388222	-9.49942063	3.234644185	0.767457727
	2020-2016	1.211582865	-8.285503639	10.70866937	0.999765006
	2021-2016	4.129326625	-0.519436204	8.778089454	0.118660597
	2022-2016	-4.302355254	-12.43517425	3.830463744	0.700791814
	2018-2017	1.25091955	-6.266034076	8.767873176	0.998915375
	2019-2017	-2.540600411	-9.931209684	4.850008862	0.948871386
	2020-2017	1.803370677	-8.408223509	12.01496486	0.998481282
	2021-2017	4.721114436	-1.25324742	10.69547629	0.2256285
	2022-2017	-3.710567443	-12.66739437	5.246259484	0.881770807
	2019-2018	-3.791519961	-11.30847359	3.725433665	0.745799658
	2020-2018	0.552451127	-9.750953272	10.85585553	0.999998601
	2021-2018	3.470194886	-2.659771343	9.600161116	0.629035296
	2022-2018	-4.961486993	-14.02284644	4.099872452	0.665409261
	2020-2019	4.343971088	-5.867623098	14.55556527	0.867905401
	2021-2019	7.261714847	1.287352991	13.2360767	0.006606392
	2022-2019	-1.169967032	-10.12679396	7.786859895	0.999730452
	2021-2020	2.91774376	-6.320684135	12.15617165	0.966040816
	2022-2020	-5.513938119	-16.91044192	5.882565686	0.781209878
	2022-2021	-8.431681879	-16.26089913	-0.602464629	0.025553291

Table 18. *Paddlefish Wr comparison by year in pools 16-19 of the Mississippi River from 2016-2022*

Year	diff	lwr	upr	p.adj
2017-2016	-5.841482763	-11.06436872	-0.61859681	0.016134881
2018-2016	7.81445221	3.585913461	12.04299096	6.55E-07
2019-2016	10.39166344	6.515361623	14.26796526	2.72E-11
2020-2016	8.105979627	-14.54534987	30.75730912	0.959839574
2021-2016	7.48820398	3.187144445	11.78926351	3.93E-06
2022-2016	19.02505521	15.32903023	22.72108019	2.71E-11
2018-2017	13.65593497	8.420923033	18.89094691	2.73E-11
2019-2017	16.23314621	11.27829748	21.18799493	2.71E-11
2020-2017	13.94746239	-8.913148668	36.80807345	0.584861259
2021-2017	13.32968674	8.035924075	18.62344941	2.81E-11
2022-2017	24.86653797	20.05141484	29.6816611	2.71E-11
2019-2018	2.577211234	-1.315413606	6.469836074	0.475981829
2020-2018	0.291527417	-22.36260113	22.94565596	1
2021-2018	-0.32624823	-4.642024575	3.989528114	0.999998338
2022-2018	11.210603	7.497462412	14.92374358	2.72E-11
2020-2019	-2.285683817	-24.87671558	20.30534794	0.999987595
2021-2019	-2.903459464	-6.874744057	1.067825128	0.340972059
2022-2019	8.633391762	5.326945203	11.93983832	2.73E-11
2021-2020	-0.617775647	-23.28555263	22.05000134	0.999999999
2022-2020	10.91907558	-11.6417223	33.47987346	0.824218357
2022-2021	11.53685123	7.74132937	15.33237308	2.72E-11

Table 19. *Paddlefish Wr comparison between years within pools in pools 16-19 of the Mississippi river from 2016 to 2022.*

