Bigheaded Carp Monitoring and Removal
2019

Geographic Location

Pools 14-19 of the Mississippi River

Participating Agencies

Western Illinois University, Illinois Natural History Survey, Illinois Department of Natural Resources, United States Geological Survey-Upper Midwest Environmental Sciences Center, and United States Fish and Wildlife Services

Prepared by: Dominique Turney, Emily Szott, Zack Witzel, and James T. Lamer

Statement of Need

Silver carp (*Hypophthalmichthys molitrix*), bighead carp (*Hypophthalmichthys nobilis*), and grass carp (*Ctenopharyngodon idella*), collectively known as Asian carp, have spread throughout the Mississippi River basin since their introduction in the 1970s and can be detrimental to native fish species and ecosystems. To limit their impact and further expansion, fishermen have been contracted through state and federal agencies to remove Asian carp, namely bighead and silver carp (bigheaded carp), using predominantly gillnets. Mesh size of entanglement gears, such as gillnets, determines the size structure of fishes able to be captured. To increase the efficiency and effectiveness of Asian carp harvest and minimize the capture of bycatch, it is important to understand the relationship of gillnet mesh size with the size structure of persistent populations. Bigheaded carp can drive density-dependent reductions in their body condition and that of other native species. Detection of a deviation from body condition baselines in bigheaded carp and native species over time can be used as a surrogate to evaluate tools used to reduce bigheaded carp populations.

Project Objectives

1) Targeted removal of 400,000-500,000 lbs of Asian carp species in UMR Pools 14-19 using commercial fishers and intensive netting protocols.
2) Tagging and recapturing jaw-tagged/spaghetti tagged fish to determine Asian carp population abundance through intense targeted sampling above LD19 in the UMR and calibrate hydroacoustic length and species targets using standardized electrofishing.
3) Use 30 larval light traps weekly in Pools 17, 18, and 19 backwaters to monitor for the presence of larval Asian carp during the periods when water temperatures are between 18-30°C.
4) Acoustically tag and monitor, collectively, 300 Bighead Carp, Silver Carp, and Bigmouth Buffalo in Pool 15, Pool 16, and Pool 19. in the fall of 2019 to assess frequency and timing of fish passage at Lock and Dam 14 and 15.

Project Highlights

- Commercial removal efforts resulted in 170,698 lbs of Asian carp removed from 01/01/2019 – 12/31/2019.
- Use of multiple crews (more than one fisherman) tended to increase catch per unit effort, specifically in Pools 18 and 19.

- A total of 225 bigheaded carp were jaw-tagged in 2019, 17 individuals (5 bighead carp, 12 silver carp) in Pool 18 and 208 individuals (9 bighead carp, 199 silver carp) in Pool 19.
- A total of 42 Asian carp with jaw tags were recaptured and removed in 2019 (5 bighead carp, 30 silver carp, and 7 grass carp).
- A total of 10 bigheaded carp with acoustic transmitters were captured in 2019 (1 removed and 9 released).
- Baseline relative weights (Wr) of silver carp and bighead carp have been established, and statistical comparisons across years show varying trends in Wr.
- The size structure of silver carp and bigmouth buffalo caught in different sized gillnets is relatively predictable and follows a logical trend, while bighead carp and paddlefish size structure are relatively unpredictable.

Methods

Study site

Data were collected from September 2015 through December 2019 on Pools 14-20 of the Upper Mississippi River (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 lock 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 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 extends 16.7 km 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 extends for 41.4 km 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 extends for 32.3 km 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 20, 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 Western Illinois University (WIU) biologists and contracted removal effort personnel. Net mesh sizes used were 3, 3.5, 4, 4.25, 4.5, 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 by utilizing side scan sonar, acoustic receivers (manual, stationary, and real-time), visual cues, and by 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 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 Asian 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. Silver carp, bighead carp, and grass carp (Asian carp) were removed from the system and bycatch were released back into the water at capture location.

Statistical analyses

Population estimates from WIU jaw tagged fish were determined using Chapman's population estimates. All tables were created using Microsoft Excel. Catch per unit of effort (CPUE) data for Asian carp from Pools 14-19 were calculated and displayed using Microsoft Excel. CPUE was analyzed for 2018-2019, for 2019 alone, and for the number of fishing crews across years and pools. Mean, minimum total length (TL), maximum TL, and modal length bins were calculated using Microsoft Excel. R (version 3.5.1) paired with R studio was used for statistical analyses and data visualization. Data were explored to remove outliers, data entry errors, and determine the shape of the data. Analyses used data from January to December, excluding weeks where conditions were unacceptable for sampling.

Relative weight 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 these 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 significant difference (α=.05) between years both in all pools combined, and in each pool separately. A Tukey's Post Hoc test (α=.05) determined between what years in each pool any difference in Wr existed.

Results and Discussion

Contracted Commercial Removal

During 2019, a total of 9,318 Asian carp at a combined weight of 170,698 lbs were captured and removed from Pools 15-19 of the Mississippi River (Table 1, 2). Silver carp were the most abundant Asian carp species removed from the UMR (5,827 fish; 90,264.64 lbs), followed by grass carp (2,626 fish; 53,730.11 lbs), bighead carp (838 fish; 24,303.83 lbs), and hybrid carp (27 fish; 613.68 lbs). Unsorted Asian carp made up 1,785.74 lbs of the total weight removed from the river in 2019. A total of 13,733 bycatch fish were captured in gill nets and released back into the river in 2019, with the highest amount of bycatch caught in Pool 19 (5,687 fish; Table 3).

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Contracted commercial efforts have been successful in removing large quantities of biomass annually from the ecosystem. Catch per unit effort has stayed relatively consistent across the past 2 years, with a slight increase in 2019 (Fig. 1) In 2019, as contracted fishing moved upstream, the total CPUE decreased. Pools 18 and 19 had the highest CPUE, and Pool 17 had the lowest CPUE. No Asian carp were removed from Pool 14 in 2019 (Fig. 2). These results suggest that Pools 19 and 18 are key focal points for removing pressure from upstream movement and contain the highest densities.

Effectiveness of using one versus 2+ fishing crews was analyzed using data from 2018-2019, which showed that catch per unit effort generally increased with additional fishing crews (Fig. 3). However, results may be slightly biased because crews of 3 and 4 fishermen were generally used during weeks of intensive harvest. Comparison of CPUE between crews of 1-4 fishermen across years showed that in 2018 and 2019, a positive trend existed between the number of fishermen and CPUE (Fig. 4). Comparison of CPUE between crews of 1-4 fishermen across Pools 14-19 of the Upper Mississippi River showed that Pools 18 and 19 benefit the most from the addition of fishermen, and Pools 15, 17, 18, and 19 all had positive trends in CPUE as the number of fishermen increased. Pools 14 and 16 were the only pools to have slightly negative trends with each additional fisherman added (Fig. 5).

Although total removed weight was lower in 2019 (170,698 lbs) than 2018 (187,086 lbs), 2019 had the highest number of Asian carp removed (9,318 fish) from the river compared to 2015-2018 data (Table 1, 2). Total removed Asian carp and CPUE calculations showcase the benefits of using additional fishermen to increase harvest efforts. This effort is further supported by better prediction tools aided by our FWS and USGS partners and using telemetry data to help guide our efforts. The poundage goal set forth by the project objectives was not achieved, however, record high flooding limited the amount of area we are able to fish and suspended fishing for several weeks. In addition, the high water events prohibited us from implementing our intensive removal efforts in a way that would of effectively removed large amounts of fish. Higher and more rapid water velocity throughout much of the harvest season resulted in considerably lower pounds removed than anticipated.

Table 1. Total weight (lbs) of Asian carp removed from Pools 14-19 on the Upper Mississippi River from 2015-2019.

Year	BHCP	SVCP	GSCP	Hybrid	Unsorted	Total
2015	205.87	1167.94	192.33	0	0	1566.14
2016	18875.41	38892.06	13485.83	1509.26	0	72762.56
2017	15809.53	33406.62	19696.85	404.97	27102.29	96420.25
2018	25573.98	98158.31	49799.93	481.89	13071.87	187085.98
2019	24303.83	90264.64	53730.11	613.68	1785.74	170698.00
Totals	84768.62	261889.57	136905.05	3009.80	41959.90	**528532.93**

Table 2. Total number of Asian carp captured and removed using gill nets in Pools 14-20 of the Upper Mississippi River from 2015-2019.

Year	Pool	Bighead Carp	Silver Carp	Hybrid Carp	Grass Carp	Total
2015	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	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	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
	16	64	330	2	127	523
	17	119	531	4	157	811
	18	266	1061	2	690	2019
	19	305	3078	22	1275	4680
Total		**756**	**5000**	**30**	**2249**	**8035**
2019	15	4	38	0	4	46
	16	116	364	2	115	597
	17	44	235	1	26	306
	18	372	1557	5	379	2313
	19	302	3633	19	2102	6056
Total		**838**	**5827**	**27**	**2626**	**9318**
Total		**2185**	**14052**	**84**	**6048**	**22369**

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Table 3. Total number of bycatch species captured using gill nets in Pools 14-20 of the Upper Mississippi River from 2015-2019.

