Commonwealth of Kentucky

Date: June 30, 2017

Period: 01 April 2016
through
31 March 2017

ANNUAL PERFORMANCE REPORT

for

Subsection IV: Critical Species Investigations

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Department of Fish and Wildlife Resources

Fisheries Division

SUBSECTION I TITLE: Critical Species Investigations

PERIOD COVERED: 1 April 2016 - 31 March 2017

RESEARCH AND SURVEY SECTION

Subsection IV

Project I: Impacts of Asian Carp Harvest Program on Sport Fish in Kentucky

Project Objectives:

1. Monitor sport fish bycatch in the Asian Carp Harvest Program through review of commercial fishing harvest reports and ride-alongs with commercial fishermen.
2. Facilitate payment of Asian carp subsidy funds by verifying harvest location of fish, sale of fish to participating fish buyers, and submission of appropriate paperwork to the Kentucky Finance Cabinet.

A. ACTIVITY

Asian Carp Harvest Program

Kentucky Lake and Lake Barkley are two of the largest reservoirs in the United States east of the Mississippi River. These reservoirs represent a 1.2-billion-dollar sport fish and recreational boating industry that is very important to western Kentucky. Asian carp threaten the sport fishery of the lakes by competing with sport fish for food and space. Silver carp also negatively impact recreational boaters as they often jump out of the water when startled by noise and can cause injuries to recreationists. The Asian Carp Harvest Program (ACHP) created by the Kentucky Department of Fish and Wildlife Resources (KDFWR) allows qualified commercial fishermen to fish specifically for Asian carp in waters where commercial fishing was previously restricted. This report focuses primarily on commercial harvest occurring in Kentucky Lake and Lake Barkley as they account for 94% of Asian carp harvested under the ACHP. Since the program's inception in 2013 commercial fishermen in Kentucky have harvested a total of 3,020,988 lbs of Asian carp through the ACHP (2,971,409 lbs silver carp, 49,579 lbs bighead carp). The number of commercial fishermen using the ACHP has doubled in the last two fishing seasons and therefore the amount of effort has increased as well (174 fishing trips in the 2014-2015 season, and 346 fishing trips in the 2015-2016 season). In the 2015-2016 season, commercial fishermen harvested 742,119 lbs of silver carp over 346 trips. There may be an increase in commercial harvest over the next few years as the 2015 silver carp year class becomes more vulnerable to commercial gillnets. It is essential to monitor impacts on sport fish and species of conservation concern as commercial fishing effort increases and types of gears used in the fishery expand.

Ride-alongs

KDFWR representatives observed commercial fishermen in the ACHP through ride-alongs to collect information on the amount of fishing effort, the type of gear used, pounds harvested, and bycatch information. Observations by KDFWR during ride-alongs were analyzed both aggregately with daily reports turned in by commercial fishermen and as a dataset on its own (i.e. ride-along data). KDFWR conducted 28 ride-alongs with commercial fishermen fishing under the ACHP January-December 2016. During ride-alongs 38,483 yards of gillnet was fished and 71,462 lbs of Asian carp was harvested. The majority of fishing effort was in Lake Barkley and Kentucky Lake. There were 583 individuals captured as bycatch, of which 16% were sport fishes. The survival rate of sport fish in Lake Barkley was 71.4%. The most common species of sport fish

caught in commercial nets during ride-alongs were blue catfish (N = 27), yellow bass (N = 20), and striped bass (N = 19). In relation to total bycatch, the number of sport fish captured is low (16% during ride-alongs in 2016, 6% from all commercial fishermen reports in April-December 2016). The survival rate of sport fish captured through the ACHP during the 2015-2016 season was 94.4%. The survival rate of fish is defined as fish that swim away after being released; we do not have a measure of post-release mortality at this time. This information shows no indication of negative impacts on the sport fishery resulting from the ACHP.

Asian Carp Subsidy Program

Commercial fishermen who signed up to receive payment of Asian carp subsidy funds were required to provide KDFWR with the date, time, and location desired to fish 48 hours prior to the date requested to fish. KDFWR staff met the fishermen at the predetermined boat ramp to verify harvest location of fish. KDFWR staff followed the fishermen to the participating fish buyers to witness the weight and species of fish sold and provide the fishermen with a voucher copy indicating the amount to be paid to the fishermen by KDFWR. This information was then submitted to the Kentucky Finance Cabinet for the appropriate payment to be made to the fishermen. In 2016, four commercial fishermen signed up to receive the subsidy. Only one fishermen actively participated in the subsidy program making thirty-two trips to the lakes under the program (3 trips to Kentucky Lake and 29 trips to Lake Barkley). These fishing trips, verified by KDFWR personnel for the subsidy, resulted in 93,847 lbs of silver carp, 1,173 lbs of bighead carp, and 355 lbs of grass carp harvested and sold to local processors. The total KDFWR expenditures toward the subsidy in 2016 was $4,768.76.

B. TARGET DATES FOR ACHIEVEMENT AND ACCOMPLISHMENTS

Planned achievement date – 31 March 2017
Work accomplished - 31 March 2017

C. SIGNIFICANT DEVIATIONS

None

D. REMARKS

None

E. RECOMMENDATIONS

Continue project as designed

Project II: Silver Carp Demographics in Kentucky Lake

Project Objectives:

1. Compare gear types for capturing juvenile Asian carp in Kentucky Lake and Lake Barkley.
2. Estimate hatch date of Asian carp in Kentucky Lake.

3. Investigate Asian carp age and growth, condition, gonadosomatic index, sex ratios, and fecundity for baseline data to be used to assess removal efforts as commercial fisheries grow.

A. ACTIVITY

In the 2015 field season, various gear types were utilized in efforts to capture juvenile Asian carp including light traps, electrofishing, cast nets, and trap nets. However, these efforts produced only one juvenile silver carp and this objective was not a priority for the 2016 field season. TWRA has shown interest in determining if Asian carp are in fact spawning in Kentucky Lake and plan to take over efforts to compare gear types for capturing juvenile Asian carp in the Lake in 2017.

Kentucky Lake Silver Carp Population Dynamics

A total of 441 silver carp were collected from February 2015 to September 2016 using various methods. There were two primary sizes: small silver carp (200-400mm) and large silver carp (850-950mm). Multiple gear types targeting all size classes were fished, and still very few mid-size silver carp (400-600mm) were captured. When compared to other river systems including the Illinois River, Wabash River, and Mississippi River, silver carp in Kentucky Lake are much larger than silver carp seen in these open river populations. When compared to silver carp from other systems, Kentucky Lake fish were among the heaviest at 800mm. Silver carp in Kentucky Lake are growing extremely fast and are reaching their asymptotic length at about 3 or 4 years of age. From July 2015 to July 2016, the mean length of silver carp in the 2015-year class tripled. Silver carp ages ranged from 2-10 years and were dominated by four and five-year-olds. Silver carp in Kentucky Lake are similar to those in other populations showing domination by individual year classes, which is indicative of variable recruitment from year to year. The catch curve regression produced an annual mortality rate of 53% (R^2 = .797; P = .005). This mortality estimate is on the low end of the range estimated in other systems. The mean gonadosomatic index (GSI) indicated overlap between months for female silver carp from Kentucky Lake. The highest mean GSI in 2016 occurred in February and June. Male GSI's peaked in April.

Kentucky Lake Standard Sampling

In November of 2016, KDFWR partnered with several federal and state agencies, and commercial fishermen to conduct a standardized sampling event of Asian carp on Kentucky Lake. Asian carp were targeted with 2-hour gillnet sets during the day. Gillnets were composed of 1-5" mesh (21,261yds of net fished). Electrofishing (11.59 hours) and boat banging were used in an effort to herd the Asian carp into the nets. These sampling efforts produced 89 silver carp and 1 bighead carp. The USFWS also targeted Asian carp using Paupier nets. The Paupier net was effective for capturing Asian carp in Kentucky Lake resulting in 1,406 silver carp in 9.12 hours of effort. Murray State University implanted 9 silver carp captured during the event with acoustic transmitters for a silver carp tracking study being conducted in Kentucky Lake. This sampling event was the first effort to identify methods for standardized Asian carp sampling in Kentucky Lake. To date, Asian carp efforts in the Mississippi River Basin have focused on large river environments. Very little information exists on capturing Asian carp in large mainstem reservoirs like Kentucky Lake. Short gillnet sets did not produce the numbers of carp that were expected, while the Paupier nets were successful at capturing silver carp. Future plans will build from the knowledge gained in this initial effort including longer gillnet sets (possibly nocturnal) and increased efforts with the Paupier nets.

B. TARGET DATES FOR ACHIEVEMENT AND ACCOMPLISHMENTS

Planned achievement date – 31 March 2017
Work accomplished - 31 March 2017

C. SIGNIFICANT DEVIATIONS

None

D. REMARKS

None

E. RECOMMENDATIONS

Continue project as designed

Project III: Tracking Silver Carp Movement in Kentucky Lake

Project Objective: Understand movement patterns, habitat use, spawning patterns, and immigration/emigration of silver carp in Kentucky Lake.

A. ACTIVITY

Kentucky Department of Fish and Wildlife Resources worked with Murray State University to begin a study tracking silver carp movement in Kentucky Lake. Surgeries were performed on 69 silver carp over seven dates in 2016. Boat-mounted hydrophones were used to track tagged silver carp on 34 separate trips starting in May of 2016. A series of 12 VR2W passive receivers were deployed throughout Kentucky Lake to record long-range movement patterns of tagged silver carp. Two passive receivers were mounted in the lock chamber of Kentucky Lake Dam – one inside the chamber, and another on the upstream approach of the lock chamber. The remaining passive receivers were attached to heavy bottom stands along the bottom of the lake. Although a passive receiver array was deployed and a great amount of effort was expended conducting manual tracking with boat-mounted hydrophones, there has not been enough silver carp detections to draw any meaningful conclusions about the movement patterns of silver carp in Kentucky Lake. The 58 fish which are presumed still alive should have active tags well into 2018. Therefore, the intent is to continue tracking these fish, as well as tag more silver carp throughout 2017. The deployment of more VR2W receivers is also planned for 2017 as these are more useful for tracking silver carp in Kentucky Lake.

B. TARGET DATES FOR ACHIEVEMENT AND ACCOMPLISHMENTS

Planned achievement date – 31 March 2017
Work accomplished – 31 March 2017

C. SIGNIFICANT DEVIATIONS

None

D. REMARKS

None

E. RECOMMENDATIONS

Continue project as designed

Project IV: Kentucky Lake Tailwater and Lake Barkley Tailwater Sport Fish Assessments

Project Objectives:

1. Investigate species composition and abundance of fish from historical data collected from Lake Barkley Dam tailwater and Kentucky Lake Dam tailwater to identify trends over time.
2. Compare current creel survey angler use and catch statistics to those collected in previous years' surveys conducted in the Kentucky Lake Dam and Lake Barkley Dam tailwaters.
3. Compare current tailwater angler opinions about the impacts of increasing densities of Asian carp on their fishing effort and success.
4. Collect baseline data on the growing bow fishing fishery in each tailwater.

A. ACTIVITY

Electrofishing

Kentucky Department of Fish and Wildlife Resources sampled the Kentucky Lake Dam Tailwater and Lake Barkley Dam Tailwater with pulsed DC electrofishing in the spring and fall of 2016 to assess fish species composition and relative abundance. The total number of fish captured was 18,754 (2,681 fish/hr CPUE in Barkley Tailwater; 944 fish/hr CPUE in Kentucky Tailwater) comprised of 57 species during 11.14 hours of effort. Spring sampling resulted in the capture of 3,410 total fish comprised of 54 species during 7.4 hours of effort (460.8 f/hr). Fall sampling resulted in the capture of 15,344 total fish comprised of 42 species over 3.74 hours of effort (4,102.7 f/hr). In Barkley Tailwater, longear sunfish were the most abundant species captured during spring sampling and threadfin shad were the most abundant species captured in the fall. In Kentucky Tailwater the most abundant species captured during spring sampling was bluegill and threadfin shad was the most abundant species captured in the fall. The most common sport fishes captured in both tailwaters were bluegill, largemouth bass, yellow bass, and flathead catfish.

Relative weights (*Wr*) were calculated for some species collected during fall sampling to monitor fish condition. Trends in fish condition are important in the current study as any observed declines in condition of individual species may be an indicator of competition for resources and reflective of high Asian carp densities in the tailwaters. In the Kentucky Tailwater, gizzard shad (72.4), hybrid striped bass (81), and redear sunfish (85) exhibited low mean relative weights. In the Barkley Tailwater, gizzard shad (70) and smallmouth bass (86) had less than ideal condition. All other mean *Wr* values compiled for species collected during electrofishing in both tailwaters were ≥ 87, which reflects fish in fair condition or above. Largemouth bass exhibited excellent condition in Kentucky Tailwater (102) and Barkley Tailwater (101).

Silver carp were captured in both tailwaters during spring and fall sampling efforts. In the Kentucky Tailwater 106 silver carp were captured, and 76 silver carp were captured from the

Barkley Tailwater. With more years of data, it will be important to compare species composition and abundance from Kentucky and Barkley Tailwaters to identify any possible impacts of Asian carp on species diversity and fish condition in the tailwater fisheries.

Creel Survey

A random, non-uniform probability creel survey was conducted in Kentucky Tailwater and at Barkley Tailwater. The survey was conducted from February 15, 2016 through November 15, 2016. Data recorded during the creel survey conducted in each tailwater was used to compare current creel survey angler use and catch statistics to those collected in previous years' surveys conducted in the tailwaters. The creel survey also attempted to encompass current tailwater angler opinions about the impacts of increasing densities of Asian carp (silver carp and bighead carp) on fishing effort and success. The 2016 creel survey was the first attempt to collect baseline data on the growing bow fishing fishery in each tailwater.

B. TARGET DATES FOR ACHIEVEMENT AND ACCOMPLISHMENTS

Planned achievement date – 31 March 2017
Work accomplished – 31 March 2017

C. SIGNIFICANT DEVIATIONS

None

D. REMARKS

None

E. RECOMMENDATIONS

Continue project as designed

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Project I: Impacts of Asian Carp Harvest Program on Sport Fish in Kentucky

FINDINGS

Asian Carp Harvest Program

The Asian Carp Harvest Program (ACHP) created by the Kentucky Department of Fish and Wildlife Resources (KDFWR) allows qualified commercial fishermen to fish specifically for Asian carp in waters where commercial fishing was previously restricted. However, this report focuses primarily on commercial harvest occurring in Kentucky Lake and Lake Barkley as they account for 94% of Asian carp harvested under the ACHP. The numbers in this report are based on monthly reports submitted by commercial fishermen fishing under the ACHP as they are required to fill out daily logs of their catch. The implementation of the ACHP has been a key element in the increased harvest of silver carp (*Hypophthalmichthys molitrix*) and bighead carp (*Hypophthalmichthys nobilis*) from Kentucky waters. Since the program's inception in 2013, commercial fishermen in Kentucky have harvested a total of 3,020,988 lbs of Asian carp through the ACHP (2,971,409 lbs silver carp, 49,579 lbs bighead carp). Fishing seasons in this report correspond to the commercial fishing license year of April – March. The number of commercial fishermen using the ACHP has doubled in the last two fishing seasons and therefore the amount of effort has increased as well (174 fishing trips in the 2014-2015 season, and 346 fishing trips in the 2015-2016 season; Table 1). Commercial fishermen harvested 780,730 lbs of silver carp in the 2014-2015 season. In the 2015-2016 season commercial fishermen harvested 742,119 lbs of silver carp (Table 1). The observed decrease in silver carp harvest is puzzling, but it is not believed to be due to decreasing Asian carp densities; as commercial fishermen harvested 1,203,325 lbs of silver carp over 487 trips under the ACHP during the partial season from April – December 2016. Therefore, the decrease in harvest in the 2015-2016 season is more likely due to the increase in inexperienced commercial fishermen fishing for Asian carp and the steep learning curve associated with the commercial fishing industry. Another factor may have been the inconsistency of Kentucky based Asian carp processors buying fish during the 2015-2016 fishing season. A very strong year class of silver carp was apparent in 2015 as millions of age-0 fish were observed in Kentucky Lake, Lake Barkley, and their associated tailwaters. This cohort of fish was apparent in 2016 as 8- to 14-inch size fish jumped alongside boats and became entangled in some commercial gillnets. Over the next few years as the 2015 silver carp year class becomes more vulnerable to commercial gillnets, there may be an increase in commercial harvest. The primary method for harvesting Asian carp has been 4- to 5-inch mesh floating gillnets. Although reports indicate the utilization of mesh sizes ranging from 3.25-inch to 7-inch mesh, bycatch is high with smaller mesh and larger mesh does not produce the same number of Asian carp as 4- and 5-inch mesh. In comparison, nets with a mesh size of 4.25 inches were the most effective (in terms of fish/yd) for harvesting silver carp during 2016 ride-alongs (1,469 fish), and 5-inch mesh nets captured the most bighead carp (44 fish) (Table 2). There has been some discussion that 4.5-inch mesh nets would be ideal to harvest the size of Asian carp that seem to be prevalent in waters fished under the ACHP. However, this size mesh is not produced in bulk, so it must be special ordered at a higher cost.

Asian carp harvest data was summarized by month of the year from April 2011 to December 2016. As expected, the number of trips made by commercial fishermen under the ACHP consistently decreased during paddlefish season (November-March) over the years, and increased again when paddlefish season ended (Table 3). This shift is expected as many commercial fishermen' fish Kentucky Lake and Lake Barkley with a special net permit during paddlefish season, which allows gill netting in the lakes without fishing under the ACHP. As a result, there is some commercial harvest of Asian carp taking place from November through March that is not recorded within the ACHP, but reported on monthly commercial fishing harvest reports. Over the past two seasons (April 2015 – December 2016) the number of trips being taken by commercial fishermen under the ACHP has been highest during the months of June through October. Average silver carp harvest per trip has varied by year peaking in September 2015 (3039 lbs/trip) and May 2016 (3640 lbs/trip). Bighead carp average harvest rates were greater in 2015 (range of 8-441 lbs/trip) than in 2016 (range of 1-58 lbs/trip) (Table 3).

Ride-Alongs

KDFWR conducted 28 ride-alongs with commercial fishermen fishing under the ACHP during January-December 2016. Ride-along data is reported by calendar year. During ride-alongs 38,483 yards of gillnet was fished and 71,462 lbs of Asian carp was harvested. The majority of fishing effort was in Lake Barkley and Kentucky Lake, with Lake Barkley receiving the bulk of this effort. Eighty-seven percent of Asian carp harvested during ride-alongs were from Lake Barkley, and 10% were harvested from Kentucky Lake (Tables 4 & 5). These percentages are reflective of the number of ride-alongs conducted in each water body with 3 in Kentucky Lake and 22 in Lake Barkley, as most commercial fishermen prefer to fish in Lake Barkley. The number of ride-alongs in Kentucky Lake decreased from 10 in 2015 to 3 in 2016, but the mean effort expended each trip remained very similar with 1,047 yds/trip in 2015 and 1,039 yds/trip in 2016 (Table 4). The number of ride-alongs on Lake Barkley increased from 16 in 2015 to 22 in 2016, however the mean effort per trip was similar with 1,116 yds/trip in 2015 and 1,143 yds/trip in 2016 (Table 5). The total weight of silver carp harvested in each lake followed the trend in witnessed effort with 6,064 lbs harvested from Kentucky Lake and 61,533 lbs harvested from Lake Barkley in 2016. The mean weight of silver carp harvested per trip increased in both lakes in 2016 (Kentucky Lake = 2,021 lbs/trip, Lake Barkley = 2,797 lbs/trip) (Tables 4 & 5). This may be a result of an increasing population of silver carp in the lakes, or another explanation may be that the fishermen regularly accompanied are becoming more knowledgeable in the movements of silver carp and are more efficient in their fishing methods. Therefore, an effort will be made to conduct ride-alongs with a wider array of fishermen in order to acquire a broader sample of the Asian carp commercial fishery.

Bighead carp harvest per trip during ride-alongs in 2016 decreased in both Kentucky Lake (Table 4; 76 lbs/trip) and Lake Barkley (Table 5; 32 lbs/trip). However, bighead carp harvest averages were higher during ride-alongs (40 lbs/trip) than the ACHP totals (23 lbs/trip) in 2016. The average weight of silver carp harvested per trip during ride-alongs (2280 lbs/trip) was slightly lower than the ACHP totals (2329 lbs/trip) in 2016 (Table 6).

Sport Fish in Bycatch

Increased effort by commercial fishermen fishing under the ACHP has translated into a growing amount of bycatch. However, the survival rate of sport fish increased from the 2011-2012 season (87.5% survival) to the 2012-2013 season (96.3% survival) and has remained relatively high through the 2015-2016 season (94.4% survival; Table 1). Although the survival rates recorded during KDFWR ride-alongs (75.2%) were less than the overall totals, the ride along data comes from a much smaller sample size and the majority of ride-alongs occurred during the summer months when fish are most vulnerable due to higher temperatures. In relation to total bycatch, the number of sport fish captured is low (16% during ride-alongs in 2016, 6% from all commercial fishermen reports in April-December 2016) (Tables 1 and 7).

During ride-alongs there were 583 individuals captured as bycatch, of which 16% were sport fishes (Table 7). No sport fish were captured in Kentucky Lake as bycatch during ride-alongs, although there was limited commercial fishing effort (Table 8). In Lake Barkley, the total bycatch as well as the number of sport fish captured increased in 2016 from the previous year (Table 9). This increase is likely due to the greater amount of fishing effort as 17,850 yards of net were observed fished in Lake Barkley during 2015 and 25,135 yards of net were observed fished during 2016 (Table 5). The survival rate of sport fish bycatch in Lake Barkley decreased from 86.3% in 2015 to 71.4% in 2016 (Table 9).

Smallmouth buffalo was the most common bycatch species during ride-alongs making up 25% of all bycatch, followed by paddlefish (14%). The mean survival rate of paddlefish during ride-alongs was 48.2% but varied between water bodies and number captured. Other species of fish that were commonly observed as bycatch included freshwater drum (13% of bycatch), common carp (8% of bycatch), and blue sucker (8% of bycatch) (Table 7). The most common species of sport fish caught in commercial gillnets during ride-alongs was blue catfish (27 fish), followed by yellow bass (20 fish), and striped bass (19 fish) (Table 7). The lowest survival rate among sport fish was exhibited by yellow bass (50%), followed by blue

catfish (74.1%) and striped bass (78.9%) (Not including species where one individual was captured and perished). No crappie and very few black bass species (2 fish total) were observed in commercial nets during ride-alongs (Table 7).

A comparison of sport fish bycatch reported by commercial fishermen through monthly reports and information collected during ride-alongs shows a decrease from 2015 in number of sport fish captured per trip for most species and no indication of negative impacts on the sport fishery resulting from the ACHP (Table 10).

Paddlefish in Bycatch

As KDFWR monitors sport fish bycatch through the ACHP it also provides the opportunity to monitor other species in the bycatch such as paddlefish. Paddlefish are considered a species of conservation need. Their life history traits and value of their roe has potential to result in recruitment overfishing of the population. Consequently, there is a need to limit the impacts of the ACHP on paddlefish. Generally, experienced commercial fishermen targeting Asian carp can avoid capturing paddlefish. The number of paddlefish captured is variable over time, but does show an increasing trend since 2013 (Table 1) with an alarming 889 paddlefish being captured during the 2015-2016 season. The large increase in the number of paddlefish captured through the ACHP is likely due to the substantial increase in effort that commercial fishermen are expending towards harvesting Asian carp. The growing number of fishermen attempting to harvest Asian carp may also be contributing to the number of paddlefish captured as novice fishermen are less experienced with gillnets and not as knowledgeable in how to avoid capturing paddlefish while targeting Asian carp.

Paddlefish exhibited a relatively low survival rate (48.2% during ride-alongs in 2016, 72.1% total ACHP in 2015-2016) in relation to other species in the bycatch (Tables 1 & 7). The survival rate of paddlefish observed during ride-alongs decreased in both Kentucky Lake and Lake Barkley in 2016 (Tables 8 & 9). However, the number of paddlefish captured in the lakes during ride-alongs also decreased when compared to the previous year. In Kentucky Lake the lower number of paddlefish caught is likely due to a decrease in effort (10,466.7 yards of net in 2015, 3,116.67 yards of net in 2016). Since much of the ACHP effort is during the summer months (i.e. warmer water temperatures), paddlefish are vulnerable bycatch in this fishery. Therefore, water temperatures were recorded during ride-alongs conducted in 2016 (Table 11). However, there did not appear to be a marked difference in the survival rate of paddlefish based solely on temperature. This may be due to the small sample size and relatively small range of temperatures observed. Another factor that may affect paddlefish survival in gillnets that needs to be examined is length of time the nets are left in the water. From conducting ride-alongs, it has been observed that the soak time of nets varies among fishermen and depends on the location being fished, weather, and water temperature. Overall, fishermen tend to leave nets in the water longer when water temperatures are cooler as it increases catch rates and like most fish, Asian carp will survive longer in the cooler temperatures. Since paddlefish have an elongated operculum, it is more likely for a gillnet to restrict the water flow over their gills than other fish species. This may be a factor in extended soak times negatively affecting paddlefish survival. Therefore, net soak times will be recorded during ride-alongs in 2017.

Asian Carp Subsidy Program

In 2015, KDFWR created a US$0.05/lb subsidy to incentivize the harvest of Asian carp from Kentucky Lake and Lake Barkley. However, commercial fishermen expressed doubts in the effectiveness of the program due to the delayed sign-up process and the inconvenience of KDFWR staff meeting them at predetermined locations. Interest in the program was renewed at the close of paddlefish season in 2016 and four fishermen signed up for the subsidy program. Only one of the fishermen actively participated in the subsidy program making thirty-two trips to the lakes under the program (3 trips to Kentucky Lake and 29 trips to Lake Barkley). These fishing trips, verified by KDFWR personnel for the subsidy, resulted in 93,847 lbs of silver carp, 1,173 lbs of bighead carp, and 355 lbs of grass carp being harvested and sold to

local processors. The total KDFWR expenditures toward the subsidy in 2016 was $4,768.76. All of the trips under the subsidy were made during the summer months when paddlefish season was closed. The effectiveness of this program may be limited as many commercial fishermen already show a preference for fishing in Kentucky Lake and Lake Barkley since the Asian carp harvested from the lakes are larger than Asian carp found in the lower Cumberland, Tennessee, and Ohio Rivers. It is expected there will be renewed interest in the subsidy program at the close of the commercial paddlefish season in 2017.

Table 1. Measures of effort, catch, and bycatch reported by commercial fishermen fishing under the Asian Carp Harvest Program for each commercial fishing season from November 2011 - December 2016. Commercial fishing seasons are defined as April through March of the following year.

	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	April 2016- Dec. 2016
Number of Days/Trips	3	6	74	174	346	487
Number of fishermen	1	1	7	11	22	21
Total number of bycatch	167	275	634	1,530	3,444	11,881
number of sport fish caught	8	54	84	221	893	734
Sport fish released alive (%)	87.5	96.3	98.8	96.8	94.4	92.9
Number of paddlefish caught	93	222	93	161	889	515
Paddlefish released alive (%)	96.8	92.3	87.1	73.9	72.1	67.2
Weight silver carp harvested (lbs)	994	2,140	242,101	780,730	742,119	1,203,325
Weight bighead carp harvested (lbs)	820	0	491	3,381	33,342	11,545

Table 2. Number of bighead and silver carp captured by gillnet mesh size as observed during KDFWR ride-alongs with commercial fishermen fishing under the Asian Carp Harvest Program in 2016.

Net Mesh Size	Effort (yds)	Silver carp	Bighead carp	Grass carp
3.5	1883	155		17
4	2067	308		1
4.25	9300	1469	8	12
5	16983	1811	44	13
6	1067	3		

Table 3. Monthly number of fishing trips made and average total weight (lbs) of silver and bighead carp harvested per trip as reported by commercial fishermen fishing under the Asian Carp Harvest Program from November 2011 - December 2016. (S.E. = standard error)

Fishing Season	Month	Number of Trips	Avg silver carp weight	S.E.	Avg bighead carp weight	S.E.
April 2011 - March 2012	November	2	430	0.0	305	0.0
	February	1	134	0.0	210	0.0
April 2012 - March 2013	November	4	280	105.1	0	
	February	2	0	0.0	0	
April 2013 - March 2014	July	12	2441	549.6	0	0.0
	August	12	4827	715.2	0	0.0
	September	27	3463	364.5	7	4.5
	October	16	1907	363.5	19	6.3
	November	6	4738	460.2	0	0.0
April 2014 - March 2015	April	3	156	156.0	523	423.0
	May	1	1131	0.0	0	0.0
	June	17	7198	1164.4	0	0.0
	July	29	4510	627.9	15	7.8
	August	30	6200	936.1	24	15.6
	September	42	5461	705.3	2	1.7
	October	38	2677	218.0	0	0.0
	January	1	1000	0.0	0	0.0
	February	3	1424	210.4	93	29.2
	March	10	981	266.7	33	9.0
April 2015 - March 2016	April	16	1830	519.4	190	45.1
	May	21	1995	363.1	135	47.2
	June	44	1532	188.8	441	122.1
	July	54	2413	164.8	46	12.4
	August	44	2359	179.9	34	12.9
	September	35	3039	253.1	44	13.4
	October	29	1922	228.6	8	12.6
	November	12	2808	430.7	71	42.4
	December	15	2234	429.8	31	25.4
	January	14	1092	282.9	28	12.2
	February	23	1551	325.9	8	8.9
	March*	41	2175	302.3	13	7.5

* Commercial fishermen began using the $0.05 / lb subsidy

Table 3 continued. Monthly number of fishing trips made and average total weight (lbs) of silver and bighead carp harvested per trip by commercial fishermen fishing under the Asian Carp Harvest Program each month from November 2011 - December 2016. (S.E. = Standard error)

April 2016 - December 2016	Month	Number of Trips	Avg silver carp weight	S.E.	Avg bighead carp weight	S.E.
	April	34	2024	335.0	35	14.6
	May	52	3640	233.8	58	10.3
	June	79	2980	168.1	31	11.7
	July	44	2212	182.2	18	9.2
	August	72	1963	138.9	10	14.4
	September	79	2359	193.7	36	12.7
	October	79	2341	182.2	24	12.2
	November	24	3435	590.6	1	1.2
	December	17	1627	319.3	7	3.6

Table 4. Fishing effort and total weight (lbs) of Asian carp harvested during KDFWR ride-alongs with commercial fishermen fishing under the Asian Carp Harvest Program on Kentucky Lake 2015 - 2016. (S.E. = standard error)

Year	Effort*	Mean effort per trip	S.E.	Number of ride - alongs	Number of fishermen	Total WT of silver carp harvested (lbs)	Mean WT of silver carp harvested per trip (lbs)	S.E.	Total WT of bighead carp harvested (lbs)	Mean WT of bighead carp harvested per trip (lbs)	S.E.
2015	10467	1047	95.6	10	5	16589	1659	437.3	1200	120	66.6
2016	3117	1039	374.2	3	2	6064	2021	1524.8	229	76	30.0

*effort is calculated in yards of gillnet fished

Table 5. Fishing effort and total weight (lbs) of Asian carp harvested during KDFWR ride-alongs with commercial fishermen fishing under the Asian Carp Harvest Program on Lake Barkely 2015 - 2016. (S.E. = standard error)

Year	Effort*	Mean effort per trip	S.E.	Number of ride - alongs	Number of fishermen	Total WT of silver carp harvested (lbs)	Mean WT of silver carp harvested per trip (lbs)	S.E.	Total WT of bighead carp harvested (lbs)	Mean WT of bighead carp harvested per trip (lbs)	S.E.
2015	17850	1116	50.5	16	5	35130	2196	256.6	1608	101	43.1
2016	25135	1143	70.4	22	4	61533	2797	481.8	704	32	13.7

*effort is calculated in yards of gillnet fished

Table 6. Comparison of the average weight harvested per trip of silver carp and bighead carp during KDFWR ride-alongs, and through commercial fishermen reports for the Asian Carp Harvest Program in 2016. (S.E. = standard error)

	SC	S.E.	BHC	S.E.
Ride Alongs	2,280	402.2	40	12.4
Commercial fishermen reports	2,329	70.6	23	3.3

Table 7. Species composition, number of individuals captured, and survival rate of bycatch observed during KDFWR ride-alongs with commercial fishermen fishing under the Asian Carp Harvest Program in 2016.

Species	Number captured	Number released alive	Number dead	Survival rate*
Paddlefish	83	40	43	48.2%
Skipjack herring	23	4	19	17.4%
Blue catfish	27	20	7	74.1%
Smallmouth buffalo	145	144	1	99.3%
Freshwater drum	76	51	25	67.1%
Common carp	48	47	1	97.9%
Channel catfish	10	8	2	80.0%
Flathead catfish	9	8	1	88.9%
Longnose gar	8	7	1	87.5%
Largemouth bass	1	1		100.0%
Shortnose gar	9	4	5	44.4%
Striped bass	19	15	4	78.9%
Yellow bass	20	10	10	50.0%
Bigmouth buffalo	8	8		100.0%
Black buffalo	17	16	1	94.1%
Grass carp	12	12		100.0%
Gizzard shad	5	0	5	0.0%
White bass	1	0	1	0.0%
River carpsucker	3	3		100.0%
Redear sunfish	1	1		100.0%
Mooneye	3	0	3	0.0%
Chestnut lamprey	1	0	1	0.0%
Threadfin shad	1	0	1	0.0%
Blue sucker	49	39	10	79.6%
Sauger	1	0	1	0.0%
Hybrid striped bass	2	2		100.0%
Spotted bass	1	1		100.0%
Total	583	441	142	63.2%

*Survival rate was defined as fish that swam away after release

Table 8. Bycatch numbers and survival rates observed during KDFWR ride-alongs with commercial fishermen fishing under the Asian Carp Harvest Program on Kentucky Lake 2015 - 2016.