Pool	Year	diff	lwr	upr	p.adj
Pool 16	2017-2016	-8.345092783	-30.31744831	13.62726274	0.88274388
	2018-2016	11.64732475	-7.769737482	31.06438699	0.514265719
	2019-2016	-0.553740489	-15.30030212	14.19282114	0.999997883
	2021-2016	-9.199727475	-29.27148036	10.87202541	0.772692403
	2022-2016	11.63190835	-8.827116626	32.09093332	0.57374854
	2018-2017	19.99241754	-2.223713384	42.20854846	0.104300448
	2019-2017	7.791352294	-10.48418456	26.06688915	0.821913317
	2021-2017	-0.854634692	-23.64519044	21.93592105	0.999997897
	2022-2017	19.97700113	-3.155354351	43.10935661	0.13300466
	2019-2018	-12.20106524	-27.30845237	2.906321887	0.188544991
	2021-2018	-20.84705223	-41.18537393	-0.508730522	0.041016123
	2022-2018	-0.015416407	-20.73602858	20.70519576	1
	2021-2019	-8.645986986	-24.58606553	7.294091557	0.623331364
	2022-2019	12.18564883	-4.239409546	28.61070722	0.272505134
	2022-2021	20.83163582	-0.503704036	42.16697568	0.059967906
Pool 17	2017-2016	-6.8112922	-12.62614147	-0.996442925	0.010092175
	2018-2016	3.207391647	-2.289303887	8.704087181	0.599577045
	2019-2016	5.641714674	-2.550788866	13.83421821	0.392984922
	2021-2016	9.864682563	4.402383477	15.32698165	2.54E-06
	2022-2016	24.24717578	19.54417659	28.95017497	4.90E-14
	2018-2017	10.01868385	3.954819323	16.08254837	2.58E-05
	2019-2017	12.45300687	3.869656396	21.03635735	0.000402687
	2021-2017	16.67597476	10.64327201	22.70867751	1.54E-13
	2022-2017	31.05846798	25.70356438	36.41337158	4.90E-14
	2019-2018	2.434323027	-5.936763828	10.80540988	0.978253941
	2021-2018	6.657290916	0.930625902	12.38395593	0.011042931
	2022-2018	21.03978413	16.0321717	26.04739656	4.90E-14
	2021-2019	4.222967889	-4.12557358	12.57150936	0.747839885
	2022-2019	18.6054611	10.73274653	26.47817567	1.24E-10
	2022-2021	14.38249321	9.412661047	19.35232538	1.15E-13
Pool 18	2017-2016	4.145556628	-10.74499531	19.03610856	0.982126908
	2018-2016	-6.93249946	-51.92669849	38.06169956	0.999306723
	2019-2016	18.44833422	10.32413941	26.57252902	1.59E-09
	2020-2016	14.18016105	-7.060586836	35.42090894	0.428829224
	2021-2016	-4.720408678	-49.7146077	40.27379035	0.999925701
	2022-2016	27.53075254	16.42234352	38.63916156	3.58E-11
	2018-2017	-11.07805609	-57.23563433	35.07952215	0.991811424
	2019-2017	14.30277759	1.186123136	27.41943205	0.022530272
	2020-2017	10.03460442	-13.57076475	33.63997359	0.868897408

Pool	Year	diff	lwr	upr	p.adj
	2021-2017	-8.865965306	-55.02354354	37.29161293	0.997584038
	2022-2017	23.38519591	8.237891403	38.53250042	0.000134518
	2019-2018	25.38083368	-19.05784354	69.8195109	0.620054718
	2020-2018	21.11266051	-27.46678846	69.69210949	0.856412269
	2021-2018	2.212090782	-60.50370817	64.92788973	0.999999887
	2022-2018	34.463252	-10.61656879	79.54307279	0.262684661
Pool 19	2017-2016	-5.407388314	-22.63525753	11.8204809	0.947078629
	2018-2016	9.910113059	3.221387754	16.59883836	0.000378143
	2019-2016	12.46394153	2.788018133	22.13986492	0.003419634
	2021-2016	5.036333029	-1.850443488	11.92310955	0.293408527
	2022-2016	11.8863688	5.730459157	18.04227845	7.57E-07
	2018-2017	15.31750137	-1.544413312	32.17941606	0.099496395
	2019-2017	17.87132984	-0.382672847	36.12533253	0.058963681
	2021-2017	10.44372134	-6.497731116	27.3851738	0.490946474
	2022-2017	17.29375712	0.636015847	33.95149839	0.036622714
	2019-2018	2.553828469	-6.454400134	11.56205707	0.965579886
	2021-2018	-4.873780029	-10.7858338	1.038273746	0.173371605
	2022-2018	1.976255744	-3.065560656	7.018072145	0.872777018
	2021-2019	-7.427608498	-16.58385375	1.728636757	0.187856194
	2022-2019	-0.577572725	-9.197570402	8.042424952	0.999964378
	2022-2021	6.850035774	1.548285382	12.15178617	0.003281357

