Monitoring and Response to Asian Carp in the Ohio River

2016 Technical Report

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Introduction:

Invasive species are continually responsible for undesirable economic and environmental impacts across the nation (Lovell and Stone 2005, Pimentel et al. 2005, Jelks et al. 2008). There has been a considerable effort towards the management and monitoring of Asian carp since their introduction in the early 1980's (Kolar et al. 2005). However, because of their tolerance for a wide range of environmental conditions, carp have successfully expanded their range into the Ohio River basin (ORB).

Assembling information on the distribution and habitat use of Asian carp provides an assessment tool that informs Asian carp prevention, removal, and response efforts. In addition, this information aids in determining impacts of carp on native fish assemblages in the Ohio River drainage. While research and baseline knowledge is available on Asian carps in other waters, there is relatively little information covering their introduced range in the ORB. This project provides an ongoing, coordinated approach to monitor relative abundance and determine fish community impacts of Asian carp in the Ohio River.

Objectives:

- Conduct targeted sampling for surveillance, early detection, distribution, and relative population densities of Asian carp at multiple life stages.
- Monitor Asian carp population dynamics in the Ohio River.
- Evaluate validity of consistent positive eDNA results in Ohio River pools upstream of the invasion front.
- Compile and incorporate all available, current, and historical fish sampling data from other state and federal agencies in select Ohio River pools to increase range and effort of Asian carp detection.
- Re-evaluate and adjust, if needed, the monitoring protocol development in 2015 that defines objectives, and specifies preferred gears, locations, and required effort for targeted surveillance monitoring of Asian Carps.
- Conduct fish community surveys in the R.C. Byrd and Greenup pools to gain fish community assemblage and condition data.

Methods:

Clarification of Terminology Referenced in This Document

With the current rate of Asian carp expansion and the massive effort to study and adaptively manage carp impacts across several Mississippi River sub-basins, it is important to clarify terminology used in technical documentation and annual reports. Currently, there may not be consistent terminology used across the basins when talking about basin-specific invasions. With this in mind, below are a list of terms used in this report that are solely for internal reference.

Established Range – the farthest upriver range expansion where Asian carp populations demonstrate the presence of natural recruitment.

Invasion Front – With a relatively poor understanding of the true established ranges for each species of bigheaded carps (*Hypophthalmichthys spp.*) in the ORB, this document utilizes the term "invasion front" to describe the six pools above the established range (currently recognized as Cannelton pool). Adults may be present here, but there is no evidence of natural recruitment in these areas (Figure 1).
Macrohabitat – One of five defined habitats identified at a scale intended to distribute effort across a variety of fixed sites within a pool (e.g. Tributary, Tailwater, Embayment, Island Back-Channel, Main Stem River).
Targeted Sampling – sampling that uses a gear or techniques that specifically targets one species of fish (i.e. silver carp).

Standardized Sampling Along the Invasion Front
Asian carp standardized monitoring sampling was conducted over two periods, each intended to be approximately 24 days in length: spring (12 April – 25 May) and fall (04 Oct – 19 Nov) along the invasion front (Cannelton – R.C. Byrd pools) (Figure 2). Pools were segmented into four sections (upper, upper-middle, lower-middle, and lower) with six fixed electrofishing sites and two fixed gill netting sites per section (24 electrofishing sites and 8 gill netting sites per pool). All sites were remotely selected using GIS or repeated from sampling efforts in 2015 with the goal to evenly distribute sampling throughout each pool while also incorporating four major macrohabitat types. Macrohabitat types included island back-channels, embayments, dam tailwaters, and tributaries in each pool. These fixed sites are intended to remain constant throughout consecutive years of monitoring in order to compare trends within pools through time. The sites also minimize effort and maximize productivity while still representing the available habitat within each pool.

Electrofishing transects were standardized when possible for the duration of 900 seconds with one dipper using these settings: ~19 amperes at 40% duty-cycle and 80 pulses per second (pulsed DC). Transects were conducted in a downstream direction in order to minimize fish loss due to flow. In areas where large schools of Clupeid or Cyprinid species were encountered, as many fish as possible were dipped while maintaining a consistent speed. Fish were identified to the lowest taxonomic level possible, enumerated, and released during spring monitoring. Additionally, during fall monitoring, fish were measured for total length and weight before release. All small, shad-like species were examined thoroughly before release to avoid misidentifying young Asian carps. After data had been recorded, all fish were released in the same location as their capture (excluding Asian carps).