Year	Number of ride alongs	Total number of bycatch	Total # of sport fish caught	Sport fish released alive (%)	Total # of paddlefish caught	Paddlefish released alive (%)
2015	10	167	18	94.4	55	72.7
2016	3	15	0		6	50.0

Table 9. Bycatch numbers and survival rates observed during KDFWR ride-alongs with commercial fishermen fishing under the Asian Carp Harvest Program on Lake Barkley 2015 - 2016.

Year	Number of ride alongs	Total number of bycatch	Total # of sport fish caught	Sport fish released alive (%)	Total # of paddlefish caught	Paddlefish released alive (%)
2015	16	385	73	86.3	162	46.9
2016	22	494	84	71.4	49	38.8

Table 10. Comparison of bycatch of sport fish reported through monthly reports by commercial fishermen fishing under the Asian Carp Harvest Program versus observations made by KDFWR staff during ride-alongs in 2015 and 2016. (S.E. = standard error)

	2015						2016					
	Totals		Number captured per trip				Totals		Number captured per trip			
Species	ACHP	Ride-alongs	ACHP	S.E.	Ride-alongs	S.E.	ACHP	Ride-alongs	ACHP	S.E.	Ride-alongs	S.E.
Blue catfish	373	67	1.32	0.25	2.09	0.63	432	27	0.74	0.06	1.21	0.28
Channel catfish	67	26	0.24	0.05	0.81	0.19	47	10	0.08	0.02	0.36	0.16
Flathead catfish	194	21	0.69	0.08	0.66	0.18	224	9	0.38	0.04	0.39	0.17
Catfish	85		0.30	0.05			43		0.07	0.02		
Bass	36		0.13	0.05			9		0.02	0.02		
Largemouth bass	13	7	0.05	0.20	0.22	0.12	46	1	0.08	0.70	0.04	0.04
Smallmouth bass							1		<0.01			
Spotted bass							1	1	<0.01		0.04	0.04
Hybrid striped bass							2	2	<0.01		0.07	0.05
Striped bass	24	4	0.08	0.03	0.13	0.06	59	19	0.10	0.03	0.68	0.37
Yellow bass	3	3	0.01	0.01	0.09	0.70	21	20	0.04	0.02	0.71	0.45
White bass	2	2	0.01	0.01	0.06	0.06	2	1	<0.01		0.07	0.05
Rock bass							9		0.02	0.01		
Sauger	8		0.03	0.02			1	1	<0.01		0.04	0.04
Walleye	1		<0.01									
Crappie	9		0.03	0.01			7		0.01	0.01		
Redear sunfish	1	1	<0.01		0.03	0.03	3	1	0.01		0.04	0.04

Table 11. Number and survival rate of paddlefish captured by commercial fishermen during KDFWR ride-alongs under the Asian Carp Harvest Program for each month in 2016.

Month	Number paddlefish captured	% released alive	Mean water temp (°F)
January	0		45.0
February	0		
March	4	50.0%	54.4
April	15	66.7%	62.5
May	9	55.6%	69.4
June	44	45.5%	81.9
July	2	0.0%	81.5
August	1	100.0%	81.5
September	8	62.5%	80.5
October	0		
November	0		
December	0		

Project II: Silver Carp Demographics in Kentucky Lake

FINDINGS

Kentucky Lake Silver Carp Population Dynamics

Silver carp (*Hypophthalmichthys molitrix*) population data was collected from fish captured in Kentucky Lake from February 2015 to September 2016. Several methods were used to collect 441 silver carp. Gillnets yielded 77 carp in over 1700 netting hours fished by Murray State University students. Boat electrofishing yielded 54 carp with 40 hours of effort. Cast nets and anglers provided 21 carp. Commercial fishermen provided the majority of silver carp for this study. Seventeen trips were made to commercial processing plants which yielded nearly 300 carp. Because most silver carp were provided by commercial fishermen that use large mesh gillnets, there is potential for size bias in these results. Adult silver carp captured in Kentucky Lake by researchers at Murray State University (MSU) and commercial fishermen were combined in these analyses.

All silver carp were measured for total length (mm) and weight (kg), gonads were removed and weighed, sex recorded, and the first pectoral fin ray was removed for aging. There were two primary sizes apparent: small silver carp (200-400mm) and large silver carp (850-950mm). A length frequency histogram for silver carp sampled throughout this study is provided in Figure 1. Gillnets used by MSU and commercial fishermen provided a higher number of large silver carp while small silver carp were more vulnerable to boat electrofishing. After targeting multiple size classes of silver carp with different gears, silver carp in the 400-600mm size class are apparently not present in Kentucky Lake. The majority of fish captured during this study were around 900mm in length (Figure 1). Silver carp in Kentucky Lake are much larger on average when compared to other river systems including the Illinois River, Wabash River, and Mississippi River (Figures 1 and 2).

The relationship between length and weight for silver carp in Kentucky Lake was used to understand the relative health or condition of individual fish. The length weight equation for Kentucky Lake silver carp was $Log_{10}(weight) = -12.39 + 3.15Log_{10}(length)$ (Figure 3). Using this equation, weights were predicted for silver carp at two lengths (450mm and 800mm). Silver carp in Kentucky Lake were among the heaviest at 800mm when compared to silver carp from the Illinois River and Middle Mississippi River (Figure 4).

Juvenile silver carp in Kentucky Lake exhibited rapid growth. In 2015, age-0 silver carp were observed in great numbers and were vulnerable to boat electrofishing. Therefore, growth was tracked throughout 2015 and 2016. From July of 2015 to July of 2016 the mean length of silver carp in the 2015-year class tripled (Figure 5). From April 2016 to August 2016 age-1 silver carp almost doubled in length (Figure 6).

Ages of silver carp collected by commercial fishermen and used for the demographics study ranged from 2-10 years and were dominated by four and five-year-olds. Silver carp in Kentucky Lake exhibited variable recruitment similar to other populations. The weighted catch curve regression produced an annual mortality rate of 53% ($R^2 = .797$; $P = .005$) (Figure 7). This mortality estimate is on the low end of the range estimated in other systems (Table 1). Mortality is higher in the Mississippi and Illinois Rivers, which have well-established commercial harvest. The Wabash River, which has a lower mortality rate does not have a commercial harvest. There is a growing commercial fishery at Kentucky Lake, however the harvest is not yet at the level seen in the Middle Mississippi and Illinois Rivers.

Gonads of silver carp harvested from Kentucky Lake were weighed to calculate the mean gonadosomatic index (GSI). This information was collected monthly from April 2015 – September 2016. The mean GSI for female silver carp from Kentucky Lake peaked multiple times, possibly indicating multiple spawning events each year (Figure 8). The highest mean GSI in 2016 occurred in February and June. Male GSI's peaked in April (Figure 8).

Lake Barkley Silver Carp Demographics

In 2016, KDFWR began collecting information from silver carp captured by commercial fishermen in Lake Barkley. Data has not yet been analyzed. However, plans are to continue this effort throughout 2017 and compare these results to those of silver carp captured in Kentucky Lake. Demographics of silver carp in Lake Barkley are desirable as this lake has more commercial fishing pressure which could be affecting population structure of silver carp differently than in Kentucky Lake.

Kentucky Lake Standardized Sampling

In November 2016, KDFWR partnered with several federal and state agencies, and commercial anglers to conduct a standardized sampling event of Asian carp on Kentucky Lake. The objective was to create a baseline for standardized sampling of Asian carp in Kentucky Lake, and to begin calculating annual relative abundance estimates. The event was conducted over a two-day period during which crews of 3-6 people sampled quasi-random locations throughout Kentucky Lake. The bulk of the effort was expended in and around Big Bear and Blood River embayments. Asian carp were targeted with 2-hour gillnet sets during the day. Gillnets were composed of 1-5" mesh (21,261yds of net fished). Electrofishing (11.59 hours) and boat banging were used in an effort to herd the Asian carp into the nets. These sampling efforts produced 89 silver carp and 1 bighead carp. The majority of fish (42) were captured during overnight gillnet sets (Table 2). Most fish captured were measured and then euthanized, however nine silver carp were implanted with sonic transmitters and released. The USFWS also conducted sampling efforts with Paupier nets November 7-9, 2016, in the Big Bear embayment of Kentucky Lake. This was the first time this gear had been used in Kentucky Lake or in a reservoir of comparable size. The Paupier nets produced 1,406 silver carp in 9.12 hours of effort (Table 3). Lengths and weights were taken from a random subsample of silver carp captured by the Paupier net with lengths ranging from 238mm to 960mm. The majority of silver carp captured with the Paupier net were given to a local Asian carp processor. This sampling event was the first effort to identify methods for standardized Asian carp sampling in Kentucky Lake. To date, Asian carp standardized sampling efforts in the Mississippi River Basin have focused on large river environments. Very little information exists on capturing Asian carp in large mainstem reservoirs like Kentucky Lake. Short gillnet sets, specifically during the day, did not produce the numbers of carp that were expected, while the Paupier nets were more successful at capturing silver carp. In the future, knowledge gained in this initial effort could lead to longer gillnet sets (possibly nocturnal) and increased efforts with the Paupier nets.

Literature Cited

Hayer, C. A., J. J. Breeggemann, R. A. Klumb, B. D.Graeb, & K. N. Bertrand. 2014. Population characteristics of bighead and silver carp on the northwestern front of their North American invasion. *Aquatic Invasions*, *9*(3), 289-303.

Seibert, J. R., Q. E. Phelps, K. L. Yallaly, S. Tripp, L. Solomon, T. Stefanavage, & M.Taylor. 2015. Use of exploitation simulation models for silver carp (*Hypophthalmichthys molitrix*) populations in several Midwestern US rivers. *Management of Biological Invasions*, *6*(3), 295-302.

Table 1. Estimates of annual mortality of silver carp from multiple locations within their introduced range in the Mississippi River Basin. Mortality rates calculated using weighted catch curve regressions.

Water Body	Silver carp mortality rate
Kentucky Lake	53.3%
Middle Mississippi River	63.0%
Illinois River	63.3%
Wabash river	43.6%

Table 2. Gillnet and electrofishing effort and number of Asian carp captured during sampling conducted on Kentucky Lake in November 2016.

	Gillnet					Electrofishing	
Date	Effort (hrs)	Yards of net fished	Number of Silver carp captured	Number of Bighead carp captured	Number of Grass carp captured	Effort (hrs)	Number of Silver carp captured
11/8/2016	13	1,000	3				
11/9/2016	165.6	11,892	21		4	6.95	7
11/10/2016	110.6	7,869	14	1	1	4.64	2
Overnight Sets	114	500	42		1		
Totals	403.2	21,261	80	1	6	11.59	9

Table 3. Paupier net effort and catch rates from sampling conducted in Big Bear embayment of Kentucky Lake in November of 2016. (S.E. = Standard error)

Date	Net Hours	Number of Silver carp captured	Mean silver carp CPUE (fish/hr)	S.E.	Number of Grass carp captured
11/7/2016	0.42	67	155.6	9.1	2
11/8/2016	3.53	563	215.0	35.0	1
11/9/2016	3.34	504	136.7	18.2	
11/10/2016	1.83	272	168.1	29.8	
Totals	9.12	1,406	168.9	23.0	3

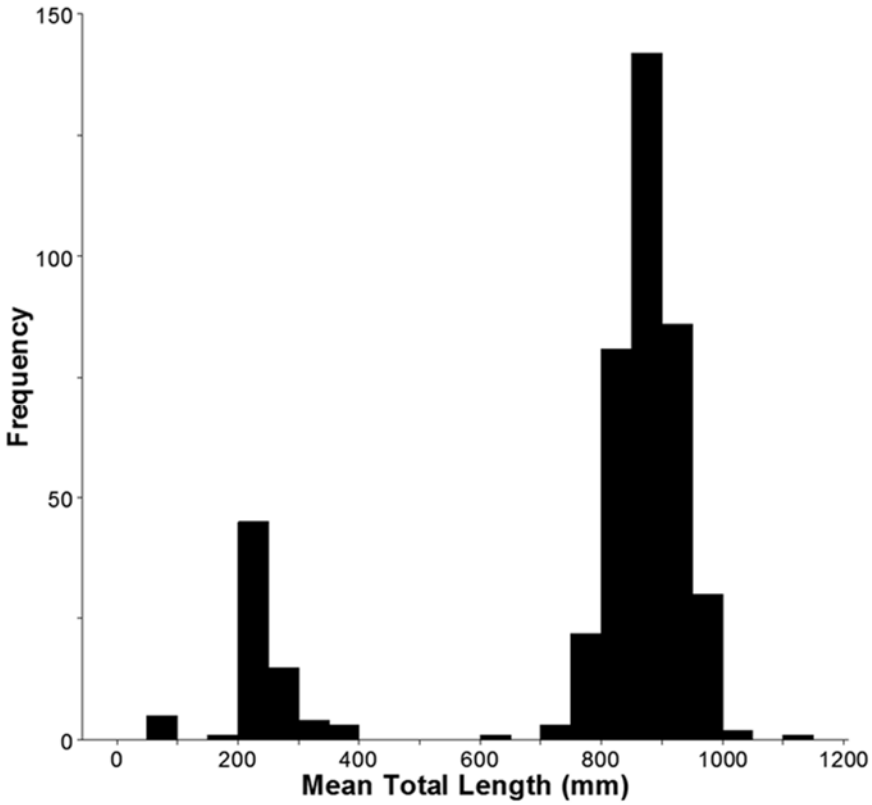

Figure 1. Length frequency histogram for distribution of lengths of silver carp (n=441) in Kentucky Lake February 2015 – September 2016.

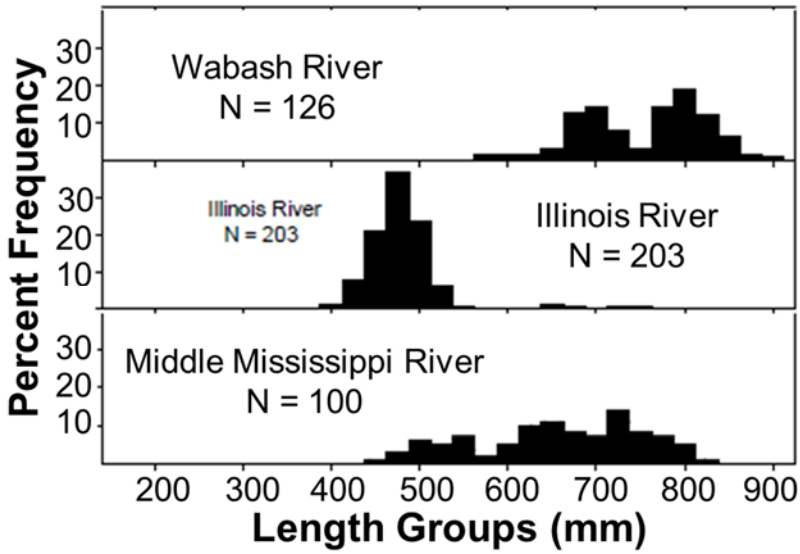

Figure 2. Length distribution of silver carp in three river populations in 2015. Amended from Seibert et al. 2015.

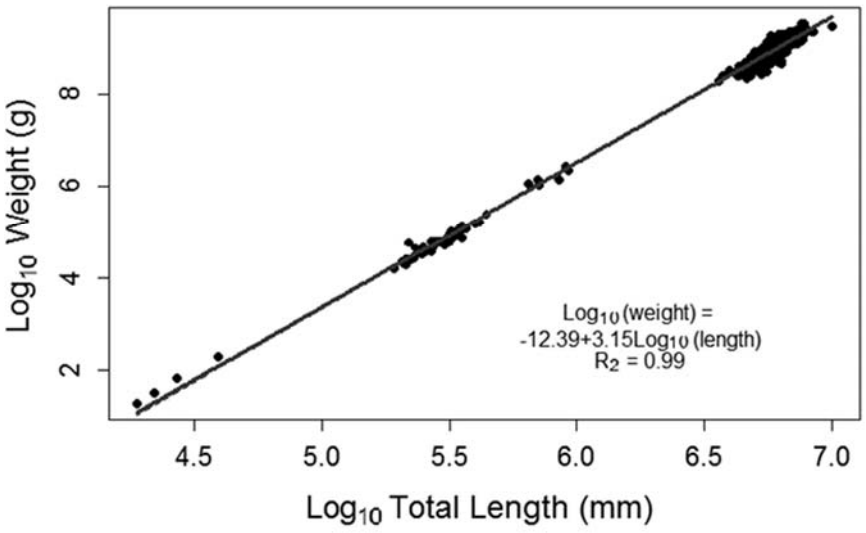

Figure 3. Log_{10} transformed relationship between length and weight for silver carp captured in Kentucky Lake from February 2015 – September 2016.

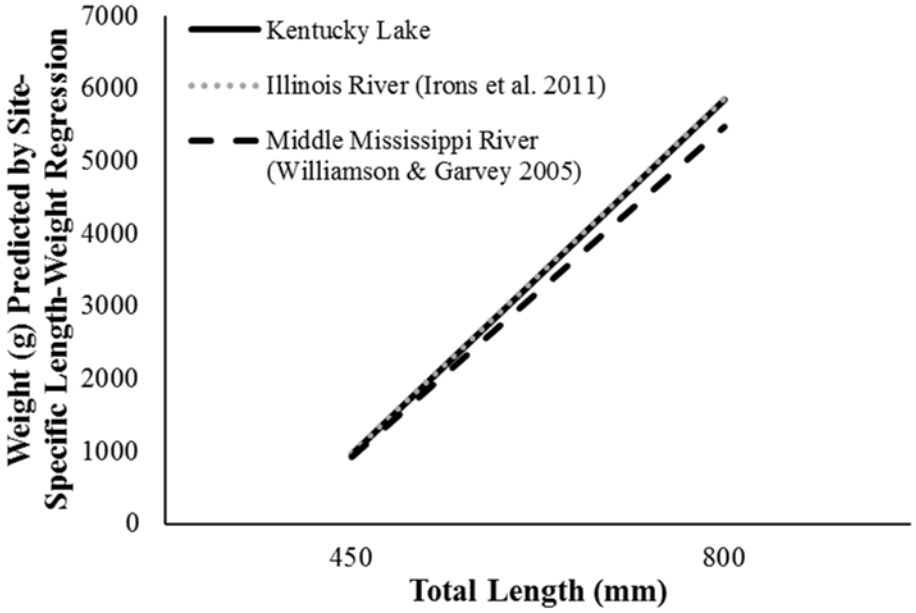

Figure 4. Comparison of length-weight relationships between silver carp populations in Kentucky Lake and the Middle Mississippi River, and Illinois River. Amended from Hayer et al. 2014. Note that the Kentucky Lake line falls directly on top of the Illinois River line.

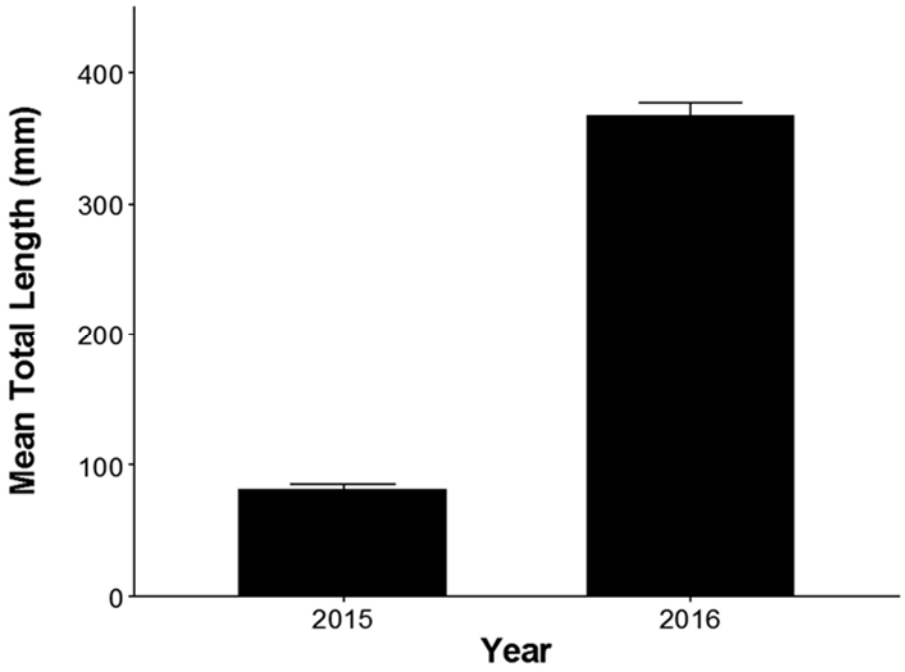

Figure 5. The mean total length of YOY silver carp captured in Kentucky Lake in July 2015 and the mean total length of silver carp exactly 1 year later in July 2016. Error bars represent +/- 1 standard error.

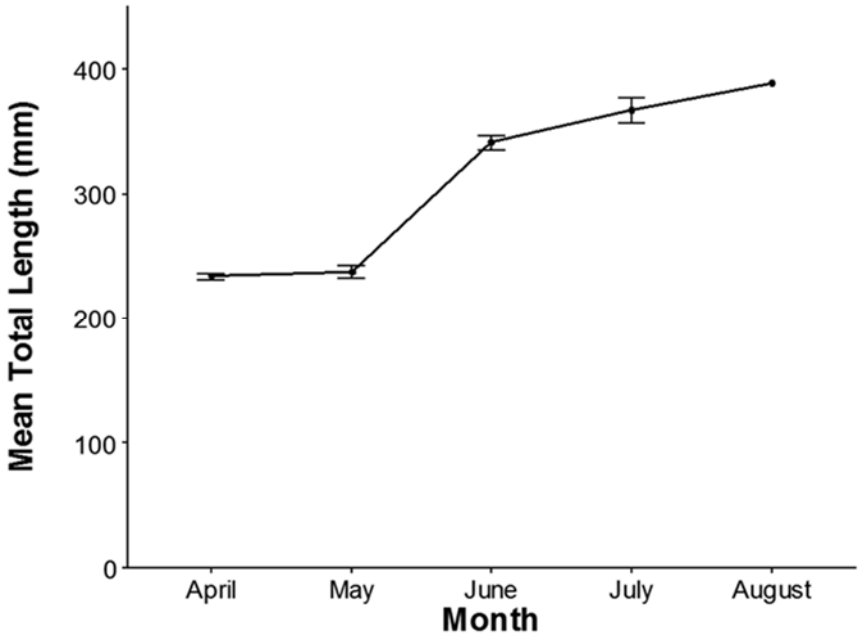

Figure 6. This graph shows the mean total length of juvenile silver carp captured in Kentucky Lake from April 2016 to Aug 2016. Error bars represent +/- 1 standard error.

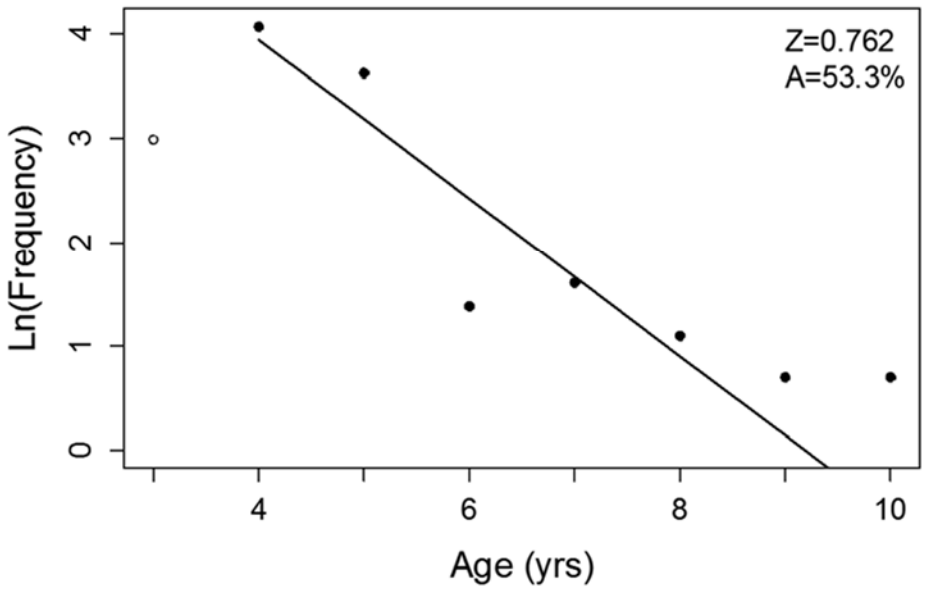

Figure 7. Weighted catch curve regression estimating mortality of silver carp in Kentucky Lake in 2015 (n=133; R^2 = 0.797; P-value = <0.005). Closed circles represent that they are part of the descending limb and were part of the catch curve regression used to estimate A and Z. The open circle shows the ascending limb and was not used to estimate A and Z as 3-year-olds have yet to fully recruit to the gear.

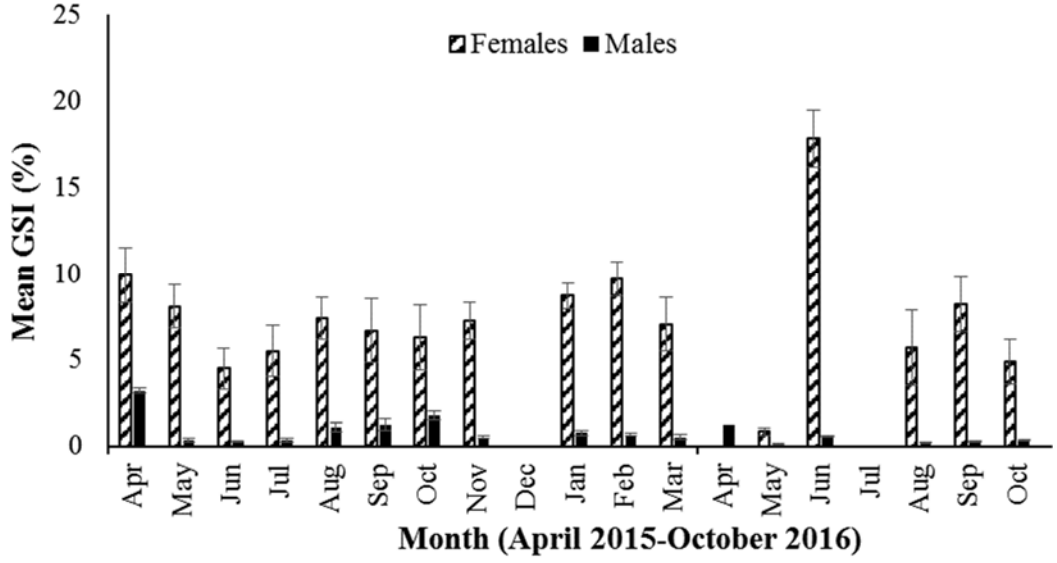

Figure 8. Mean gonadosomatic index (GSI) for silver carp captured in Kentucky Lake from April 2015 – October 2016 (n=319). Error bars represent +/- 1 standard error.

Project III: Tracking Silver Carp Movement in Kentucky Lake

FINDINGS

Tagged Fish

Kentucky Department of Fish and Wildlife Resources worked with Murray State University (MSU) to begin a study tracking silver carp movement in Kentucky Lake. Silver carp were implanted with VEMCO V13 transmitters and tagged with a jaw tag. VEMCO VR100 telemetry receivers were used to manually track tagged fish, and VEMCO VR2W stationary telemetry receivers were deployed throughout Kentucky Lake to quantify large scale movements. Surgeries were performed on 69 silver carp over seven dates in 2016 (Table 1). During May and June, fish were obtained from commercial gill nets, tagged, and released at Hancock Biological Station, located in an embayment on west side of Kentucky Lake just south of Ledbetter Creek. In November, fish were obtained from multiple gear types during the "Carp Blitz" on Kentucky Lake; these fish were released at Camp Currie (Big Bear embayment) and at the Wildcat Creek boat ramp (Blood River embayment). In December, fish were obtained from short duration gillnet sets below Lake Barkley Dam and were released at MSU's Hancock Biological Station (Figure 1). Several of the fish tagged during spring 2016 have been consistently tracked in the same location several times, so it is believed these fish are dead. The fish tagged in November and December have been relocated infrequently, so no conclusions can be made about the mortality of these fish. However, one of the November fish has been found in the same spot several times, so it is believed to be dead. Mortality was highest during the first tagging sessions, probably due to a variety of reasons. Early surgeries were on fish that were stressed from being in the commercial gillnets for an extended period of time. Also, after the first tagging session, surgery procedures were modified so that the fishes' gills were irrigated with lake water during the surgery. This modification seems to have improved survival. Finally, research personnel performing surgeries have likely become more proficient (Table 2).

Tracking Effort

Boat-mounted hydrophones were used to track tagged silver carp on 34 separate trips starting in May of 2016. Tests with the boat-mounted hydrophone suggested that the detection range in Kentucky Lake was approximately 500 m. The basic technique used to track fish involved drifting for approximately two minutes while listening for the acoustic tags. Then, the boat would travel about one km parallel to the shore and stop again to listen. This procedure was continued down one side of Kentucky Lake, and then the same technique was employed on the return trip up the other side of the lake. The average width of the portion of Kentucky Lake where manual tracking was utilized was 2.3 km. The linear distance traveled on each tracking trip averaged 34 km. The estimated detection range and the linear distance traveled was used to estimate the total area covered on each manual tracking trip. A map was generated which uses color coding to summarize the number of visits and areas tracked in Kentucky Lake during 2016 (Figure 2). Most of the effort was in the middle portion of the lake near the Hancock Biological Station and upstream of Blood River. One trip of 61 km in length was made in Lake Barkley, but no fish were detected.

A series of 12 VR2W passive receivers were deployed throughout Kentucky Lake to record long-range movement patterns of tagged silver carp (Figure 3). This includes two passive receivers to monitor the lock chamber of Kentucky Lake Dam – one inside the chamber, and another on the upstream approach of the lock chamber. These two receivers were mounted inside protective covers and then hung behind ladders in the lock walls. The remaining ten receivers were attached to heavy bottom stands constructed of concrete and steel, and deployed along the bottom of the lake. Our testing suggested that passive receivers deployed in this way have a detection range of about 300 m, therefore receivers were placed near enough to each other to maximize the chance of detecting passing fish. However, this placement was not always possible due to the local bathymetry. For example, only two receivers are deployed immediately north of Hancock Biological Station because the water is too deep in the channel near that area. In other areas, such as near the mouth of Blood River, there is nearly bank-to-bank coverage with

the passive receivers. The most recent deployment of receivers was at the railroad bridge crossing near Danville, TN. This is an ideal area as the lake is constricted to just a few hundred meters, so any fish swimming through this area has an excellent chance of being detected (Figure 4).

Fish Detections

Although a passive receiver array was deployed and a great amount of effort was expended conducting manual tracking with boat-mounted hydrophones, there has not been enough silver carp detections to draw any meaningful conclusions about the movement patterns of silver carp in Kentucky Lake. Of the 58 fish that are presumed to still be alive, 8 fish have not been detected since they were tagged (neither via manual or passive tracking). A large percentage of the 58fish have been detected at least once, but few fish have been detected more than once (Table 3). Most of the detections occurred within the first few weeks after the fish were released and were in areas near their release site. One interesting anecdotal story is of a single fish which was tagged and released in May 2016. This fish was detected near its release site a few times right after it was tagged, but was then not detected again for several months, even though extensive manual tracking was conducted in the area. The fish was again detected late in 2016 back near its release site, suggesting that this fish had left the area but then returned. The VR2W receivers proximate to this area have yet to be downloaded to see if this fish was detected in other locations. With this in mind, the objective is 200 tagged fish in order to quantify movement patterns of silver carp in Kentucky Lake.

Fish that were tagged by other agencies have also been detected during this study. Specifically, several paddlefish which were tagged by the Missouri Department of Conservation in the Mississippi River basin were located either in Kentucky Lake or in the lock chamber at Kentucky Lake Dam. Some of these paddlefish were detected multiple times throughout Kentucky Lake. There were also multiple detections of an unknown tag number and attempts to determine the origin of the fish have so far been unsuccessful.

The 58 fish which are presumed still alive should have active tags well into 2018. Therefore, the intent is to continue tracking these fish, as well as tag several more silver carp throughout 2017. The deployment of more VR2W receivers is also planned for 2017 as these are more useful for tracking silver carp in Kentucky Lake. Specifically, VR2W receivers on buoys in the canal which connects Kentucky Lake and Lake Barkley would allow documentation and frequency of silver carp travelling between these two basins. Also, VR2W receivers deployed between the KY HWY 80 bridge and Kentucky Lake Dam could give a more complete picture of silver carp movement patterns in Kentucky Lake. If it was found that some of the fish are continually found in an area, the intent would be to track them extensively over a 24-to-48-hour period to collect fine-scale movement data.