Figure 1. *Total catch per unit effort by year for invasive carp removed by contracted removal from the Upper Mississippi River Pools 14–19 using gill nets from 2018 through 2022.*

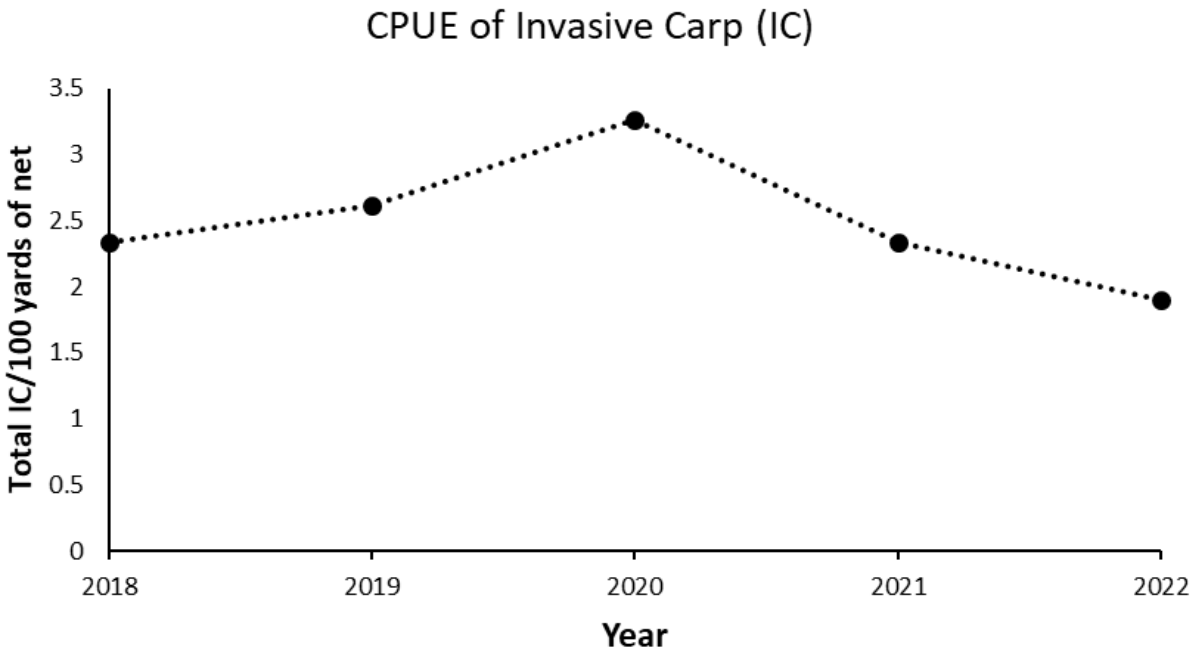

Figure 2. *Catch per unit effort by year and pool in the Upper Mississippi River in pools 14-19 for invasive carp removed during contracted commercial removal using gill nets from 2018 through 2022.*