Gill nets used in standardized sampling were 300 feet in length, 10 feet in depth, and constructed of large mesh (either 4"or 5" bar mesh). Sites sampled consisted of two sets fished for two hours while creating noise and water disturbance every 30 minutes within 150 yards of the set. This was intended to drive fish into the gear. Gill net data recording mimicked the same procedures used for spring and fall electrofishing.

Upon capture, all bigheaded carps were examined for the presence of tags (jaw tags and sonic implants attached in 2013-2015 through the Ohio River Asian Carp Telemetry Project), identified, geo-located, weighed, and measured. In most cases, bigheaded carps were euthanized and the left, pectoral fin ray was collected for aging (Beamish 1981, Schrank and Guy 2002, Williamson and Garvey 2005, Seibert and Phelps 2013). Grass carp (*Ctenopharyngodon idella*) presence was also recorded and fish were euthanized. Other *Hypophthalmichthys spp*. captured were tagged with a distinct jaw tag and a 95mm VEMCO 69 kHz – V16 acoustic-coded transmitter. Tagged fish were released where captured to further inform the Ohio River Asian Carp Telemetry project.

Throughout all ORB projects, a subsample of lengths, weights, and spines from 182 euthanized Asian carp were taken to aid in assessing population characteristics of carp along the invasion front. Maximum total length in inches was taken along with weight in pounds. Pectoral spines were collected and

sectioned on a low speed saw for aging (Beamish 1981, Schrank and Guy 2002, Williamson and Garvey 2005, Seibert and Phelps 2013). Cross sections were placed in water with a dark background and aged with reflected light under a dissecting microscope (Figure 3). An image was collected using a Moticom wireless camera, and each fish was aged blindly by two readers using images of fin ray cross sections. Spines where ages differed too widely (> 2 years), or were damaged, were excluded from analyses. Spines that differed to a lesser degree were recounted, and an agreed upon age was assigned to each fish. Age data was used to calculate the mean length (range, 95% confidence interval) at each age and the distribution of ages in two pools (Cannelton and McAlpine). Fish captured outside of those pools were rare and often tagged for telemetry and are not included here.

Monitoring Asian Carps Ahead of the Invasion Front

On 08 November and 06 December the Montgomery slough of the Ohio River and the Harmar Mine backwater on the Allegheny River were evaluated for different macrohabitat types in order to direct and distribute monitoring efforts throughout those water bodies. On November 9th and December 7th standard gill nets of 3", 4", and 5" bar mesh were fished in total of 140 hours in the Montgomery slough and Harmar Mine backwater, respectively. A total of 900 feet of gill net was fished over six sites at each location.

Fish community electrofishing surveys were conducted in the Montgomery and New Cumberland pools of the Ohio River. In addition, pools three, seven, and eight of the Allegheny River and pool four of the Monongahela River were also electrofished and community data was gathered. A total of 15.25 hours of electrofishing were expended across 54 sample sites using pulsed DC at 300V and 5400watts. Detections of Asian carps were to be reported during any of the above sampling events.

Compilation and Incorporation of Other ORB Data Sources

A georeferenced database is ideal for the purpose of receiving and compiling both historical and current capture data from surrounding Ohio River Basin states and participating basin groups. The Nonindigenous Aquatic Species (NAS) database currently maintained by USGS was accessed in December 2016 and used to inform the extended range of carp captured throughout the ORB. The USGS NAS database provides one location where confirmed sightings from all partners are submitted and considered annually when discussing the range and expansion of Asian carps in select pools and tributaries of the Ohio River Basin.

In January 2017, data from the Ohio River Valley Water Sanitation Commission (ORSANCO) was downloaded and compiled to determine the occurrences of Asian carp captures from community sampling data taken between 1957 – Present. Data was sorted in order to discover the farthest upstream detections of bigheaded carps in select Ohio River pools. Tributaries of the Ohio River were also included in this search, but were only referenced using their associated pools.

Information is also included in this report from additional projects focusing on Asian carps in the basin. The Ohio River Control and Removal of Asian Carp project supplied the majority of spines from euthanized bighead carps. These were used for aging populations along the invasion front. Subsets of lengths and weights were taken from all captures of tagged or euthanized carp during projects outside of monitoring and used in deriving a regression line for weight at length estimates. Lastly, captures during the Ohio River Asian Carp Leading Edge and the Ohio River Asian Carp Telemetry projects provided additional locations for sampling sites with the expansion of monitoring in the Cannelton and R.C. Byrd pools in 2016.