Table 1. Summary of tagged silver carp in Kentucky Lake during 2016.

Date	Number Tagged		Mean TL (mm)		Mean W (g)		Release Location
	F	M	F	M	F	M	
5/11/2016	10	3	878	913	8,766	9,318	Hancock
5/16/2016	1		902				Hancock
6/2/2016	5	5	889	825	9,256	6,732	Hancock
11/8/2016	2		847		5,340		Camp Currie
11/9/2016	6	2	897	834	7,282	5,990	Camp Currie
11/10/2016*	1	1	920	835	7,340	5,820	Wildcat Ramp
12/13/2016	15	17	822	795	5,469	4,875	Hancock
Total	40	28	879	840	7,242	6,547	

*One Silver Carp of unknown sex was also tagged on this date (851 mm, 6,150g)

Table 2. Summary of estimated mortality of tagged silver carp in Kentucky Lake in 2016. Mortality was assumed when fish were consistently found in the same location.

Date	Alive	Dead
5/11/2016	6	7
5/16/2016	1	
6/2/2016	7	3
11/8/2016	2	
11/9/2016	8	
11/10/2016	2	1
12/13/2016	32	
Total	58	11

Table 3. Summary of unique detections days of individual silver carp with both manual and passive tracking during the Kentucky Lake telemetry study in 2016. Unique detection days are defined as the number of unique dates on which a fish was detected.

Unique Detection Days	Number of Individual fish[a]	
	Manual	Passive
0	10[b]	45
1	35	3
2	10	1
3	2	6
4	1	1
More than 4	0	2

a – These numbers are based on the 58 fish that are presumably still alive on January 1, 2017.

b – 2 of these fish were detected via the passive receivers

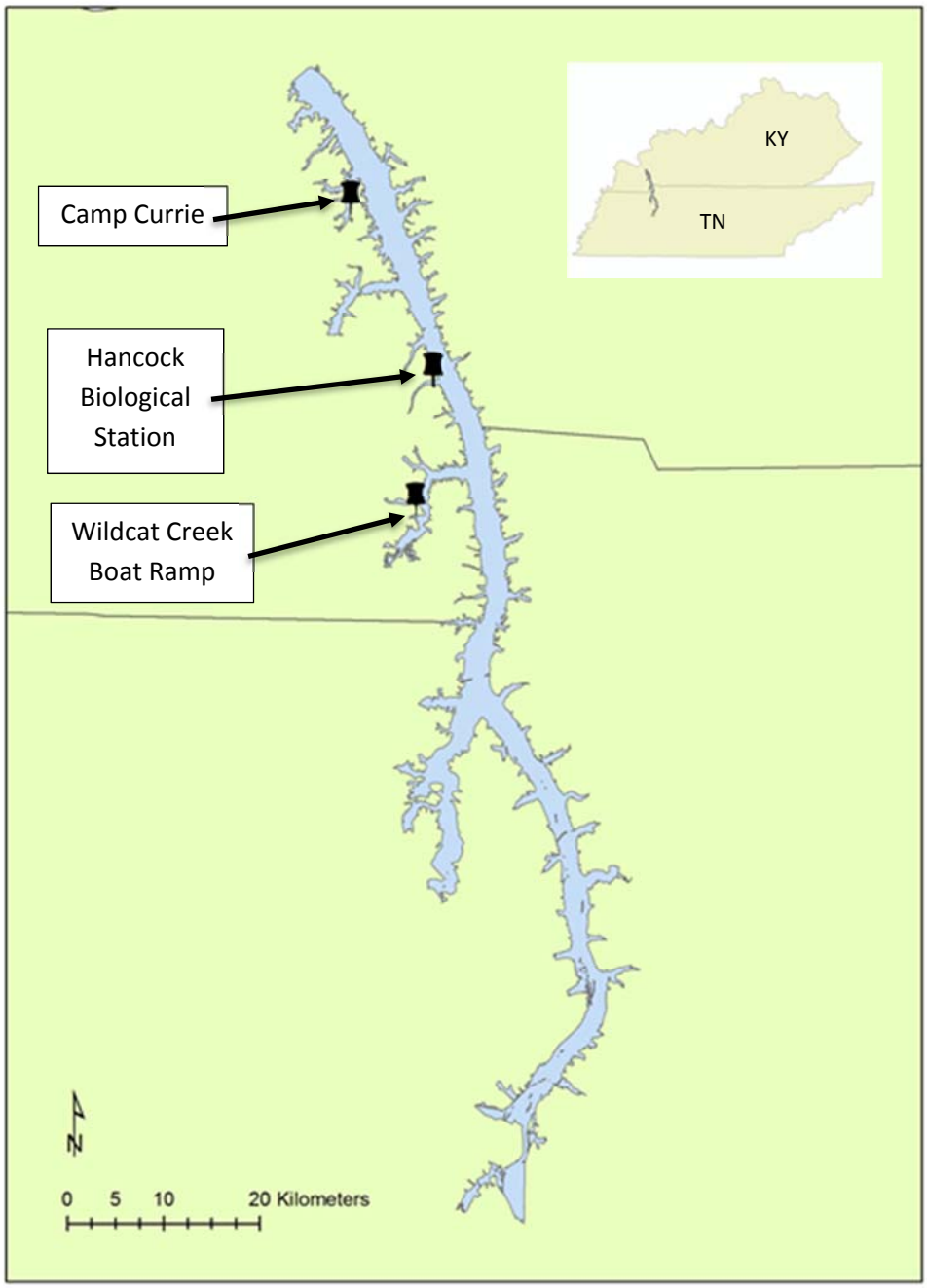

Figure 1. Release locations for Silver Carp in Kentucky Lake during 2016. Inset shows relative location of Kentucky Lake in Kentucky and Tennessee.

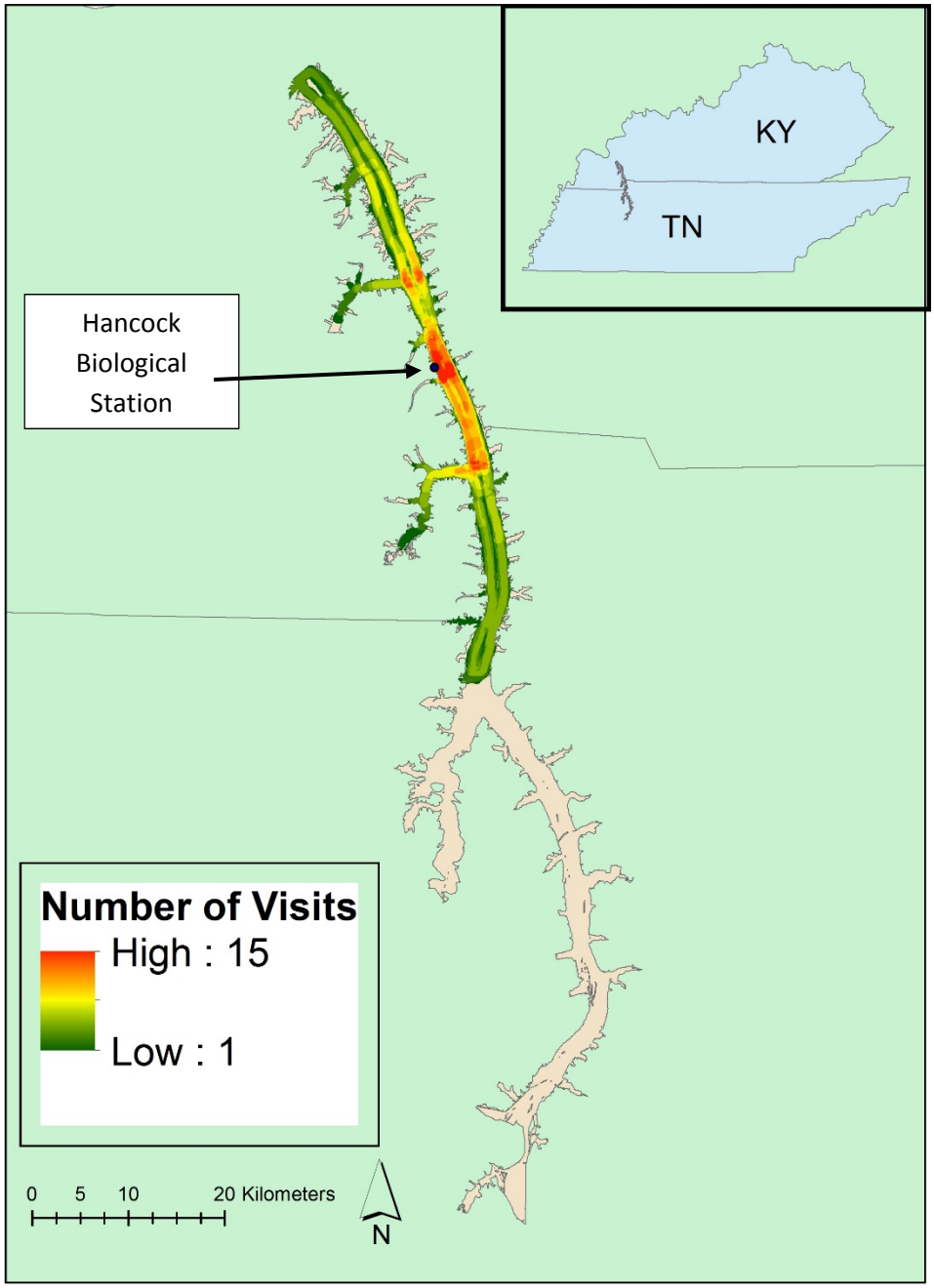

Figure 2. Tracking effort in Kentucky Lake during 2016. “Number of Visits” is determined based upon a 500 m listening radius around the direction of travel.

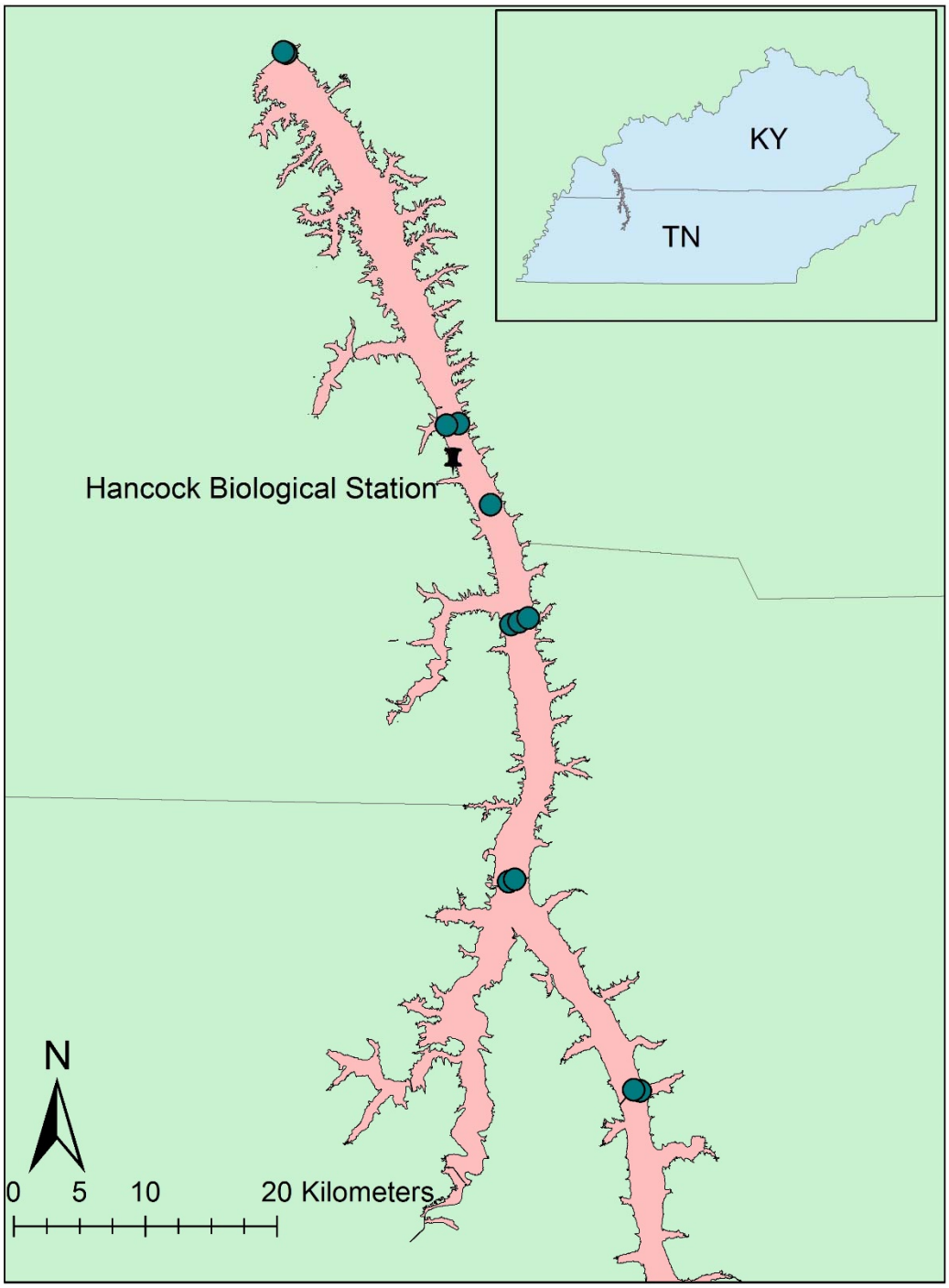

Figure 3. Location of VR2W passive receivers deployed throughout Kentucky Lake.

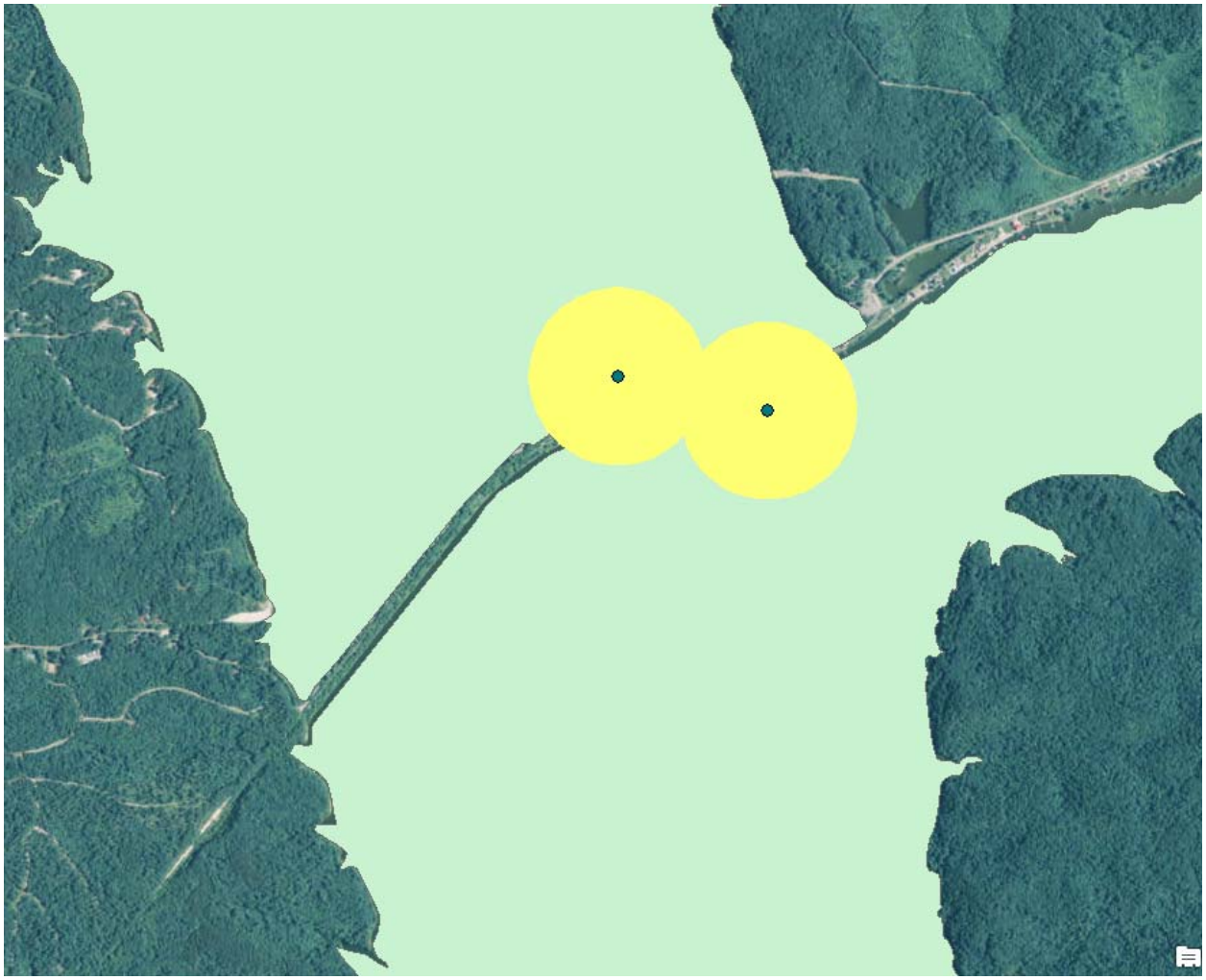

Figure 4**.** Location of the VR2W passive receivers deployed at the Danville railroad bridge. Yellow circles indicate the estimated 300 m detection range of each VR2W.

Project IV: Kentucky Lake Tailwater and Lake Barkley Tailwater Sport Fish Assessments

FINDINGS

Electrofishing

Kentucky Department of Fish and Wildlife Resources (KDFWR) personnel sampled the lower Tennessee River below the Kentucky Lake Dam (hereafter referred to as Kentucky Tailwater) and the lower Cumberland River below the Lake Barkley Dam (hereafter referred to as Barkley Tailwater). Kentucky Tailwater electrofishing extended from the dam downstream to the Interstate 24 bridge; at Barkley Tailwater electrofishing extended from the dam downstream to the US Hwy 62 bridge (Figure 1). Sampling consisted of 900-second runs using pulsed DC electrofishing in the spring and fall of 2016 to assess species composition and relative abundance. Spring sampling took place during the months of April, May, and June, with fall sampling occurring in September, October, and November. Fish were identified and total length (in) was recorded. Weight (lbs) was also recorded in fall sampling. When large numbers of any species were collected, random subsamples were measured for length and weight to decrease processing time. All Asian carp captured were sexed, had a fin ray removed for aging, and were euthanized.

Spring sampling in the Barkley Tailwater resulted in the capture of 1,242 total fish comprised of 42 species during 2.75 hours of effort in 2016 (Table 1). Longear sunfish were the most abundant species captured with a CPUE of 110.1 fish/hr. Other prevalent rough fish species caught during spring sampling at Barkley Tailwater were silver carp (24.3 fish/hr) and smallmouth buffalo (23.1 fish/hr). Prominent sport fish captured in Barkley Tailwater during spring sampling were bluegill (69.4 fish/hr) and largemouth bass (63.7 fish/hr).

Spring sampling in the Kentucky Tailwater resulted in the capture of 2,167 total fish comprised of 47 species during 4.65 hours of effort in 2016 (Table 1). Bluegill were the most abundant species captured with a CPUE of 91.5 fish/hr. Other prominent sport fish captured in the Kentucky Tailwater during spring sampling were yellow bass (31 fish/hr) and flathead catfish (18.7 fish/hr). Prevalent rough fish species captured during spring sampling at Kentucky Tailwater included longear sunfish (74.2 fish/hr), and gizzard shad (52.1 fish/hr).

Spring sampling was also conducted in 2015 at Kentucky Tailwater. Gizzard shad, longear sunfish, and largemouth bass were among the most abundant species in both the 2015 and 2016 samples. However, bluegill were the sixth most abundant species in 2015, but the most abundant species in the 2016 sample.

Fall sampling in the Barkley Tailwater resulted in the capture of 11,468 total fish comprised of 33 species in 1.99 hrs of effort in 2016 (Table 2). Threadfin shad were the most abundant species captured in Barkley Tailwater (4,598.5 fish/hr). Other prevalent rough fish species caught in Barkley Tailwater during 2016 fall sampling were gizzard shad (208.7 fish/hr) and longear sunfish (101.6 fish/hr). Abundant sport fish species captured included largemouth bass (48.2 fish/hr) and bluegill (46.5 fish/hr).

Fall sampling in the Kentucky Tailwater resulted in the capture of 3,876 total fish comprised of 35 species in 1.75 hrs of effort in 2016 (Table 2). Threadfin shad were the most abundant species captured and in the Kentucky Tailwater (1,690.3 fish/hr). Other prevalent rough fish species caught in the Kentucky Tailwaters during 2016 fall sampling included gizzard shad (184.0 fish/hr) and longear sunfish (48.0 fish/hr). Prominent sport fish captured in the Kentucky Tailwater during fall sampling were largemouth bass (86.3 fish/hr), bluegill (40.6 fish/hr), and smallmouth bass (20.6 fish/hr) (Table 2).

Electrofishing was also conducted in the Kentucky Tailwater in fall 2015. The capture rate of threadfin shad was much higher in 2016 (1690.3 fish/hr) than in the fall of 2015 (251.0 fish/hr; Table 2). However, the catch rate of skipjack herring was down in 2016 (0.6 fish/hr) as compared to 2015 (22.0 fish/hr).

Length frequency distribution for silver carp captured in Kentucky Tailwater during spring sampling ranged from 8-37 inches (N=29; Table 3). Silver carp lengths from Barkley Tailwater in spring ranged from 4-35 inches (N=67; Table 4). Fall sampling in Kentucky Tailwater captured silver carp with lengths ranging from 11-36 inches (N=77; Table 5). Silver carp lengths from Barkley Tailwater in the fall ranged from 15-31 inches (N=9; Table 6).

Silver carp were captured in both tailwaters during spring and fall sampling efforts, however no bighead carp were captured in either season. Although silver carp capture rates were higher in 2016 than in previous years, these capture rates are not reflective of the relative number of Asian carp in the tailwaters. Silver carp are known to be very sensitive to electrofishing and will often leap out of the water at feeling the slightest current and then dive deep upon re-entering the water. This behavior makes silver carp difficult to immobilize and net relative to their density with electrofishing. Another method of sampling such as gill netting or purse seining is better suited for quantifying Asian carp populations in the tailwaters but the bycatch could potentially be very high. Electrofishing resulted in the collection of 106 silver carp from Kentucky Tailwater and 76 silver carp from Barkley Tailwater in 2016 (Tables 3 and 4). Silver carp catch rates in 2015 were much lower. Silver carp CPUE during spring sampling was highest in Barkley Tailwater with 24.31 fish/hr (Table 1). However, silver carp CPUE during fall sampling was highest in the Kentucky Tailwater with 44 fish/hr (Table 2).

Relative weights (*Wr*) were calculated for selected species collected during fall sampling to monitor fish condition (Table 7). Trends in fish condition are important in the current study, as any observed declines in condition of individual species may be an indicator of competition for resources and reflective of high Asian carp densities in the tailwaters. Low relative weight is generally characteristic of fish in poor health, whereas high values indicate fish in excellent health. However, ideal target ranges of *Wr* values have not been identified for all species and in every habitat type. Therefore, the *Wr* values compiled through this study will be used to assess changes in the tailwater fish community over time. In the Kentucky Tailwater, the mean *Wr* of gizzard shad decreased from 76 in 2015 to 72.4 in 2016 (Table 7). Hybrid striped bass (*Wr* = 81) and redear sunfish (*Wr* = 85) in the Kentucky Tailwater also had less than ideal condition in 2016. In the Barkley Tailwater, gizzard shad (*Wr* = 70) and smallmouth bass (*Wr* = 86) exhibited low mean relative weights in 2016. All other mean *Wr* values compiled for species collected during electrofishing in both tailwaters were ≥ 87, which reflects fish in fair condition or above. Largemouth bass exhibited excellent condition in Kentucky Tailwater (*Wr* = 102) and Barkley Tailwater (*Wr* = 101) (Table 7).

Data from 2015 marked a baseline on which to measure future trends. With more years of data, it will be important to compare species composition and abundance from Kentucky and Barkley Tailwaters to identify any possible impacts of Asian carp on species diversity and fish condition in the tailwater fisheries.

Creel Survey

A random, non-uniform probability creel survey was conducted in Kentucky Tailwater and at Barkley Tailwater. The survey was conducted from February 15, 2016 through November 15, 2016. The Kentucky Tailwater survey extended from the Kentucky Lake Dam downstream to the Interstate 24 bridge. The Barkley Tailwater survey extended from the Lake Barkley Dam downstream to the US Hwy 62 bridge (Figure 1). The days and time periods to be surveyed each week were randomly selected. The overall

temporal sampling scheme was a minimum of 10 days per month in each tailwater, consisting of at least 3 weekend days in each. There were three time periods: morning, afternoon, and late evening. The late evening time period was only utilized for a portion of the survey to collect snagging and bow fishing data. Daily surveys had two parts, angler counts conducted from the bank with binoculars, and angler interviews. All anglers were counted at a randomly chosen time each day in order to calculate a daily average for total effort. An attempt was made to interview all anglers in the tailwater area. This survey was an access point survey and no boat was used. Data recorded during each tailwater creel survey was used to compare current estimated angler use and catch statistics to those collected in previous tailwater surveys. Anglers were also administered an angler attitude survey to gauge angler opinions regarding the impacts of increasing Asian carp densities on their fishing effort and success. The increasing number of Asian carp in the tailwaters over the past decade has sparked an increase in popularity of bow fishing. The 2016 creel survey was the first attempt to collect baseline data on the growing bow fishing fishery in each tailwater.

Kentucky Lake Dam Tailwater

During the 2016 survey it was estimated that anglers made 29,212 trips and spent 95,643 hours fishing to catch 171,171 fish (1.81 fish/hr) (Table 8) in the Kentucky Tailwater. In comparison, during the 2007 creel survey, anglers made 13,288 trips and exerted 38,701 hours of fishing pressure with a total catch of 58,636 fish (1.48 fish/hour). This represents increases of 120% for trips, 147% for total hours fished, and a 192% increase in total catch in the 2016 survey.

During the 2016 survey 68.3% of anglers fished from the bank while only 25.5% of anglers fished from a boat (Table 8). In comparison, the mode of fishing was more evenly split during the 2007 creel survey when 54.2% of anglers fished from the bank and 45.8% fished from boats. There was construction of new road and railroad bridges across the tailwater that caused the closure of some bank fishing area throughout the duration of the survey in 2007, so the higher proportion of bank anglers in the 2016 survey is likely the result of the construction projects restricting bank access in 2007. The fishing method most commonly used by anglers in the tailwater during the 2016 survey was casting (38.2%), followed by still fishing (36.6%). Several new Method categories were added since the previous survey; anglers snagging and bow fishing accounted for 11.1% and 9.2%, respectively (Table 8). Female anglers using the tailwater increased almost 5 percentage points to a total of 14.1% in the 2016 creel survey (Table 8).

Catfish were the most targeted species group during the 2016 creel survey with 19.4% of all fishing trips in the Kentucky Tailwater (Table 9). This value declined from the 2007 survey when catfish anglers accounted for 38.0% of all trips. However, fishing pressure increased from 14,693 hrs in 2007 to 18,518 hrs in 2016. The total number of catfish caught increased about 63% between the two survey periods. The number of catfish harvested also increased from 14,328 in 2007 to 22,279 in 2016; however, the total weight of catfish harvested remained relatively similar (Table 9). Therefore, anglers generally caught more, but smaller catfish than during the previous creel survey. Catch increased for all catfish species, but the majority of this increase was related to blue catfish, which also accounted for 74% of catfish harvested (Table 9). The length distribution for catfish captured is provided in Table 10. The highest number of catfish caught (5,316) was recorded in August (Table 11), whereas the month of highest catch in 2007 was in April (3,399). Overall, the harvest rate for catfish during the 2016 creel survey was 0.9 fish/hour, as compared to 0.7 fish/hour reported in 2007 (Table 11).

Anglers fishing for *Morone* spp. (white bass, yellow bass, striped bass, and hybrid striped bass) accounted for 7% of all anglers in Kentucky Tailwater (Table 9), a decrease from 2007 when 23% of anglers were fishing for *Morone* spp. However, the amount of angling pressure directed at *Morone* spp. was more similar (6,468 hours in 2016; 8,784 hours in 2007). Total catch of *Morone* spp. increased from

11,223 fish caught in 2007 to 34,499 fish caught in 2016 (Table 9). White bass catch alone increased 625% between the two surveys, while catch of striped bass decreased. The best months for catching *Morone* spp. stretched from March to June, when the number caught ranged from 2,937 to 11,295 fish per month (Table 12). The highest harvest rate was reported in the month of May (3,519 fish). Striped bass accounted for 10% of the *Morone* spp. caught and 6% of the harvest (Table 9). In comparison, during the 2007 survey, striped bass accounted for 51% of the *Morone* spp. caught and 55% of the harvest. The mean length, mean weight, and total weight of striped bass harvested also decreased in 2016.

Black bass (largemouth, smallmouth, and spotted) and crappie (white and black) comprised 6% and 2% of the angling pressure in the Kentucky Tailwater, respectively (Table 9). The number of fishing trips for black bass (1,765) and the number caught (7,048) in the tailwater increased from levels reported in the 2007 survey (429 trips, 1,538 fish caught). Largemouth bass comprised 75% of the black bass caught, while smallmouth bass accounted for 22%. The monthly creel statistics for black bass are reported in Table 13. During the 2016 survey, white crappie accounted for 64% of crappie caught with black crappie making up the remainder (Table 9). In 2007, white crappie and black crappie catch were about even. Angler effort towards crappie in the tailwater decreased slightly from 2,170 hours in 2007 to 1,851 hours in 2016. The monthly creel statistics for crappie are reported in Table 14.

Baitfish were captured in the Kentucky Tailwater through dipping and casting effort. The catch of skipjack herring (51,810) and shad (1,401) increased during the 2016 creel survey (Table 9). In the 2007 survey, anglers caught an estimated 12,580 skipjack herring and 57 shad. Anglers expended 10,492 hours of effort fishing for skipjack in 2016, and 1,971 hours of effort in 2007. In 2016, effort spent fishing for skipjack was second only to fishing pressure for catfish. This increased level of effort and harvest, along with anecdotal information of possible decreasing baitfish populations, may be a management concern. Therefore, baitfish numbers will continue to be monitored through the creel survey and with electrofishing as this study progresses.

Sauger anglers accounted for less than one percent of all trips to Kentucky Tailwater (19 trips) and 63 hours of fishing effort in 2016 (Table 9). In comparison, during the 2007 survey, sauger anglers accounted for 4.5% of all trips and 597 hours of effort. Sauger anglers were also more successful in 2007 (0.50 fish harvested/hr) than in 2016 (0.27 fish harvested/hr). The number of trips (391) and hours of fishing effort (1,281 hrs) expended towards panfish also decreased in 2016 (Table 9). However, the number of panfish caught more than doubled (11,378 fish in 2016; 4,965 fish in 2007). The majority of this increase was the result of bluegill catch, which rose 134% since 2007. The best months for panfish fishing were May and June with catches of 3,679 fish and 3,568 fish respectively (Table 15).

There are special regulations for the nontraditional fishing methods of bow fishing and snagging on the Kentucky Tailwater (Appendix 1). Snag anglers made up 11% of all trips to the tailwater, while bow fishing accounted for 9% of trips (Table 8). Most bow fishers' primary target is Asian carp but some also harvest paddlefish. Snagging and bow fishing anglers harvested 1,505 paddlefish during the 2016 creel survey in the Kentucky Tailwater (Table 9). The average paddlefish harvested in 2016 was 29.4 inches long and weighed 3.3 pounds (Table 9). The average paddlefish harvested in 2007 (N=1,788) was 34.0 inches long and weighed 8.8 pounds. Angler success fishing for paddlefish was much lower in the 2016 survey (18% success) than in 2007 (45% success). The lower success rate is likely due in part to the increased density of Asian carp species congregating in the tailwater. Since Asian carp outnumber paddlefish, anglers using snagging are more likely to snag an Asian carp than a paddlefish.

Asian carp, specifically silver carp and bighead carp, have increased in density in the Lower Tennessee River and Kentucky Lake since the 2007 creel survey. This fact is obvious to anglers in the tailwater as

Asian carp are often snagged on baits and lures meant for other fish species and can often be seen swimming in large schools just under the water's surface. Some anglers reported that they can feel their bait bouncing off the carps as it travels down through the water column. The 2007 creel survey estimated 116 bighead carp and 58 silver carp were caught by anglers in the Kentucky Tailwater. The number of each species caught increased dramatically in the 2016 creel survey, when catch was 2,718 bighead carp and 22,678 silver carp (Table 9). Overall, bighead carp caught in 2016 were larger (mean length = 44.8 in, mean weight = 42.0 lbs) than bighead carp caught in 2007 (mean length = 33.7 in, mean weight = 17.7 pounds). In contrast, silver carp caught during the 2016 survey were smaller (mean length = 27.9 in, mean weight = 10.33 lbs) than silver carp caught in 2007 (mean length = 29.8 in, mean weight = 13.8 lbs). The length frequency distribution for silver carp and bighead carp caught is reported in Table 10.