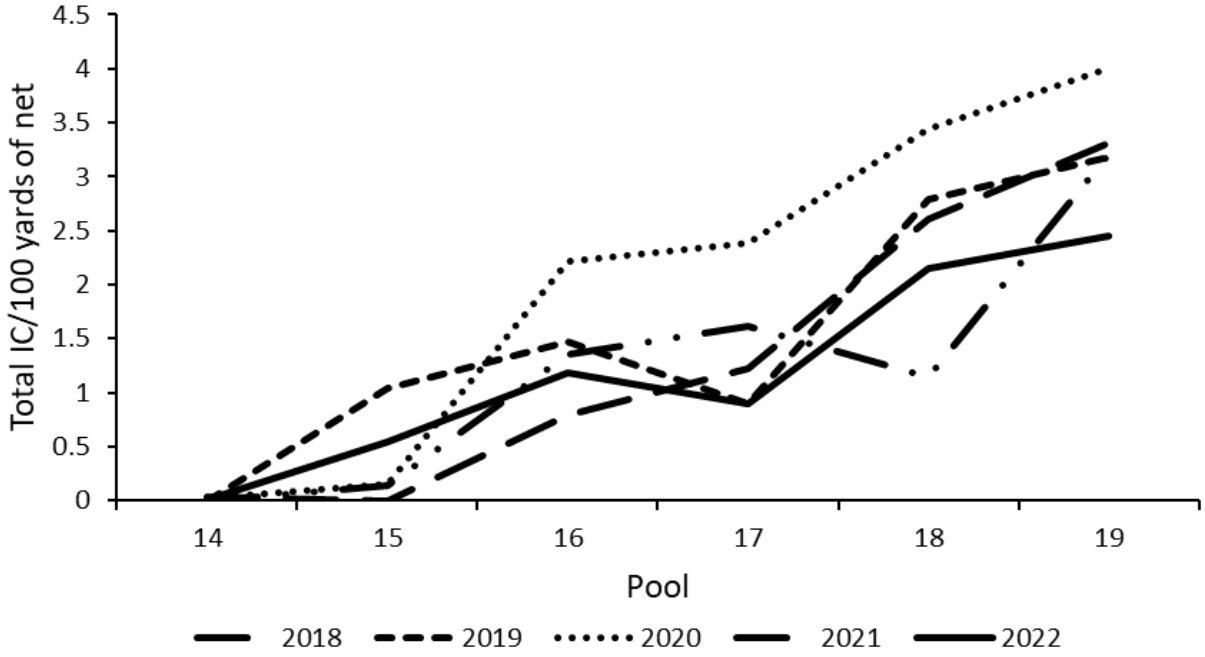

Figure 3. *Catch per unit effort by year and pool in the Upper Mississippi River in pools 14-19 for invasive carp removed during contracted commercial removal using gill nets from 2018 through 2022.*