Results:

Spring Standardized Electrofishing Sampling and Catch

Spring electrofishing in 2016 throughout the invasion front (Cannelton through R.C. Byrd) produced no bighead carp and an overall CPUE of 0.70 fish/hour (n = 22, SE = 0.32) for silver carp and 0.16 fish/hour (n = 5, SE = 0.10) for grass carp (Table 1). A total of 125, fifteen-minute transects yielded a catch of 11,955 fish comprising 51 unique taxa. All silver carp were captured within the Cannelton, McAlpine, and Markland pools. Gizzard shad and emerald shiner combined made up over 50% of the total catch by number (Table 2).

Fall Standardized Electrofishing Sampling and Catch

Fall electrofishing in 2016 throughout the invasion front (Cannelton through R.C. Byrd) no bighead carp and an overall CPUE 0.49 fish/hour (n = 12, SE = 0.19) for silver carp and 0.12 fish/hour (n = 3, SE = 0.07) for grass carp (Table 3). A total of 98, fifteen-minute transects yielded a catch of 10,188 fish comprising 62 unique taxa. All silver carp were captured within the Cannelton and McAlpine pools. Gizzard shad alone comprised over 50% of the total catch by number (Table 2).

Spring Standardized Gill Net Sampling and Catch

Spring gill netting in 2016 along the invasion front (Cannelton through Greenup) produced an overall CPUE of 0.02 fish/set (n = 1, SE = 0.02) for bighead carp, 0.35 fish/set (n = 22, SE = 0.16) for silver carp, and 0.03 fish/set (n = 2, SE = 0.02) for grass carp (Table 4). Sixty-two sets made up 18,590ft of net, yielding a total catch of 165 fish and 13 unique taxa. No Asian carps were caught with gill nets above Meldahl Locks and Dam. Smallmouth buffalo and silver carp made up over 50% of the total catch by number (Table 5).

Fall Standardized Gill Net Sampling and Catch

Fall gill netting in 2016 along the invasion front (Cannelton through R.C. Byrd) produced an overall CPUE of 0.01 fish/set (n = 1, SE = 0.01) for bighead carp, 0.13 fish/set (n = 10, SE = 0.07) for silver carp, and 0.05 fish/set (n = 3, SE = 0.03) for grass carp (Table 6). Seventy-eight sets made up 23,400ft of net, yielding a total catch of 63 fish and 12 unique taxa. No Asian carps were caught with gill nets above Meldahl Locks and Dam. Smallmouth buffalo, paddlefish, and bigmouth buffalo made up over 50% of the total catch by number (Table 5).

Hypophthalmichthys spp. Population Parameters

In total, the number of bighead carp captures across all projects this year was only 22 fish. Spines from 14 individuals ranging from Newburgh through the Meldahl pools were cross-sectioned for aging, but the presence of a hollowed lumen in larger fish did not allow proper resolution of early annuli. Considering this and the small number of observed catches between all pools, no attempts to describe the population parameters of bighead carp were pursued. It is recommended that otoliths are taken from all euthanized bighead carp in the future to aid in aging. Silver carp captured in each pool were considered for population analyses; however, sample sizes in J.T. Meyers, Newburgh, and Markland were so small that it is less likely that individual analyses reflect accurate within-pool trends. Therefore, those regressions are not included in these analyses. Back-calculations of weights for carp of known length were achieved using a standard linear regression using all known lengths and weights of carp captured, regardless of pool.

The mean total length of silver carp captured in the J.T. Meyers pool was 27.4 inches (n = 5, SE = 3.33). All carp taken in J.T. Myers were captured during juvenile carp sampling in August 2016. The mean total length of silver carp captured in the Newburgh pool was 27.5 inches (n = 16, SE = 1.72). All fish taken in the Newburgh pool were also captured solely during juvenile carp sampling in August 2016. Because both the J.T. Myers and Newburgh pools are outside of the current monitoring range these fish were used only for the weight-length regression. The mean total length of silver carp captured in the Markland pool was 32.9 inches (n = 12, SE = 1.78). These fish were caught during leading edge and monitoring efforts throughout the year. The age distribution when including all carp sampled regardless of pool was 1 to 9

years old. Length at age varies widely with ages four through nine having substantial overlap in total length measurements (Figure 4).