Anglers targeting any species increased greatly between the two survey periods from 5.4% of all anglers in 2007 to 47.1% of anglers in 2016. With the exception of black bass, angler effort towards sport fish species in the tailwater declined in 2016. This shift in angler focus from sport fish to any fish species is likely the direct result of increased Asian carp populations. The presence of Asian carp in the numbers observed in the tailwater often makes fishing for a specific species of fish difficult. In addition, many anglers targeting sport fish may keep Asian carp that they snag accidentally. Therefore, there is a shift from anglers expending the time to fish for a specific sport fish to anglers fishing for whatever they can catch.

An Angler Attitude Survey (AAS) was also conducted during the 2016 Kentucky Tailwater creel survey. Anglers interviewed for the AAS were chosen at random and asked a series of questions relating to the species they were targeting or fished for the most (Appendix 2). Five groups of anglers were asked specific questions about species they were targeting. These were anglers targeting: *Morone* spp., crappie, black bass, catfish, and paddlefish. When asked about their level of satisfaction with their respective fisheries, the majority of anglers responded that they were either very satisfied or somewhat satisfied, except for paddlefish anglers. The majority of paddlefish anglers responded that they were either somewhat dissatisfied (31%) or very dissatisfied (25%) with the fishery. When asked about the reason for their dissatisfaction, most paddlefish anglers (60%) cited Asian carp for their dissatisfaction (Appendix 2). Asian carp were also the number one response for dissatisfaction among all other angler groups. Asian carp can present difficulties to tailwater anglers due to their high abundance and their tendency to jump out of the water when disturbed. Also, Asian carp caught by bow fishers and snag anglers are often killed and subsequently thrown back into the water to later wash up on the banks. The sight and smell of these decomposing fish can discourage some bank fishing in the tailwater.

Lake Barkley Dam Tailwater

During the 2016 creel survey it was estimated that anglers made 23,346 trips and spent 75,048 hours fishing the Barkley Tailwater to catch 127,537 fish (0.9 fish/hr) (Table 16). In comparison, during the 2001 creel survey, anglers made 31,040 trips and exerted 92,263 hours of fishing pressure with a catch of 208,080 fish (1.7 fish/hour). Total hours fished decreased about 19% during the 2016 survey, while total catch decreased 39%. During the 2016 survey 66% of anglers fished from the bank while 34% of anglers fished from a boat (Table 16). This is similar to the modes of fishing during the 2001 survey when 60% of anglers fished from the bank and 40% of anglers used boats. The fishing method most commonly used in the tailwater during the 2016 survey was still fishing (35% of anglers), followed by casting (31% of anglers) (Table 16). These numbers have decreased since the 2001 survey when 62% of anglers used still fishing, and 38% of anglers used casting. Bow fishing was added as a new method category in the

2016 survey and was the chosen method for 24% of anglers. Female anglers using the tailwater increased 5% to a total of 14% in the 2016 creel survey (Table 16).

Catfish were the most targeted species group during the 2016 creel survey with 34.3% of all fishing trips in the Barkley Tailwater (Table 17). This value increased from the 2001 survey when catfish anglers accounted for 17% of all trips. However, fishing pressure decreased from 46,703 hrs in 2001 to 25,773 hrs in 2016. The total number of catfish caught declined about 48% between the two survey periods; however, the success rate for catfish increased slightly from 60.4% in 2001 to 62.2% in 2016. The number of catfish harvested decreased from 69,201 fish harvested in 2001 to 34,406 fish harvested in 2016. Pounds of catfish harvested between the two survey periods also decreased (99,883 pounds in 2001, 50,347 pounds in 2016). Catch decreased for all catfish species, but the majority of this decline was related to blue catfish. However, blue catfish still accounted for roughly 85% of catfish harvested (Table 17). The length frequency for catfish is tabulated in Table 18. The highest number of catfish caught in 2016 was recorded in June (10,581) whereas the month of highest catch in 2001 was reported in July (13,744) (Table 19). Overall, the harvest rate for catfish during the 2016 creel survey was 1.1 fish/hour, as compared to 1.3 fish/hour reported in 2001.

Anglers fishing for *Morone* spp. (white bass, yellow bass, striped bass, and hybrid striped bass), accounted for 9% of all anglers at Barkley Tailwater (Table 17), a decrease from 2001 when 20% of anglers were fishing for *Morone* spp. Fishing pressure also declined between 2001 (18,109 hours) and 2016 (6,707 hours). However, the success rate increased for *Morone* spp. anglers between survey periods (28% in 2001; 32% in 2016). Total catch of *Morone* spp. decreased from 23,678 fish caught in 2001 to 18,491 fish caught in 2016. White bass and yellow bass catch increased, 218% and 449% respectively, between the two survey periods. Striped bass accounted for 8% of the *Morone* spp. caught and 4.5% of the harvest in 2016. In comparison, during the 2001 survey, striped bass accounted for 60% of the *Morone* spp. caught and 50% of the harvest. The mean length and mean weight of striped bass increased in 2016 (mean length = 20.9 in, mean weight = 3.8 lbs) compared to striped bass caught in 2001 (mean length = 19.2 in, mean weight = 2.9 lbs) (Table 17). The best months for catching *Morone* spp. stretched from February to June, when the number caught ranged from 1,253 to 6,135 fish per month. The highest harvest rate was reported in the month of May (1,660 fish) (Table 20).

Black bass (largemouth, smallmouth, and spotted) and crappie (white and black) comprised 3% and 2% of the angling pressure in the Barkley Tailwater, respectively (Table 17). The number of fishing trips for black bass (770) and the number caught (4,503) in the tailwater increased from levels reported in the 2001 survey (640 trips, 2,985 fish caught). Largemouth bass comprised 81% of the black bass caught, while smallmouth bass accounted for 12%. The monthly creel statistics for black bass are reported in Table 21. During the 2016 survey, black crappie accounted for 88% of crappie caught with white crappie making up the remainder. During the 2001 survey, white crappie comprised 82% of crappie caught, while black crappie made up the remainder. Angler effort expended towards crappie in the tailwater decreased from 4,808 hours in 2001 to 1,790 hours in 2016. However, the success rate of crappie anglers remained similar between the two survey periods (25% in 2001, 26% in 2016) (Table 17). The monthly creel statistics for crappie are reported in Table 22.

Baitfish were captured from the Barkley Tailwater through dipping and casting effort. Skipjack herring and shad made up 11% and 5% respectively of the total number of fish harvested during the 2016 creel survey (Table 17). The estimated number of shad caught increased from 631 fish in 2001 to 6,223 shad caught in 2016. Skipjack herring catch declined between the two survey periods from 65,368 fish caught in 2001 to 7,350 fish caught in 2016. This decrease in the number of skipjack herring caught is due mostly to the reduced effort by anglers targeting this species. Skipjack herring were the targeted species for 7,425 angler hours in 2001, and 901 angler hours in 2016 (Table 17). Therefore, success rate of

anglers targeting skipjack herring increased 6% between the two surveys. The baitfish industry is very important to western Kentucky as anglers from other states often travel to the tailwaters catch or buy baitfish.

Sauger fishing in Barkley Tailwater between the 2001 and 2016 survey periods has followed a similar trend as Kentucky Tailwater with decreases in both effort and catch. The 2001 creel survey estimated that 2,752 hours of effort was spent fishing for sauger with 1,685 fish caught. In comparison, during the 2016 survey only 57 hours were spent fishing for sauger and 119 fish caught (Table 17). Panfish numbers also decreased between the 2001 (5,802 hours, 1,952 trips) and 2016 (1,181 hours, 368 trips). The success rate of anglers targeting panfish decreased slightly from 51.3% in 2001 (20,680 fish caught) to 48.1% in 2016 (14,690 fish caught). Longear sunfish catch accounted for the majority of the decrease as it declined 89% between 2001 and 2016 (Table 17). The most productive month for catching panfish in Barkley Tailwater was May with 5,146 fish harvested (Table 23).

Snagging and bow fishing anglers harvested 662 paddlefish during the 2016 creel survey in the Barkley Tailwater (Table 17). Snag anglers made up less than 1% of all trips to the tailwater, and bow fishing accounted for 24% of trips (Table 16). Bow fishing effort is greater in the Barkley Tailwater than in the Kentucky Tailwater as a result of snagging not being allowed in the Barkley Tailwater so bow fishers do not have to compete with snag anglers for bank access (Appendix 1). Also, Asian carp congregate more heavily on the surface of the Barkley Tailwater than in the Kentucky Tailwater. The average paddlefish harvested from the Barkley Tailwater in 2016 was 31.6 inches long and weighed 4.2 pounds (Tables 15 and 16). Paddlefish caught in 2001 (N = 813) were larger with an average length of 39.0 inches and weight of 9.0 pounds.

The 2001 creel survey conducted in the Barkley Tailwater did not record any Asian carp captured or harvested. Since then, the density of Asian carp, specifically silver carp and bighead carp, has increased dramatically in the Lower Cumberland River and Lake Barkley reservoir. In the 2016 creel survey it was estimated that 2,853 bighead carp and 21,599 silver carp were caught in Barkley Tailwater (Table 17). It should be noted that many anglers are not proficient in identifying between these two species and may be an area where we can better educate anglers through this survey. The number of Asian carp captured in the Barkley Tailwater in 2016 was similar to the number of silver and bighead carp caught by anglers in the Kentucky Tailwater. Bighead carp caught in Barkley Tailwater had a mean length of 38.8 inches and mean weight of 29.0 pounds. Silver carp captured by anglers had a mean length of 27.4 inches and a mean weight of 10.2 pounds (Table 17). In comparison to the mean lengths and weights of Asian carp species captured in the Kentucky Tailwater, bighead and silver carp caught in Barkley Tailwater were slightly smaller. The length frequency for silver carp and bighead carp captured is reported in Table 18.

An Angler Attitude Survey (AAS) was also conducted during the 2016 creel survey at the Barkley Tailwater. This AAS was conducted in the same manner as the AAS in the Kentucky Tailwater with a similar format (Appendix 3). The majority of anglers for all five angler groups responded that they were either neutral or satisfied with the Barkley Tailwater fisheries. For anglers who were dissatisfied with the fisheries, they indicated that the ‘number of fish’ was the number one reason for their dissatisfaction in all angler groups. Asian carp were also commonly listed as a reason for dissatisfaction with the fisheries, but was not the overwhelming majority as was the case with anglers at the Kentucky Tailwater.

Asian carp have the potential to negatively affect tailwater fisheries in various ways. Asian carp have been shown to change the trophic dynamics of a large river ecosystem by changing the way native fish feed, and the food that is available to them (Freedman et al. 2012). If Asian carp are affecting the food web dynamics of the ecosystem, changes in the fish community over time may be observed. In their highest densities, Asian carp may outcompete other fish species for space, which may be apparent

through decreasing species diversity in an area. Additionally, Asian carp may directly compete with native fish for food, causing declines in native fish condition through time (Irons et al. 2007; Schrank et al. 2003). This study strives to monitor these parameters through routine surveys of the fish community. Growing populations of Asian carp may also have a social impact on our sport fisheries. Some anglers may not fish in the tailwater because they fear silver carp will jump in their boat, creating a mess, or even causing an injury. At their highest densities, schools of Asian carp make fishing for other species difficult, as it may be impossible to drop bait to the bottom of the river without snagging a carp. These issues could lead to decreases in sport fishing effort and success. The higher densities of Asian carp can also positively affect anglers' usage of the tailwater as observed with the rising sport of bow fishing. The number of anglers utilizing the method of snagging has also increased as many anglers now use this method to target Asian carp specifically to either use as bait or for sustenance. KDFWR plans to continue this study to monitor the impacts Asian carp have on the tailwater fisheries over time.

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Table 1. Comparison of spring electrofishing catch rates for all species collected in Kentucky Tailwater in 2015 (Effort = 2.33 hrs), and Kentucky (4.65 hrs) and Barkley (2.75 hrs) tailwaters in 2016. (CPUE = catch per unit effort; S.E. = standard error).

Species	Kentucky Spring 2015		Kentucky Spring 2016		Barkley Spring 2016	
	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.
Chestnut lamprey			0.8	0.5		
Spotted gar	0.1	0.1	3.2	2.1	0.4	0.4
Longnose gar	0.1	0.1	5.6	2.0	12.7	7.6
Shortnose gar	2.4	1.1	6.6	3.1	15.6	6.3
Bowfin	0.3	0.2	0.8	0.5	0.3	0.3
Goldeye					0.4	0.4
Mooneye					0.4	0.4
American eel			0.6	0.3	0.7	0.5
Skipjack herring	0.7	0.4	0.2	0.2		
Gizzard shad	23.6	4.8	52.1	14.7	19.4	8.1
Threadfin shad			7.6	4.1	6.5	5.0
Grass carp	0.4	0.3	3.2	1.1	6.7	2.9
Common carp	0.2	0.2	0.6	0.3	0.3	0.3
Silver carp	0.7	0.3	6.1	2.3	24.3	9.8
Golden shiner					0.3	0.3
Emerald shiner	0.2	0.2	22.0	9.8	10.5	5.5
Striped shiner			0.2	0.2	0.3	0.3
River carpsucker	0.8	0.5	2.7	1.5	2.1	1.1
Quillback	0.1	0.1				
Highfin carpsucker			0.2	0.2		
Northern hogsucker			0.4	0.3		
Blue sucker					5.0	3.3
Smallmouth buffalo	3.0	1.0	27.4	6.1	23.1	3.6
Bigmouth buffalo	2.1	1.0	0.6	0.3	1.1	0.6
Black buffalo			1.7	1.1	1.4	0.8
Spotted sucker					0.3	0.3
Golden redhorse					0.4	0.4
Shorthead redhorse			5.9	1.9	0.7	0.7
Yellow bullhead			0.2	0.2		
Blue catfish			0.4	0.3		
Channel catfish	0.2	0.2	1.1	0.7	1.1	0.8
Flathead catfish			18.7	5.5	16.4	5.5
Inland silverside			0.6	0.5	1.1	0.8
White bass	1.0	0.6	7.6	2.1	7.7	3.6
Yellow bass	0.9	0.5	31.0	12.3	1.8	1.0
Striped bass					1.1	1.1
White bass/Striped bass hybrid			1.9	0.8		
Sunfish family			0.2	0.2		
Flier			0.2	0.2		
Green sunfish			3.6	1.5	1.5	0.8
Warmouth			0.2	0.2		
Orangespotted sunfish			0.2	0.2	0.3	0.3
Bluegill	1.7	0.7	91.5	16.3	69.4	16.1
Longear sunfish	3.1	1.8	74.2	15.2	110.1	23.6
Redear sunfish	0.6	0.3	3.0	1.1	9.6	2.6
Sunfish hybrids			0.2	0.2		
Smallmouth bass	0.9	0.8	10.0	2.5	10.1	2.7
Spotted bass	0.3	0.3	0.8	0.5	1.1	0.6
Largemouth bass	4.9	1.6	46.3	5.2	63.6	6.2
White crappie			1.5	0.9	0.4	0.4
Black crappie	0.1	0.1	0.6	0.3	0.7	0.7
Logperch			2.3	1.9	2.6	1.9
Sauger			1.1	0.6	0.4	0.4
Freshwater drum	0.1	0.1	14.1	3.4	15.0	3.4

Table 2. Comparison of fall electrofishing catch rates for all species collected in Kentucky Tailwater in 2015 (Effort = 1.0 hrs), and Kentucky (1.75 hrs) and Barkley (1.99 hrs) tailwaters in 2016. (CPUE = catch per unit effort; S.E. = standard error)

Species	Kentucky TW Fall 2015		Kentucky TW Fall 2016		Barkley TW Fall 2016	
	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.
Spotted gar					1.8	1.0
Longnose gar	1.0	1.0	1.1	1.1	0.4	0.4
Shortnose gar			0.6	0.6		
Bowfin			0.6	0.6		
American eel			1.1	0.7	1.3	0.9
Skipjack herring	22.0	8.4	0.6	0.6	0.5	0.5
Gizzard shad	275.0	58.6	184.0	78.0	208.7	52.4
Threadfin shad	251.0	176.3	1690.3	1251.0	4598.5	1818.7
Grass carp	13.0	1.9	5.7	2.5	5.0	2.6
Common carp	2.0	2.0			2.3	1.6
Silver carp	6.0	2.6	44.0	22.4	4.0	2.0
Golden shiner			0.6	0.6	1.9	1.9
Emerald shiner	12.0	9.4	14.3	13.6	8.4	5.4
Bluntnose minnow			0.6	0.6	0.4	0.4
River carpsucker					4.5	3.5
Blue sucker					0.9	0.9
Smallmouth buffalo	10.0	2.6	9.1	3.7	14.9	7.6
Bigmouth buffalo					0.9	0.9
Black buffalo	6.0	2.0	2.9	1.9		
Spotted sucker			0.6	0.6		
Shorthead redhorse	2.0	2.0	0.6	0.6		
Channel catfish			0.6	0.6	0.4	0.4
Flathead catfish			4.0	1.2	7.6	3.6
Inland silverside			10.9	10.9	4.3	3.8
Silverside family	1.0	1.0				
White bass	8.0	4.3	7.4	4.0	6.7	3.9
Yellow bass	162.0	83.5	16.6	13.3	1.8	0.7
Striped bass					0.9	0.9
White bass/Striped bass hybrid	1.0	1.0	1.1	1.1	0.4	0.4
White bass/Yellow bass hybrid			1.7	1.2	1.3	1.3
Sunfish family			1.1	1.1		
Green sunfish			2.9	1.1	4.5	2.2
Warmouth	1.0	1.0				
Bluegill	96.0	29.2	40.6	11.8	46.5	15.3
Longear sunfish	14.0	14.0	48.0	12.0	101.6	25.0
Redear sunfish	1.0	1.0	6.3	2.3	8.0	2.1
Sunfish hybrids					0.4	0.4
Smallmouth bass	9.0	2.5	20.6	5.2	7.2	2.3
Spotted bass	1.0	1.0	0.6	0.6	1.8	1.0
Largemouth bass	62.0	19.8	86.3	9.4	48.3	8.0
White crappie	2.0	2.0	1.1	0.7	3.5	1.5
Black crappie	2.0	2.0	0.6	0.6		
Logperch			1.1	1.1		
Sauger	1.0	1.0				
Freshwater drum	13.0	5.7	6.3	1.5		

Table 3. Species composition, length frequency and CPUE (fish/hr) of fish collected during 4.65 hours of electrofishing at the Kentucky Tailwater in spring of 2016. (CPUE = catch per unit effort; S.E. = standard error)

Species	Inch Class																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Chestnut lamprey						1			1			1	1							
Paddlefish																				
Spotted gar												1	1	3	1	4		1		
Longnose gar													2	2	4	6	3	4		
Shortnose gar													1	2	8	5	2			1
Bowfin																1				
American eel																		1		
Skipjack herring											1									
Gizzard shad			1	4	25	18	15	33	69	36	26	13	6	1						
Threadfin shad			1	18	14		2	1												
Grass carp						2	4	1	3	1										
Common carp							1					1								
Silver carp								3		2	1	1								
Emerald shiner	1	12	87	3																
Striped shiner							1													
River carpsucker						4	1	2	1					3	1	1				
Highfin carpsucker						1														
Northern hog sucker						1		1												
Smallmouth buffalo				1		1				1	5	11	22	18	21	19	9	5	2	5
Bigmouth buffalo																		1		1
Black buffalo								1							1				1	1
Shorthead redhorse					2	6	8	6	4	1		1								
Yellow bullhead								1												
Blue catfish																1				1
Channel catfish																	1		1	1
Flathead catfish			1	2	3		3	13	12	10	6	9	6	8	2	2	3		2	1
Inland silverside			2	1																
White bass			1	2	4	6	6	3	3		1	1	1	3	2	2	1			
Yellow bass		1	13	58	33	24	12	5	1											
White bass/Striped bass hybrid						2	2	1	1	1							1			
Sunfish family					1															
Flier			1																	
Green sunfish		2	4	4	5	2														
Warmouth						1														
Orangespotted sunfish		1																		
Bluegill	1	29	101	96	125	54	26	1	1											
Longear sunfish		36	106	90	95	24														
Redear sunfish			1	3	6	4														
Sunfish hybrids				1																
Smallmouth bass		1		4	5	8	2	5	1		2	7	1	2	1	1	4	1		2
Spotted bass					2							1							1	
Largemouth bass		2		1	2	6	28	41	24	15	7	5	4	7	24	22	11	10	6	1
White crappie				1		4	2													
Black crappie						2			1											
Logperch				9	2															
Sauger								2			1				1	1				
Freshwater drum					6	6	8	2	2	2		4	3	2	4	5	7	4	4	4

Table 3 continued. Species composition, length frequency and CPUE (fish/hr) of fish collected during 4.65 hours of electrofishing at the Kentucky Tailwater in spring of 2016. (CPUE = catch per unit effort; S.E. = standard error)

Species	Inch Class																	TOTAL	CPUE	S.E.
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	37	40			
Chestnut lamprey																		4	0.84	0.49
Paddlefish															1			1	0.21	0.21
Spotted gar		2		1		1												15	3.16	2.11
Longnose gar	2											1						24	5.61	2.02
Shortnose gar	2		1		2	2												26	6.6	3.12
Bowfin		1	1		1													4	0.84	0.49
American eel								1		1								3	0.63	0.34
Skipjack herring																		1	0.21	0.21
Gizzard shad																		247	52.14	14.69
Threadfin shad																		36	7.58	4.11
Grass carp			1	1			1			1								15	3.16	1.08
Common carp					1													3	0.63	0.34
Silver carp	2	1	4	2	1			1	1	2	5		1	1		1		29	6.11	2.3
Emerald shiner																		103	21.96	9.79
Striped shiner																		1	0.21	0.21
River carpsucker																		13	2.74	1.5
Highfin carpsucker																		1	0.21	0.21
Northern hog sucker																		2	0.42	0.29
Smallmouth buffalo		3	5		1												1	130	27.37	6.13
Bigmouth buffalo							1											3	0.63	0.34
Black buffalo		1			2	1												8	1.68	1.12
Shorthead redhorse																		28	5.89	1.87
Yellow bullhead																		1	0.21	0.21
Blue catfish																		2	0.42	0.29
Channel catfish		1		1														5	1.05	0.67
Flathead catfish					1				1									85	18.74	5.51
Inland silverside																		3	0.63	0.46
White bass																		36	7.58	2.05
Yellow bass																		147	30.95	12.33
White bass/Striped bass hybrid	1																	9	1.89	0.83
Sunfish family																		1	0.21	0.21
Flier																		1	0.21	0.21
Green sunfish																		17	3.58	1.46
Warmouth																		1	0.21	0.21
Orangespotted sunfish																		1	0.21	0.21
Bluegill																		434	91.51	16.32
Longear sunfish																		351	74.18	15.22
Redear sunfish																		14	2.95	1.1
Sunfish hybrids																		1	0.21	0.21
Smallmouth bass																		47	10.04	2.53
Spotted bass																		4	0.84	0.49
Largemouth bass		1																217	46.25	5.24
White crappie																		7	1.47	0.93
Black crappie																		3	0.63	0.34
Logperch																		11	2.32	1.89
Sauger																		5	1.05	0.6
Freshwater drum	1	1		1			1											67	14.11	3.42

Table 4. Species composition, length frequency and CPUE (fish/hr) of fish collected during 2.75 hours of electrofishing at the Barkley Tailwater in spring of 2016. (CPUE = catch per unit effort; S.E. = standard error)

Species	Inch Class																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Spotted gar																				
Longnose gar													2	1	4	4	4	6	4	4
Shortnose gar											1		3	8	7	7	8	4		2
Bowfin																				
Goldeye							1													
Mooneye										1										
American eel																				
Gizzard shad				3	5	2		6	14	11	7	5	1	1						
Threadfin shad			1	14	3															
Grass carp						2	2	1	3	4	2	4								
Common carp											1									
Silver carp				1	2															
Golden shiner				1																
Emerald shiner	7	1	14	6		1														
Striped shiner						1														
River carpsucker						1		1							1	1				1
Blue sucker														1						1
Smallmouth buffalo												2	1	2	10	20	19	5	1	1
Bigmouth buffalo																				1
Black buffalo																				2
Spotted sucker							1													
Golden redhorse																1				
Shorthead redhorse							1	1												
Channel catfish														1			2			
Flathead catfish					2	3			1	5	5	6	6	7	1		5			1
Inland silverside		2	1																	
White bass						1	3	6	5	1				2	2	2				
Yellow bass			1	3		1														
Striped bass																		1		
Green sunfish			2	1	1															
Orangespotted sunfish							1													
Bluegill	10	2	58	30	51	33	9													
Longear sunfish	127	8	53	58	52	8														
Redear sunfish				8	7	4	2	1	2	1		1	1							
Smallmouth bass				2	4	7	5	3					1	1		2	2		1	
Spotted bass				1	1		1													
Largemouth bass		1	1		6	10	20	29	19	9	3	9	11	14	19	10	6	2	5	1
White crappie														1						
Black crappie								1					1							
Logperch			2	4	1															
Sauger							1													
Freshwater drum						1			1			2	2	1	1	4	8	7	8	6

Table 4 continued. Species composition, length frequency and CPUE (fish/hr) of fish collected during 2.75 hours of electrofishing at the Barkley Tailwater in spring of 2016. (CPUE = catch per unit effort; S.E. = standard error)

Species	Inch Class																TOTAL	CPUE	STE
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	37			
Spotted gar						1											1	0.36	0.4
Longnose gar							1	1	1					1	1	1	35	12.67	7.6
Shortnose gar	1	1		1													43	15.64	6.3
Bowfin	1																1	0.34	0.3
Goldeye																	1	0.36	0.4
Mooneye																	1	0.36	0.4
American eel							1					1					2	0.73	0.5
Gizzard shad																	55	19.41	8.1
Threadfin shad																	18	6.49	5
Grass carp						1											19	6.69	2.9
Common carp																	1	0.34	0.3
Silver carp	1	1	3	6	2	2	3	13	8	7	5	5	5	1	2		67	24.31	9.8
Golden shiner																	1	0.34	0.3
Emerald shiner																	29	10.46	5.5
Striped shiner																	1	0.34	0.3
River carpsucker	1																6	2.13	1.1
Blue sucker				1	4	5		2									14	5.01	3.3
Smallmouth buffalo			1	1						1							64	23.06	3.6
Bigmouth buffalo		1	1														3	1.06	0.6
Black buffalo	1							1									4	1.43	0.8
Spotted sucker																	1	0.34	0.3
Golden redhorse																	1	0.36	0.4
Shorthead redhorse																	2	0.73	0.7
Channel catfish																	3	1.09	0.8
Flathead catfish		1				1	1										45	16.36	5.5
Inland silverside																	3	1.09	0.8
White bass																	22	7.73	3.6
Yellow bass																	5	1.79	1
Striped bass			1					1									3	1.09	1.1
Green sunfish																	4	1.45	0.8
Orangespotted sunfish																	1	0.34	0.3
Bluegill																	193	69.35	16
Longear sunfish																	306	110.1	24
Redear sunfish																	27	9.6	2.6
Smallmouth bass																	28	10.1	2.7
Spotted bass																	3	1.09	0.6
Largemouth bass	1																176	63.57	6.2
White crappie																	1	0.36	0.4
Black crappie																	2	0.73	0.7
Logperch																	7	2.55	1.9
Sauger																	1	0.36	0.4
Freshwater drum	1																42	15	3.4

Table 5. Species composition, length frequency and CPUE (fish/hr) of fish collected during 1.75 hours of electrofishing at the Kentucky Tailwater in fall of 2016. (CPUE = catch per unit effort; S.E. = standard error)

Species	Inch Class																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Longnose gar																1				
Shortnose gar																		1		
Bow fin																				
American eel																		1		
Skipjack herring							1													
Gizzard shad*					1	2	4	29	33	19	10	2	2							
Threadfin shad*	4	43	14	15	1															
Grass carp											1		3	1			1	1	1	
Silver carp											1				1	3	1	2		3
Golden shiner		1																		
Emerald shiner	2	15	8																	
Bluntnose minnow		1																		
Smallmouth buffalo												1	2	3	2	2		2	2	
Black buffalo														1		1	1			1
Spotted sucker									1											
Shorthead redhorse									1											
Channel catfish																				1
Flathead catfish						1		1	1	2		1	1							
Inland silverside		4	12	3																
White bass										1	1	3	3	2	1	2				
Yellow bass					1	13	14		1											
White bass/Striped bass hybrid								2												
White bass/Yellow bass hybrid						1	1	1												
Sunfish family			2																	
Green sunfish					4	1														
Bluegill		16	11	11	22	7	4													
Longear sunfish	1	35	13	22	13															
Redear sunfish			2	6	1	1				1										
Smallmouth bass				1	11	11	8	1	1		1	1			1					
Spotted bass											1									
Largemouth bass					6	21	34	40	15	4	3	5	3	4	3	5			3	2
White crappie										1				1						
Black crappie			1																	
Logperch					2															
Freshwater drum													1			1	1	3	2	1

* species were randomly subsampled

Table 5 continued. Species composition, length frequency and CPUE (fish/hr) of fish collected during 1.75 hours of electrofishing at the Kentucky Tailwater in fall of 2016. (CPUE = catch per unit effort; S.E. = standard error)

Species	Inch Class														TOTAL	CPUE	S.E.
	21	22	23	24	25	26	27	28	29	30	31	32	33	36			
Longnose gar			1												2	1.14	1.14
Shortnose gar															1	0.57	0.57
Bowfin				1											1	0.57	0.57
American eel															2	1.14	0.74
Skipjack herring															1	0.57	0.57
Gizzard shad*															322	184	78
Threadfin shad*															2958	1690	1251
Grass carp									1					1	10	5.71	2.45
Silver carp	5	9	7	6	10	4	3	5	3	5	4	1	2	1	77	44	22.4
Golden shiner															1	0.57	0.57
Emerald shiner															25	14.29	13.6
Bluntnose minnow															1	0.57	0.57
Smallmouth buffalo				1	1										16	9.14	3.67
Black buffalo			1												5	2.86	1.9
Spotted sucker															1	0.57	0.57
Shorthead redhorse															1	0.57	0.57
Channel catfish															1	0.57	0.57
Flathead catfish															7	4	1.23
Inland silverside															19	10.86	10.9
White bass															13	7.43	4.04
Yellow bass															29	16.57	13.3
White bass/Striped bass hybrid															2	1.14	1.14
White bass/Yellow bass hybrid															3	1.71	1.19
Sunfish family															2	1.14	1.14
Green sunfish															5	2.86	1.14
Bluegill															71	40.57	11.8
Longear sunfish															84	48	12
Redear sunfish															11	6.29	2.29
Smallmouth bass															36	20.57	5.2
Spotted bass															1	0.57	0.57
Largemouth bass	1	1													151	86.29	9.44
White crappie															2	1.14	0.74
Black crappie															1	0.57	0.57
Logperch															2	1.14	1.14
Freshwater drum				1	1										11	6.29	1.48

* species were randomly subsampled

Table 6. Species composition, length frequency and CPUE (fish/hr) of fish collected during 1.99 hours of electrofishing at the Barkley Tailw ater in fall of 2016. (CPUE = catch per unit effort; S.E. = standard error)

Species	Inch Class																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Spotted gar														1						1
Longnose gar																				
American eel																		1		
Skipjack herring						1														
Gizzard shad*				3	2	7	18	112	132	41	27	6		2	1					
Threadfin shad*	27	75	65	4	1															
Grass carp											1	1	3	1	1	1				
Common carp																		1	1	1
Silver carp															2		1			
Golden shiner				3	1															
Emerald shiner		4	13	2																
Bluntnose minnow	1																			
River carpsucker														5	2	2	1			
Blue sucker																				
Smallmouth buffalo							1								4	6	11	7	1	2
Bigmouth buffalo													2							
Channel catfish																				1
Flathead catfish						1	1	2	2	4	1	3	1	1	1					
Inland silverside		3	6	1																
White bass			1				4		1		1	4		3		1				
Yellow bass					1	1	1	1												
Striped bass						2														
White bass/Striped bass hybrid						1														
White bass/Yellow bass hybrid							3													
Green sunfish			3	4	1	2														
Bluegill	1	9	22	19	40	9	3													
Longear sunfish		18	53	95	57	2														
Redear sunfish				1	9	3	2			1	2									
Sunfish hybrids					1															
Smallmouth bass					3	9	1		1	1		1								
Spotted bass						1	1			1			1							
Largemouth bass				4	8	23	20	7	1	10	11	2	2	1	3	4	6	1	3	2
Freshw ater drum													1				2	1	1	1

* species w ere randomly subsampled

Table 6 continued. Species composition, length frequency and CPUE (fish/hr) of fish collected during 1.99 hours of electrofishing at the Barkley Tailwater in fall of 2016. (CPUE = catch per unit effort; S.E. = standard error)

Species	Inch Class														
	21	22	23	24	25	26	27	28	29	30	31	34	TOTAL	CPUE	STE
Spotted gar	1	1											4	1.78	0.97
Longnose gar			1										1	0.44	0.44
American eel						1	1						3	1.33	0.94
Skipjack herring													1	0.46	0.46
Gizzard shad*													470	208.73	52.36
Threadfin shad*													10346	4598.5	1818.6
Grass carp						1			1			1	11	4.98	2.63
Common carp	1		1										5	2.28	1.55
Silver carp			1					1	2	1	1		9	4	2
Golden shiner													4	1.85	1.85
Emerald shiner													19	8.44	5.43
Bluntnose minnow													1	0.44	0.44
River carpsucker													10	4.45	3.49
Blue sucker		1			1								2	0.85	0.85
Smallmouth buffalo		1		1									34	14.92	7.6
Bigmouth buffalo													2	0.89	0.89
Channel catfish													1	0.44	0.44
Flathead catfish													17	7.63	3.64
Inland silverside													10	4.31	3.82
White bass													15	6.72	3.9
Yellow bass													4	1.78	0.7
Striped bass													2	0.89	0.89
White bass/Striped bass hybrid													1	0.44	0.44
White bass/Yellow bass hybrid													3	1.33	1.33
Green sunfish													10	4.46	2.15
Bluegill													103	46.48	15.34
Longear sunfish													225	101.64	25.02
Redear sunfish													18	8.02	2.1
Sunfish hybrids													1	0.44	0.44
Smallmouth bass													16	7.19	2.29
Spotted bass													4	1.78	0.97
Largemouth bass													108	48.27	8
Freshwater drum	2												8	3.52	1.54

* species were randomly subsampled

Table 7. Relative weight (*Wr*) and standard error for a subsample of fish collected during fall electrofishing at Kentucky Tailwaters in 2015, and Kentucky and Barkley tailwaters in 2016. (S.E. = standard error)

Species	Kentucky Lake TW 2015			Kentucky Lake TW 2016			Lake Barkley TW 2016		
	N	Mean *Wr*	S.E.	N	Mean *Wr*	S.E.	N	Mean *Wr*	S.E.
Gizzard shad	19	76	2.5	45	72	1.6	96	70	1.6
Channel catfish				1	102		1	67	
White bass	7	92	4.1	13	99	2.6	11	96	3.7
White bass/Striped bass hybrid				2	81	7.5			
Bluegill	69	88	1.7	49	103	3.7	49	111	3.1
Redear sunfish	1	98	0.0	10	85	6.9	17	93	2.1
Smallmouth bass	6	93	3.1	13	91	2.0	4	86	3.6
Spotted bass	1	103	0.0	1	123		3	107	11.0
Largemouth bass	42	102	3.2	89	102	1.7	37	101	1.9
White crappie	2	79	0.9	2	90	8.7			
Black crappie	1	91	0.0						
Sauger	1	87	0.0						
Freshwater drum	12	91	5.4	11	100	2.7	6	84	4.4

Table 8. Fishery statistics derived from a creel survey at Kentucky Tailwater (226 acres), February - November 2016.