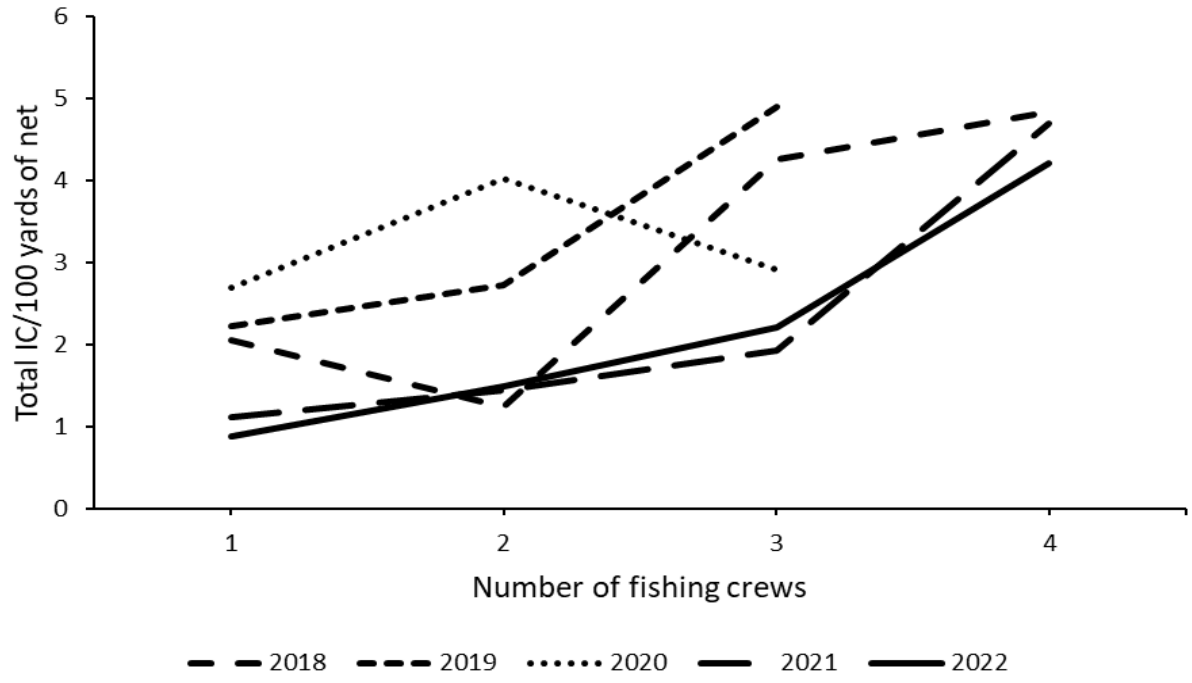

Figure 4. *Bighead Carp Wr by year in Pools 16–20 of the Upper Mississippi River from 2016 through 2022.*

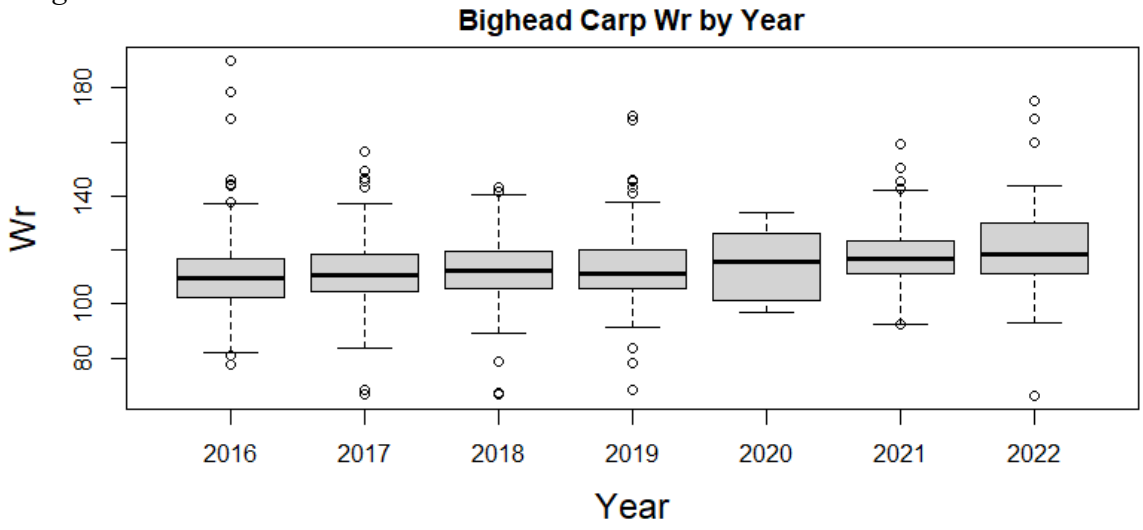

Figure 5. *Bighead Carp Wr by year and by pool in Pools 16–19 of the Upper Mississippi River from 2016 through 2022.*