The mean total length of silver carp captured in the Cannelton pool was 32.2 inches (n = 1,334, SE = 0.07). A normalized, weight-length regression using LOG_{10} transformed data produced the curve $Log_{10}[Weight_{lbs}] = 2.51 * Log_{10}[Length_{inches}] - 2.70$ ($r^2 = 0.72$). Sixty-three silver carp spines were aged from the Cannelton pool with 50 age estimates agreed upon between two readers. Silver carp ages appeared to range from three to nine years, with ages five and six making up ~ 66% of the sampled population (Figure 5). This data is being used to estimate total annual mortality (A), a growth coefficient (k) and the asymptotic average maximum length (L_∞) for silver carp populations in the Cannelton pool. However, with the lack of verified methods for aging carp pectoral fin rays, an additional year of collections (in 2017) is being proposed where otoliths are also harvested for referential integrity before any age and growth or mortality calculations are pursued.

The mean total length of silver carp captured in the McAlpine pool was 33.2 inches (n = 221, SE = 0.15). The weight-length regression using LOG_{10} transformed data produced the line $Log_{10}[Weight_{lbs}] = 2.29 * Log_{10}[Length_{inches}] - 2.32$ ($r^2 = 0.61$). Seventy-seven silver carp spines were aged from the McAlpine pool with 65 age estimates agreed upon between two readers. Silver carp ages appeared to range from four to nine years, with age five making up ~ 42% of the sampled population (Figure 5). This data is also being used to estimate total annual mortality (A), a growth coefficient (k) and the asymptotic average maximum length (L_∞) for silver carp populations in the McAlpine pool. However, with the lack of verified methods for aging carp pectoral fin rays, an additional year of collections (in 2017) is being proposed where otoliths are also harvested for referential integrity before any age and growth or mortality calculations are pursued.

The mean total length of silver carp captured across all pools was 32.3 inches (n = 1,588, SE = 0.07). The weight-length regression using LOG_{10} transformed data produced the curve $Log_{10}[Weight_{lbs}] = 2.94 * Log10[Length_{inches}] - 3.34$ ($r^2 = 0.86$) (Figure 6). Silver carp of known weights made up ~9,549lbs while an additional 9,487lbs were back calculated using the above formula totaling in ~19,036lbs of silver carp removed from all pools of the Ohio River. For more information on carp removed from the ORB please reference the Control and Removal of Asian Carp in the Ohio River report for 2016.

Monitoring Asian Carps Ahead of the Invasion Front

A total of 1,800 feet of gill net was fished with no Asian carps being seen or captured. In addition, no carp were seen or captured during 15.25 electrofishing hours across 54 sampled sites in the Montgomery and New Cumberland pools of the Ohio River or any sampling sites on the Allegheny and Monongahela Rivers. Assistance was given to USFWS when sampling for eDNA detections of Asian carp with intent to evaluate the validity of any positive results. No positive eDNA detections were found in 2016.

Compilation and Incorporation of Other ORB Data Sources

Data taken from ORSANCO records since 1957 show a similar pattern in presence/absence of Asian carps as seen during standard monitoring sampling conducted along the invasion front in 2015-2016. The farthest up-river accounts of Asian carps by ORSANCO were in the Markland Pool in 2012 and McAlpine Pool in 2014. The USGS NAS database expands the range of carp sightings depending on the species. A silver carp was captured in Raccoon Creek, a tributary of the R.C. Byrd Pool in 2016 while a bighead carp was captured as far up as a tributary of the Pike Island Pool 2016.

Discussion:

The 2016 Monitoring and Response to Asian carp in the Ohio River project built on the design and efforts of monitoring in 2015. The original four pools (McAlpine through Greenup) sampled were expanded to include one additional down-river pool (Cannelton) and one additional up-river pool (R.C. Byrd) in 2016.

There were~173 fixed sites sampled across six pools in 2016. Sampling during 2016 provided the first spring community data obtained during this project and added an additional year of fall community data. There were 15 unique species (~25% of the total species richness) captured across both seasons with a total number of 65 observed taxa levels. Four of those levels included ichthyofauna that could only be identified to family or genus. Asian carp were captured from Cannelton up through Markland pool. This is farther up the river than carp were previously caught during monitoring in 2015 and likely reflects a better understanding of site selection and improved capture techniques. Catch per unit effort (CPUE) of silver carp typically increased from Markland down river to Cannelton. This supports previous assumptions about increases in relative abundances of silver carp from upstream to downstream pools, across the invasion front. This trend among silver carp densities is also supported by removal efforts and observations during projects further up the Ohio River. No gear types were particularly effective at catching bighead carp. With little information about the relative abundances of bighead carp in each pool, it is difficult to determine if they follow a similar decrease in relative abundance along pools where standardized monitoring was conducted.