	2015		**2016**					**2017**						**2018**						**2019**						**Total**
Family/Species	**17**	**19**	**16**	**17**	**18**	**19**	**20**	**14**	**15**	**16**	**17**	**18**	**19**	**14**	**15**	**16**	**17**	**18**	**19**	**14**	**15**	**16**	**17**	**18**	**19**	
Acipenseridae																										
Lake Sturgeon										1				1												2
Shovelnose Sturgeon																1						2				3
Amiidae																										
Bowfin					2	2	3						3			1	1	6	8					2	4	32
Catostomidae																										
Bigmouth Buffalo	15	64	20	152	282	365	3	4	1	213	980	194	742	2		442	661	630	682	41	49	353	431	375	736	7437
Black Buffalo			12	36	35	138	5			210	121	59	629	3		228	189	146	387		5	149	118	226	361	3057
Golden Redhorse																	1									1
Quillback						6				2															7	15
River Carpsucker	2	14		17	8	64				12	2	5	45			27	12	17	87	2	1	1	3	13	62	394
River Redhorse																		1								1
Shorthead Redhorse						2																			2	4
Smallmouth Buffalo	5	14		62	11	240	8			1,800	770	271	396		1	374	199	178	431	1	76	129	99	274	395	5734
Centrarchidae																										
Black Crappie																1							1		3	5
Bluegill																					1				1	2
Largemouth Bass		1				3	2				1							4	3				1	1	9	25
Smallmouth Bass																								1		1
White Crappie							1						6				1		2						2	12
Clupeidae																										
Gizzard Shad		4			1	7		1		5			5			1	4	5	1				2	1	5	42
Cyprinidae																										
Common Carp	40	43	42	67	298	1,037	16	33	7	137	357	489	1,250	3	2	299	391	1,245	1,879	6	28	435	231	1293	1971	11599
Goldfish													1									2				3

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Hiodontidae																										
Mooneye													3			2	1	2	8					1	12	29
Ictaluridae																										
Channel Catfish	1			5	2	48				7	1	2	24			11	9	24	58	4	2	2	2	11	70	283
Flathead Catfish					1	3			2	7	9	7	12			29	41	62	13	1	2	26		29	32	276
Lepisosteidae																										
Longnose Gar		21	3	16		14				1	10	2	14			13	67	3	41			8	6	11	86	316
Shortnose Gar		37	1	3	3	26					8		20			5	16	7	81			3	26	9	141	386
Moronidae																										
Striped x White Bass	1										2						6	9	9		3	2	20	10	17	79
White Bass	1				1	4					2	1					2	5						3		19
Sciaenidae																										
Freshwater Drum	49	19	5	145	74	125	1	14	2	60	290	85	355	3		118	492	500	734	622	464	83	180	320	1439	6179
Esocidae																										
Northern Pike			1	2	5	9				5	2	2	19			13	14	9	28			3		13	51	176
Polyodontidae																										
Paddlefish	5		18	574	65	353				249	1,290	102	436	66		356	1,116	594	857	8	2	393	757	648	279	8168
Percidae																										
Sauger										1						1		2			2	2		1	2	11
Walleye	3				1			1								13	2	5	1	2	3	3	1	5		40
Total	122	217	102	1,079	789	2,446	39	53	12	2,710	3,845	1,219	3,960	78	3	1,935	3,225	3,454	5,310	687	638	1596	1878	3247	5687	**44331**

Table 4. Total Asian carp gill netting effort in Pools 14-19 of the UMR in 2018.

2018	Pool 19	Pool 18	Pool 17	Pool 16	Pool 15	Pool 14	Total
Netting Effort							
Total Yards of Net	141,100	77,300	62,800	65,600	1,200	5,600	353,600
Catch Effort (Removed)							
Total AC (N)	4,830	2,033	903	541	0	2	8,309
Total AC Weight (kg)	43,383	19,540	10,188	5,792	0	29	78,932
Average AC Weight (kg)	9.0	9.6	11.3	10.7	0	14.5	9.5
Total Unsorted AC Weight (kg)	3,499	702	0	1728	0	0	5,929
Total BHCP (N)	327	275	139	71	0	2	814
Total BHCP Weight (kg)	3,738	4,597	2,378	858	0	29	11,600
Average BHCP Weight (kg)	11.4	16.7	17.1	12.1	0	14.5	14.3
Total SVCP (N)	3,154	1,065	593	341	0	0	5,153
Total SVCP Weight (kg)	25,420	8,994	6,031	4,079	0	0	44,524
Average SVCP Weight (kg)	8.1	8.4	10.2	12.0	0	0	8.6
Total HYBRID (N)	22	2	4	2	0	0	30
Total HYBRID Weight (kg)	137	30	26	27	0	0	219
Average HYBRID Weight (kg)	6.2	15.0	6.5	13.5	0	0	7.3
Total GSCP (N)	1,327	691	167	127	0	0	2,312
Total GSCP Weight (kg)	14,088	5,920	1,753	828	0	0	22,589
Average GSCP Weight (kg)	10.6	8.6	10.5	6.5	0	0	9.8
Catch per unit of effort							
CPUE (BHCP/100 yds of net)	0.23	0.36	0.22	0.11	0	0.04	0.23
CPUE (SVCP/100 yds of net)	2.24	1.38	0.94	0.52	0	0	1.46
CPUE (HYBRID/100 yds of net)	0.02	0.003	0.006	0.003	0	0	0.008
CPUE (GSCP/100 yds of net)	0.94	0.89	0.27	0.19	0	0	0.65
CPUE (Total AC/100 yds of net)	3.42	2.63	1.44	0.82	0	0.04	2.35

Table 5. Total Asian carp gill netting effort in Pools 14-19 of the UMR in 2019.

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 AC (N)	6,071	2,322	312	597	42	0	9,344
Total AC Weight (kg)	48,131	19,605	2,794	5,763	323	0	76,617
Average AC Weight (kg)	7.9	8.4	9.0	9.7	7.7	0	8.2
Total Unsorted AC 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 AC/100 yds of net)	3.19	2.80	0.91	1.47	0.95	0	2.62

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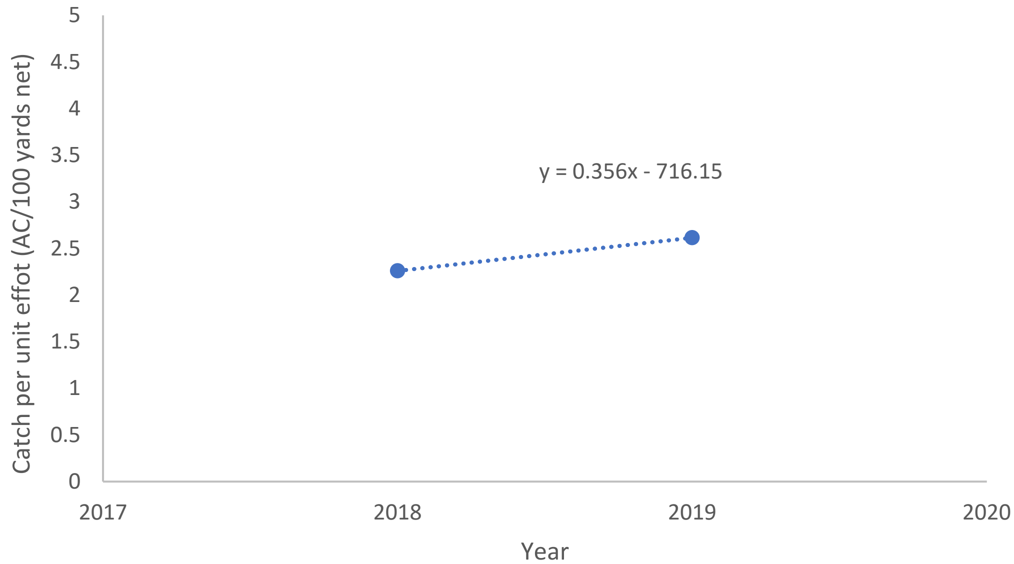

Figure 1. Total catch per unit effort per year for Asian carp removed from the Upper Mississippi River Pools 14-19 using gill nets from 2018-2019.

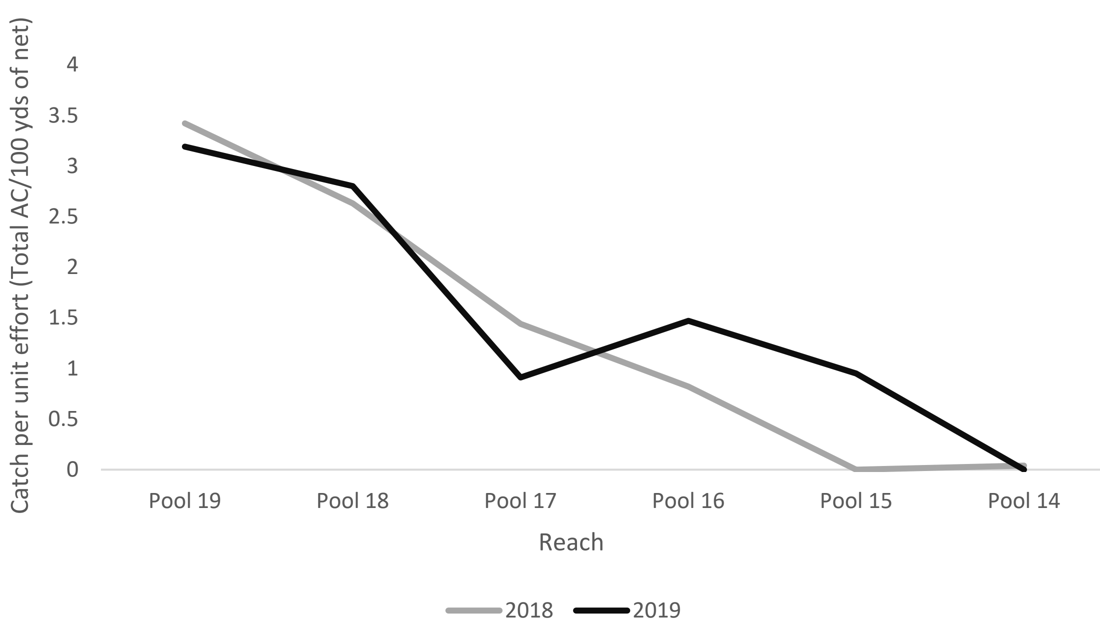

Figure 2. Catch per unit effort for Asian carp contracted commercial removal using gill nets by Upper Mississippi River reach in 2018 and 2019. The gray line represents 2018 and the black line represents 2019.

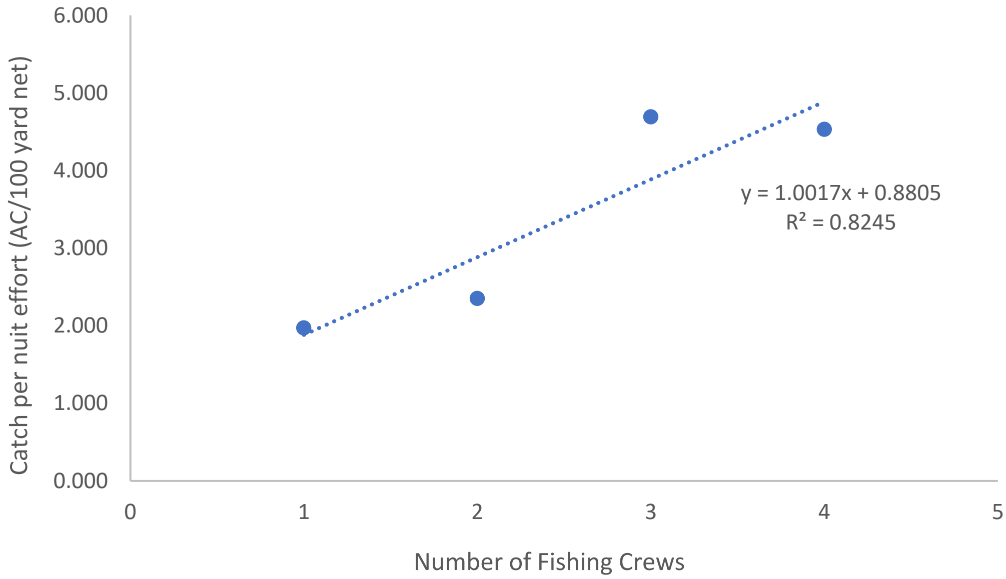

Figure 3. Total catch per unit effort per number of fishermen for Asian carp removed from the Upper Mississippi River Pools 14-19 using gill nets from 2018-2019.