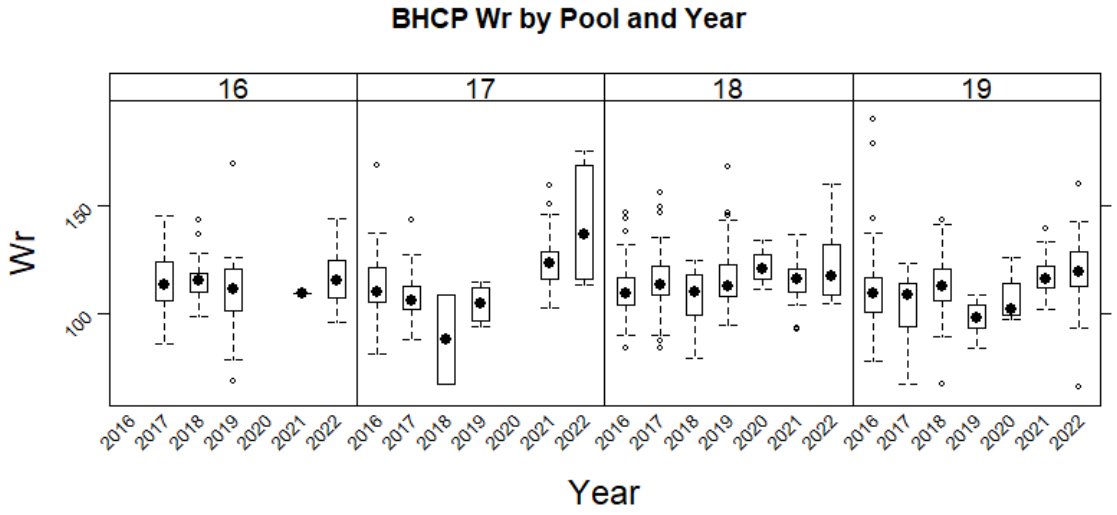

Figure 6. *Silver Carp Wr by year in Pools 16–19 of the Upper Mississippi River from 2016 through 2022.*

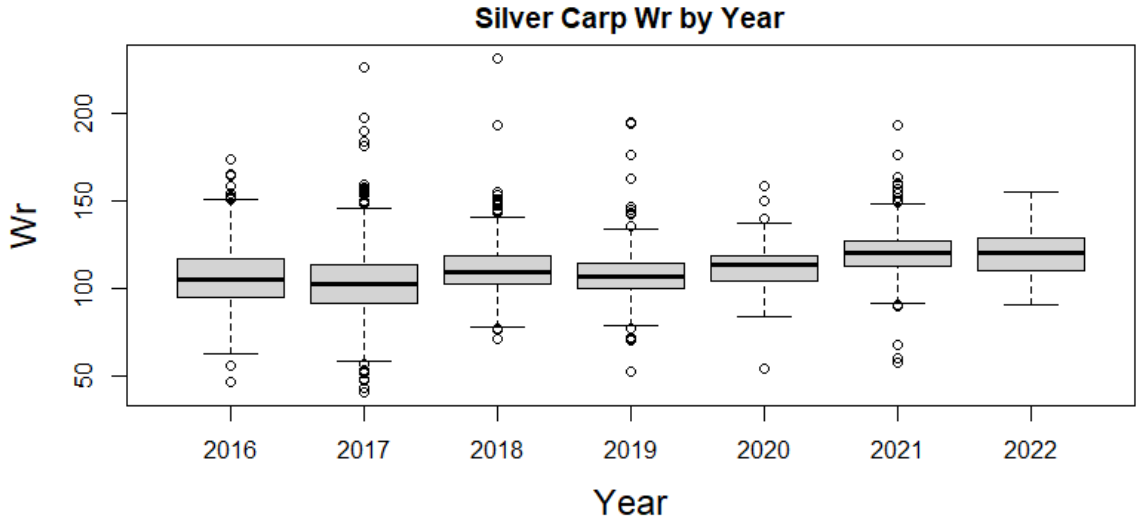

Figure 7. *Silver Carp Wr by year and by pool in Pools 16–19 of the Upper Mississippi River from 2016 through 2022.*