Fishing Trips		
No. of fishing trips	29,212	
Trips/acre	129.3	
Fishing Pressure		
Total angler-hours (S.E.)	95,643	(2934.1)
Angler-hours/acre	423.2	
Catch / Harvest		
No. of fish caught (S.E.)	171,171	(18,834.1)
No. of fish harvested (S.E.)	96,609	(13,444.7)
Lb of fish harvested	106,452	
Harvest Rates		
Fish/hour	1.1	
Fish/acre	427.5	
Pounds/acre	471.0	
Catch Rates		
Fish/hour	1.8	
Fish/acre	757.4	
Miscellaneous Characteristics (%)		
Male	85.9	
Female	14.1	
Resident	76.0	
Non-resident	24.0	
Method (%)		
Still fishing	36.6	
Casting	38.2	
Trolling	<1	
Drifting	4.0	
Snagging	11.1	
Bowfishing	9.2	
Dipping	<1	
Mode (%)		
Boat	25.5	
Bank	68.3	
Pier	6.2	

Table 9. Fish harvest statistics derived from a creel survey at Kentucky Tailwater (226 acres), February - November 2016.

	Black bass group	Largemouth bass	Smallmouth bass	Spotted bass	Illegal black bass	Crappie group	White crappie	Black crappie	Catfish group	Channel catfish	Flathead catfish	Blue catfish	Panfish group	Bluegill	Green Sunfish	Longear sunfish	Sauger	Yellow perch
No. caught	7,048	5,259	1,540	25	476	1,413	963	450	28,118	5,893	524	21,701	11,378	11,327	24	27	307	112
(per acre)	(31.19)	(23.27)	(6.81)	(0.11)	(2.11)	(6.25)	(4.26)	(1.99)	(124.42)	(26.08)	(2.32)	(96.02)	(50.35)	(50.12)	(0.11)	(0.12)	(1.36)	(0.50)
No. harvested	885	641	194			1,077	685	392	22,279	4,117	464	17,699	4,169	4,142		27	145	12
(per acre)	(3.92)	(2.84)	(0.86)			(4.77)	(3.03)	(1.73)	(98.58)	(18.22)	(2.05)	(78.31)	(18.45)	(18.33)		(0.12)	(0.64)	(0.05)
% of total no. harvested	0.92	0.66	0.20			1.11	0.71	0.41	23.06	4.26	0.48	18.32	4.32	4.29		0.03	0.15	0.01
Lb. harvested	1,516	1,229	287			669	356	313	34,978	6,596	2,515	25,868	938	936		1	204	6
(per acre)	(6.71)	(5.44)	(1.27)			(2.96)	(1.58)	(1.38)	(154.77)	(29.19)	(11.13)	(114.46)	(4.15)	(4.14)		(0.01)	(0.90)	(0.02)
% of total lb. harvested	1.42	1.15	0.27			0.63	0.33	0.29	32.86	6.20	2.36	24.30	0.88	0.88		0.00	0.19	0.01
Mean length (in)		15.5	14.6				11.0	10.9		15.3	23.4	15.9		6.6		4.0	16.3	10
Mean weight (lb)		1.97	1.53				0.68	0.73		1.26	6.59	1.40		0.19		0.04	1.41	0.45
No. of fishing trips for that species	1765					565			5,656				391				19	
% of all trips	6.0					1.9			19.4				1.3				0.1	
Hours fished for that species	5,778					1,851			18,518				1,281				63	
(per acre)	(25.57)					(8.19)			(81.94)				(5.67)				(0.28)	
No. harvested fishing for that species	331					796			19,859				1,348				38	
Lb harvested fishing for that species	583.7					443.9			30,175.8				472.2				35.2	
No./hour harvested fishing for that species	0.05					0.44			0.86				2.09				0.27	
% success fishing for that species	10.7					31.0			53.9				54.5					

Table 9 (continued). Fish harvest statistics derived from a creel survey at Kentucky Tailwater (226 acres), February - November 2016.

	Morone Group	White bass	Striped bass	Hybrid striped bass	Yellow bass	Freshwater drum	Common Carp	Bighead carp	Silver carp	Grass carp	Suckers	Buffalo	Skipjack herring	Shad	Gar	Mooneye	Paddlefish	Bowfin	Anything
No. caught	34,499	20,605	3,303	2,667	7,924	3,954	340	2,718	22,678	223	51	1,249	51,810	1,401	2,327	53	1,629	60	
(per acre)	(152.65)	(91.17)	(14.62)	(11.80)	(35.06)	(17.50)	(1.50)	(12.03)	(100.35)	(0.99)	(0.23)	(5.53)	(229.25)	(6.20)	(10.30)	(0.23)	(7.21)	(0.27)	
No. harvested	10,601	6,685	661	1,390	1,865	538		101	1,958	50	27	314	50,904	1,241	815		1,505	12	
(per acre)	(46.91)	(29.58)	(2.92)	(6.15)	(8.25)	(2.38)		(0.45)	(8.66)	(0.22)	(0.12)	(1.39)	(225.24)	(5.49)	(3.61)		(6.66)	(0.05)	
% of total no. harvested	10.97	6.92	0.68	1.44	1.93	0.56		0.10	2.03	0.05	0.03	0.33	52.69	1.28	0.84		1.56	0.01	
Lb. harvested	11447	5623	2485	2832	506	805		3564	22243		144	1251	21897	308	1822		4659	2	
(per acre)	(50.65)	(24.88)	(11.00)	(12.53)	(2.24)	(3.56)		(15.77)	(98.42)		(0.64)	(5.54)	(96.89)	(1.36)	(8.06)		(20.62)	(0.01)	
% of total lb. harvested	10.75	5.28	2.33	2.66	0.48	0.76		3.35	20.89		0.14	1.18	20.57	0.29	1.71		4.38	0.00	
Mean length (in)		12.3	20.4	15.3	7.9	14.7		44.8	27.9	16.3	24.0	17.6	12.1	9.6	31.8		29.4	7.0	
Mean weight (lb)		0.81	3.77	1.89	0.21	1.49		42.01	10.33		5.41	3.44	0.46	0.32	3.85		3.30	0.13	
No. of fishing trips for that species	1975							97	480			195	3,205				1,094		13,769
% of all trips	6.8							0.3	1.6			0.7	11.0				3.7		47.1
Hours fished for that species	6,468							319	1,571			639	10,492				3,581		45,082
(per acre)	(28.62)							(1.4)	(7.0)			(2.83)	(46.42)				(15.85)		(199.48)
No. harvested fishing for that species	5,953								525			87	46,055				471		
Lb harvested fishing for that species	8,356.9								8,413.5			169.7	19,624.0				1,219.1		
No./hour harvested fishing for that species	0.86								0.46			0.14	4.35				0.10		
% success fishing for that species	45.5								25.0			40.0	76.4				17.7		22.2

Table 10. Length distribution (lengths of released fish are estimated) for each species of fish harvested or released at Kentucky Tailwater during the February 2016 to November 2016 creel survey.

Species		Inch class																									
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Blue catfish	H					18		129	148	481	647	2,478	1,535	2,478	1,775	1,184	1,276	1,609	1,091	888	481	259	148	573		74	92
	R			38	192	173	327	423	250	500	192	654	269	231	135	19	212	77		19	58		19	38		38	
Channel catfish	H					22	22	45	112	135	22	202	405	360	135	292	405	562	202	405	180	337	112	90	45		
	R			23	46	92	138	392	23	138		300	69	115	23		46	23		23			46	46	46	46	46
Flathead catfish	H							22					22			44	44			22	44	88	22		22		
	R					20						20													20		
White bass	H			21		84	63	292	251	752	794	982	961	1,003	752	501	146	21	21					41			
	R		60	895	1,969	3,122	1,750	1,969	795	1,352	358	1,233	159	179	60		18										
Yellow bass	H			70	35	158	141	528	581	176		53	18					104									
	R	46	107	367	842	1,239	1,163	1,316	474	337	77	77			13												
Hybrid striped bass	H							20		143		61	225	245	41	163	163	143	41		61	20	63				
	R		46	137	137	205	160	137	91	91	46	91		91	45												
Striped bass	H														97	39	136	97	19	19	19	19	39		58	58	
Legal	R														133	133	95	19	19								
Sub-legal	R			38	133	323	304	228	114	209	228	228	133	266													
Sauger	H													54	36		18	18	18								
Legal	R													20		20											
Sub-legal	R						20	20			41	41															
Yellow perch	H									12																	
	R			25	25	25		24																			
Smallmouth bass	H									25			58	78		39					19						
Legal	R											207	83	145	41	145	83	124	21	20							
Sub-legal	R			21	41	207		41	21	124	21																
Spotted bass	H																										
	R														25												
Largemouth bass	H											69	104	104	87	104	104	17		35				16			
Legal	R											427	371	390	315	352	93	111	56	130	19			19			
Sub-legal	R		19	37	74	223	204	427	297	816	241																
White crappie	H					43		86		257	107	107	43	41													
	R					139	70	46							23												
Black crappie	H							33	65	114	49	65	16	49													
	R				19				19		19																
Bluegill	H		89	267	468	891	980	869	245	245	88																
	R	21	541	2,083	1,749	1,187	583	437	333	146	105																
Longear sunfish	H			26																							
	R																										
Green sunfish	H																										
	R		12		11																						
Paddlefish	H																	25				25		247	25	123	25
	R									25																	
Gar	H											186		23				116		93						70	
	R						24	24			24	142		24	47	47		260	24	47		24	24	260	47	24	24
Suckers	H																							26			
	R															24											
Buffalo	H									21		126			21	21	21	21						21			
	R											153		57	19	133	133	210		76				38	19	38	19
Common carp	R									49	24	73						24		24		24					
Bighead carp	H																										
	R																	104	78	207	78	104	52	130	104	130	52
Silver carp	H															18		18		37		37	18	91	37	128	238
	R							24		24		119	24	71	476	238	286	1,381	595	2,096	714	1,572	714	2,310	1,072	1,096	619
Grass carp	H											13	25							12							
	R									19				19	19			39				19			19		
Freshwater drum	H									21		62	83	62	103	41	83	21				41				21	
	R				21	206	62	144	247	41	247	391	62	123	432	226	144	226	103	329	41		21	103	62	103	
Skipjack herring	H				38	724	533	3,771	5,256	6,094	4,609	6,265	4,513	4,456	5,142	4,609	3,428	1,447		19							
	R				59	104	45	119	30	59	45	45	15	119	74	74	45	30				15	15				
Mooneye	R											27						26									
Shad	H					171	171	300	43	193	21	321	21														
	R			23	23	23	23	23				23	21														
Bowfin	H						12																				
	R						12															12				12	

Table 10 (continued). Length distribution (lengths of released fish are estimated) for each species of fish harvested or released at Kentucky Tailwater during the February - November 2016 creel survey.

Species		Inch class																									
		28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	51	52	53	54	Total
Blue catfish	H	74		111		18	37			55								18			21						17,624
	R	38		19		19				62																	3,964
Channel catfish	H			26																							4,116
	R	46	23	25																							1,729
Flathead catfish	H		22				22	44			22		23														463
	R																										60
White bass	H																										6,685
	R																										13,919
Yellow bass	H																										1,864
	R																										6,058
Hybrid rockfish	H																										1,389
Legal	R																										1,277
Striped bass	H			39			21																				660
Legal	R					19				20																	438
Sub-legal	R																										2,204
Sauger	H																										144
Legal	R																										40
Sub-legal	R																										122
Yellow perch	H																										12
	R																										99
Smallmouth bass	H																										219
Legal	R																										869
Sub-legal	R																										476
Spotted bass	H																										0
	R																										25
Largemouth bass	H																										640
Legal	R																										2,283
Sub-legal	R																										2,338
White crappie	H																										684
	R																										278
Black crappie	H																										391
	R																										57
Bluegill	H																										4,142
	R																										7,185
Longear sunfish	H																										26
	R																										0
Green sunfish	H																										0
	R																										23
Paddlefish	H	173	173	296	74	74	99			74	25	25	22														1,332
	R									98																	123
Gar	H		23	93		23				47		23							47					23	23	25	815
	R	24		118					24	118				24		24	94					19					1,487
Suckers	H																										26
	R																										24
Buffalo	H		21	21		20																					314
	R								19					20													934
Common carp	R					24				24		24										24				55"-1	315
Bighead carp	H								20						20			20		20					20		100
	R	207		233	78	181	52	52	155	155	52	78		155		52		26				52	26			60"-24	2,410
Silver carp	H	274	146	348	128	91	73	91	55	55	18		37			19											1,683
	R	691	310	1,929	500	1,024	524	381	524	595	143	119	95	333		121											20,029
Grass carp	H																										50
	R			19										20													173
Freshwater drum	H																										538
	R	41		41																							3,375
Skipjack herring	H																										50,904
	R			12																							905
Mooneye	R																										53
Shad	H																										1,241
	R																										159
Bowfin	H																										12
	R			11																							47

Table 11. Monthly catfish angling success at Kentucky Tailwater during the February - November 2016 creel survey.

Month	Total catch of catfish by all anglers	Total catfish harvested by all anglers	No. of trips for catfish	Hours fished for catfish	Number caught by catfish anglers	Catfish caught / hour by catfish anglers	Number harvested by catfish anglers	Catfish harvested / hour by catfish anglers
February	16	16						
March	815	767	225	737	536	0.53	487	0.48
April	3,563	2,734	421	1,379	3,025	1.76	2,353	1.37
May	4,078	2,666	1,051	3,441	2,720	0.60	2,240	0.50
June	4,465	3,179	924	3,024	3,763	0.75	2,840	0.57
July	3,310	2,928	1,126	3,686	2,723	0.66	2,520	0.61
August	5,316	4,609	770	2,521	5,089	1.62	4,427	1.41
September	3,097	2,559	674	2,207	2,821	1.19	2,367	1.00
October	3,186	2,551	422	1,380	2,970	1.46	2,399	1.18
November	271	271	32	106	226	1.43	226	1.43
Total	28,118	22,279	5,656	18,518	23,873		19,859	
Mean						1.04		0.86

Table 12. Monthly *Morone* spp. angling success at Kentucky Tailwater during the February - November 2016 creel survey.

Month	Total catch of *Morone's* by all anglers	Total *Morone's* harvested by all anglers	No. of trips for *Morone's*	Hours fished for *Morone's*	Number caught by *Morone* anglers	*Morone's* caught / hour by *Morone* anglers	Number harvested by *Morone* anglers	*Morone's* harvested / hour by *Morone* anglers
February	978	620	11	37	16	0.33		
March	5,695	986	235	768	1,083	2.69	462	1.15
April	11,295	2,644	324	1,061	1,883	1.68	1,300	1.16
May	8,823	3,519	504	1,652	3,572	1.97	2,452	1.35
June	2,937	995	266	872	1,407	1.07	582	0.44
July	713	509	191	625	459	0.47	459	0.47
August	319	114						
September	2,068	897	225	736	1,268	1.88	634	0.94
October	1,333	114	144	470	242	0.72	64	0.19
November	338	203	16	53	23	0.33		
Total	34,499	10,600	1,975	6,468	9,953		5,953	
Mean						1.51		0.86

Table 13. Monthly black bass angling success at Kentucky Tailwater during the February - November 2016 creel survey.

Month	Total catch of black bass by all anglers	Total black bass harvested by all anglers	No. of trips for black bass	Hours fished for black bass	Number caught by black bass anglers	Black bass caught / hour by black bass anglers	Number harvested by black bass anglers	Black bass harvested / hour by black bass anglers
February	33	33	23	75				
March	146	24	56	184	49	0.42	0.11	0.11
April	605		65	212	404	0.92		
May	1,066		336	1,101	320	0.23		
June	1,262	218	178	582	363	0.60	0.04	0.04
July	1,120	204	477	1,562	967	0.60	0.10	0.10
August	456	91	178	582	206	0.33	0.04	0.04
September	1,255	251	286	936	1,005	0.60	0.07	0.07
October	698	64	134	439	267	0.34		
November	406		32	106				
Total	7,048	885	1,765	5,778	3,581		0	
Mean						0.49		0.05

Table 14. Monthly crappie angling success at Kentucky Tailwater during the February - November 2016 creel survey.

Month	Total catch of crappie by all anglers	Total crappie harvested by all anglers	No. of trips for crappie	Hours fished for crappie	Number caught by crappie anglers	Crappie caught / hour by crappie anglers	Number harvested by crappie anglers	Crappie harvested / hour by crappie anglers
February	33	33	23	75				
March	49	49	94	307	12	0.04	12	0.04
April	314	269	146	477	179	0.37	135	0.28
May	133	80	42	138	80	1.00	27	0.33
June								
July								
August	23							
September	84	84	31	100	60	0.90	60	0.91
October	102	89	163	533	88	0.26	88	0.26
November	677	474	48	158	677	2.86	474	2.00
Total	1,413	1,077	565	1,851	1,096		796	
Mean						0.58		0.44

Table 15. Monthly panfish angling success at Kentucky Tailwater during the February - November 2016 creel survey.

Month	Total catch of panfish by all anglers	Total panfish harvested by all anglers	No. of trips for panfish	Hours fished for panfish	Number caught by panfish anglers	Panfish caught / hour by panfish anglers	Number harvested by panfish anglers	Panfish harvested / hour by panfish anglers
February	65	65	0	0				
March	292		19	61	207	8.50	0	0.00
April	896	493	0	0				
May	3,679	1,546	210	688	2,187	5.94	1,067	2.90
June	3,568	1,311	89	291	703	6.44	218	2.00
July	255	102	19	63	76	6.00	0	0.00
August	913	91	0	0				
September	658	144	0	0				
October	850	305	38	126	63	1.25	63	1.25
November	203	113	16	53	23	1.00	0	0.00
Total	11,378	4,169	391	1,281	3,259		1,348	
Mean						5.31		2.09

Table 16. Fishery statistics derived from a creel survey at Barkley Tailwater (75.2 acres) February - November 2016.

Fishing Trips		
No. of fishing trips (per acre)	23,346	(310.5)
Fishing Pressure		
Total angler-hours (S.E.)	75,048	(1,915)
Angler-hours/acre	998.0	
Catch / Harvest		
No. of fish caught (S.E.)	127,537	(16,603)
No. of fish harvested (S.E.)	63,207	(8,021)
Lb of fish harvested	107,430	
Harvest Rates		
Fish/hour	0.9	
Fish/acre	840.5	
Pounds/acre	1428.6	
Catch Rates		
Fish/hour	1.7	
Fish/acre	1696.0	
Miscellaneous Characteristics (%)		
Male	86	
Female	14	
Resident	83	
Non-resident	17	
Method (%)		
Still fishing	35	
Casting	31	
Trolling	<1	
Drifting	9	
Snagging	<1	
Bowfishing	24	
Dipping	<1	
Mode (%)		
Boat	34	
Bank	66	

Table 17. Fish harvest statistics derived from a creel survey at Barkley Tailwater (75.2 acres) February - November 2016.

	Black bass group	Largemouth bass	Smallmouth bass	Spotted bass	Crappie group	White crappie	Black crappie	Catfish group	Channel catfish	Flathead catfish	Blue catfish	Panfish group	Bluegill	Redear sunfish	Longear sunfish	Green sunfish	Sauger
No. caught	4,503	3,644	558	118	1,092	134	958	41,284	6,877	374	34,033	14,690	13,997	425	251	17	119
(per acre)	(59.88)	(48.46)	(7.42)	(1.57)	(14.52)	(1.78)	(12.74)	(548.99)	(91.45)	(4.97)	(452.57)	(195.35)	(186.13)	(5.65)	(3.34)	(0.23)	(1.58)
No. harvested	454	273	99	1	478	48	429	34,406	5,035	232	29,139	6,752	6,199	386	151	17	67
(per acre)	(6.04)	(3.63)	(1.32)	(0.01)	(6.36)	(0.64)	(5.70)	(457.53)	(66.95)	(3.09)	(387.49)	(89.79)	(82.43)	(5.13)	(2.01)	(0.23)	(0.89)
%of total no. harvested	0.72	0.43	0.16	0.00	0.76	0.08	0.68	54.43	7.97	0.37	46.10	10.68	9.81	0.61	0.24	0.03	0.11
Lb. harvested	803	507	242	54	314	19	295	50,347	6,540	449	43,358	1,504	1,211	268	21	4	88
(per acre)	(10.67)	(6.74)	(3.22)	(0.72)	(4.18)	(0.25)	(3.92)	(669.51)	(86.97)	(5.97)	(576.57)	(20.00)	(16.10)	(3.56)	(0.28)	(0.05)	(1.17)
%of total lb. harvested	0.75	0.47	0.23	0.05	0.29	0.02	0.27	46.86	6.09	0.42	40.36	1.40	1.13	0.25	0.02	0.00	0.08
Mean length (in)		15.4	16.8	14.0		10.1	11.1		15.4	18.7	16.0		7.2	10	6.2	7	15.6
Mean weight (lb)		1.97	2.25	1.13		0.49	0.76		1.19	2.90	1.42		0.25	0.68	0.14	0.21	1.2
No. of fishing trips for that species	770				557			8,018				368					18
%of all trips	3.3				2.4			34.3				1.6					0.1
Hours fished for that species	2,475				1,790			25,773				1,181					57
(per acre)	(32.9)				(23.8)			(342.7)				(15.7)					(0.8)
No. harvested fishing for that species	160				432			32,330				4,302					
Lb harvested fishing for that species	239				273			46,620				900					
No./hour harvested fishing for that species	0.04				0.22			1.07				4.46					
%success fishing for that species	6.9				26.3			62.2				48.1					0.0

Table 17 (continued.). Fish harvest statistics derived from a creel survey at Barkley Tailwater (75.2 acres) from February - November 2016.

	Morone Group	White bass	Striped bass	Hybrid striped bass	Yellow bass	Freshwater drum	Common carp	Suckers	Buffalo	Skipjack herring	Shad	Gar	Bighead carp	Silver carp	Grass carp	Paddlefish	Bowfin	Anything
No. caught	18,491	9,032	1,460	1,169	6,831	5,502	255	95	329	7,350	6223	2,339	2853	21599	183	742	72	
(per acre)	(245.89)	(120.11)	(19.41)	(15.55)	(90.84)	(73.16)	(3.39)	(1.26)	(4.38)	(97.74)	(82.75)	(31.10)	(37.94)	(287.22)	(2.43)	(9.87)	(0.96)	
No. harvested	5,707	4,028	254	935	491	920	0	0	34	6,795	3424	126	210	3152	34	662	19	
(per acre)	(75.89)	(53.56)	(3.38)	(12.43)	(6.53)	(12.23)	(0.00)	(0.00)	(0.45)	(90.36)	(45.53)	(1.68)	(2.79)	(41.91)	(0.45)	(8.80)	(0.25)	
%of total no. harvested	9.03	6.37	0.40	1.48	0.78	1.46	0.00	0.00	0.05	10.75	5.42	0.20	0.33	4.99	0.05	1.05	0.03	
Lb. harvested	7,705	4,253	1,087	2,302	63	2180	0	0	709	3,636	472	254	6,271	30,433		2,659	55	
(per acre)	(102.46)	(56.56)	(14.45)	(30.61)	(0.84)	(28.99)	(0.00)	(0.00)	(9.43)	(48.35)	(6.28)	(3.38)	(83.39)	(404.69)	(0.00)	(35.36)	(0.73)	
%of total lb. harvested	7.17	3.96	1.01	2.14	0.06	2.03	0.00	0.00	0.66	3.38	0.44	0.24	5.84	28.33	0.00	2.48	0.05	
Mean length (in)		14.2	20.9	17.8	7.7	15.4			31.0	12.1	7.5	21.9	38.8	27.4	24.5	31.6	21.0	
Mean weight (lb)		1.12	3.84	2.95	0.2	1.66			19.32	0.46	0.17	1.4	28.97	10.24		4.21	2.83	
No. of fishing trips for that species	2086									901			16	1340		59		9215
%of all trips	8.9									3.9			0.1	5.7		0.3		39.5
Hours fished for that species	6,707									2,898			51	4,306		190		29,621
(per acre)	(89.2)								(0.0)	(38.5)			(0.7)	(57.3)				(393.9)
No. harvested fishing for that species	3,754									5,888				1840		25		
Lb harvested fishing for that species	5,401									3,110				18,764		121		
No./hour harvested fishing for that species	0.72									3.29				0.39		0.10		
%success fishing for that species	31.5									66.3			0.0	17.2		33.3		20.1

Table 18. Length distribution (lengths of released fish are estimated) for each species of fish harvested or released at Barkley Tailwater during the February - November 2016 creel survey.

Species		Inch class																									
		1-2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Blue catfish	H					16		333	317	982	903	2,692	2,708	3,532	2,882	3,294	1,885	2,550	1,140	1,742	697	760	396	665	348	285	158
	R			94	203	468	546	888	499	639	203	436	125	125	140	78	62	156	47	78	31	31					16
Channel catfish	H					16	48	95	79	143	111	492	334	492	476	667	508	461	127	429	95	175	95	111	48	16	16
	R			35		142	124	390	106	266	71	230	124	106	35	35	71	71		18				18			
Flathead catfish	H									14		27	14	41	14	14	14	41	14	14				14			11
	R						18			18			35	18	18									18		16	
White bass	H					13	40	40	120	226	106	479	784	585	744	492	239	66	53			41					
	R	28	70	155	323	801	520	914	281	464	267	408	337	295	84	42					14						
Yellow bass	H			70	70	98	28	70	126	14	15																
	R		51	410	1,350	1,452	1,145	1,162	120	342	137	154		16													
Hybrid striped bass	H					22	11	11	33	22	33	54	54	54	76	98	87	98	43	120	22	54	22	11	9		
	R						10	133	41	10				10	10	10							10				
Striped bass	H														24	36	12		36	12		24	12	12	24	12	12
Legal	R														60	15	30	15		29							
Sub-legal	R			15	89	208	74	149	74	134	15	149	89	60													
Sauger	H													13	27		13		14								
Legal	R													17													
Sub-legal	R						17	17																			
Smallmouth bass	H														17	33	33			16							
Legal	R											79	16	79		16	16	16		16		14					
Sub-legal	R		16			47	32	32	47	16	16																
Spotted bass	H													47													
	R									14		14		28		14											
Largemouth bass	H											32	32	32	48	48	16	32	32								
Legal	R											447	447	160	368	240	160	288	16		16		13				
Sub-legal	R			16	16	256	160	240	112	240	176																
White crappie	H							10	10	19	9																
	R						29	29		27																	
Black crappie	H							17	52	103	69	155	33														
	R			106	63	63	63	85	21	63		42				22											
Bluegill	H		320	511	415	607	1,981	1,693	463	208																	
	R		207	2,438	2,559	1,695	501	259	69	70																	
Longear sunfish	H			34	34	17	17	34	14																		
	R	50		50																							
Redear sunfish	H							34	84	134	84	50															
	R							19	19																		
Green sunfish	H						16																				
	R																										
Paddlefish	H																							31	31	62	31
	R											16												16		16	
Gar	H													42						14				14		14	
	R				50	67	83	150	67	116	100	133	83	100	33	17		83		17	17	33	17	266	33	50	
Suckers	R											27						27						27			
Buffalo	H																							17			
	R											16		16		33		16		115		16		66			
Common carp	R						17	51						17	34			17		17							
Bighead carp	H											35												138	138	121	225
	R																										
Silver carp	H													17				85	51	239	119	204	204	256	187	153	119
	R						82	49	65	131	16	262	98	131	360	262	147	1,177	376	1,603	491	1,014	572	2,061	720	916	605
Grass carp	H												17														
	R												33	33												33	
Freshwater drum	H									16	82	66	66	49	49	49	49	66	49	49	82	49	49	49	49	16	16
	R			29		229	143	372	72	272	100	745	129	344	530	344	200	415	14	286	57	14		86	14	158	
Skipjack herring	H					24	60	120	179	455	562	1,113	957	969	981	622	706	46									
	R					22		11		67	33	89	33	100	89	67	44										
Shad	H	486	243	243	284	284	608	669	304	182	61	60															
	R			16	645	676	676	676			47	31				31											
Bowfin	H																				19						
	R														17					17				18			

Table 18 (continued). Length distribution (lengths of released fish are estimated) for each species of fish harvested or released at Barkley Tailwater during the February - November 2016 creel survey.

Species		Inch class																								
		28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	50-56	58-66	Total
Blue catfish	H	206	48	253	48	127	63	32	16	48					12										29,138
	R	16									13														4,894
Channel catfish	H																								5,034
	R																								1,842
Flathead catfish	H																								232
	R																								141
White bass	H																								4,028
	R																								5,003
Yellow bass	H																								491
	R																								6,339
Hybrid rockfish	H																								934
	R																								234
Striped bass	H	24						13																	253
Legal	R																								149
Sub-legal	R																								1,056
Sauger	H																								67
Legal	R																								17
Sub-legal	R																								34
Smallmouth bass	H																								99
Legal	R																								252
Sub-legal	R																								206
Spotted bass	H																								47
	R																								70
Largemouth bass	H																								272
Legal	R																								2,155
Sub-legal	R																								1,216
White crappie	H																								48
	R																								85
Black crappie	H																								429
	R																								528
Bluegill	H																								6,198
	R																								7,798
Longear sunfish	H																								150
	R																								100
Redear sunfish	H																								386
	R																								38
Green sunfish	H																								16
	R																								0
Paddlefish	H	92	46	15	31	123	15	15	31	46		46	15			15						17			662
	R									31															79
Gar	H							14		14												14			126
	R	150		67	17	50		83		166		17		17		17						50	33	30	2,212
Suckers	H			13																					94
Buffalo	H											16													33
	R	16																							294
Common carp	R			51				17		17						16									254
Bighead carp	H			32				32			16	16	16				16	16		32	16		17		866
	R	155	155	155	86	138	104	121	104	155	104	138	86	138	35	35	17		17			121	68	54	1,986
Silver carp	H	119	153	290	85	204	119	136	85	170	17	17	17	34		17	17	17	20						3,151
	R	1,259	491	2,339	294	769	327	507	278	720	82	65	16	98		16						48			18,447
Grass carp	H	19								17															53
	R	14	15							16												33			177
Freshwater drum	H																								900
	R																								4,553
Skipjack herring	H																								6,794
	R																								555
Shad	H																								3,424
	R																								2,798
Bowfin	H																								19
	R			13																					65

Table 19. Monthly catfish angling success at Barkley Tailwater during the February - November 2016 creel survey.