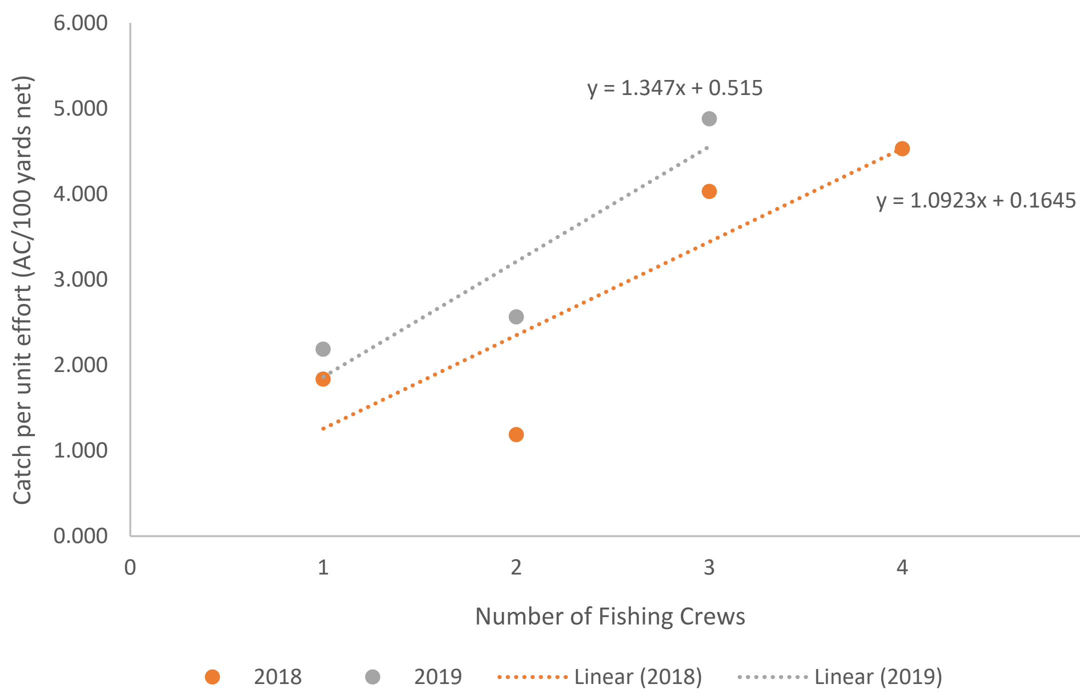

Figure 4. Total catch per unit effort per number of fishermen across years for Asian carp removed from the Upper Mississippi River Pools 14-19 using gill nets from 2018-2019.

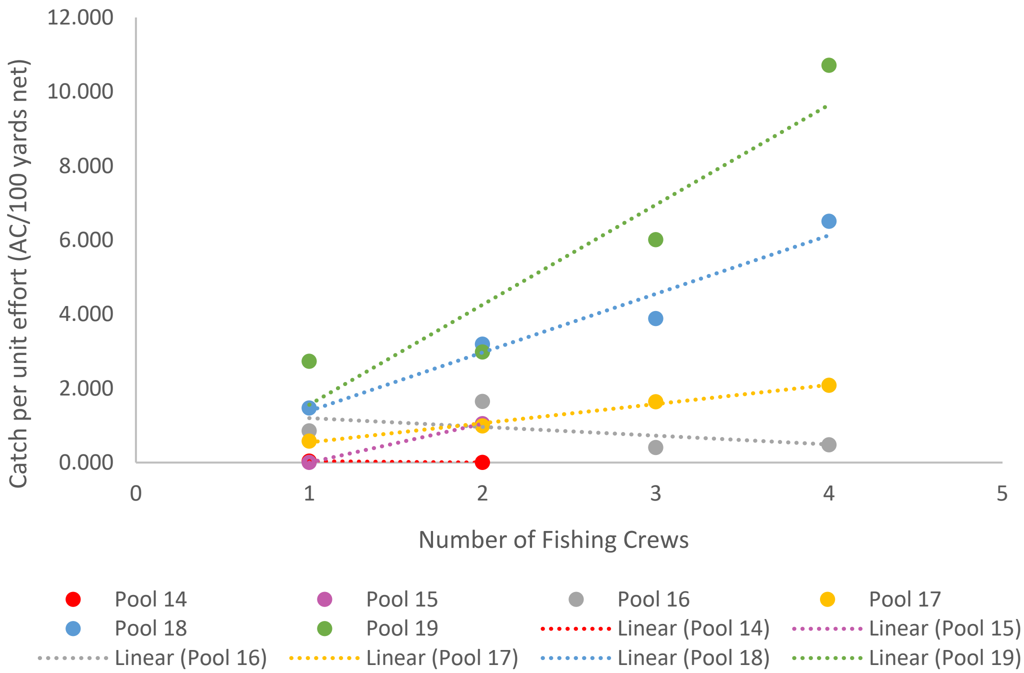

Figure 5. Total catch per unit effort per number of fishermen across pools for Asian carp removed from the Upper Mississippi River Pools 14-19 using gill nets from 2018-2019.

Population Estimates Using Jaw Tagging

A total of 4,077 Asian carp species have been jaw tagged from 2015-2019. Of those individuals, we have recaptured a total of 166 (4% of tagged individuals) Asian carp species from 2015-2019. In 2019, we focused our jaw tagging efforts in Pools 18 and 19, tagging 17 individuals in Pool 18 and 208 individuals in Pool 19. We were limited in our tagging efforts in 2019 due to the extreme flooding conditions which compromised our accessibility to launch sites and crew safety in the spring. We recaptured and removed 5 bigheaded carp, 30 silver carp, and 7 grass carp in 2019. Using 2018 recapture data, we estimate that there is a population size of 28,951 ± 9,836 silver carp and 1,359 ± 826 bighead carp in Pool 19. We estimate that there are 3,758 ± 1,847 silver carp and 620 ± 282 bighead carp in Pool 18. Our population estimates were derived from using a Chapman population estimator.

Our commercial removal efforts have been unsuccessful in recapturing jaw-tagged fish which has impacted our ability to confidently estimate population sizes for our fish. We have recaptured 10% of our bighead carp, 5% of our hybrid carp, 3% of our silver carp, and 4% of our grass carp. We believe that the low deployment number, low recapture rate, great mobility of our fish, and the extent of our study area has compromised our ability to accurately estimate the population size using jaw tags in our study area.

Table 6. Total number of jaw tags deployed and recaptured among species in Pools 16-20 in the UMR from 2015-2019.

	2015				2016				2017				2018				2019		Total
	Pool 17	Pool 18	Pool 19	Pool 20	Pool 17	Pool 18	Pool 19	Pool 20	Pool 16	Pool 17	Pool 18	Pool 19	Pool 16	Pool 17	Pool 18	Pool 19	Pool 18	Pool 19	
Marked individual																			
BHCP	9	1	11	92	20	40	46	108	0	0	2	0	0	3	0	33	5	9	379
SCBC	0	1	5	56	3	6	13	21	0	0	0	0	0	3	0	4	0	0	112
SVCP	26	15	248	1686	51	10	82	516	0	0	4	0	0	37	51	334	12	199	3271
GSCP	32	12	219	45	0	0	0	7	0	0	0	0	0	0	0	0	0	0	315
Recapture Total																			
BHCP	0	0	0	0	0	0	0	0	1	5	6	4	0	3	8	5	3	2	37
SCBC	0	0	0	0	0	0	0	0	0	0	1	1	0	2	0	2	0	0	6
SVCP	0	0	0	0	0	0	0	0	0	6	2	7	1	21	26	17	5	25	110
GSCP	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	3	0	7	13

Bigheaded Carp Monitoring and Removal
2019

Acoustic Monitoring

We monitored acoustically tagged fish through two methods; a Vemco VR100 receiver to detect individuals in the vicinity of sample sites and through the recapture of individuals in our fishing equipment. Our Vemco VR100 receiver was equipped with a portable omni-directional hydrophone (Vemco Model VH165). In 2019, we had 36 detections among three different species, bighead carp, paddlefish, and silver carp. There were 7 bighead carp individuals, 4 paddlefish individuals, and 13 silver carp individuals captured from our manual tracking efforts. Most of our bigheaded carp detections were captured in Pools 18 and 19, primarily above Lock and Dam 18 and Carthage Lake (Fig. 6). We suspect that there were fewer detections of fish in 2019 than previous years due to the underutilization of the VR100 during contracted commercial efforts. Our VR100 receivers were primarily used for paddlefish and Illinois River Asian carp telemetry studies in 2018 and 2019 and were infrequently used for commercial efforts.

We had 10 detections of bigheaded carp and recaptured 6 unique telemetered individuals during our commercial removal efforts in 2019. Five individuals were bighead carp, three individuals were silver carp, one individual was a silver carp x bighead carp hybrid, and one individual was unknown. Most fish were recaptured in Pool 18, primarily in New Boston Bay and above LD 18 near Big Dasher Island.

All fish besides one was released after capture in 2019. We removed one bighead carp (A69-9001-17388; jaw tag #1043) on 11/8/2019 from Pool 18 as instructed by USFWS. This fish did not possess an acoustic tag upon capture and was 1212 mm in length and 17500 kg in weight. Hard structures for aging and a fin clip were removed from this individual.

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.

Table 7. Number of tagged bigheaded carp captured (release/killed) from commercial removal efforts in Pools 16-19 in the Upper Mississippi River from 2017 to 2019.