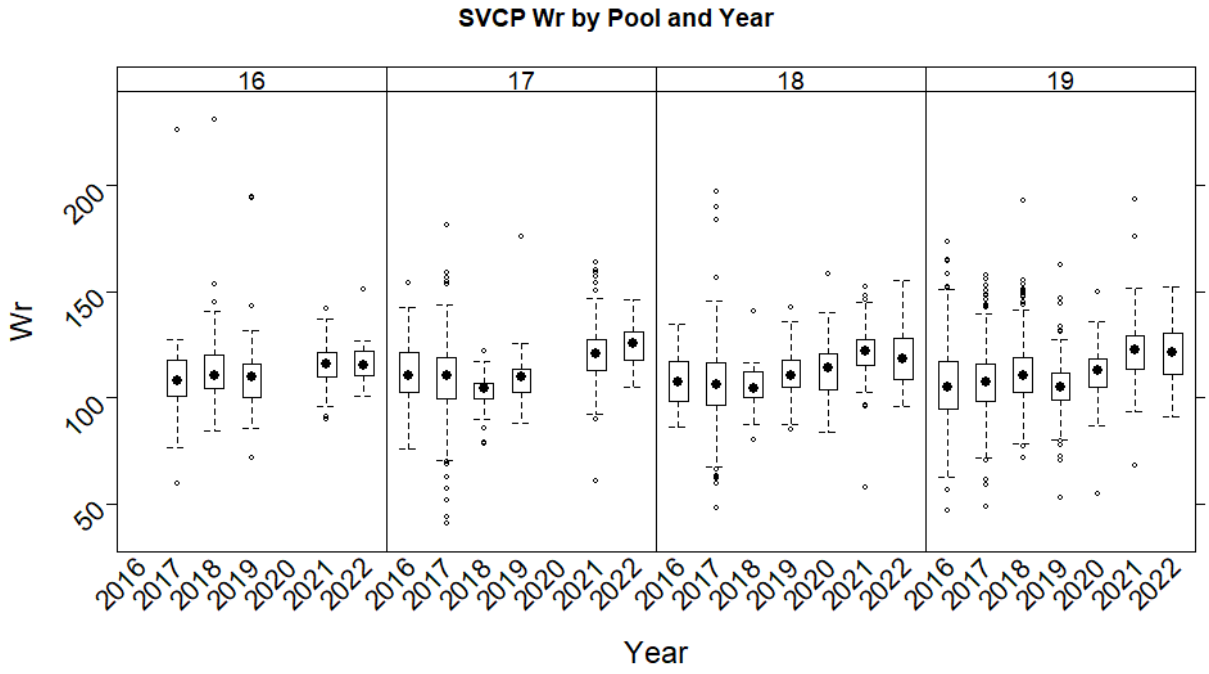

Figure 8. *Bigmouth buffalo Wr by year in Pools 16–19 of the Upper Mississippi River from 2015 through 2022.*

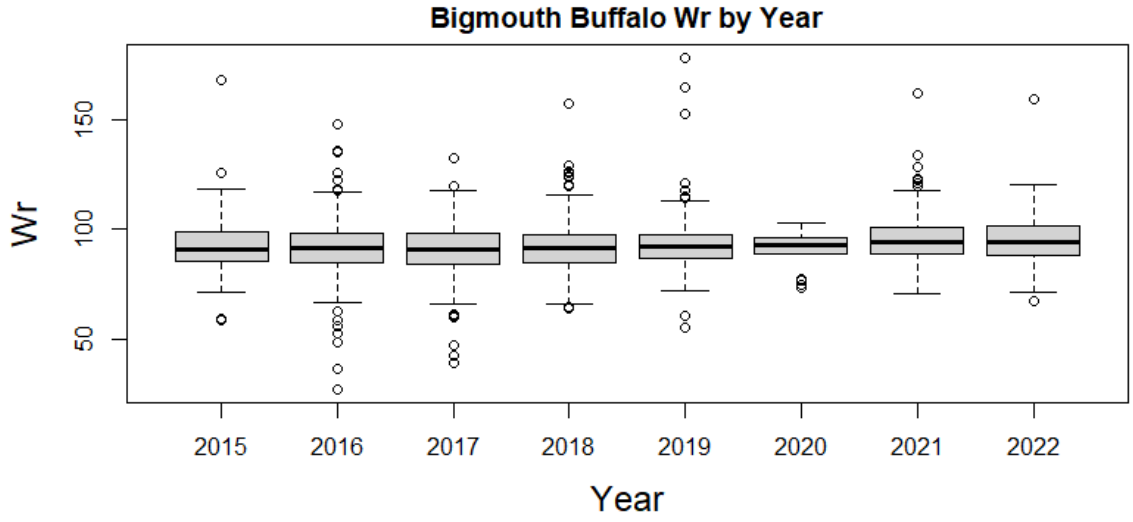

Figure 9. *Bigmouth buffalo Wr by year and by pool in Pools 16–19 of the Upper Mississippi River from 2015 through 2022.*