The majority of carp encountered during monitoring were captured in tributaries. It is currently not clear if this can be attributed to habitat preference or increased effectiveness in capture due to gear constraints in deeper water. As additional years of data become available, trends in habitat preference may become apparent. All silver carp captured were large and their corresponding weights suggest that resources are not limiting. Silver carp in the current study show similar weight-length relationships to those from other systems (Table 7). While ages ranged from 1 to 9 years old, there was a large amount of variation in growth across all pools. Younger fish appear to demonstrate rapid growth and reach an average asymptotic length quickly. Large variations in length at age may be explained by several factors including the time of spawning, tributary use, time of harvest, and the specific habitat characteristics within each pool.

Data from 2016 continues a baseline on which to measure future trends. When more years of data are available, it will be important to compare population parameters of Asian carps between pools and across different habitats. Over time, this information will provide a measure of the effectiveness of control efforts such as removal or barrier defenses. In addition, monitoring potential community impacts as Asian carp either invade new water or are pushed back down the system will provide a quantitative measure of the success in managing these invasive species.

Recommendations:

It is recommend that community monitoring continue in fall 2017 using the consistent and repeatable design established in 2015. However, with a better understanding of how to conduct targeted sampling for silver carp, it is recommend that future spring sampling be shifted away from community sampling protocols and focus on specifically targeting Asian carp in the pools along the invasion front. Careful design and development of targeted sampling for Asian carp will lead to better estimates of relative abundances and allow for better adaptive management strategies during other projects that focus on containment and population control. This will allow future monitoring efforts to better address the objectives of this project. It is important to note that the current design of Asian carp monitoring is malleable and protocols are subject to change due to the size and complexity of the Ohio River and the Asian carp populations therein. Future monitoring will provide a better understanding of this invader and its effect on the ORB and will allow for adjustments in response to its presence.

Project Highlights:

- The 2016 Monitoring and Response to Asian Carp in the Ohio River project built on the design and efforts of monitoring in 2015.
- Work conducted in 2016 was an increase in effort and geographic range when compared to previous efforts conducted since the “Leading Edge” projects were established in 2013.

- A total of 125 transects totaling in ~31 electrofishing hours yielded a catch of 11,955 fish comprising 51 taxa in spring 2016. No bighead carp were captured, but 22 silver carp and 5 grass carp were obtained and removed from the pools on the leading edge.
- A total of 98 transects totaling in ~24 electrofishing hours yielded a catch of 10,188 fish comprising 62 taxa in fall 2016. No bighead carp were captured, but 12 silver carp and 3 grass carp were obtained and removed from the pools on the leading edge.
- A total of 18,590ft of net was deployed through 62 gill net sets yielding a catch of 165 fish comprised of 13 species in spring 2016. One bighead carp, 22 silver carp, and 2 grass carp were captured and removed from the pools on the leading edge.
- A total of 23,400ft of net was deployed through 78 gill net sets yielding a catch of 63 fish comprised of 12 species in fall 2016. One bighead carp, 10 silver carp, and 3 grass carp were captured and removed from the pools on the leading edge.
- Continual incorporation of data sources and additional monitoring ahead of the current invasion front should continue in order to inform managers of significant expansions of Asian carp up-river.
- An additional 1,610 silver and bighead carp were removed from the ORB in 2016. This adds to the various sampling efforts since 2013 that had previously resulted in a minimum of 889 Asian carp removed.
- Capture numbers still appear to reflect that McAlpine has a much higher density of invasive carps then the pools above it with Cannelton densities being even higher.
- It is recommended that monitoring continue in 2017 and 2018 with more focus on targeted sampling for Asian carp in addition to community fish sampling.

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Tables and Figures:

Table 1. Electrofishing effort and summaries of the resulting total catch including the number of fish, number of species, and catch per unit effort (fish per hour) of three species of Asian carp captured in five pools of the Ohio River from 13 April through 25 May, 2016. Standard errors are in parentheses.

	Ohio River Pool						
	Cannelton	McAlpine	Markland	Meldahl	Greenup	RC Byrd	Total
Sampling Dates	13 April - 25 May						
Electrofishing Hours	5.00	5.00	6.25	5.75	4.55	4.65	31.20
Samples (transects)	20	20	25	23	18	19	125
All Fish (*N*)	1366	1310	2117	2313	2223	2626	11955
Species (*N*)	38	31	36	36	38	34	51
Bighead Carp (*N*)	0	0	0	0	0	0	0
Silver Carp (*N*)	16	5	1	0	0	0	22
Grass Carp (*N*)	0	4	0	0	1	0	5
Mean CPUE (BigheadCarp/hour)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mean CPUE (SilverCarp/hour)	3.20 (1.85)	0.10 (0.49)	0.16 (0.16)	0.00	0.00	0.00	0.70 (0.32)
Mean CPUE (GrassCarp/hour)	0.00	0.80 (0.55)	0.00	0.00	0.22 (0.22)	0.00	0.16 (0.10)

Table 2. Number of fish captured by species and percent of total catch in four pools of the Ohio River with electrofishing in Spring (13 April - 25 May) and Fall (04 October - 04 September) of 2016.