Month	Total catch of catfish by all anglers	Total catfish harvested by all anglers	No. of trips for catfish	Hours fished for catfish	Number caught by catfish anglers	Catfish caught / hour by catfish anglers	Number harvested by catfish anglers	Catfish harvested / hour by catfish anglers
February	565	452	113	365	566	1.67	452	1.33
March	2,666	2,331	230	739	1,847	1.76	1,649	1.57
April	2,320	1,892	299	961	2,153	1.57	1,726	1.26
May	7,359	6,152	1,256	4,037	7,073	1.22	5,900	1.01
June	10,581	7,458	1,732	5,567	9,558	1.39	6,918	1.01
July	5,071	4,149	1,238	3,978	4,768	1.00	4,005	0.84
August	1,627	1,311	490	1,576	1,514	0.97	1,312	0.84
September	6,392	6,246	1,455	4,676	6,392	1.36	6,246	1.33
October	3,105	2,930	748	2,404	2,798	1.15	2,637	1.09
November	1,598	1,484	457	1,470	1,571	0.83	1,485	0.78
Total	41,284	34,405	8,018	25,773	38,240		32,330	
Mean						1.26		1.07

Table 20. Monthly *Morone* spp. angling success at Barkley Tailwater during the February - November 2016 creel survey.

Month	Total catch of *Morone's* by all anglers	Total *Morone's* harvested by all anglers	No. of trips for *Morone's*	Hours fished for *Morone's*	Number caught by *Morone* anglers	*Morone's* caught / hour by *Morone* anglers	Number harvested by *Morone* anglers	*Morone's* harvested / hour by *Morone* anglers
February	2,317		68	219	57	0.22		
March	1,896	474	206	664	681	1.46	316	0.68
April	3,567	1,622	272	874	2,058	2.42	820	0.96
May	6,135	1,660	556	1,788	1,458	1.38	888	0.84
June	1,253	116	89	287	19	0.14		
July	525	32						
August	492		85	273	114	0.56		
September	347	18	160	514	37	0.19		
October	1,304	1,216	435	1,399	1,245	0.71	12	0.70
November	657	571	139	447	514	1.33	514	1.33
Total	18,491	5,708	2,086	6,707	6,183		3,754	
Mean						1.31		0.72

Table 21. Monthly black bass angling success at Barkley Tailwater during the February - November 2016 creel survey.

Month	Total catch of black bass by all anglers	Total black bass harvested by all anglers	No. of trips for black bass	Hours fished for black bass	Number caught by black bass anglers	Black bass caught / hour by black bass anglers	Number harvested by black bass anglers	Black bass harvested / hour by black bass anglers
February	226							
March	109		12	38				
April	140	52	5	17				
May	184	17	32	102	117	1.08		
June	385	77	18	57	116	0.92	39	0.31
July	1,733	159	302	970	1,288	0.77	48	0.03
August	681		151	484	315	0.45		
September	712	91	128	411	584	0.80	73	0.10
October	190		122	393	146	0.27		
November	143	57						
Total	4,503	454	770	2,475	2,566		160	
Mean						0.62		0.03

Table 22. Monthly crappie angling success at Barkley Tailwater during the February - November 2016 creel survey.

Month	Total catch of crappie by all anglers	Total crappie harvested by all anglers	No. of trips for crappie	Hours fished for crappie	Number caught by crappie anglers	Crappie caught / hour by crappie anglers	Number harvested by crappie anglers	Crappie harvested / hour by crappie anglers
February	57		91	292	57	0.18		
March	168	119	136	436	138	0.24	89	0.15
April	35	17	33	105	18	0.34	18	0.34
May	34	17	79	255	17	0.11		
June	116		36	115	58	0.75		
July	16		30	97	16	0.25		
September	110	110	32	103	110	0.55	110	0.55
October	44	44	41	131	44	0.35	44	0.35
November	514	171	80	256	428	1.43	171	0.57
Total	4,503	477	770	1,789	886		432	
Mean						0.40		0.22

Table 23. Monthly Panfish angling success at Barkley Tailwater during the February - November 2016 creel survey.

Month	Total catch of panfish by all anglers	Total panfish harvested by all anglers	No. of trips for panfish	Hours fished for panfish	Number caught by panfish anglers	Panfish caught / hour by panfish anglers	Number harvested by panfish anglers	Panfish harvested / hour by panfish anglers
February	57							
March	69	20	29	95				
April	759	427	27	87	489	3.29	262	1.76
May	10,376	5,146	254	818	8,415	13.32	4,040	6.39
June	2,293	983						
July	143	111						
August	50	50						
September			16	51				
October	29	15						
November	913							
Total	14,690	6,752	368	1,181	8,904		4,302	
Mean						9.19		4.46

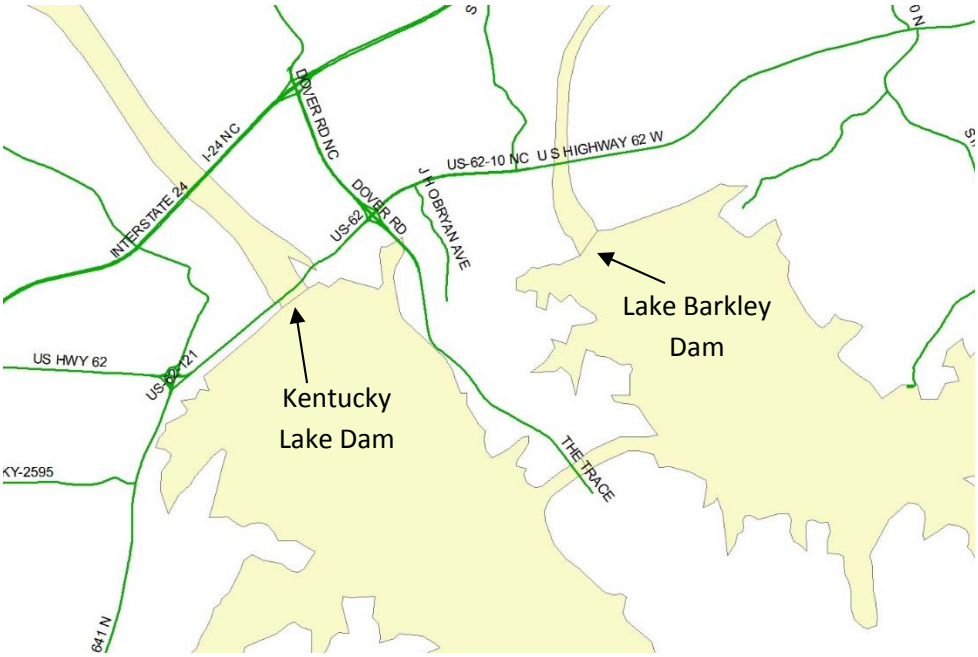

Figure 1. The tailwater electrofishing and creel survey at Kentucky Lake Tailwater extended from the dam downstream to the Interstate 24 bridge. The electrofishing and creel survey at Lake Barkley Tailwater extended from the dam downstream to the US Hwy 62 bridge.

Appendix 1. 301 KAR 1:410 sections 5 and 7. Taking of fish by nontraditional fishing methods.

Section 5. Snagging and Gigging

- A person may snag sport fish or rough fish in the Tennessee River below the Kentucky Lake Dam to the U.S. 62 bridge: for twenty-four (24) hours a day from January 1 through May 31; and from sunset to sunrise from June 1 through December 31.

- A person shall not snag in that section of the Tennessee River from the U.S. 62 bridge to the Interstate 24 bridge.

- A person may snag sport fish or rough fish year round in the section of the Tennessee River from the Interstate 24 bridge to the Ohio River.

- A person shall not snag on the Tennessee River: under the U.S. 62 bridge; under the P & L Railroad bridge; or from the fishing piers located below the U.S. 62 bridge.

- There shall not be a daily creel limit for rough fish except: the daily creel limit for rough fish in the Cumberland River below Barkley Lake Dam shall be eight (8) except there shall not be a creel limit on Asian Carp; the daily aggregate creel limit for snagging of rough and sport fish in the Tennessee River below Kentucky Lake Dam shall be eight (8) except there shall not be a creel limit on Asian Carp

- All snagged fish in the Tennessee River below Kentucky Lake Dam shall be immediately retained, and not released or culled, except for Asian carp, shad, or herring.

- All gigged or snagged rough fish in the Cumberland River below Barkley Lake Dam shall be immediately retained, and not released or culled, except for Asian carp, shad, or herring.

Section 7. Bow Fishing

- An angler using archery equipment, a crossbow, or a pneumatic arrow launching device shall not take: sport fish; alligator gar; more than five (5) catfish daily; or more than two

- Any paddlefish or catfish shot with archery equipment, a crossbow, or a pneumatic arrow launching device shall:Be immediately retained, and not released or culled; andCount toward a person's daily limit.

- Bow fishing shall be open statewide, except: in the Cumberland River below Wolf Creek Dam downstream to the Tennessee line including Hatchery Creek; in any tributary of the Cumberland River below Wolf Creek Dam to the Tennessee line, from the junction of the tributary with the Cumberland River to one-half (1/2) mile upstream; or from a boat in restricted areas below navigation, power generating, or flood control dams. (32 Ky.R. 434; Am. 622; eff. 10-12-05; 33 Ky.R. 1889; eff. 4-6-07; 34 Ky.R. 374; eff. 10-9-2007; 35 Ky.R. 995; 1448; eff. 1-5-2009; 37 Ky.R. 744; 10-7-2010; 38 Ky.R. 1974; 39 Ky.R. 13; eff. 7-12-2012; 1944; eff. 5-31-2013; 41 Ky.R. 564;p 1048; eff. 12-5-2014; 42 Ky.R. 1322; eff. 1-4-2016.)

KENTUCKY LAKE TAILWATER ANGLER ATTITUDE SURVEY 2016

1. Have you previously completed this survey? Yes - stop survey No – continue

2. Name _____ and Zip Code _____ (**Optional**)

3. Have you fished at the Kentucky Lake Tailwaters in the last 12 months? Yes 97%, No 3%

   3a. If yes, How many times have you fished at the Kentucky Lake Tailwaters in the past 12 months?
   1-4 = 38%, 5-10 = 16%, More than 10 = 51%

4. What species of fish do you fish for at the Kentucky Lake Tailwaters (check all that apply)?
62.9% - Catfish, 44.8% - Striped bass/White bass/Hybrids, 28.4% - Crappie, 27.6% - Black bass, 25% - Panfish, 14.7% - Paddlefish, 6% - Skipjack/Bait, 5.2% - Asian carp, 3.5% - Rough fish, 1.7% - Anything

5. Which one species do you fish for most at Kentucky Lake Tailwaters (check only one)?
37% - Catfish, 27% - Striped bass/White bass/Hybrids, 11% - Black bass, 9% - Crappie, 6% - Paddlefish, 3% - Panfish, 3% - Asian carp, 2% - Skipjack, 1% - Rough fish

Striped Bass/White Bass/Hybrid Anglers

6. In general, what level of satisfaction do you have with Striped Bass/White Bass/Hybrid fishing at Kentucky Lake Tailwaters?
24% - Very satisfied 44% - Somewhat satisfied 14% - Neutral 10% - Somewhat dissatisfied 0% - Very dissatisfied 8% - No opinion

   6a. If you responded with somewhat or very dissatisfied in question (6) - what is the single most important reason for your dissatisfaction?
   33% - Asian carp, 33% - Number of fish, 17% - Size of fish, 8% - Fluctuating water, 8% - Red/black dots in fillets, 0% Too many anglers,

Crappie Anglers

7. In general, what level of satisfaction do you have with crappie fishing at Kentucky Lake Tailwaters?
23% - Very satisfied 29% - Somewhat satisfied 20% - Neutral 11% - Somewhat dissatisfied 9% - Very dissatisfied 9% - No opinion

   7a. If you responded with somewhat or very dissatisfied in question (7) - what is the single most important reason for your dissatisfaction?
   43% - Asian carp, 29% - Number of fish, 29% - Size of fish

Black Bass Anglers

8. In general, what level of satisfaction do you have with the black bass fishing at the Kentucky Lake Tailwaters?
33% - Very satisfied 37% - Somewhat satisfied 15% - Neutral 4% - Somewhat dissatisfied 4% - Very dissatisfied 8% - No opinion

   8a. If you responded with somewhat or very dissatisfied in question (8) - what is the single most important reason for your dissatisfaction?
   40% - Asian carp, 20% - Number of fish, 20% - Size of fish, 20% - Fluctuating water

Catfish Anglers

9. In general, what level of satisfaction do you have with the catfish fishing at the Kentucky Lake Tailwaters?
38% - Very satisfied 38% - Somewhat satisfied 6% - Neutral 9% - Somewhat dissatisfied 4% - Very dissatisfied 6% - No opinion

   9a. If you responded with somewhat or very dissatisfied in question (9) - what is the single most important reason for your dissatisfaction?
   23% - Asian carp, 15% - Number of fish, 15% - Too much commercial fishing, 15% - Snaggers, 8% - Water levels, 8% - More bait, 8% Too many anglers, 8% - Not happy with regulations, 0% - Size of fish,

Paddlefish Anglers

10. In general what level of satisfaction do you have with Paddlefish fishing at Kentucky Lake Tailwaters?

6% - Very satisfied 38% - Somewhat satisfied 0% - Neutral 31% - Somewhat dissatisfied 25% - Very dissatisfied 0% - No opinion

10a. If you responded with somewhat or very dissatisfied in question (10) - what is the single most important reason for your dissatisfaction?

60% - Asian carp, 10% - Number of fish, 10% - Too much commercial fishering, 10% - Too much harvest, 10% - Less restrictions during summer snagging, 0% - Size of fish

11. Currently, the creel limit for the Kentucky Lake Tailwaters is 8 fish per day, while the statewide creel limit in Kentucky is 2 fish per day. Would you support or oppose a reduction in the creel limit in the Kentucky Lake Tailwaters to 2 fish per day?

71% - Support 29% - Oppose

11a. If you answered "oppose" to the previous question, what creel limit would you support for paddlefish in the Kentucky Lake Tailwaters?

40% - 4 fish per day 20% - 5 fish per day 40% - Keep the same

12. Currently, paddlefish can be harvested year round in the Kentucky Lake Tailwaters. From January 1 - May 31 it is open 24 hours per day. From June 1 - December 31 snagging is allowed from sunset to sunrise. Would you support or oppose changing the Kentucky Lake Tailwaters snagging season to mimic the statewide season from February 1 - May 10?

47% - Support 53% - Oppose

12a. If you answered "oppose" to the previous question, what months would you prefer for a paddlefish snagging season?

0% = January-March, 11% = March-June, 22% = April-June, 0% = July-September, 0% = October-December, 67% = Keep same

All Anglers

13. Are you satisfied with the current size and creel limits on all sportfish at Kentucky Lake Tailwaters?

93% - Yes 7% - No

13a. If not, which species are you dissatisfied with and what size limits would you prefer?

Species	Size Limit	Creel Limit	# of Anglers
Striped bass/White bass/Hybrids	None		1
Black bass	12"	1	1
Black bass	18"	3	1
Crappie	10"	15	1
Crappie		30	1
Catfish	15"	6	1
Catfish	34"	20	1

LAKE BARKLEY TAILWATER ANGLER ATTITUDE SURVEY 2016

1. Have you previously completed this survey? Yes - stop survey No – continue

2. Name _____ and Zip Code _____ (**Optional**)

3. Have you fished at the Barkley Tailwaters in the last 12 months? Yes 99%, No <1%

   3a. If yes, How many times have you fished at the Lake Barkley Tailwaters in the past 12 months?
   1-4 = 29%, 5-10 = 16%, More than 10 = 55%

4. What species of fish do you fish for at the Lake Barkley Tailwaters (check all that apply)?

67.7% - Catfish, 43.5% - Stiped bass/White bass/Hybrids, 21.8% - Crappie, 21% - Black bass, 12.9% - Panfish, 8.9% - Paddlefish, 5.6% - Skipjack/Bait, 4.8% - Asian carp, 0.8% - Sauger, 1.6% - Anything

5. Which one species do you fish for most at Lake Barkley Tailwaters (check only one)?

54% - Catfish, 23% - Striped bass/White bass/Hybrids, 6% - Crappie, 4% - Paddlefish, 4% - Black bass, 3% - Bluegill, 3% - Anything, 1% - Skipjack, 1% - Yellow bass

Striped Bass/White Bass/Hybrid Anglers

6. In general, what level of satisfaction do you have with Striped Bass/White Bass/Hybrid fishing at Lake Barkley Tailwaters?

15% - Very satisfied 40% - Somewhat satisfied 17% - Neutral 15% - Somewhat dissatisfied 6% - Very dissatisfied 6% - No opinion

   6a. If you responded with somewhat or very dissatisfied in question (6) - what is the single most important reason for your dissatisfaction?
   56% - Number of fish, 22% - Size of fish, 19% - Asian carp, 4% Too many anglers

Crappie Anglers

7. In general, what level of satisfaction do you have with crappie fishing at Lake Barkley Tailwaters?

13% - Very satisfied 21% - Somewhat satisfied 33% - Neutral 13% - Somewhat dissatisfied 8% - Very dissatisfied 13% - No opinion

   7a. If you responded with somewhat or very dissatisfied in question (7) - what is the single most important reason for your dissatisfaction?
   67% - Number of fish, 17% - Size of fish, 17% - Fluctuating water levels

Black Bass Anglers

8. In general, what level of satisfaction do you have with the black bass fishing at the Lake Barkley Tailwaters?

24% - Very satisfied 20% - Somewhat satisfied 32% - Neutral 4% - Somewhat dissatisfied 8% - Very dissatisfied 12% - No opinion

   8a. If you responded with somewhat or very dissatisfied in question (8) - what is the single most important reason for your dissatisfaction?
   50% - Number of fish, 33% - Asian carp, 17% - Size of fish,

Catfish Anglers

9. In general, what level of satisfaction do you have with the catfish fishing at the Lake Barkley Tailwaters?

40% - Very satisfied 35% - Somewhat satisfied 8% - Neutral 14% - Somewhat dissatisfied 0% - Very dissatisfied 4% - No opinion

   9a. If you responded with somewhat or very dissatisfied in question (9) - what is the single most important reason for your dissatisfaction?
   35% - Asian carp, 35% - Number of fish, 12% - Too much commercial fishering, 8% - Size of fish, 4% Too many anglers, 4% - Too many people littering, 4% - Water levels

Paddlefish Anglers

10. In general what level of satisfaction do you have with Paddlefish fishing at Lake Barkley Tailwaters?

18% - Very satisfied 46% - Somewhat satisfied 18% - Neutral 18% - Somewhat dissatisfied 0% - Very dissatisfied 0% - No opinion

10a. If you responded with somewhat or very dissatisfied in question (10) - what is the single most important reason for your dissatisfaction?

67% - Number of fish, 33% - Asian carp, 0% - Size of fish, 0% - Too much commercial fishering

11. Currently, snagging is only allowed downstream of the 62 bridge below Lake Barkley Tailwaters. The creel limit below the 62 bridge is 8 fish in aggregate (maximum of 8 paddlefish allowed). Would you support or oppose decreasing the creel limit for paddlefish to 2 fish per day?

100% - Support 0% - Oppose

12. Currently, snagging below the 62 bridge in the Lake Barkley Tailwaters is regulated by the statewide snagging regulations, and is allowed only during the snagging season from February 1 - May 10. Do you suport or oppose the paddlefish snagging season below the 62 bridge in the Lake Barkley Tailwaters?

100% - Support 0% - Oppose

12a. If you answered "oppose" to the previous question, what months would you prefer for a paddlefish snagging season?

All Anglers

13. Are you satisfied with the current size and creel limits on all sportfish at Lake Barkley Tailwaters?

90% - Yes 10% - No

13a. If not, which species are you dissatisfied with and what size limits would you prefer?

Species	Size Limit	Creel Limit	# of Anglers
Striped bass/White bass/Hybrids	15"	30	1
Black bass	15"	5	2
Black bass		12	1
Crappie	10"		3
Crappie	12"	15	2
Crappie		20	2
Crappie		30	1
Catfish	28"	1	2
Catfish		30	1
Paddlefish	36"	2	1
Paddlefish		4	1
Paddlefish		5	1
Sauger	10"	10	1
Sauger		unlimited	1

Project V: Monitoring and Response to Asian Carp in the Ohio River

FINDINGS

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 be 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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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%
Lampery 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%

Table 2 (Continued). 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
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 Capture	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

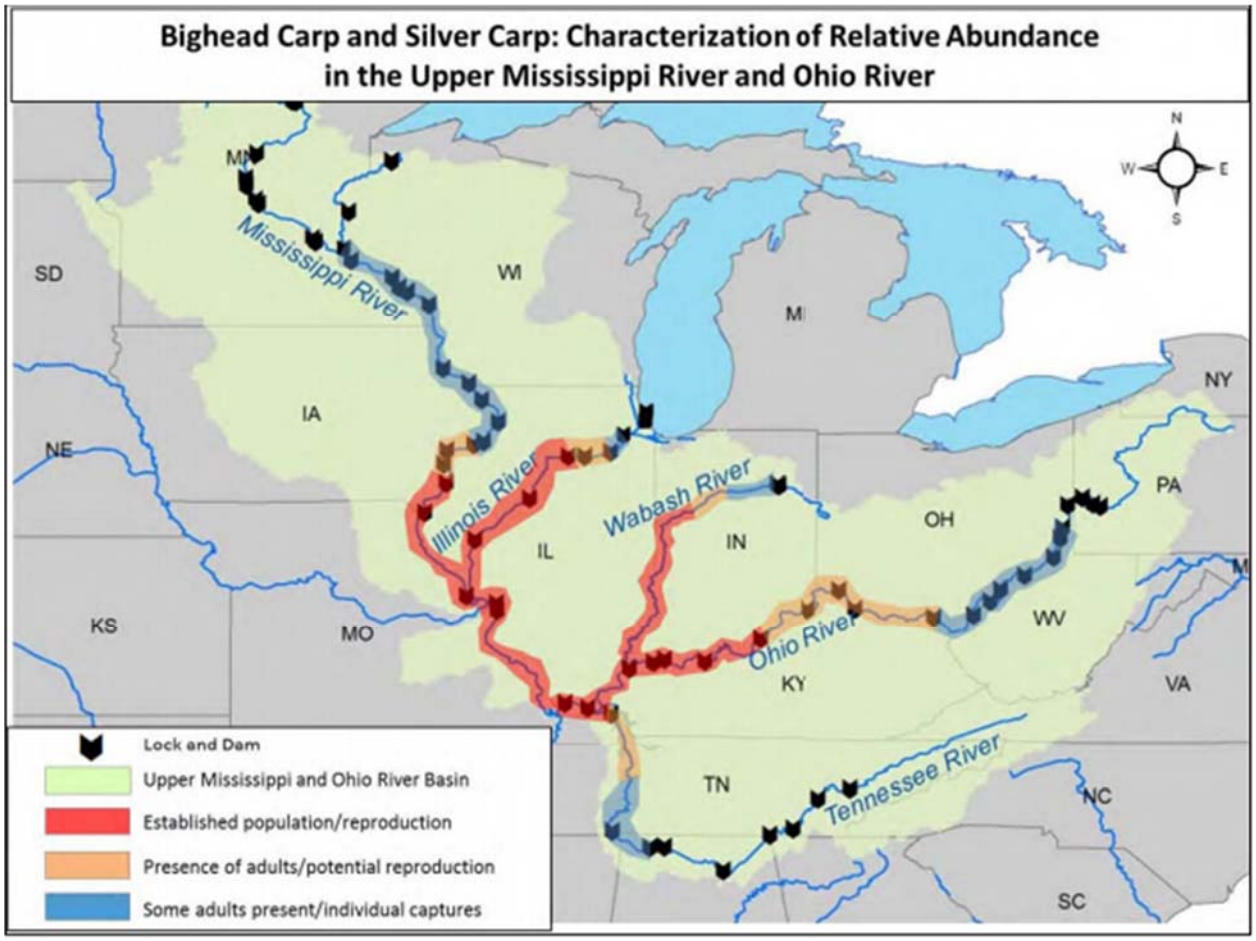


Figure 1. A map illustrating the established ranges of bigheaded carps in the Upper Mississippi River and Ohio River sub-basins.

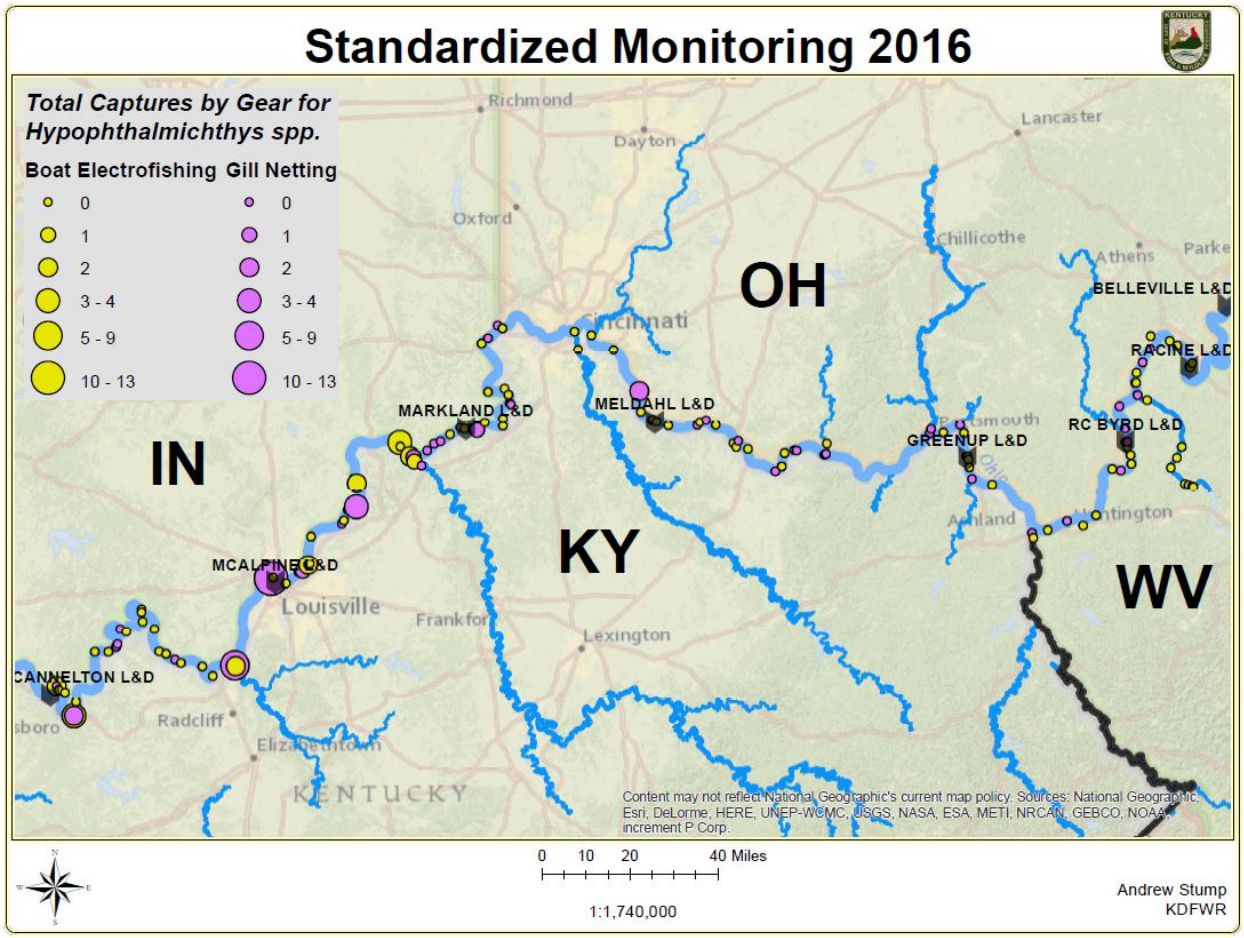


Figure 2. A map of the Ohio River where standardized community sampling was conducted over both the spring and fall sampling seasons in 2016. The gear used and total number of Asian carps caught at each location are designated by the color and proportional sizes of each symbol used to indicate a sampled location.

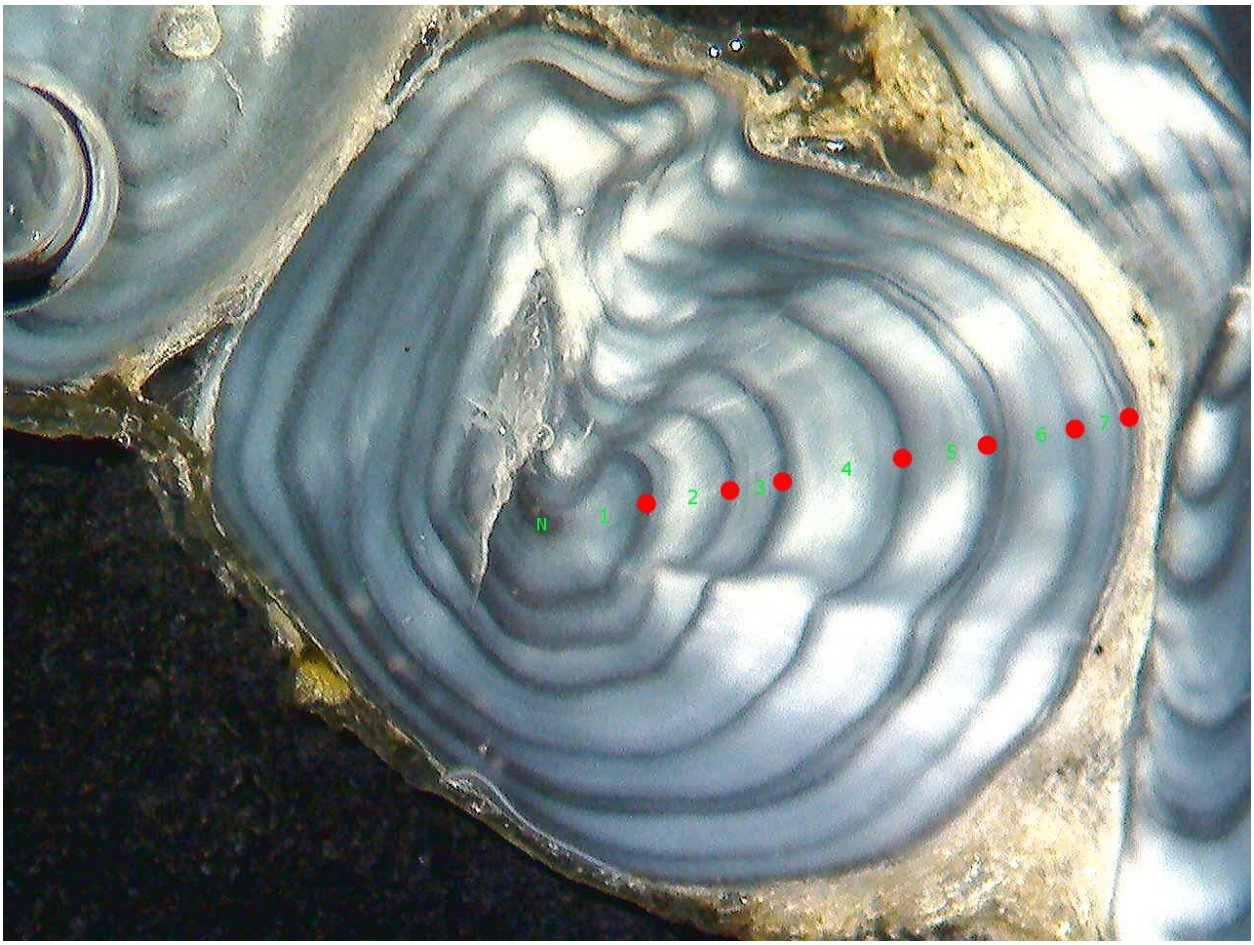


Figure 3. A cross-section of the left, pectoral fin-ray of an age-7 silver carp harvested in May 2016.