USFWS/USGS Acoustically Tagged Fish Recaptures													
	2017				**2018**				**2019**				**Total Removed**
Pool	**16**	**17**	**18**	**19**	**16**	**17**	**18**	**19**	**16**	**17**	**18**	**19**	
BHCP	3	0	0	0	1	8	6	2	1	1	3	0	8
SCBC	0	0	0	0	0	1	4	0	0	0	0	1	0
SVCP	1	0	0	0	1	12	7	4	0	0	2	1	5
Total Detections	4	0	0	0	2	21	17	6	1	1	5	2	

Table 8. Number of fish detections from the VR100 receiver during commercial removal efforts in Pools 16-19 in the Upper Mississippi River from 2017 to 2019.

VR100 Detections												
	2017				**2018**				**2019**			
Pool	**16**	**17**	**18**	**19**	**16**	**17**	**18**	**19**	**16**	**17**	**18**	**19**
BHCP	2	5	1	0	1	2	3	7	1	3	6	2
BMBF	0	0	0	1	0	0	0	0	0	0	0	0
GSCP	0	0	0	1	0	0	0	0	0	0	0	0
PDFH	0	1	0	0	15	0	0	1	3	3	0	1
SCBC	0	0	0	0	0	1	0	0	0	0	0	0
SVCP	0	17	4	1	4	4	5	8	0	3	4	10
Total Detections	2	23	5	3	20	7	8	16	4	9	10	13

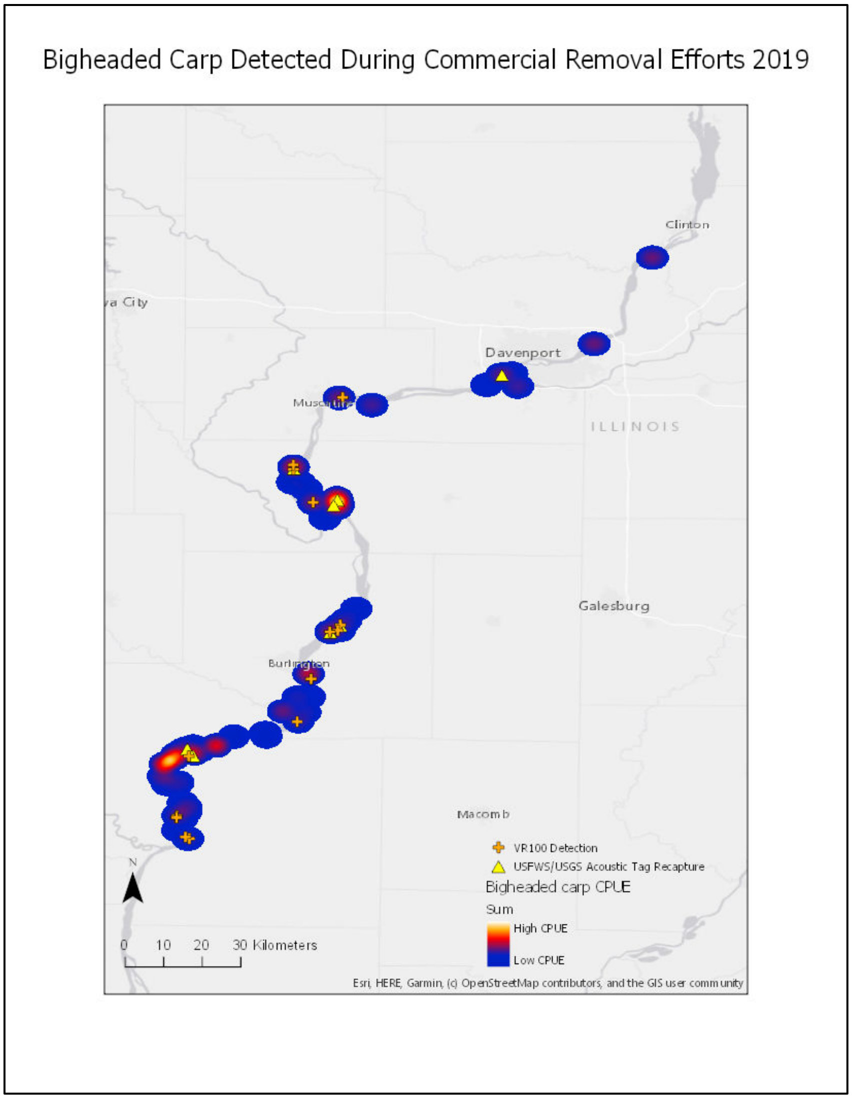

Figure 6. Heat map of the CPUE of Asian carp from 2019. The blue represents low CPUE and yellow represents high CPUE. The yellow triangles represent locations where USFWS/USGS acoustic fish were captured during 2019 removal efforts. The orange cross represents locations where Asian carp were detected with VR100 receiver in 2019 during removal efforts.

Relative Weight of 4 Common Species Caught During Commercial Efforts

Bighead Carp

Bighead carp showed an increase in Wr from 2015 to 2016, a slight decrease in Wr from 2016 to 2017, a slight increase from 2017 to 2018, and held steady from 2018 to 2019 (Fig. 7). A statistically significant difference was detected with the ANOVA ($p=0.001$) and the Tukey's test determined that the significant difference occurred between 2015 and 2016 ($p=0.001$), 2015 and 2018 ($p\leq0.001$), 2015 and 2019 ($p\leq0.001$), 2016 and 2017 ($p\leq0.001$), 2017 and 2018 ($p\leq0.001$), and 2017 and 2019 ($p\leq0.001$).

Wr seemed to hold steady in Pool 16 for 2017-2019 (Fig. 8). There were no data available for 2015 and 2016, and there were no statistically significant differences detected. In Pool 17, Wr dropped significantly from 2015 to 2017, and increased again in 2018 (Fig. 8). A statistically significant difference was detected with the ANOVA ($p=0.02$) and the Tukey's test determined that the significant difference occurred between 2015 and 2017 ($p=0.01$). In Pool 18, there were limited data for 2015. Wr was steady in Pool 18 through the years (Fig.8). An ANOVA indicated that there was no significant difference between years ($p=0.734$). In Pool 19, Wr decreased in 2015 and 2017 (Fig. 8), but increased in 2018. However, the ANOVA indicates that there was no significant difference between the years ($p=0.725$). We have discontinued fishing in Pool 20 for bighead and silver carp.

There were low amounts of data associated with bighead carp, because there are far fewer of this species than silver carp that are captured using gill nets. More data are needed to analyze the effects of bighead carp in the UMR.

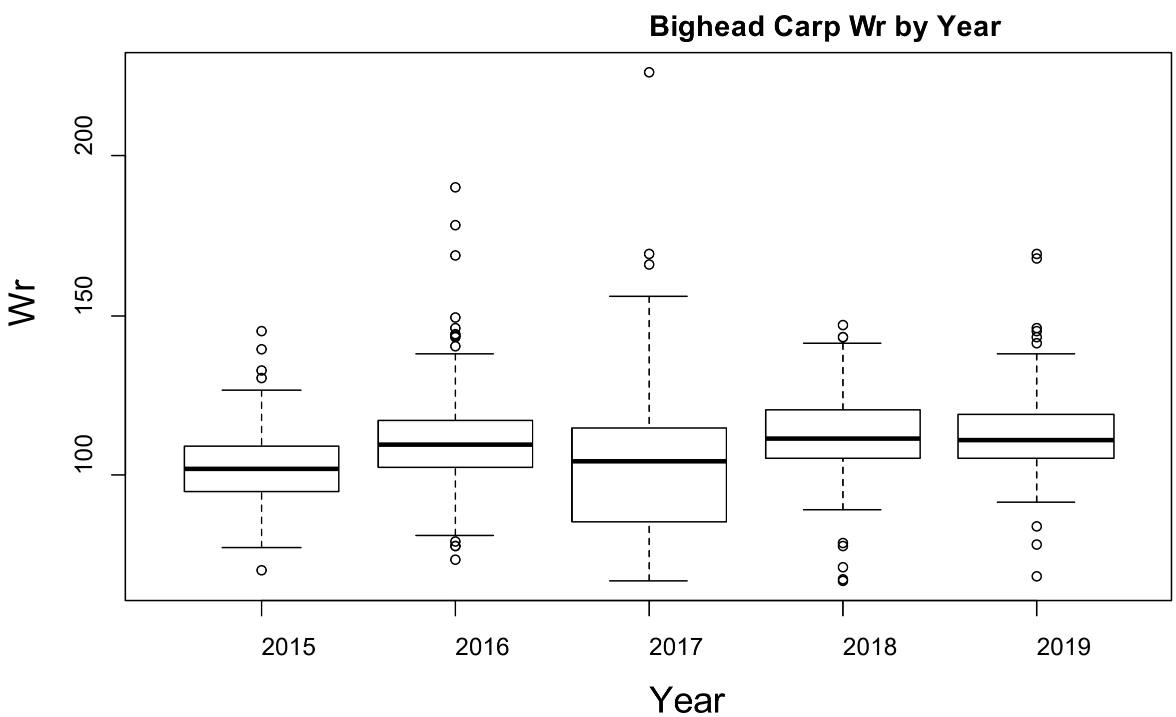

Figure 7. Bighead Carp Wr by year in Pools 16-20 of the Upper Mississippi River from 2015 to 2019.