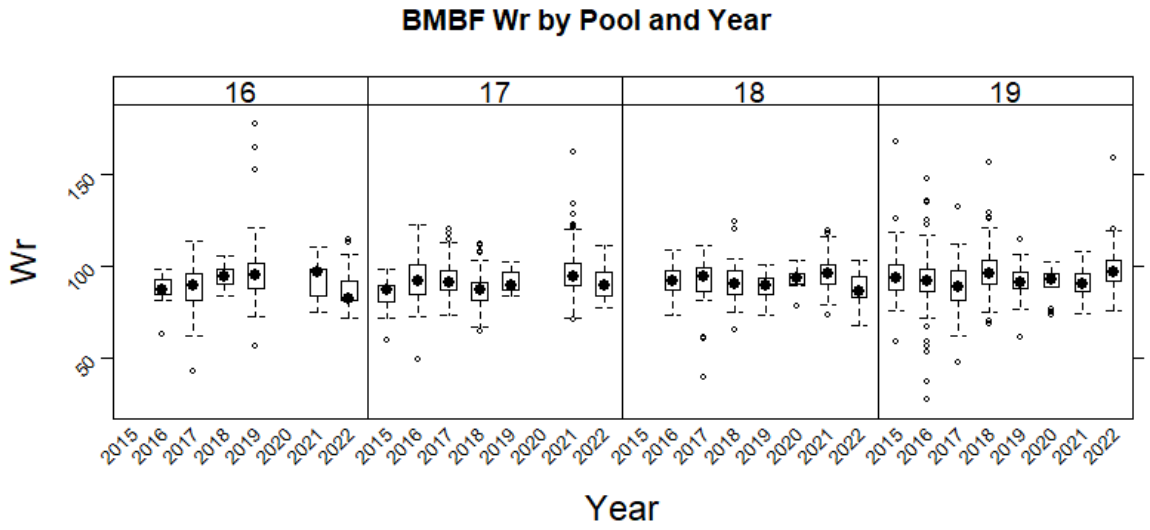

Figure 10. *Paddlefish Wr by year in Pools 16–19 of the Upper Mississippi River from 2015 through 2022.*

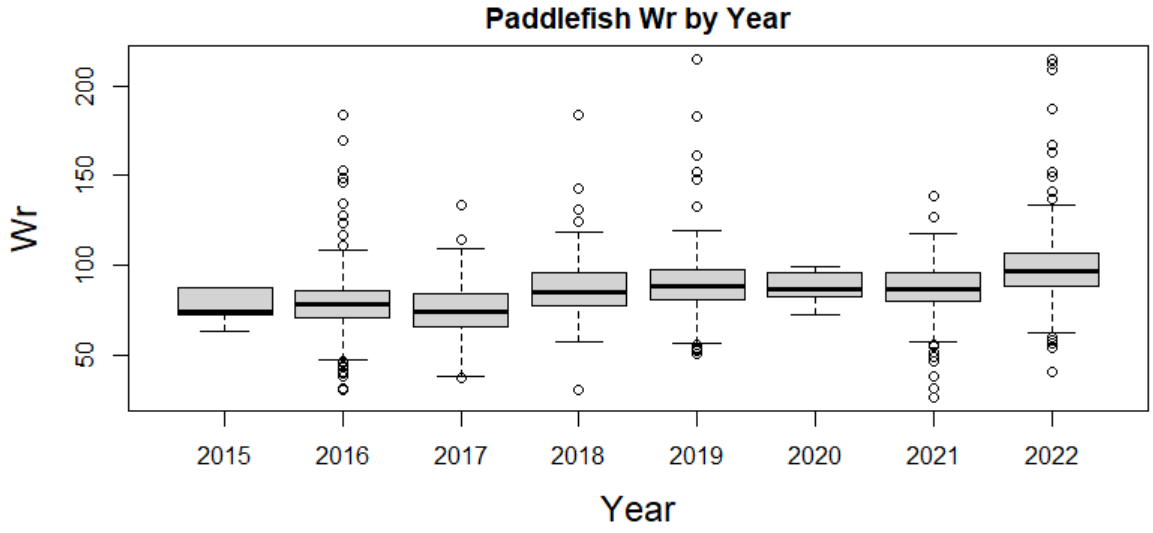

Figure 11. *Paddlefish Wr by year and by pool in Pools 16–19 of the Upper Mississippi River from 2015 through 2022.*