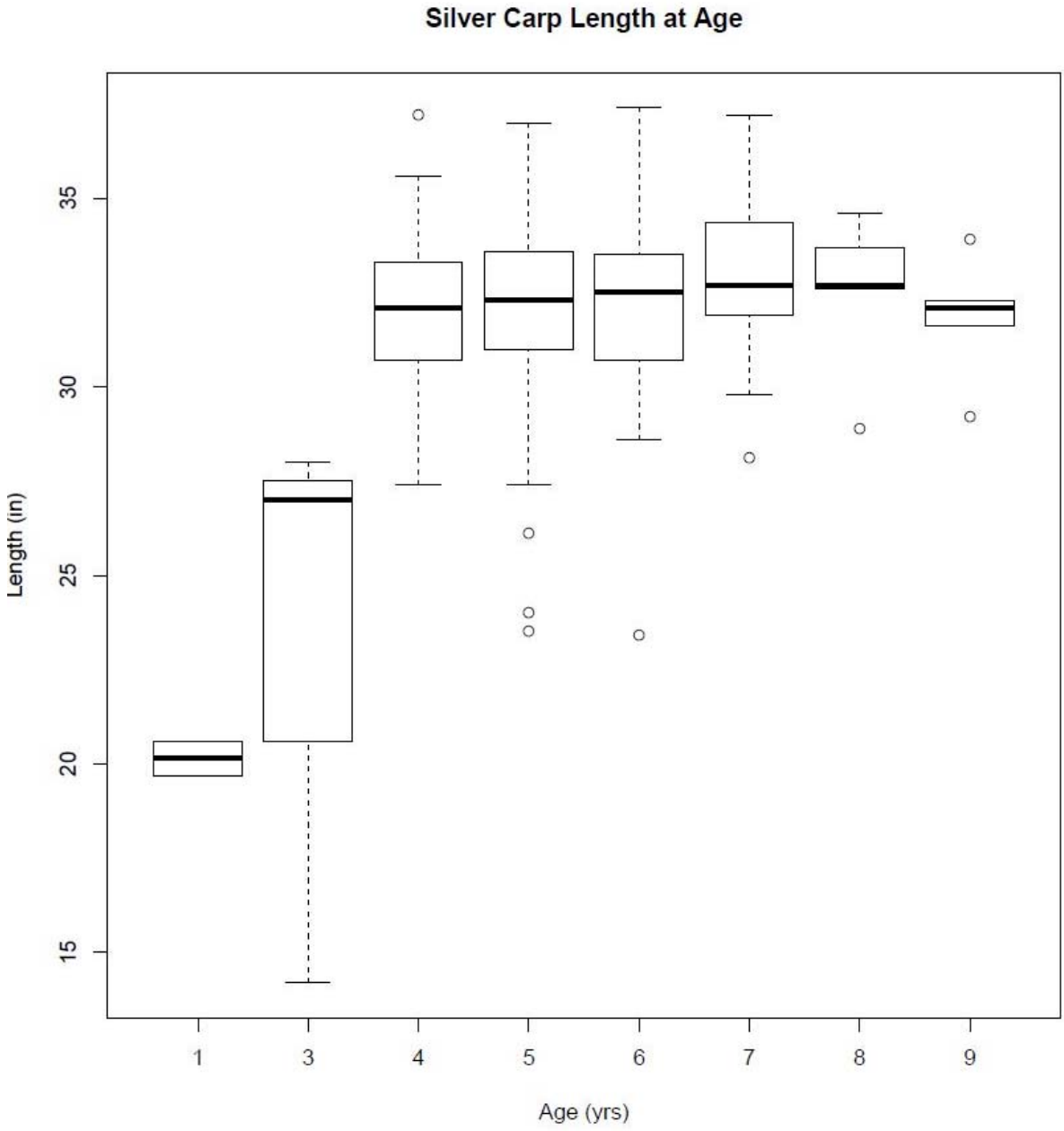
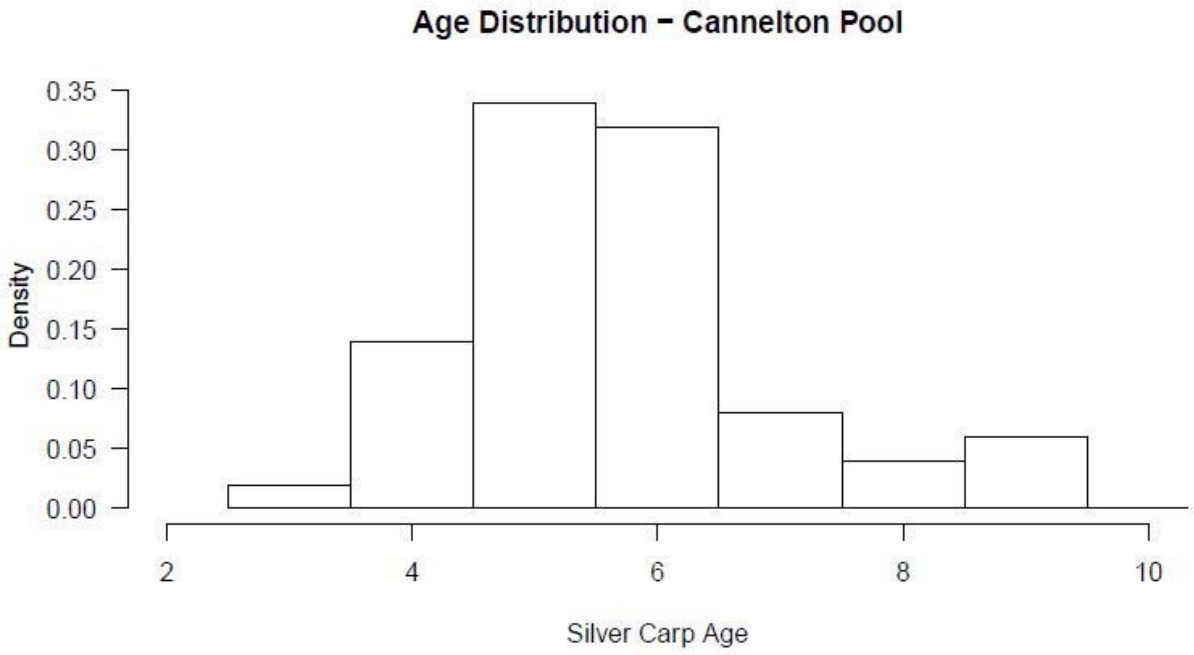


Figure 4. A boxplot showing the mean length (in) at age for silver carp harvested throughout all pools sampled during 2016.



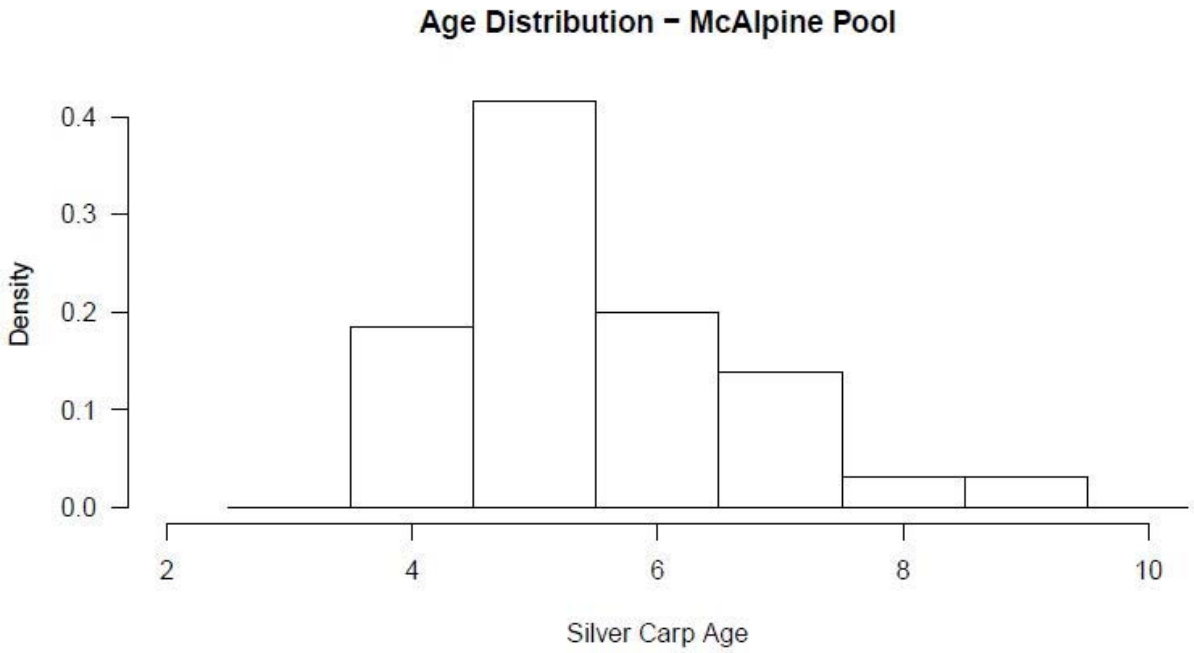


Figure 5. The relative proportion of silver carp at each age harvested from the Cannelton and McAlpine pools during 2016 sampling.

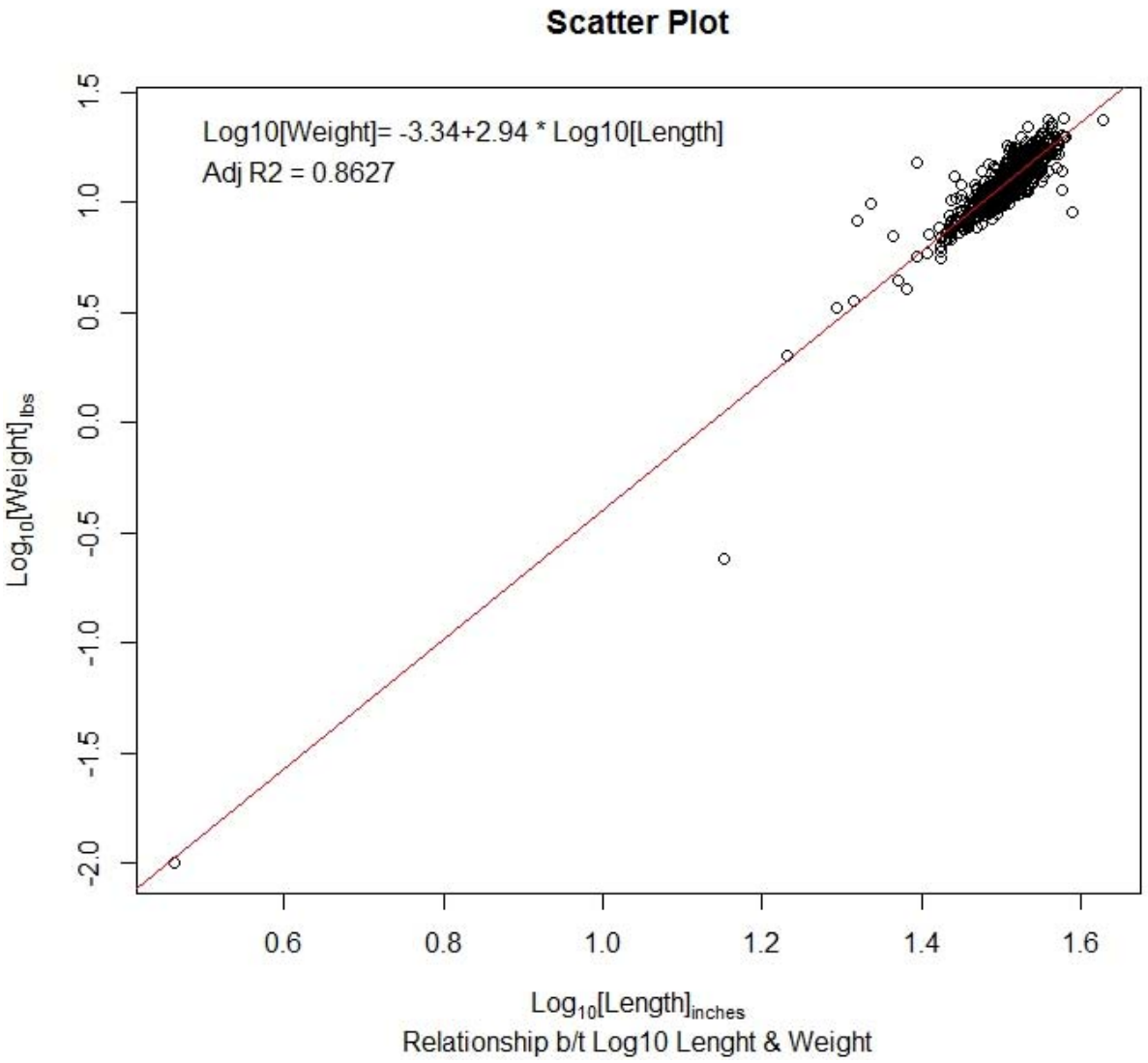


Figure 6. A weight-length regression line of log_{10}-transformed data from silver carp harvested throughout sampled pools during the 2016 sampling seasons.

Project VI: Abundance and Distribution of Early Life Stages of Asian carp in the Ohio River

FINDINGS

Introduction:

Understanding fish assemblages is critical in large-river ecology, especially the growth of nonindigenous fish populations. Until recently, the effects of Asian carp (i.e. bighead carp and silver carp) on native biota has received minimal attention in the Ohio River basin (ORB). Both silver carp and bighead carp are filter feeders that were brought to the United States to control water quality in wastewater treatment lagoons and aquaculture facilities during the 1970's (Kolar et al. 2005). After their escape into natural waters, Asian carp quickly spread throughout the Mississippi, Missouri, and Ohio River basins. Planktivorous species like the bigheaded carps may compete with native biota (e.g. fishes, mollusks, invertebrates) or disrupt trophic interactions (Irons et al. 2007, Sampson et al. 2009). In order to limit the negative impacts of Asian carp populations and their further spread, efforts in the ORB have increased to understand the distribution and abundance of Asian carp in the waters they currently inhabit.

Knowledge of the geospatial ranges for Asian carp in the Ohio River is necessary for evaluating the invasion status of each pool (i.e. the "extent of invasion"). The extent of invasion has three predominant levels (presence front, invasion front, and established front) and is used to guide specific management and control actions in other Mississippi River sub-basins. The "presence front" is the upmost extent of Asian carp capture where densities are low and reproduction has not been documented. The "invasion front" is the location(s) where reproduction (i.e., eggs, embryos, or larvae) has been observed, but recruitment has yet to be documented. Lastly, the "established front" is the location(s) where reproduction and recruitment to the adult life stage is actively occurring. Identifying the specific spatial extents that differentiate the presence, invasion, and established fronts are crucial information that remains unknown for the ORB.

Confirmed Asian carp spawning events have been reported in tributaries (i.e. Wabash River) as far upstream as JT Myers Locks and Dam and signs of spawning (i.e. spawning patches) have been observed as far up river as the Markland pool. Suspected reproduction of nonindigenous *Hypophthalmichthys spp.* has also been suggested as far up river as the Meldahl pool using ichthyoplankton data provided by a private consulting company (EA Engineering) in 2015 and 2016. Last year (2016) marked the first efforts toward targeted sampling for juvenile Asian carp in the Ohio River and the intent was to determine the geographic extent of population recruitment in the ORB.

Objectives:

- Attempt to define the "established" population range of Asian carp in the Ohio River via targeted sampling for juvenile Asian carp.
- Identify characteristics of potential Asian carp nursery areas when juvenile Asian carp are encountered.
- Identify other sources of fish sampling data in the Ohio River that may inform previous objectives.

Methods:

Targeted Sampling and Nursery Habitat Parameters

KDFWR's Critical Species Investigations (CSI) branch conducted targeted sampling for juvenile Asian carp between JT Meyers Locks and Dam and Markland Locks and Dam (Figure 1). Because typical Asian carp nursery habitat (shallow backwater lakes and sloughs) is less prominent along pools in the middle and upper Ohio River, flooded creek mouths and tributaries were assumed to serve as a likely substitute. Tributaries large enough for entrance with a shocking boat were identified and targeted with pulsed DC electrofishing along a 15-minute transect during July and August (Table 1). All fish resembling

Asian carp were dipped and identified. Where Asian carp were encountered, a subsample of lengths and weights were recorded. All fish other than Asian carp were released immediately after capture. In addition, a suite of habitat measurements were collected at each site to describe both the morphology of the tributary as well water quality parameters (Table 2).

Identification of Other Data Sources
Additional sources of information from other projects, reports, and fisheries biologists was identified and data sharing was requested for the 2016 report. Relevant information from these records was summarized and included as supplemental material to help guide future juvenile sampling efforts. Some recommendations on sampling efforts and protocols for this project are based off this supplemental material.

Results:
Targeted Sampling and Nursery Habitat Parameters
This project yielded the first collections of juvenile Asian carp along the sampling range in the ORB (Figure 1). KDFWR crews collectively put over 17 hours of electrofishing effort, covering approximately 314 river miles (Table 1). The majority of juvenile Asian carp were captured by INDNR at two known locations in the JT Myers pool (Hovey Lake and the Inland Marina embayment). In addition, one young-of-year (YOY) silver carp was captured in the Newburgh pool by KDFWR crews in a borrow pit just north of Owensboro, KY. In total, 11 YOY silver carp were captured and removed from these lower pools during the project period (Table 3). Each YOY silver carp was frozen whole and sent to Dr. Gregory Whitledge Ph.D., Southern Illinois University, and are awaiting otolith microchemistry analysis.

Identification of Other Data Sources
Outside of the juvenile project, several notable juvenile fish were captured during other project time-periods. One juvenile silver carp with a TL 231mm was captured in the lower half of Cannelton pool, in Clover Creek, by KDFWR during removal efforts on 30 August 2016. In addition, two larger silver carp with a TL of 500mm and 523mm were captured in the Markland pool using alternating current (AC) around the mouth of Big Indian Creek, OH on 08 September 2016. These fish mark the smallest individuals (absent carp-type larvae or eggs) taken from the river above the McAlpine Locks and Dam structure. Finally, spawning activity within pools was also tracked throughout other projects. Spawning patches in 2016 began to appear on female silver carp around mid-June and had disappeared by late August. Silver carp bearing spawning patches were captured in Cannelton, McAlpine, and Markland. One female bighead with fresh markings from spawning activity was captured on 29 June 2016 in the Meldahl pool in Brush Creek, OH.

The KDFWR Ichthyology Branch also alerted CSI of juvenile Asian carp sightings reported in two ichthyofaunal surveys in 2016 (i.e. Survey and Assessment of the Fish Fauna of the Clarks River National Wildlife Refuge in Marshall, McCracken, and Graves Counties, Kentucky and the Survey of the Fishes of the Lower Ohio River Drainage in the Coastal Plain Province of Western Kentucky). Of the 32 sites sampled within the Clarks River drainage, YOY juvenile (identified as < 127mm in TL) silver carp were found at eight locations using either backpack electrofishing or seining between July and September. In some cases, YOY silver carp were observed schooling in high densities along shallow riffles and runs along both river and creek sites. While all sites were hydrologically connected to pools along the Ohio River where there is known Asian carp recruitment, it is important to note that some locations were well over 40 stream-miles from the main stem of the river.

Discussion:
Results specifically derived from juvenile sampling indicate that the current established range for silver carp is at least as far upstream as Cannelton Lock and Dam. However, as the additional evidence from

other sources above suggest, the established range likely falls somewhere above the Cannelton Locks and dam complex and may extend as far up as the Meldahl pool. Despite efforts in 2016, the spatial extent of silver carp spawning and recruitment in the Ohio River remains a knowledge gap. In addition, with no data on YOY or juvenile bighead carp, it is difficult to speculate on their establishment range in the ORB despite signs that spawning activity is likely in the Meldahl pool. Additional years of data collection and coverage along a broader spatial scale will likely begin to provide an understanding of Asian carp early life history among pools. This information should be used to target carp on a pool-by-pool basis and aid in strategic population control measures for the ORB

Recommendations

It was recommended that INDNR take the lead on managing and coordinating this project. INDNR currently has full records on all data for work conducted in the ORB and a full, technical report of basin-wide efforts and findings can be viewed at asiancarp.us. KDFWR is planning to assist INDNR in the same capacity during the 2017 sampling season as the agency has in the previous season.

In addition, based on data gathered in 2016, it is recommended that juvenile sampling continue with a higher emphasis on larval sampling. It is likely that spawning in 2017 will occur during a similar timeframe as seen in 2016, but may occur earlier due to warmer weather conditions. Asian carp spawning activities should continue to be tracked during all projects on the Ohio River, and records should be used to help guide the timing of juvenile sampling efforts in order to determine pools where recruitment is occurring.

Finally, due to several reports and personal communications of confirmed presences of YOY silver carp farther inland than was originally expected, it may be important to discuss whether exploration of recruitment from tributaries is an important contributing factor to population growth within each Ohio River pool. Also, results from this sampling should be aimed at providing recommendations and guidance for removal efforts in 2018.

Project Highlights:

- Confirmed Asian carp spawning events have been reported in tributaries (i.e. Wabash River) as far upstream as JT Myers Locks and Dam.
- Signs of spawning (i.e. spawning patches) have been recorded as far up river as the Markland pool.
- Suspected reproduction of nonindigenous *Hypophthalmichthys spp.* has been suggested as far up river as the Meldahl pool using ichthyoplankton data provided by a private consulting company (EA Engineering) in 2015 and 2016.
- 2016 marked the earliest efforts toward targeted sampling for juvenile Asian carp in the Ohio River with the intent to determine the geographic extent of population recruitment in the ORB.
- KDFWR's Critical Species Investigations (CSI) branch conducted over 17 hours of targeted sampling for juvenile Asian carp between JT Meyers Locks and Dam and Markland Locks and Dam (Figure 1).
- In total, 11 YOY silver carp were captured and removed from these lower pools during the project period (Table 3).
- Results specifically derived from juvenile sampling indicate that the current established range for silver carp is at least as far upstream as Cannelton Lock and Dam but additional evidence suggests that silver carp are likely established farther upstream.
- With no data on YOY or juvenile bighead carp, it is difficult to speculate on their established range in the ORB despite signs of spawning activity in the Meldahl pool.

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Table 1. Electrofishing effort conducted by several agencies within each pool of the juvenile sampling range from 25 July through 18 August, 2016.

		Effort (hrs) by Agency Crews in Four Pools of the ORB				
Agency	Crew	JT Myers	Newburgh	Cannelton	McAlpine	Total
KDFWR	CSI - F	0.0	0.0	7.5	6.0	13.5
KDFWR	CSI - M	1.9	2.2	0.0	0.0	4.1
INDNR	Big Rivers	4.5	3.0	0.0	0.0	7.5
USFWS	Carterville	0.0	0.0	8.5	7.0	15.5
Total Pool Effort		6.4	5.2	16.0	13.0	40.6

Table 2. A list and desctription of habitat parameters taken after each 15-minute transect during juvenile sampling in 2016

labitat Observations/Parameter	**Description**
Asian Carp Presence	A binary variable noting the observed presence of Asian carp within the 15-minute transect sampled
Aquatic Vegetation Presence	A binary variable noting the observed presence of submerged or emergent aquatic vegetation
Average Depth	The average depth along the entire 15-minute electrofishing transect
Average Width	The average width along the entire 15-minute electrofishing transect
Conductivity	A measurement of the conductivity of the water within the first half-meter of water depth in microsiemens per centimeter (µS/cm)
Dissolved Oxygen	A measurement of the level of dissolved oxygen within the first half-meter of water depth in milligrams per liter (mg/L)
Juvenile Asian Carp Presence	A binary variable noting the observed presence of Asian carp < 200mm within the 15-minute transect sampled
Maximum Depth	The deepest depth recorded during the 15-minute electrofishing transect
pH	A measurement of the acidity of the water within the first half-meter of water depth
River Stage	The recorded river height (in feet) at gauge stations above and below the pool being sampled
Secchi Depth	A measurement of the water clarity (in inches) within the 15-minute transect
Water Color	A subjective description of the water color using six color options (Clear, Amber, Brown, GreenBrown, Green, or Other)
Water Temperature	A measurement of the water temperature within the first half-meter of water depth in degrees Celsius (˚C)
Water Velocity	A tertiary variable noting the observed surface velocity at the midpoint of the 15-minute transect
Woody Debris Presence	A binary variable noting the observed presence of usable woody debris along the 15-minute transect

Table 3. The date, pool, and specific location of all YOY Asian carp captured during juvenile sampling in 2016

Date	Pool	Specific Location	Total Length (mm)
7/25/2016	Newburgh	Borrow Pit 2	73
7/28/2016	Myers	Hovey Lake	60
7/28/2016	Myers	Hovey Lake	75
7/28/2016	Myers	Hovey Lake	75
7/28/2016	Myers	Hovey Lake	76
7/28/2016	Myers	Hovey Lake	78
7/28/2016	Myers	Hovey Lake	81
7/28/2016	Myers	Hovey Lake	82
7/28/2016	Myers	Hovey Lake	100
8/11/2016	Myers	Hovey Lake	98
8/11/2016	Myers	Hovey Lake	108

Project VII: Control and Removal of Asian carp in the Ohio River

FINDINGS

Introduction:
Eradication of invasive species after establishment is difficult and often limited by available resources. Since their introduction in the Mississippi River basin, Asian carp (silver carp, bighead carp, and grass carp) have steadily increased their range (Kolar et al. 2005) and may densely colonize river reaches, affecting the native food webs in large river ecosystems (Irons et al. 2007, Freedman et al. 2012). Prevention and rapid response are the best tools for limiting establishment of costly invasive species and physical removal of Asian carp in the Ohio River basin may be an effective tool to slow their upriver expansion.

Recent studies on Asian carp harvest programs in the Illinois River show that the collapse of silver and bighead carp populations are possible if all fish sizes are targeted (Tsehaye et al. 2013). Diverse and consistent removal efforts in portions of the Ohio River where Asian carp are established may disrupt upriver movement of Asian carp, decrease pressure on defined barriers, and reduce numbers of Asian carp in sensitive areas to protect species of conservation need or important sport fisheries. Removal efforts also provide data on the population parameters for Asian carp in higher density pools of the Ohio River Basin (ORB). This data will provide an assessment tool that will guide monitoring, barrier defense, and population control efforts in future years.

Objectives:
- Remove Asian carp from portions of the Ohio River where they are established.
- Pursue novel gear types, attractants, and the use of sound to congregate Asian carp for capture.
- Identify private entities that have a use for removed fish and support the creation of Asian carp markets as possible.
- Encourage removal of all size classes of Asian carps in the commercial fishery.

Methods:
Removal efforts in 2016 were confined to Ohio River pools below Markland Lock and Dam (Figure 1). This was a change from 2015 in order to focus removal efforts in higher density pools where the largest impact could be made. All removal or tagging efforts conducted in pools above Markland Lock and Dam are reported in the Leading Edge Asian Carp Suppression project for the 2016 sampling season.

Physical Removal of Asian Carps
Electrofishing and gill netting for removal in 2016 were conducted for approximately 18 weeks from May through September. Removal took place a minimum of 4 days per week. Electrofishing was not standardized, but total effort (hours) was recorded. Pulsed DC electricity at 40% duty-cycle and 80 pulses per second was used most often and voltage was adjusted to attain maximum power for each run. Large mesh (4.0" – 5.0") gill nets were used with each set consisting of a minimum 180 minutes of soak time with fish being driven toward the nets with boat noise at 30-minute intervals. Nets were occasionally set overnight in areas where they did not create hazards to navigation.

Sampling sites focused on tributaries and embayments where densities of Asian carp are highest and fish are easiest to capture. The majority of these locations were derived from monitoring sampling sites in 2015 and 2016. Some effort was expended to investigate additional sites that were either remotely identified using GIS and map study or contained characteristics of typical carp habitat; however, the majority of effort was spent in known, high-density locations where the largest impact could be made.

All Asian carps and by-catch were identified to species. All carp were inspected for tags (either jaw or ultrasonic VEMCO tags) before being euthanized for population control or tagged for the Ohio River Telemetry project. All by-catch was immediately returned to the water upon recovery. Asian carp species (bighead carp, silver carp, and grass carp) from each sampling location were measured for total length (in) and weight (lbs) to provide estimates of the minimum total weight harvested. When possible, supplemental data included a record of sex and a collection of aging structures (spines) for each silver or

bighead carp captured (Williamson and Garvey 2005, Seibert and Phelps 2013). In addition to spines, some otoliths were taken for microchemistry analysis. These samples were sent to Dr. Gregory Whitledge Ph.D., Southern Illinois University, and are awaiting analysis.

Pursuit of Novel Capture Techniques
Several novel techniques were explored during removal in 2016. These efforts were intended to inform basin partners on strategies and gears that may effectively target carp for population control in the future. However, because the primary goal during this project was to remove carp and reduce propagule pressure, little time was given to conducting controlled experiments to specifically test the effectiveness of each technique.

A four-foot, winged hoop net was purchased and modified with the intention of testing its utility when targeting Asian carp at known high-density locations. This gear was appealing due to existing literary references when targeting bighead carp and because it could be left unmonitored for several days at a time. Hoop nets were fished over a 48-hour period on three separate occasions. Nets were set well below the surface in flow, with throat facing downstream, and the two 25-ft wings positioned to either side to act as a corral for fish swimming upriver towards the throat.

Night electrofishing was attempted on three occasions where carp were known to congregate. An electrofishing boat was outfitted with four LED floodlights at the bow allowing the driver and dipper to navigate and capture fish in the dark. An additional floodlight was positioned at the stern of the boat for rear visibility and a spotlight could be used by the driver to visually investigate any objects outside of the of the floodlight range. Electrofishing was not standardized, but total effort was recorded. Pulsed DC electricity at 40% duty-cycle and 80 pulses per second was used and voltage was adjusted to attain maximum power goals for each run.

The use of boat electrofishing as a herding tool, in combination with top-set gill nets, was also employed as a removal technique. Large mesh, floating gill nets were set in areas where fish could be pushed into entanglements. Because of the large amount of variation between sets and sites there was no effort to maintain consistency in the design or implementation of this technique. In addition, these captures were achieved during the combination of active boat electrofishing and passive net sets and comparisons between individual gears were never made.

Collaborative work between USGS, KDFWR, and USFWS was conducted using sound equipment and attractants in an effort to herd or congregate fish in low-density areas of the Ohio River during the month of August. Gill nets were used to block off sections of a tributary into defined reaches. Then complex sound was applied in an effort to herd fish downstream towards an entanglement. In addition to using sound, an automatic feeder was set up in an attempt to congregate fish around the feeder for easier capture. No data was collected associated with the feeder's ability to increase densities of carp because the platform was destroyed during a heavy rain event.

Support Creation of Asian Carp Markets
The Kentucky Department of Fish and Wildlife Resources executive leadership is currently working with private business and commercial anglers to aid in furthering the development of an Asian carp fishing industry in Kentucky. Several barriers for a successful industry start-up have been identified and multiple strategies are being developed to address some of the logistical hurdles to increase the productivity of the market. One strategy being assessed is the feasibility of a partnership is to between commercial anglers, processors, and KDFWR to overcome some startup costs and training of new fisherman.

Results:
Physical Removal of Asian Carps
A total of 90.45 hours were spent electrofishing in four pools of the Ohio River and its tributaries between Newburgh and Markland Lock and Dam (Table 1). Fifteen thousand and twenty-one carp were removed using DC-pulsed electrofishing over these four pools in 2016. The highest level of effort was expended in the Cannelton pool where a total number of 1,297 carps, weighing approximately 16,445lbs, were removed. Total effort and capture numbers accounted for in this report include some time and effort

placed into the Abundance and Distribution of Juvenile Asian Carp project. However, this report does not contain all effort in the pools where juvenile sampling took place. For more detail on effort and removal conducted during juvenile sampling in 2016, please refer to that report.

A total of 6,745ft of large mesh (4" and 5" bar) gill nets were used in capturing 21 invasive carps in the Cannelton and McAlpine pools (Table 2). This amounted to 353lbs of bighead and silver carp combined. The largest amount of effort was expended in the Cannelton pool with 4,090ft of gill net fished to remove 16 fish, weighing approximately 233lbs.

Pursuit of Novel Capture Techniques
Winged hoop nets were fished for a total of 144 hours; however, they did not require crews to be present for fish capture. All other techniques required crews to be present and less effort could be dedicated to investigate their use. No carp were captured using the hoop net, and by-catch was high. Hoop nets were the only gear that included sportfish species as by-catch. Nets were deliberately set at sites where electrofishing and gill nets have consistently caught Asian carp (particularly bighead carp) in the past.

Sound herding into net entanglements did not produce any carp captures. On one occasion in Eagle Creek (Meldahl pool), a tagged bighead carp was located near the mouth of the tributary using manual tracking. Nets were placed downstream of the fish and sound was applied in an attempt to move the fish closer to the net set. After sound application was finished, manual tracking revealed that the fish did not appear to have moved in the intended direction. Additional replications of this design were cut short by poor weather conditions and no conclusions about the utility of this technique could be made.

The use of boat electrofishing in combination with gill nets captured 11 total carp, but usually included by-catch in gill nets. Three bighead carp were captured, which have been difficult to catch using established gear types. Night electrofishing captured seven silver carp in total and resulted in no captures of bighead carp. This method did not produce any by-catch since carp could be visually targeted by the dipper, but carp are more difficult to chase and dip in the dark so a higher proportion eluded the dipper during these runs.

As mentioned above, calculating capture efficiencies for novel techniques was not attempted due to variations in the gear, set characteristics, duration of application, and site characteristics. However, an attempt to quantify the total effort, in hours, for each method was tracked along with the resulting catch of targeted fish. In addition, by-catch from each technique was tracked to gain an idea of a particular strategy's ability to specifically target carp (Table 3).

Support Creation of Asian Carp Markets
In 2015, over 1 million pounds of Asian carp were harvested from Kentucky waters and sold to processors within various domestic and exported markets. In 2016, commercial fisherman participating in the Asian Carp Harvest Program in Kentucky waters yielded ~1.4 million pounds of carp which were also sold to various markets. Executive leadership in the KDFWR agency has gained an understanding of how commercial fishers and processors operate from inquiries conducted over these two years and have identified several limiting factors in growing the industry.