	Spring								Fall							
	Ohio River Pool								Ohio River Pool							
Species Captured	Cannelton	McAlpine	Markland	Meldahl	Greenup	RC Byrd	Total	Percent	Cannelton	McAlpine	Markland	Meldahl	Greenup	RC Byrd	Total	Percent
American Eel				1			1	0.008%							0	0.000%
Bigmouth Buffalo	3		1	1	1		6	0.050%	1	1		2			4	0.039%
Black Crappie	2		2	1	2		7	0.059%	4	3	1	2		1	11	0.108%
Black Redhorse						2	2	0.017%						1	1	0.010%
Blue Catfish	3		2	2			7	0.059%				1			1	0.010%
Bluegill Sunfish	90	23	72	142	52	28	407	3.404%	57	20	103	23	21	29	253	2.483%
Bowfin					2		2	0.017%					1		1	0.010%
Brook Silverside							0	0.000%						1	1	0.010%
Bullhead Minnow							0	0.000%	8						8	0.079%
Channel Catfish	46	19	19	48	12	11	155	1.297%	24	30	16	21	1	4	96	0.942%
Common Carp	5	8	20	33	25	10	101	0.845%	9	17	25	8	2	3	64	0.628%
Emerald Shiner	100	50	18		636	1035	1839	15.383%	940	2	2	3	77	215	1239	12.161%
Fathead Minnow						1	1	0.008%						2	2	0.020%
Flathead Catfish	1		4	12	2	8	27	0.226%	2	1	1	4	2		10	0.098%
Freshwater Drum	80	19	36	127	77	79	418	3.496%	48	24	6	15	32	45	170	1.669%
Gizzard Shad	516	829	1373	1145	653	801	5317	44.475%	1320	374	573	850	736	2898	6751	66.264%
Golden Redhorse	8	29	19	2	13	15	86	0.719%	44	21	12	17	10	8	112	1.099%
Goldeye		6	2				8	0.067%				2			2	0.020%
Goldfish							0	0.000%			1				1	0.010%
Grass Carp		4			1		5	0.042%			3				3	0.029%
Green Sunfish	2	4			1	9	16	0.134%		1	5	1	1	3	11	0.108%
Highfin Carpsucker	1	1			2	2	6	0.050%			2			1	3	0.029%
Lamprey Family					2		2	0.017%		1					1	0.010%
Largemouth Bass	27	48	34	64	29	13	215	1.798%	40	23	50	26	2	9	150	1.472%
Logperch		1	1			4	6	0.050%					1	2	3	0.029%
Longear Sunfish	21	15	23	14	14	18	105	0.878%	16	6	9	3	5	2	41	0.402%
Longnose Gar	51	34	50	182	383	105	805	6.734%	10	32	1	8	5	2	58	0.569%
Minnow Family							0	0.000%	2						2	0.020%
Mooneye	1		1		1	13	16	0.134%		1		1			2	0.020%
Moxostoma Genus							0	0.000%	6		1	2			9	0.088%
Muskellunge							0	0.000%		1					1	0.010%
Northern Hogsucker		1				1	2	0.017%		1			6	2	9	0.088%
Orangespotted Sunfish							0	0.000%	11				7	4	22	0.216%
Paddlefish	1	1	2				4	0.033%							0	0.000%
Quillback	5	5	2	1	7	5	25	0.209%	1	1		1	1		4	0.039%
Rainbow Trout		1					1	0.008%							0	0.000%
Redear Sunfish	15		3	2	4		24	0.201%	29	1	1	1		1	33	0.324%
River Carpsucker	64	67	73	125	42	41	412	3.446%	42	12	24	17	2	2	99	0.972%
River Redhorse	1	6	3	3	7	5	25	0.209%	3			3	3	8	17	0.167%
Rock Bass	3	1					4	0.033%		1			3		4	0.039%
Sauger	53	14	16	23	28	68	202	1.690%	11	4	8	8		5	36	0.353%
Saugeye							0	0.000%				1		2	3	0.029%
Sharpnose Darter							0	0.000%						1	1	0.010%
Smallmouth Redhorse	2		1	3	7	1	14	0.117%	2	9	3	20		1	35	0.344%
Shortnose Gar	2		1				3	0.025%							0	0.000%
Silver Carp	16	5	1				22	0.184%	6	6					12	0.118%
Silver Chub							0	0.000%	3				3		6	0.059%
Silver Redhorse		4		8	10	27	49	0.410%			1	4	1		6	0.059%
Skipjack Herring	8	5	2	14	2	1	32	0.268%	33	18	11	21		3	86	0.844%
Smallmouth Bass		7	4	1	9	42	63	0.527%	5	8	1	6	11	11	42	0.412%
Smallmouth Buffalo	199	52	123	231	108	181	894	7.478%	65	51	95	76	2	45	334	3.278%
Spotfin Shiner						7	7	0.059%						2	2	0.020%
Spotted Bass	2	26	12	35	39	13	127	1.062%	51	26	13	30	16	6	142	1.394%
Spotted Gar							0	0.000%	11						11	0.108%
Spotted Sucker		6	35	5	9	29	84	0.703%	8	3	15	5	1	16	48	0.471%
Striped Bass	20	8	75	30	2		135	1.129%	4	10	21	17			52	0.510%
Sunfish Family							0	0.000%						1	1	0.010%
Sunfish Hybrid						1	1	0.008%	1				3	1	5	0.049%
Threadfin Shad							0	0.000%	9			1			10	0.098%
Walleye		1			1		2	0.017%	2						2	0.020%
Warmouth	1	3	1	1			6	0.050%	2		3	2		1	8	0.079%
White/Striped Bass Hyb	1				27	44	72	0.602%	18				1	7	26	0.255%
White Bass	6	4	3	33	8	3	57	0.477%	7	1	7	10	1	9	35	0.344%
White Crappie	10	3	83	24	5	3	128	1.071%	9	3	61	10	1	1	85	0.834%
Yellow Bass							0	0.000%	1						1	0.010%
Totals	1366	1310	2117	2313	2223	2626	11955		2865	713	1075	1222	958	3355	10188	