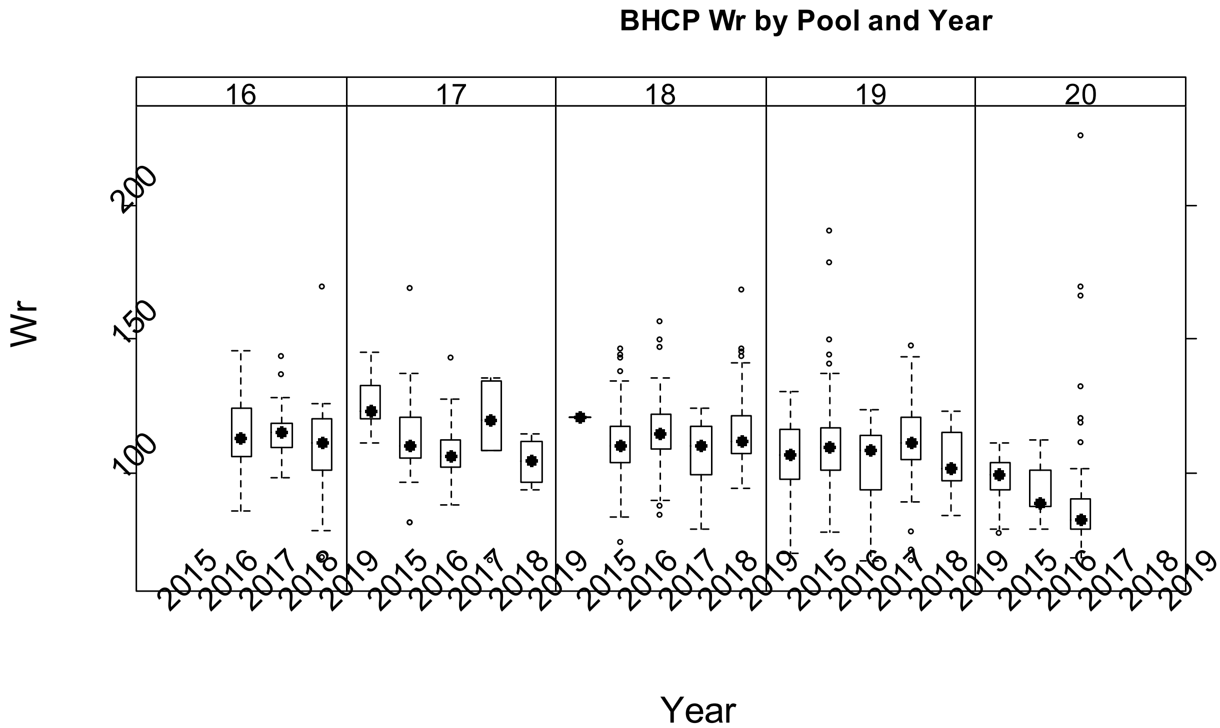

Figure 8. Bighead Carp Wr by year and by pool in Pools 16-20 of the Upper Mississippi River from 2015 to 2019.

Silver Carp

Silver carp Wr (Fig. 9) seems to display a steady trend throughout the years with little interannual variability. However, when an ANOVA was conducted it showed that there were significant differences in the data ($p \leq 0.001$). A Tukey's test revealed there was a significant difference between 2015 and 2017 ($p \leq 0.001$), 2015 and 2018 ($p \leq 0.001$), 2016 and 2017 ($p \leq 0.001$), 2016 and 2018 ($p \leq 0.001$), 2017 and 2018 ($p \leq 0.001$), 2017 and 2019 ($p \leq 0.001$), and 2018 and 2019 ($p \leq 0.001$).

In Pool 16, there were no data available for 2015 and 2016, but a steady trend exists in silver carp Wr from 2017 to 2019 (Fig. 10). An ANOVA run on the data revealed there was a significant difference in the data ($p=0.02$) and the Post Hoc Tukey's ($p=0.02$) confirmed there was a significant difference between 2017 and 2018 silver carp Wr in Pool 16. In Pool 17, silver carp Wr remained steady throughout all years. An ANOVA supports this steady trend ($p=0.93$). In Pool 18, silver carp Wr was variable throughout the years, starting high in 2015, dropping to a low in 2017, and rising again in 2018 and 2019. An ANOVA revealed a significant difference in the data ($p=0.03$). There was only a significant difference found between 2017 and 2018 ($p=0.009$) and 2017 and 2019 ($p=0.013$). In Pool 19, silver carp Wr was variable between 2015 to 2019 with no real apparent trend in the data. The ANOVA revealed a significant difference in the data ($p=0.001$). A Post Hoc Tukey's test revealed a significant difference between 2015 and 2016 ($p \leq 0.001$), 2015 and 2017 ($p \leq 0.001$), 2015 and 2019 ($p \leq 0.001$), 2016 and 2018 ($p \leq 0.001$), 2017 and 2018 ($p \leq 0.001$), and 2018 and 2019 ($p \leq 0.001$).

Data are lacking in several areas of this data set. 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.

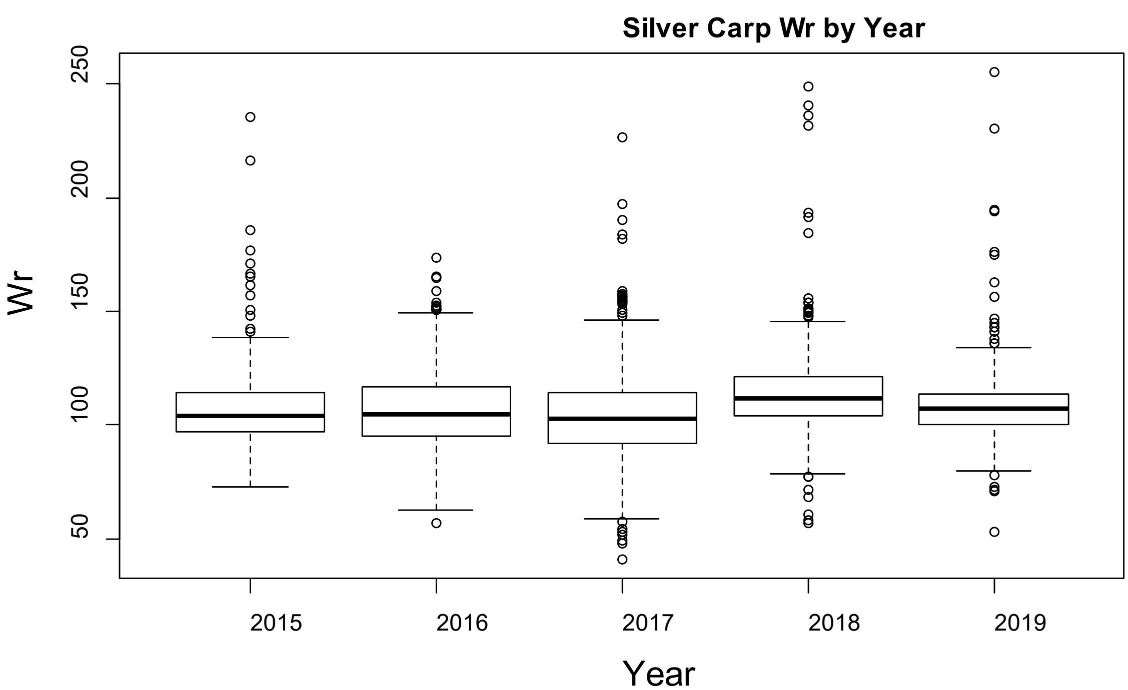

Figure 9. Silver Carp Wr by year in Pools 16-20 of the Upper Mississippi River from 2015 to 2019.

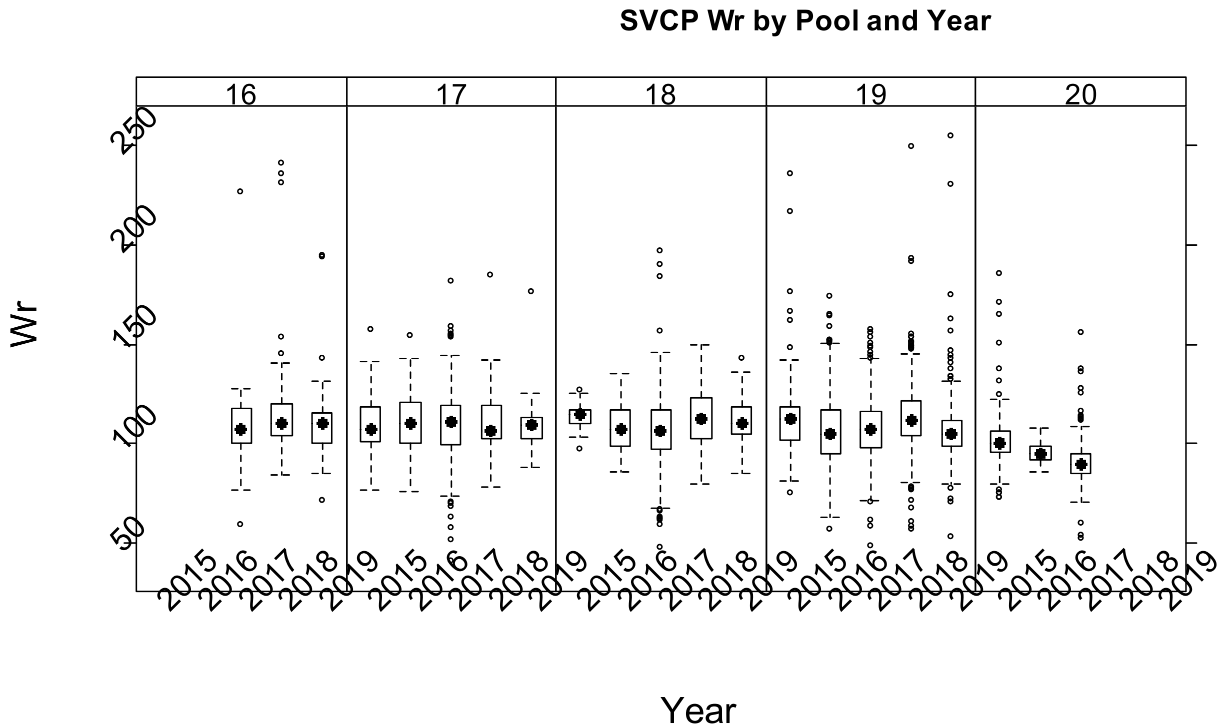

Figure 10. Silver Carp Wr by year and by pool in Pools 16-20 of the Upper Mississippi River from 2015 to 2019.

Bigmouth Buffalo

When all data are combined, bigmouth buffalo show relatively stable Wr throughout all years of sampling (Fig. 11). There were no significant differences found in the data with an ANOVA (p=.51).

When examining the data between pools and years, Wr appeared variable. In Pool 16, there were no data from 2015. A slight upward trend in Wr existed from 2016 to 2019 in Pool 16, and there was a significant difference shown in the ANOVA (p=0.001). Post Hoc Tukey's test (p=0.03) showed that there was a significant difference between 2016 and 2019. In Pool 17, the Wr of bigmouth buffalo appeared variable throughout the years (Fig. 12). The ANOVA indicated that there was a significant difference in the data (p≤0.001), and the Post Hoc Tukey's test showed that there was a significant difference between 2015 and 2016 (p=0.044), 2015 and 2017 (p=0.03), 2016 and 2018 (p≤0.001), and 2017 and 2018 (p≤0.001). 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 that there was no significant difference between any of the years in Pool 18 (p=0.307). In Pool 19, Wr was stable for 2015-2017 with an increase in Wr in 2018 and 2019 (Fig. 12). The ANOVA (p≤0.001) and Post Hoc Tukey's test (p=0.001) indicated a difference between 2017 and 2018 and 2018 and 2019 (p=0.003).