Table 3. Electrofishing effort and summaries of the resulting total catch including the number of fish, number of species, and catch per unit effort (fish per hour) of three species of Asian carp captured in five pools of the Ohio River from 04 October through 04 September, 2016. Standard errors are in parentheses.

	Ohio River Pool						
	Cannelton	McAlpine	Markland	Meldahl	Greenup	RC Byrd	Total
Sample Dates	04 Oct. - 17 Nov.						
Electrofishing Hours	5.50	6.00	3.50	5.10	1.50	2.58	24.18
Samples (transects)	22	24	14	21	6	11	98
All Fish (*N*)	2865	713	1075	1222	958	3355	10188
Species (*N*)	40	34	31	36	30	38	62
Bighead Carp (*N*)	0	0	0	0	0	0	0
Silver Carp (*N*)	6	6	0	0	0	0	12
Grass Carp (*N*)	0	0	3	0	0	0	3
Mean CPUE (BigheadCarp/hour)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mean CPUE (SilverCarp/hour)	1.09 (0.65)	0.99 (0.50)	0.00	0.00	0.00	0.00	0.49 (0.19)
Mean CPUE (GrassCarp/hour)	0.00	0.00	0.86 (0.46)	0.00	0.00	0.00	0.12 (0.07)

Table 4. Gill netting effort and summaries of the resulting total catch including the number of fish, number of species, and catch per unit effort (fish per set) of two species of Asian carp captured in six pools of the Ohio River from 12 April to 25 May, 2016. Standard errors are in parentheses.

	Ohio River Pool						
	Cannelton	McAlpine	Markland	Meldahl	Greenup	RC Byrd	Totals
Sample Dates	12 April - 25 May						
Gill Netting Effort (ft)	4800	4800	3000	4790	1200	0	18590
Net Sets	16	16	10	16	4	0	62
All Fish (*N*)	74	8	48	34	1	0	165
Species (*N*)	10	4	9	6	1	0	13
Bighead Carp (*N*)	1	0	0	0	0	0	1
Silver Carp (*N*)	19	0	3	0	0	0	22
Grass Carp (*N*)	1	0	1	0	0	0	2
Mean CPUE (BigheadCarp/Set)	0.06 (0.06)	0.00	0.00	0.00	0.00	0.00	0.02 (0.02)
Mean CPUE (SilverCarp/Set)	1.18 (0.59)	0.00	0.30 (0.15)	0.00	0.00	0.00	0.35 (0.16)
Mean CPUE (GrassCarp/Set)	0.06 (0.06)	0.00	0.10 (0.10)	0.00	0.00	0.00	0.03 (0.02)

Table 5. Number of fish captured by species and percent of total catch in six pools of the Ohio River with gill netting in spring (12 April - 25 May) and fall (04 Oct - 19 Nov) of 2016.