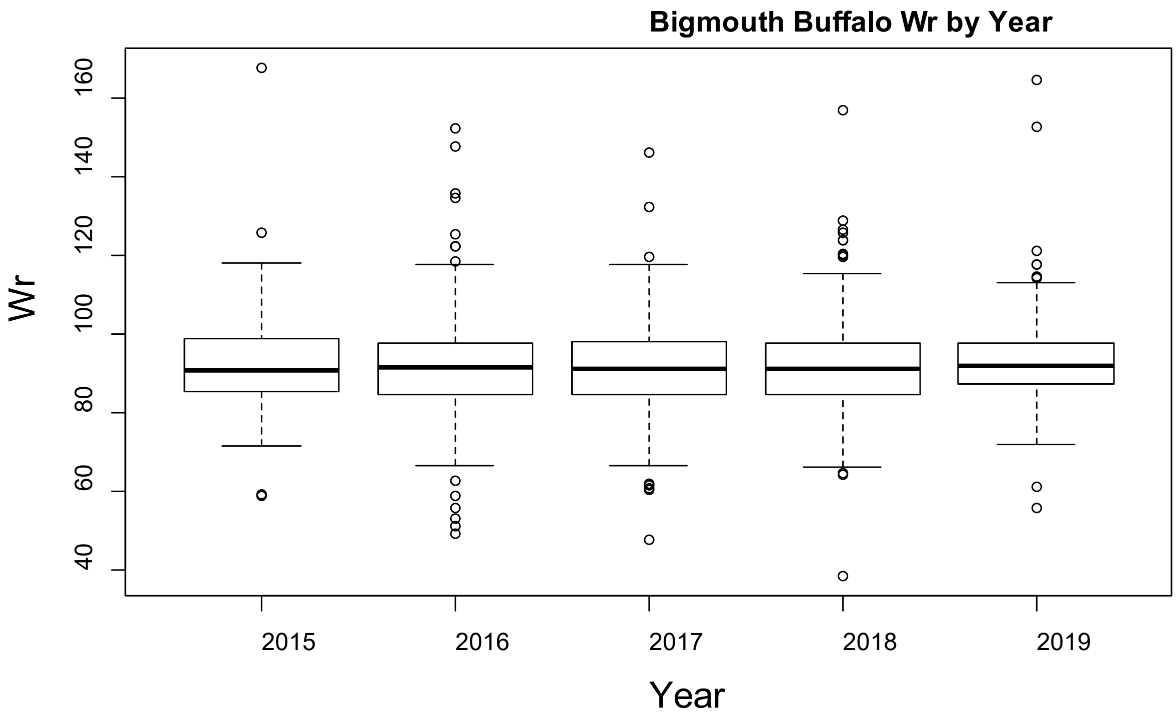

Figure 11. Bigmouth buffalo Wr by year in Pools 16-19 of the Upper Mississippi River from 2015 to 2019.

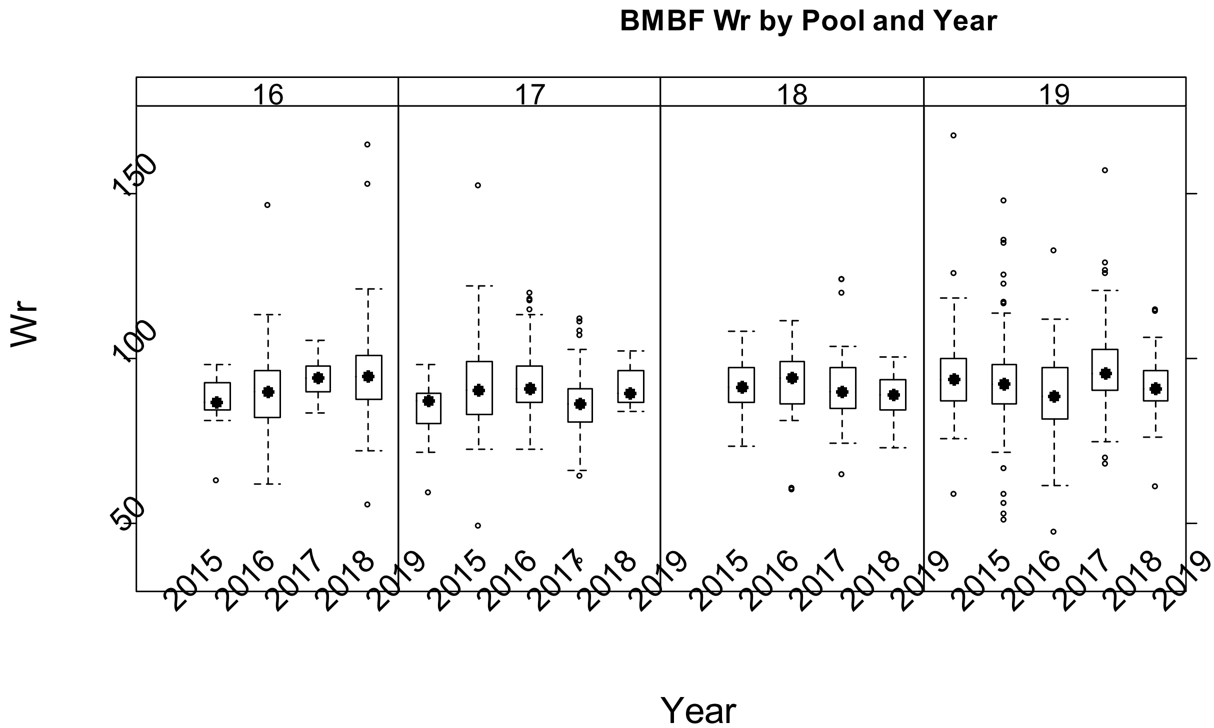

Figure 12. Bigmouth buffalo Wr by year and by pool in Pools 16-19 of the Upper Mississippi River from 2015 to 2019.

Paddlefish

For paddlefish, there were no data in 2015 for Pools 16, 18, and 19. 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).

In Pool 16, paddlefish Wr was variable throughout the years (Fig. 14). An ANOVA indicated there was a significant difference between years in Pool 16 ($p=0.004$). The years that were significantly different from each other were 2016 and 2018 ($p=0.01$), 2017 and 2018 ($p=0.01$), and 2018 and 2019 ($p=0.02$). In Pool 17, paddlefish Wr appeared steady. However, an ANOVA showed there was a significant difference in the data ($p<0.001$). A Tukey's test revealed a significant difference between 2016 and 2017 ($p<0.001$), 2017 and 2019 ($p<0.001$), and 2017 and 2019 ($p<0.001$). In Pool 18, there were no data for 2015 and limited data for 2018. An ANOVA ($p<0.001$) showed there was 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 ($p<0.001$), showing 2019 Wr was higher than previous years. In Pool 19, there were no significant differences detected in the data.

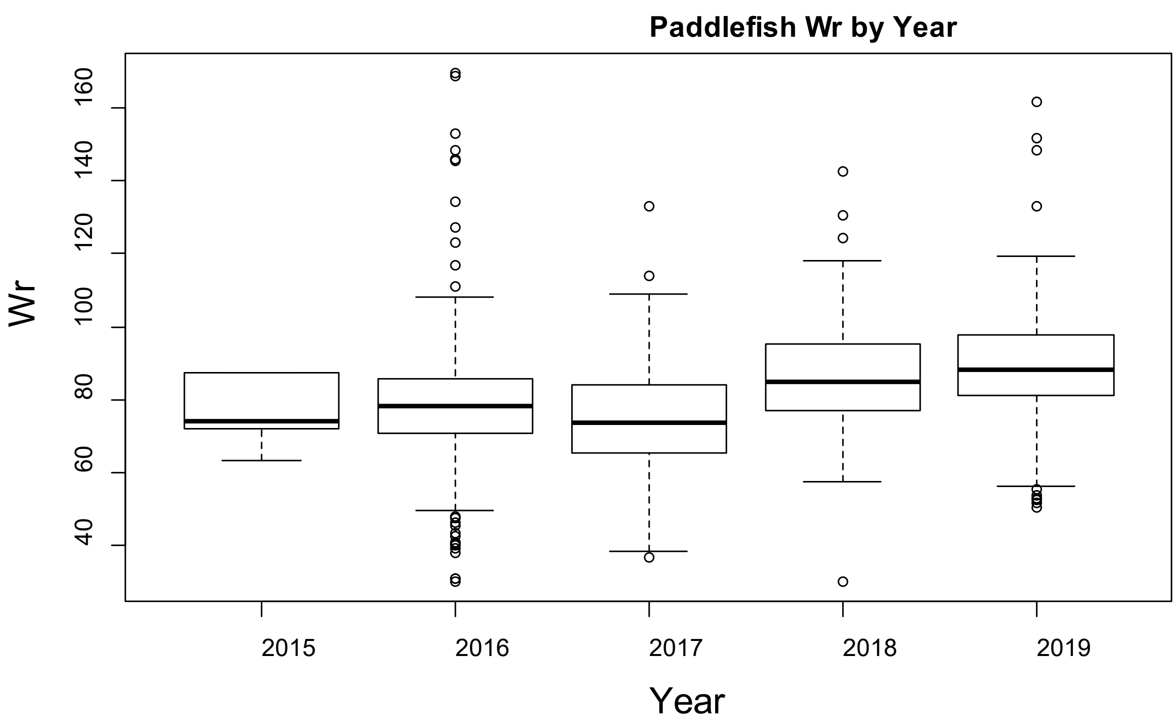

Figure 13. Paddlefish Wr by year in Pools 16-19 of the Upper Mississippi River from 2015 to 2019.