	2016 Spring Monitoring Gill Netting								2016 Fall Monitoring Gill Netting							
	12 April - 25 May								04 October - 19 November							
	River Pool								River Pool							
Species Captured	Cannelton	McAlpine	Markland	Meldahl	Greenup	RC Byrd	Total	Percent	Cannelton	McAlpine	Markland	Meldahl	Greenup	RC Byrd	Total	Percent
Bighead Carp	1						1	0.606%		1					1	1.587%
Bigmouth Buffalo			5	2			7	4.242%		1	4	2			7	11.111%
Black Buffalo	2						2	1.212%							0	0.000%
Blue Catfish	7		2	2			11	6.667%			1				1	1.587%
Common Carp	2		6	8			16	9.697%		2	1	3			6	9.524%
FlatheadCatfish	2		12	1			15	9.091%				1			1	1.587%
FreshwaterDrum	7	4	2	2			15	9.091%				1			1	1.587%
Grass Carp	1		1				2	1.212%		1	2	1			4	6.349%
Longnose Gar		1					1	0.606%		2					2	3.175%
Muskellunge							0	0.000%					1		1	1.587%
Paddlefish	4	1	1				6	3.636%	2		9	1			12	19.048%
Silver Carp	19		3				22	13.333%	5	5					10	15.873%
Skipjack Herring					1		1	0.606%							0	0.000%
Smallmouth Buffalo	29	2	16	19			66	40.000%		8		7	2		17	26.984%
Totals	74	8	48	34	1	0	165		7	20	17	16	3	0	63	

Table 6. Gill netting effort and summaries of the resulting total catch including the number of fish, number of species, and catch per unit effort (fish per set) of three species of Asian carp captured in six pools of the Ohio River from 04 October - 19 November 2016. Standard errors are in parentheses.

	Ohio River Pool						
	Cannelton	McAlpine	Markland	Meldahl	Greenup	RC Byrd	Totals
Sample Dates	04 October - 19 November						
Gill Netting Effort (ft)	3000	4800	4200	4800	3000	3600	23400
Net Sets	10	16	14	16	10	12	78
All Fish (*N*)	7	20	17	16	3	0	63
Species (*N*)	2	7	5	7	2	0	12
Bighead Carp (*N*)	0	1	0	0	0	0	1
Silver Carp (*N*)	5	5	0	0	0	0	10
Grass Carp (*N*)	0	1	2	0	0	0	3
Mean CPUE (BigheadCarp/Set)	0.00	0.06 (0.06)	0.00	0.00	0.00	0.00	0.01 (0.01)
Mean CPUE (SilverCarp/Set)	0.50 (0.31)	0.31 (0.25)	0.00	0.00	0.00	0.00	0.13 (0.07)
Mean CPUE (GrassCarp/Set)	0.00	0.06 (0.06)	0.14 (0.10)	0.06 (0.06)	0.00	0.00	0.05 (0.03)

Table 7. Estimated weights at two lengths for Silver carp from published data collected throughout the Silver carp range in the Mississippi River basin. Amended from Hayer et al. 2014.

System: Specific Locale	Predicted weight for 450mm (g)	Predicted weight for 800mm (g)	Reference
Ohio River: All Pools	970	5266	This Report 2016
Ohio River: McAlpine Pool	1024	5560	WRRDA Report 2015
Ohio River: Cannelton Pool	1040	5584	WRRDA Report 2015
Tennessee River: Kentucky Lake	803	5743	KDFWR data
Missouri River tributary: James River	981	5869	Hayer et al. 2014
Illinois River	972	5856	Irons et al. 2011
Missouri River tributary: Big Sioux River	970	6150	Hayer et al. 2014
Middle Mississippi River	915	5477	Williamson and Garvey 2005
Missouri River: Interior Highlands	900	5453	Wanner and Klumb 2009
Missouri River: Gavins Point	788	6628	Wanner and Klumb 2009
Missouri River tributary: Vermillion River	748	3971	Hayer et al. 2014