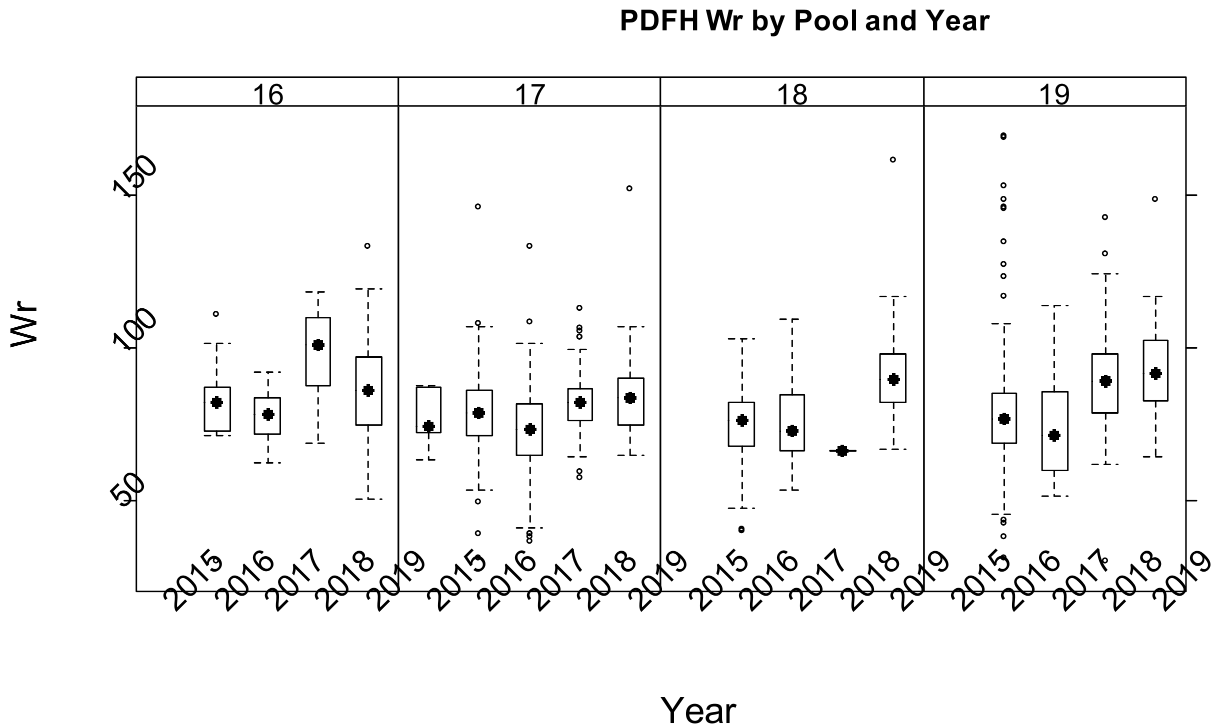

Figure 14. Paddlefish Wr by year and by pool in Pools 16-19 of the Upper Mississippi River from 2015 to 2019.

Size Selectivity of Gill Nets Used during Commercial Efforts

Silver Carp

Silver carp size selection was relatively determinant and predictable based on the mesh size of gill nets. The average size, modal length bin, mean total length, minimum total length of fish caught, and maximum total length of fish caught in the gillnets were calculated (Table 9). Silver carp caught in different sized gill nets (Fig. 15) showed trends in which size gill net is most selective for the specific size of silver carp. More mesh sizes and fish need to be added to this model to increase validity.

Table 9. Statistics about the different bar mesh sizes for silver carp in Pools 16-19 of the Mississippi River. Bar mesh (in) indicates the mesh size, N indicates the number of fish caught and measured in that mesh size, Modal Length Bin (mm) is the length bin that has the highest frequency of occurrence, Mean TL (mm) indicates the average size of fish caught in that mesh size, Minimum TL (mm) indicates the smallest fish caught in that mesh size, Maximum TL (mm) indicates the largest fish caught in that mesh size.

Bar Mesh (in)	N	Modal Length Bin (mm)	Mean TL (mm)	Minimum TL (mm)	Maximum TL (mm)
3	36	625-649	624	584	803
3.5	130	700-724	717	550	1090
4	703	825-849	840	335	1142
4.25	535	850-874	851	641	1020
4.5	53	875-899	892	715	1049
5	372	975-999	922	609	1134

Bigheaded Carp Monitoring and Removal
2019

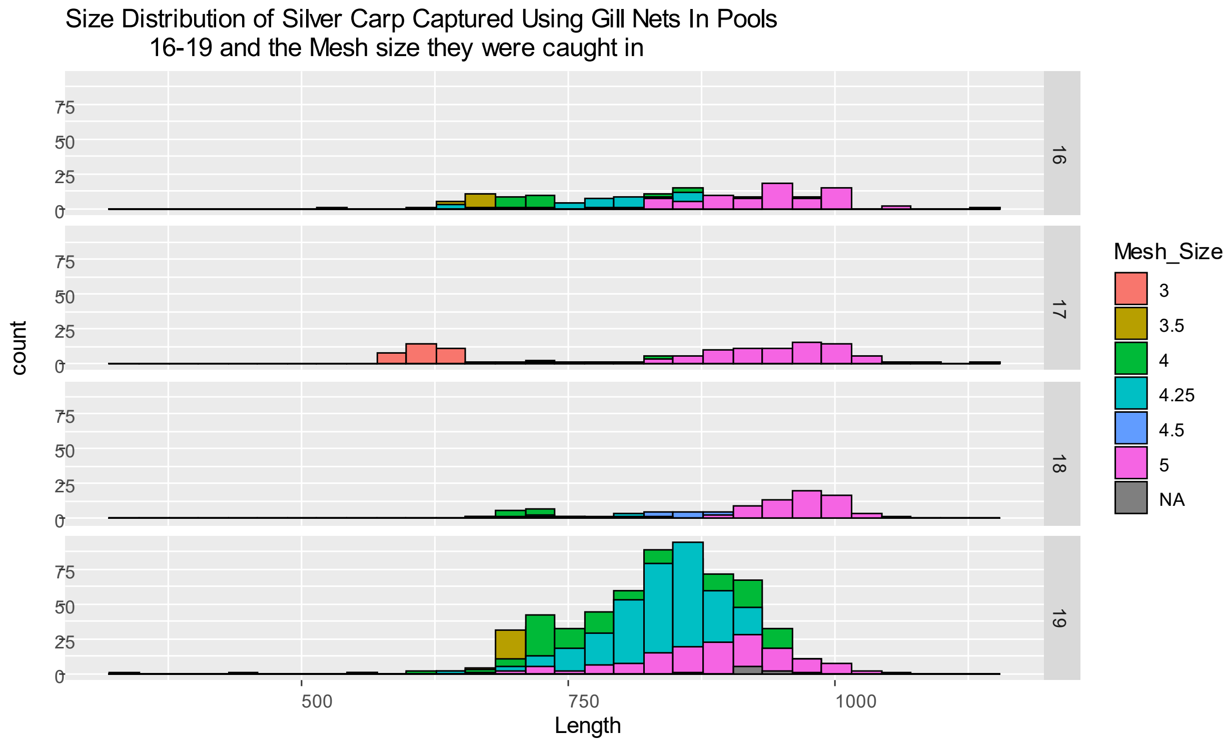

Figure 15. Length frequency histogram for silver carp on Pools 16-19 color coordinated to gill net mesh size on the Mississippi River.

Bigheaded Carp Monitoring and Removal
2019

Bighead Carp

Bighead carp size selection was unpredictable based on the mesh size of gill nets. Based on the data collected, the size of bighead carp can be variable. Bighead carp were not caught in this stretch of the river nearly as often as silver carp. Due to the lack of large numbers, it was difficult to view clear trends in the data. The average size, modal length bin, mean total length, minimum total length of fish caught, and maximum total length of fish caught in the gillnets were calculated (Table 10). Bighead carp caught in different sized gill nets (Fig. 16) showed the variability in catches for different sized gill nets. More mesh sizes and fish need to be added to this model to increase validity.

Table 10. Statistics about the different bar mesh sizes for bighead carp in Pools 16-19 of the Mississippi River. Bar mesh (in) indicates the mesh size, N indicates the number of fish caught and measured in that mesh size, Modal Length Bin (mm) is the length bin that has the highest frequency of occurrence, Mean TL (mm) indicates the average size of fish caught in that mesh size, Minimum TL (mm) indicates the smallest fish caught in that mesh size, Maximum TL (mm) indicates the largest fish caught in that mesh size.

Bar Mesh (in)	N	Modal Length Bin (mm)	Mean TL (mm)	Minimum TL (mm)	Maximum TL (mm)
3	3	NA	849	680	1130
3.5	6	NA	881	641	1212
4	50	1075-1099	1036	672	1360
4.25	65	1100-1125	1011	742	1278
4.5	14	NA	1035	779	1310
5	122	1100-1125	1126	749	1400
5.25	2	NA	1020	887	1154
6	6	NA	1205	1091	1300

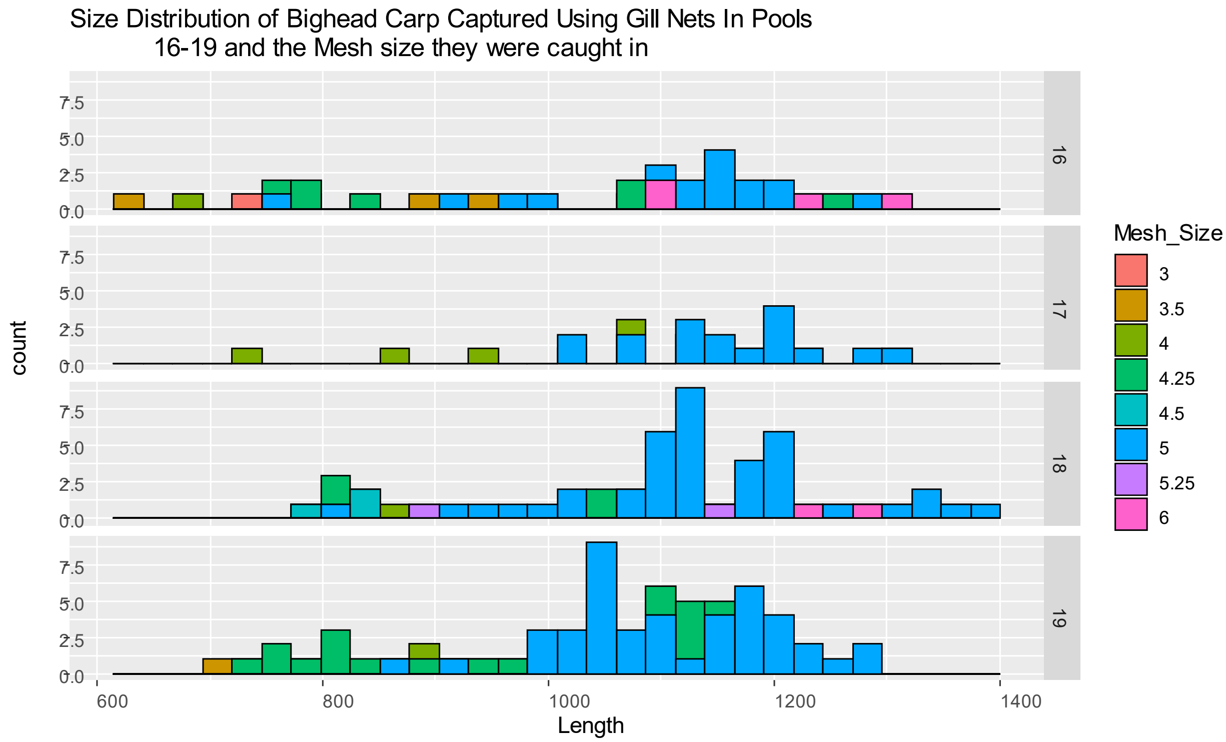

Figure 16. Length frequency histogram for bighead carp on Pools 16-19 color coordinated to gill net mesh size on the Mississippi River.

Bigmouth Buffalo

Bigmouth buffalo size selection was predictable based on the mesh size of gill nets. The average size, modal length bin, mean total length, minimum total length of fish caught, and maximum total length of fish caught in the gillnets were calculated (Table 11). Bigmouth buffalo caught in different sized gill nets (Fig. 17) showed trends in which size gill net is most selective for the specific size of bigmouth buffalo. More mesh sizes and fish need to be added to this model to increase validity.

Table 11. Statistics about the different bar mesh sizes for bigmouth buffalo in Pools 16-19 of the Mississippi River. Bar mesh (in) indicates the mesh size, N indicates the number of fish caught and measured in that mesh size, Modal Length Bin (mm) is the length bin that has the highest frequency of occurrence, Mean TL (mm) indicates the average size of fish caught in that mesh size, Minimum TL (mm) indicates the smallest fish caught in that mesh size, Maximum TL (mm) indicates the largest fish caught in that mesh size.

Bar Mesh (in)	N	Modal Length Bin (mm)	Mean TL (mm)	Minimum TL (mm)	Maximum TL (mm)
3	37	500-524	545	421	685
3.5	93	550-599	576	482	750
4	293	600-625	643	252	886
4.25	122	650-674	667	510	815
4.5	14	650-674	691	648	765
5	83	775-799	733	581	852

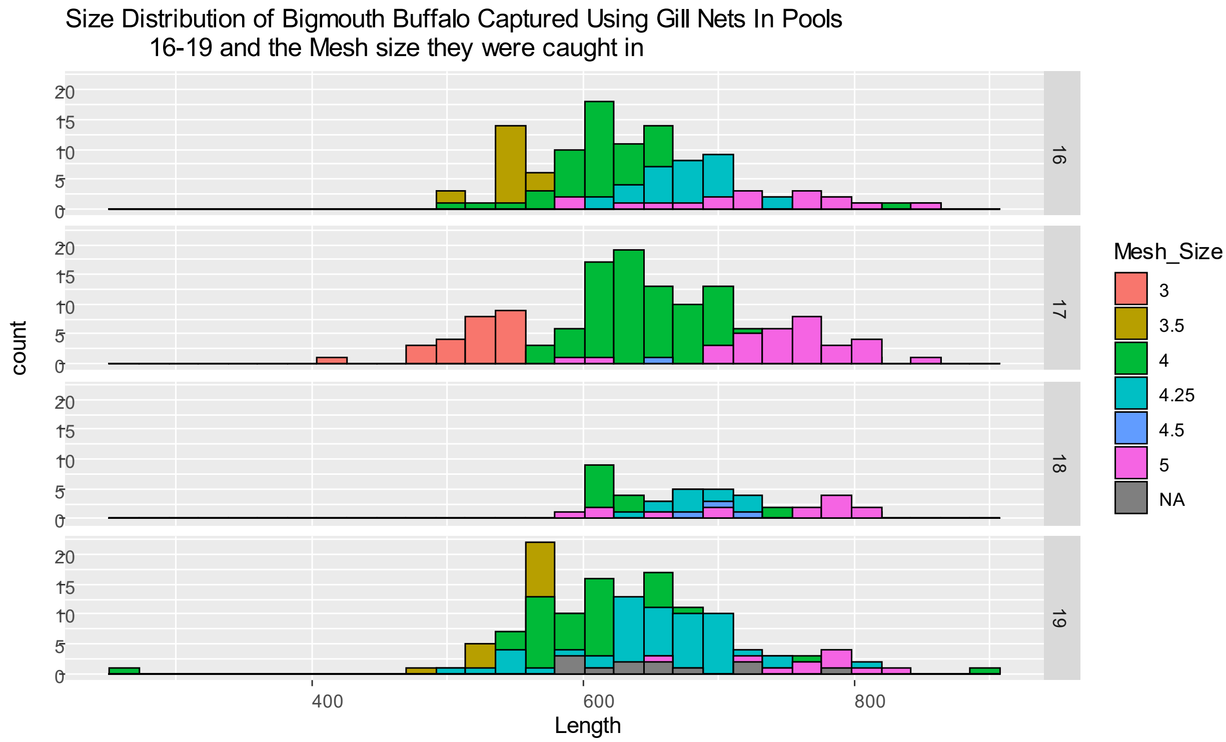

Figure 17. Length frequency histogram for bigmouth buffalo on Pools 16-19 color coordinated to gill net mesh size on the Mississippi River.

Paddlefish

Paddlefish size selection was relatively unpredictable based on the mesh size of gill nets. Based on the data collected, the size of paddlefish was variable in any given mesh size. The greatest size range captured by a gill net size was found in the 5-in net. This shows that if targeting paddlefish, 5-in net is a good choice to capture a wide variety of fish. The average size, modal length bin, mean total length, minimum total length of fish caught, and maximum total length of fish caught in the gillnets were calculated (Table 12). Paddlefish caught in different sized gill nets (Fig. 18) showed the variability of catches for different sized gill nets and how dominant 5-in net is at capturing paddlefish of all sizes. More mesh sizes and fish need to be added to this model to increase validity.

Table 12. Statistics about the different bar mesh sizes for paddlefish in Pools 16-19 of the Mississippi River. Bar mesh (in) indicates the mesh size, N indicates the number of fish caught and measured in that mesh size, Modal Length Bin (mm) is the length bin that has the highest frequency of occurrence, Mean TL (mm) indicates the average size of fish caught in that mesh size, Minimum TL (mm) indicates the smallest fish caught in that mesh size, Maximum TL (mm) indicates the largest fish caught in that mesh size.

Bar Mesh (in)	N	Modal Length Bin (mm)	Mean TL (mm)	Minimum TL (mm)	Maximum TL (mm)
3	66	650-699	619	350	930
3.5	26	600-649	673	555	820
4	210	650-699	742	321	1075
4.25	101	700-749	771	370	1075
4.5	66	650-699	746	574	1024
5	325	850-899	787	321	1110
6	8	850-899	793	567	978

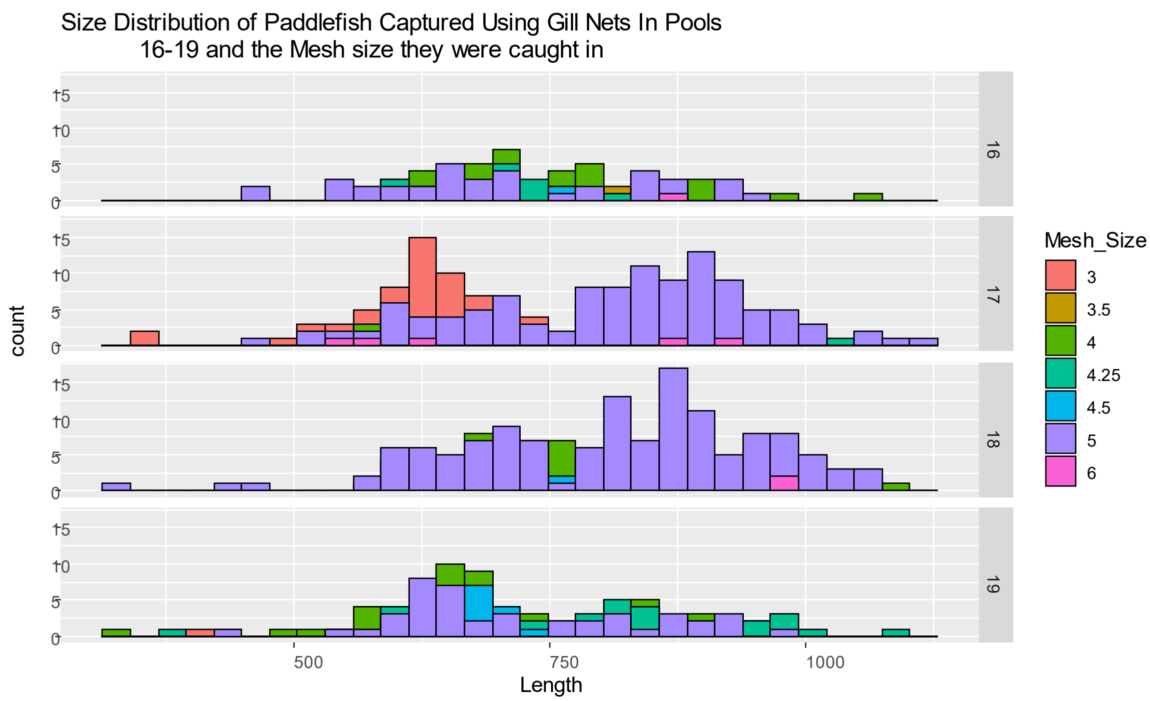

Figure 18. Length frequency histogram for paddlefish on Pools 16-19 color coordinated to gill net mesh size on the Mississippi River.

Recommendation

It is recommended that commercial removal efforts continue to reduce the number of bigheaded carp in Pools 16-19 in 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 and the gillnet size selectivity. 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

Butler, S. E., A. P. Porreca, S. F. Collins, J. A. Freedman, J. J. Parkos, M. J. Diana, and D. H. Wahl. 2019. Does fish herding enhance catch rates and detection of invasive bigheaded carp? Biological Invasions 21(3):775–785.

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.

Koel, T. M. 2001. Classification of Upper Mississippi River Pools Based on Contiguous Aquatic/Geomorphic Habitats. Journal of Freshwater Ecology 16(2):159–170.