Removal in Other Projects
While removal was not listed as a primary objective in other ORB projects, Asian carp captured during any sampling on the Ohio River were euthanized unless they were tagged for tracking purposes. Accounts of 51 additional fish captured outside of this project were removed from the system during monitoring and leading edge projects. Details on these additional fish captured during non-targeted sampling are not included here, but are mentioned in each respective ORB report. Considering this, the numbers of removed fish referenced here should be considered a minimum total count of targeted Asian carps removed during the 2016 sampling season.

Discussion:
Because removal was confined to the lower pools of the invasion front in 2016, efforts from 2015 are only comparable on a pool-by-pool basis. Despite this, electrofishing conducted within the removal framework

in 2016 was about a 100% increase in effort when compared to work completed in all five pools sampled in 2015. In addition, there was roughly a 340% increase in catch of targeted carp with the bulk of those captures being in the Cannelton and McAlpine pools. The disproportional increase in catch, when compared to the increase in effort, can be partially attributed to the redirection of effort to higher density pools; but this increase is also likely due to better site selection and increased experience among removal crews. An electrofishing technique involving more aggressive movements and a sinuous pattern along structure was developed for targeting silver carp and needs to be further developed and compared to other capture techniques. It is also necessary to begin standardizing effort between these runs now that a specific electrofishing technique has been developed. This will likely give more precise estimates of silver carp abundances by pool. These estimates may be useful for model-based applications leading to more informed removal and measures of performance on an annual basis.

Gill netting efforts in Cannelton and McAlpine pools alone were approximately equivalent to all the effort placed into the five pools previously targeted for removal in 2015. Total catch in Cannelton and McAlpine also increased (over 160%) when compared to total carp captured by gill netting in all pools in 2015. Again, this can be partially attributed to the focus in higher density pools and increased crew experience. Gill net designs in 2016 were also different from those used in 2015 and the new design appeared to have slightly better success when targeting carp than previous sets.

No quantitative comparisons can be made between alternative methods used during removal. However, it did appear that both night electrofishing and the combination of boat electrofishing with gill nets produced higher success rates than the other alternative techniques. With the lack in ability to target bighead carp using conventional gears on the Ohio River, it may be important to pursue the use of combined electrofishing runs and gill net sets to target bighead in the future. Exploration of these gears needs to be better structured during future removal efforts if direct comparisons are to be made between alternative techniques.

Recommendations:

We recommend that removal continue in the Cannelton and McAlpine pools with more emphasis on comparing gear types for targeted efficiency. Electrofishing runs during removal should be conducted in consistent time intervals to make CPUE data more comparable across sites for better relative abundance estimates. These estimates may be important for data-driven modeling and more productive population control during future removal seasons. Variations in sampling techniques should be tracked consistently and total man-hours should be recorded for each activity to gain a better assessment of the costs and benefits for strategies using multiple gears or novel removal methods. Target parameters should be established to provide a measurement of population control efforts; this would allow for informed decisions on a regular basis when considering adaptive management strategies.

Project Highlights:

- Prevention and control are currently the best tools for limiting establishment of costly invasive species. Physical removal of Asian carps in the Ohio River basin may be an effective tool to slow their upstream expansion.
- Removal in 2016 was altered from removal conducted in 2015 in order to focus removal efforts in higher density pools were larger impacts could be made.
- Electrofishing conducted in JT Myers though McAlpine pools in 2016 produced about a 100% increase in effort and a 340% increase in catch when compared to work completed in all five pools sampled in 2015.
- Gill netting efforts in Cannelton and McAlpine alone were approximately equivalent to all the effort placed into the five pools previously targeted for removal in 2015. Total catch increased (over 160%) when compared to removal in all pools in 2015.
- Both night electrofishing and the combination of boat electrofishing with gill nets produced higher success rates than the other alternative techniques.
- It may be important to pursue the use of combined electrofishing runs and gill net sets to target bighead carp in the future.

- Exploration of novel gears needs to be better structured in order to make direct comparisons between alternative techniques.
- Development of target parameters should be established to provide a measurement of population control efforts and be used to inform decisions on regular basis for adaptive management strategies.

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Table 1. Electrofishing effort (hours) and resulting catch of three species of Asian carp (number and weight) in four pools of the Ohio River during Asian carp removal efforts in 2016.

Pool	Electro Hours	Bighead Carp (N)	Silver Carp (N)	Grass Carp (N)	Total (N)	Bighead Carp (Lbs)	Silver Carp (Lbs)	Grass Carp (Lbs)	Total (Lbs)
McAlpine	30.95	1	201	0	202	50	2881	0	2931
Cannelton	55.37	9	1274	14	1297	165	16045	235	16445
Newburgh	2.25	1	16	0	17	4	136	0	140
JT Myers	1.88	0	5	0	5	0	40	0	40
Total	90.45	11	1496	14	1521	219	19102	235	19556

Table 2. Gill netting effort (ft) and resulting catch of three species of Asian carp (number and weight) in four pools of the Ohio River during Asian carp removal efforts in 2016.

Pool	Electro Hours	Bighead Carp (N)	Silver Carp (N)	Grass Carp (N)	Total (N)	Bighead Carp (Lbs)	Silver Carp (Lbs)	Grass Carp (Lbs)	Total (Lbs)
McAlpine	2655	1	4	0	5	56	64	0	120
Cannelton	4090	1	15	0	16	32	201	0	233
Newburgh	0	0	0	0	0	0	0	0	0
JT Myers	0	0	0	0	0	0	0	0	0
Total	6745	2	19	0	21	88	265	0	353

Table 3. Effort (hours) expended into exploring novel capture techniques and the total resultant capture of Asian carps produced using each method.

		Total Captures (N)				
Capture Technique	Effort (hrs)	Bighead Carp	Silver Carp	Grass Carp	Totals	By-Catch
Winged Hoop Net	144.00	0	0	0	0	YES
Night Electrofishing	4.50	0	7	0	7	NO
Boat EF Herding w/ Nets	9.00	3	8	0	11	YES
Sound Herding w/ Nets	8.00	0	0	0	0	YES
Attractants	N/A	N/A	N/A	N/A	N/A	N/A

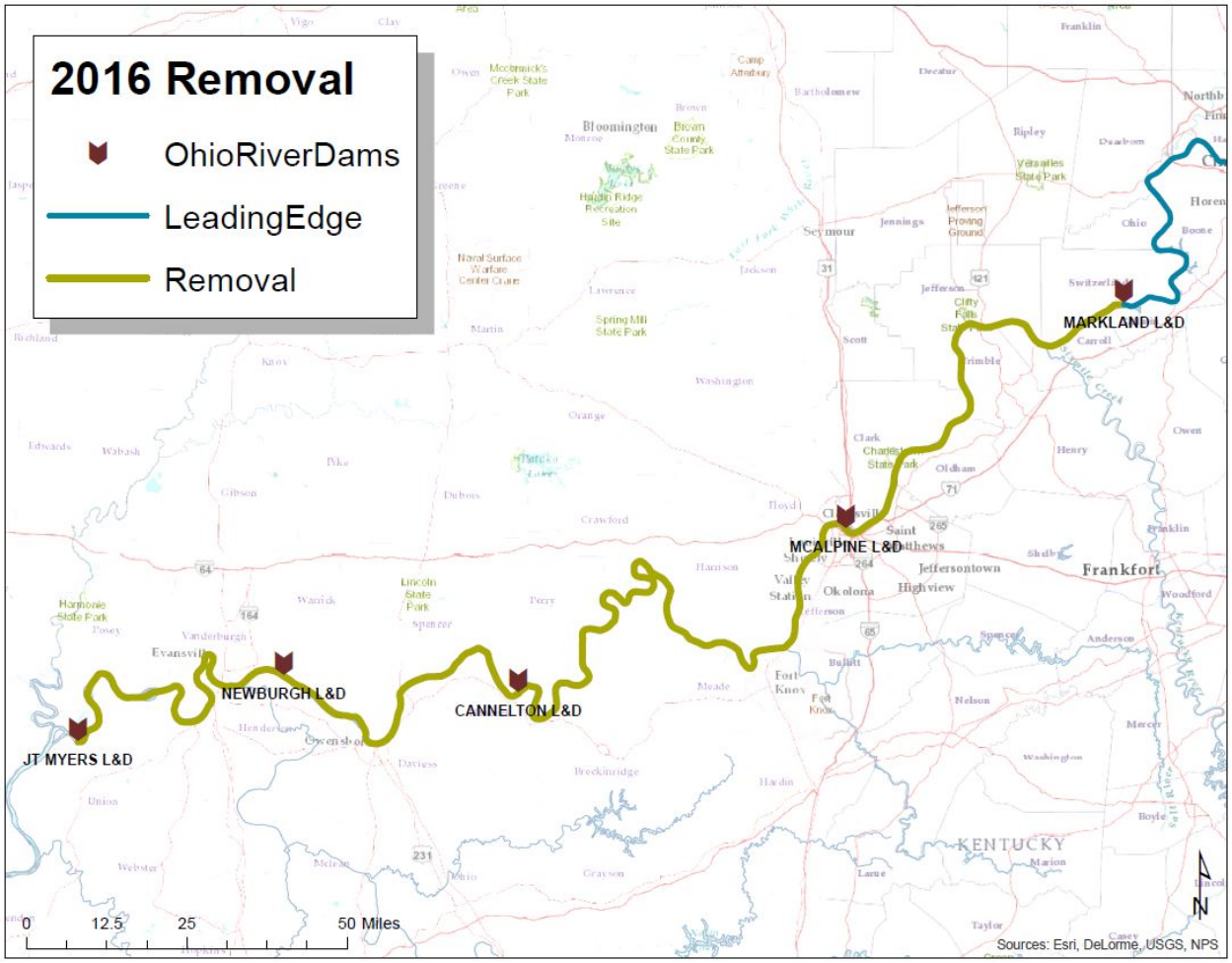

Figure 1. A map highlighting the four pools of the Ohio River where Asian carp removal was conducted in 2016.

Project VIII: The Leading Edge Suppression of Asian carp in the Ohio River

FINDINGS

Introduction:
Eradication of invasive species after establishment is difficult and often limited by available resources. Since their introduction in the Mississippi River basin, Asian carp (silver carp, bighead carp, and grass carp) have steadily increased their range. Asian carp rapidly and densely colonize river reaches affecting the native food web in large river ecosystems (Irons et al. 2007, Freedman et al. 2012). As a result, significant funding has been allocated in the basin to limit the impacts of Asian carp where they exist as well as halt their spread into uninhabited waters.

Diverse and consistent removal efforts where Asian carp densities are relatively high may disrupt upriver movement of Asian carp. However, there are few tools available to limit the negative impacts of Asian carp and their spread into new waters. Integrated pest management approaches include barrier technologies that prevent movement of the Asian carps into critical areas as well as the targeted removal of Asian carp below barriers to decrease propagule pressure (Tsehaye et al. 2013). Planning and implementation of barriers to Asian carp movement are widely believed to be an important aspect of the control of Asian carp in the Mississippi River basin. However, planning barrier projects requires an understanding of the distribution and abundance of invading populations, which requires years of data collection. Urgent efforts to gather this data in the Ohio River basin began in earnest in 2015 and will continue in the foreseeable future. In the meantime, the best tool for limiting impacts and dispersal of Asian carps is the physical removal of fish.

For this project, the term “leading edge” was intended to define the geographical range where carp populations are noticeably lower when compared to adjacent downstream locations. The bottom of this range is generally accepted to be McAlpine Lock and Dam (RM 606); above this point, there is a prominent decrease in carp abundances. Multi-agency sampling and removal projects have successfully targeted Asian carp along this reach, but the effort required is usually extensive. Removal of Asian carp along this stretch of river reduces the number of Asian carp moving upstream, lessens the likelihood of successful reproduction, and buys managers time to plan and implement potential barriers to Asian carp movement.

Objectives:
- Remove Asian carp from the leading edge of invasion along the Ohio River, above river-mile (RM) 606.
- Compare methodologies and gear types to increase efficiency of Asian carp removal.
- Provide data for monitoring and response efforts and utilize active telemetry to inform removal efforts.

Methods:
Leading Edge effort in 2016 was originally defined as work in Ohio River pools above RM 606. Due to a geographical overlap with the Control and Removal project and a higher focus on decreasing propagule pressure in the McAlpine pool, efforts in McAlpine were treated as an extension of the Control and Removal project. This report focuses on effort placed into the pools above Markland Lock and Dam (Figure 1). All other removal effort below Markland Locks and Dam is reported in the 2016 Control and Removal of Asian Carp report. This was altered from removal conducted in 2015 in order to focus removal efforts in higher density pools were the largest impact could be made. Leading Edge efforts typically focused more on tagging fish for tracking purposes and some removal of fish that looked in too poor of a condition to tag along the invasion front. Some manual tracking was conducted in the Racine pool in 2015; however, manual tracking was not conducted in 2016 due to limited man-power.

Physical Removal of Asian Carps
Electrofishing and gill netting along the “leading edge” of invasion in 2016 were conducted for roughly 18 weeks from May – September. Electrofishing was not standardized, but total effort (hours) was recorded. Pulsed DC electricity at 40% duty-cycle and 80 pulses per second was used most often and voltage was

adjusted to attain maximum power for each run. Large mesh (4.0" – 5.0") gill nets were used, with each set consisting of a minimum 180 minutes of soak time, while fish were driven toward nets with boat noise at 30-minute intervals.

Sampling sites focused on tributaries and embayments (mimicking site selection and protocols from lower pools) where densities of Asian carp were likely the highest and fish were easiest to capture. The majority of these locations were derived from monitoring sampling sites in 2015 and 2016. Some effort was expended to investigate additional sites that were either remotely identified through GIS and map study or contained features characteristic of typical carp habitat.

All Asian carps and by-catch were identified to species. All carp were inspected for tags (either jaw or ultrasonic VEMCO tags) before being euthanized for population control or tagged for the Ohio River Telemetry project. All by-catch was returned to the water. Asian carp species (bighead carp, silver carp, and grass carp) from each sampling location were measured for total length (in) and weight (lbs) to provide estimates of the minimum total weight harvested. When possible, supplemental data included a record of sex and a collection of aging structures (spines) for each silver or bighead carp captured (Williamson and Garvey 2005, Seibert and Phelps 2013). In addition to spines, some otoliths were taken for microchemistry analysis. These samples were sent to Dr. Gregory Whitledge Ph.D., Southern Illinois University, and are awaiting analysis.

Pursuit of Novel Capture Techniques

Several novel techniques were explored throughout the months of leading edge work in 2016. These efforts were intended provide basin partners with information on strategies and gears that may more effectively target carp for suppression in the future. This same information is covered in the Control and Removal of Asian Carp project it is not reported in detail here. The only alternative techniques used in the pools along the leading edge of invasion were winged hoop netting, sound herding, attractants and night electrofishing. A short description of each is provided below.

A four-foot, winged hoop net was purchased and modified with the intention of testing its utility when targeting Asian carp at known high-density locations. This gear was appealing due references citing its use when targeting bighead carp and because it could be left unmonitored for several days at a time. Hoop nets were fished over a 48-hour period on three separate occasions. Nets were set well below the surface in flow, with throat facing downstream, and the two 25-ft wings positioned to either side to act as a corral for fish swimming upriver towards the throat.

Night electrofishing was attempted on two occasions in RC Byrd where the presence of a group of bighead carp elicited an emergency response effort. An electrofishing boat was outfitted with four LED floodlights at the bow allowing the driver and dipper to navigate and capture fish in the dark. An additional floodlight was positioned at the stern of the boat for rear visibility and a spotlight could be used by the driver to visually investigate any objects outside of the of the floodlight range. Electrofishing was not standardized, but total effort was recorded. Pulsed DC electricity at 40% duty-cycle and 80 pulses per second was used and voltage was adjusted to attain maximum power for each run.

Collaborative work between USGS, KDFWR, and USFWS was conducted using sound equipment and attractants in an effort to herd or congregate fish in low-density areas of the river during one week in the month of August. Gill nets were used to block off sections of a tributary into defined reaches. Then complex sound was applied in an effort to herd fish downstream towards an entanglement. In addition to using sound, an automatic feeder was set up in an attempt to congregate fish around the feeder for easier capture. No data was collected in association with the feeder's ability to increase densities of carp because the platform was destroyed during a storm.

Results:

Physical Removal of Asian Carps

A total of 34.98 hours were spent electrofishing in the four Ohio River pools and tributaries from Markland up through RC Byrd pool (Table 1). Ten carp totaling 195lbs were removed along the leading edge. The largest amount of electrofishing effort was expended in the Markland pool where seven silver carp and

three grass carp made up the entirety of fish removed via boat electrofishing for this project. All other fish captured with electrofishing were tagged for the Telemetry of Asian Carp in the Ohio River project.

Gill netting totaled 8,135 ft of net fished to capture six bighead carp and one silver carp in the four pools along the leading edge (Table 2). The majority of effort was placed in Meldahl pool, where only one bighead carp was captured. Four bighead carp were captured by USFWS using gill nets in the RC Byrd pool after receiving reports of carp frequenting a tributary just upriver of Greenup Lock and Dam.

Pursuit of Novel Capture Techniques
Calculating capture efficiencies for novel techniques was not attempted due to variations in the gear, set characteristics, duration of application, and site characteristics. However, the total effort (hrs) used to employ each method was quantified, along with the resulting catch of targeted fish. In addition, by-catch from each technique was documented. A summary of this information can be found in Table 3 of the 2016 Control and Removal of Asian Carp in the Ohio River report.

Sound herding into net entanglements did not produce any carp captures. On one occasion in Eagle Creek (Meldahl pool), a tagged bighead carp was located near the mouth of the tributary using manual tracking. Nets were placed downstream of the fish and sound was applied in an attempt to move the fish closer to the net set. After sound application was finished, manual tracking revealed that the fish did not appear to have moved in the intended direction. Additional replications of this design were cut short by poor weather conditions and no conclusions about the utility of this technique could be made. Other novel techniques in these lower density pools did not produce many results.

Discussion:
Total captures of invasive bighead carps across all activities in the pools along the leading edge were low. While more detail will be provided in the 2016 report covering acoustic telemetry efforts in the ORB, it should be noted that some contributions were made to the 110 fish tagged in the pools between McAlpine and RC Byrd Locks and Dams during this time. To avoid redundancy, all information pertaining to those fish captured along the leading edge are included in a separate report for that project.

Overall, electrofishing seems slightly more effective for capturing carp in the low-density pools along the leading edge. Due to their lower numbers, electrofishing may be a better gear to utilize when seeking out groups of silver carp. Electrofishing allows for greater coverage when surveying for the presence of these fish than gill nets. Netting is often limited by the number of nets that can be deployed over a stretch of river and the man-hours required to run and maintain them. However, boat electrofishing rarely yields bighead carp captures and nets remain the better choice when targeting these fish. It is important to mention that this work is conducted during the day, in warmer months of the year. Reports of greater success when targeting *Hypophthalmichthys spp*. at night and in cooler the months suggests that some gears may be more successful if when deployed during these times.

With reports of fish being seen above Greenup Locks and Dam, removal effort in the RC Byrd pool and tagging efforts in the Greenup pool are likely to increase. The four bighead carp caught in RC Byrd were euthanized because they had exceeded the verbally agreed-upon, exclusion point for tolerable upriver expansion. With dam passage being a main objective of the telemetry efforts in the Ohio River, a better understanding of the rate of passage will likely inform response activities and removal efforts in future leading edge projects. This was the first year where the leading edge project was separated from removal efforts. Tailoring this work to fit the needs of the basin is currently under discussion and will be important for future progress.

Recommendations:
A focus on suppression and containment of carp populations along the leading edge should guide the future progress of this project. It may be necessary to better structure activities in order to develop a response plan that defines pool-specific goals for halting upriver expansion of carp populations. Ideally, carp captured between Markland Lock and Dam and RC Byrd Lock and Dam should be tagged if possible before being euthanized in order to maintain and grow the number of tagged fish in lower density pools. Any Asian carp that move past the RC Byrd Locks and Dam should be targeted for removal.

Project Highlights:

- The Leading Edge project was separated from removal conducted in 2015.
- Work conducted along the leading edge still involves removal of carp, but places more focus into tagging fish below Greenup Locks and Dam.
- There is need of an upper boundary defining the exclusion point for tolerable upriver expansion. Currently, Asian carps above RC Byrd Lock and Dam are considered too far up the system and are targeted for removal.
- A total of 34.98 hours were spent boat electrofishing along with 8,135ft of gill net worked to remove 600lbs of Asian carps from the pools between Markland and RC Byrd Locks and Dams.
- Efforts to tag fish contributed to the 110 individuals surgically implanted with transmitters along the leading edge in 2016.
- Due to the lower numbers of invasive carps in these pools, electrofishing may be better utilized when seeking out groups of silver carp.
- Gill netting remains the more effective gear to use when targeting bighead carp.
- This was the first year where the Leading Edge project was separated from removal efforts in 2015 and a focus on suppression and containment of carp populations along the leading edge should guide future progress.

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Table 1. Electrofishing effort (hours) and resulting removal of three species of Asian carp (number and weight) in four pools of the Ohio River during Asian carp Leading Edge efforts in 2016.

Pool	Electro Hours	Bighead Carp (N)	Silver Carp (N)	Grass Carp (N)	Total (N)	Bighead Carp (Lbs)	Silver Carp (Lbs)	Grass Carp (Lbs)	Total (Lbs)
RC Byrd	8.15	0	0	0	0	0	0	0	0
Greenup	2.67	0	0	0	0	0	0	0	0
Meldahl	9.68	0	0	0	0	0	0	0	0
Markland	14.48	0	7	3	10	0	106	89	195
Total	34.98	0	7	3	10	0	106	89	195

Table 2. Gill netting effort (ft) and resulting removal of three species of Asian carp (number and weight) in four pools of the Ohio River during Asian carp Leading Edge efforts in 2016.

Pool	Electro Hours	Bighead Carp (N)	Silver Carp (N)	Grass Carp (N)	Total (N)	Bighead Carp (Lbs)	Silver Carp (Lbs)	Grass Carp (Lbs)	Total (Lbs)
RC Byrd	1800	4	0	0	4	266	0	0	266
Greenup	900	0	0	0	0	0	0	0	0
Meldahl	3640	1	0	0	1	62	0	0	62
Markland	1795	1	1	0	2	53	24	0	77
Total	8135	6	1	0	7	381	24	0	405

Figure 1. A map showing where Asian carp leading edge work was conducted in 2016. No effort was placed in the Racine pool in 2016; however, some manual tracking was conducted in 2015.

Project IX: Distribution, Movement, and Lock & Dam Passage of Asian Carp in the Ohio River Through Acoustic Telemetry

FINDINGS

After their discovery in waterbodies throughout the lower Mississippi River Basin during the 1980's, Asian Carp utilized their remarkable mobility to quickly spread up the main river. Upon reaching the confluence of the Ohio River, populations of both Bighead Carp (*Hypophthalmichthys nobilis*) and Silver carp (*H. molitrix*) expanded into the lower Ohio River Basin (ORB) and its many tributaries. These two species of invasive Asian Carp are now prevalent throughout the lower and parts of the middle Ohio River Basin and successful spawning is suspected as far upriver as the McAlpine Lock and Dam. However, there are some pools and tributaries of the middle Ohio River that are like the upper ORB in that they still do not contain any established Asian Carp populations. Many state and federal agencies throughout the basin have made it one of their top priorities to prevent the Asian carp from expanding into these areas. The importance of these preventative efforts increased once the Great Lakes and Mississippi River Interbasin Study (GLMRIS) concluded that tributaries of the upper ORB provided as many as six potential routes that Asian Carp could use to gain access to the Great Lakes. It has long been recognized that their introduction into any of the Great Lakes could cause irreparable damage to some very important commercial and recreational fisheries. Despite having a reasonable understanding about the potential impacts of a newly established population, several Fish & Wildlife agencies have realized that there's still much to learn about the life history of Asian Carp within North American waters. As a result, a handful of these agencies have combined resources in an effort to learn as much as possible about the dynamics of these Bighead Carp and Silver Carp populations. This knowledge could provide assistance to the ongoing efforts to prevent the Asian Carp from advancing further upriver and even possibly lead to successful control of these invasive species. The Ohio River Asian Carp Telemetry Project is one of these multi-agency research efforts, and it uses ultrasonic acoustic telemetry to better understand the distribution and movements of Bighead Carp and Silver carp. The project will provide some early detection if Asian Carp happen to move into new areas of the river, but more importantly, it could substantially increase the effectiveness of control efforts by providing reliable information on when/where the Asian Carp are likely to be congregated.

<u>Asian Carp Telemetry Project Objectives:</u>

- Understand use of tributaries for potential recruitment and routes of invasion into adjacent basins.
- Delineate the upstream population distribution and potential for further upstream dispersal.
- Use telemetry data to inform agency sampling efforts.
- Quantify passage of Asian carp at Ohio River locks and dams.

The Asian Carp Telemetry Project relied on a relatively large array of stationary receivers that was initially established in 2013 using 60 VR2W ultrasonic receivers from Vemco, which continued to be the preferred receiver model as the array doubled in size by the end of 2016. The sites selected for most VR2W's were dependent on the location types that were still available and the density of the previously established receiver stations in each section of the array. A receiver's location type was also referred to as its habitat, and for this project, there were primarily three types of habitat being considered, which included 1) the main stem river at regular intervals between lock and dams, 2) directly above/below a dam or inside a lock chamber, and 3) the lower portion of both small and large tributaries. Most of the stations created during previous years required that the VR2W be clamped to a steel rod and then securely attached to a navigational buoy located on or near the mainstem river. However, on those occasions where buoys were not available, receivers were deployed using other structures, such as docks and bridge piers. Although there are receiver stations in lock chambers and tributaries that remain active throughout the

year, the telemetry array isn't 100% functional until the successful redeployment of those VR2W's that were pulled from navigational buoys for the purpose of overwinter storage.

Biologists from the KDFWR, US Fish and Wildlife Service (USFWS) and Indiana Department of Natural Resources (INDNR) utilized a small surgical incision to implant ultrasonic transmitters into the abdominal cavities of adult Bighead Carp and Silver Carp. After being implanted with a transmitter, each carp was measured for total length (in) and weight (lb), checked for characteristics that could identify its sex and then had a uniquely numbered metal tag applied to its dentary bone. Vemco model V16-6H transmitters were utilized to ensure compatibility with the receiver array, and each unit was programed to emit a unique signal every 40 seconds at a frequency of 69 kHz. If any of these signals were detected, decoded and logged by a VR2W, they could be used to identify Asian Carp that were tagged earlier in the project. Aside from their compatibility with the receivers, these transmitters were also chosen for a longer battery life that allows each unit to remain fully functional for an average of 1,825 days, or about five years. This was only possible because each unit lacked additional sensors, was large enough to accommodate a bigger battery and exhibited a relatively long period (40 sec) between transmissions.

As the project grew, biologists with KDFWR's Critical Species Investigation (CSI) office worked with the USFWS and the Ohio Department of Natural Resources (ODNR) to develop a strategy for handling the array of 100+ receivers in a more efficient manner. This strategy was to divide the array up between the KDFWR and teams from the USFWS and ODNR, and then each group would be allowed to focus on deploying, maintaining and offloading receivers that are only located within their assigned area of the array. Hence, in 2016, KDFWR biologists assumed responsibility for all receiver work that was required to maintain the receiver stations within a 170-mile stretch of the Ohio River that's located on the most downstream end of the telemetry array and includes the Cannelton Pool, the McAlpine pool and the first ~40 miles of the Markland Pool (Figure 1). The USFWS and ODNR would then share the responsibility for the remaining 330 miles of the telemetry array, which includes 5 ½ pools of the middle to upper Ohio River (Upper Markland, Meldahl, Greenup, RC Byrd, Racine, Belleville) and then a single receiver station in the Willow Island Pool that has long been the most upriver site within array.

Beginning at the end of 2014, VR2W's were pulled from stations on the mainstem river to be held onto for 2-3 months during the winter after it was determined that this season tends to exhibit river conditions that are most likely to result in substantial receiver losses. The redeployment of these receivers can get started each year once biologists are confident that the worst of the winter season has passed, which for the Ohio River Basin is typically after the first half of March. Late March of 2016, CSI biologists completed the redeployment work by servicing five VR2W's and returning them to their mainstem stations that had been previously established within the McAlpine Pool.

The remainder of KDFWR's early spring telemetry work was used to establish new receiver stations within the first 170 miles of the telemetry array. As was mentioned earlier, the Cannelton and McAlpine pools of the Ohio River were only recently added to the downstream end of the array, so the criteria used previously to identify sites for new receiver stations was unlikely to apply in this situation. However, since there was already a limited number of available VR2W's and there had yet to be any tagging efforts conducted in the Cannelton Pool, it was determined that the McAlpine Pool would be the initial focus for the establishment of additional receiver stations in 2016. As a result, five mainstem and two tributary sites were selected for the seven new receiver stations that were established in the McAlpine Pool during the early spring of 2016. Later in July – August 2016, additional receiver stations were established at seven new mainstem sites located throughout the upper half of the Cannelton Pool. By the end of 2016, a total of 23 receiver stations were located within KDFWR's 170-mile stretch of the telemetry array, which was a substantial improvement in coverage over the 9 sites that had been established by the end of 2015 (Table 1). In total, the combined efforts of all agencies working on this project finished out 2016 with a telemetry array that consisted of 123 active receivers spread out over 501.8 miles of the Ohio River.

While focusing on KDFWR's section at the downstream end of the array, CSI field crews made monthly visits to each active receiver station from May through November of 2016. The regular visits offered these crews the opportunity to address a number a possible issues, such as switching out batteries, updating receiver firmware and replacing missing VR2W's. However, the primary purpose for the monthly visits was to allow biologists to connect to the receiver with a field computer and offload any new detections that had been recorded since the previous effort. Upon completion of the field efforts, the telemetry data was exported from the computer and then combined with all datasets obtained from the same visit into a CSV file that was specifically named for the agency completing the offloads along with the month and year that the efforts occurred. All monthly files from the same year were ultimately uploaded to KDFWR's directory on a FTP site that the ODNR specifically created the Asian Carp telemetry project.

Aside from the receiver work, the KDFWR also worked with biologists from the USFWS, ODNR, INDNR and West Virginia Department of Natural Resources (WVDNR) during a multi-agency effort to collect adult Bighead Carp and Silver Carp that were large enough to accept the Model V16-6H transmitter. In 2016, at least one full sampling crew from the KDFWR was present for all tagging efforts that started in early June and then continued for the rest of the month until electrofishing and gill net crews spent at least three days in each of the four most downstream pools of the telemetry array (Cannelton, McAlpine, Markland and Meldahl). During the first half of September 2016, both the KDFWR and USFWS resumed separate attempts to tag additional Asian Carp that were collected from upper pools. Even though these efforts resulted in a total of only seven Asian Carp, they were all captured and successfully implanted with transmitters in areas upstream of the McAlpine Pool, which was an area of the Ohio River where lower densities of Asian Carp have always hindered tagging efforts. As expected, the higher densities of Asian Carp in the Cannelton and McAlpine pools resulted in greater numbers of newly tagged fish with totals of 96 and 95, respectively. The remaining 15 fish tagged in 2016 were spread out over the Markland, Meldahl and RC Byrd pools, which all have substantially lower densities of Asian Carp. The overall tagging efforts were very successful, especially after considering that the 206 Asian Carp tagged in 2016 was higher than the combined total (n = 195 fish) of all previous years (Table 2).

During mid-December, CSI finished their 2016 field season by making an effort to visit all mainstem sites and pull VR2W's for overwinter storage. Additional efforts were made to service and offload VR2W's at tributary stations that will be left unattended during the winter months. By the end of 2016, CSI field crews had successfully serviced and offloaded data from two tributary sites and pulled VR2W's from eight mainstem receiver stations located throughout both the Cannelton and McAlpine pools. These receivers were ultimately stored off-river for nearly three months, and then as in previous years, the efforts to redeploy the VR2W's to their sites in the mainstem Ohio River began in mid-March of 2017.

For the past several years, KDFWR biologists have also played a primary role in the development of an Asian Carp Telemetry Database and the subsequent analysis of the detection data. In 2016, these efforts started by downloading monthly CSV files that contained raw detection data from the entire Ohio River telemetry array. Prior to being imported into the database, the data in each file was checked for errors, including duplicate entries, false detections or transmitter data that the VR2W had logged incorrectly. After error-checking, all offloaded data was imported into the same Microsoft Access database, which ultimately contained 3.65 million Asian Carp detections in 2016. However, since the raw data consisted of detections that were often only 40 seconds apart, the initial database was at a much finer scale than what was required for the analysis. Hence, in order to make it more user-friendly, this raw detection data was reduced to create new datasets that contained detections on an hourly and daily scale, which in 2016 resulted in reduced totals of 213,210 and 21,118 detections, respectively. These datasets of hourly and daily detections were subsequently used to further analyze the 2016 telemetry data.

The initial analysis of the 2016 telemetry data indicated that 82.4% of the 213,000+ hourly detections were logged by receiver stations in the McAlpine and Cannelton pools (Table 3), which was not entirely surprising since 83% of the project fish were tagged and released in these same pools. Additional

analysis of the hourly detection data from a series of five VR2W's in the upper McAlpine Pool showed a steady decline in unique tag detections going upstream towards Markland Lock and Dam (L&D). Moving upstream, the location and number of unique tags detected by each receiver in the series is as follows: river mile 545 (n = 114 unique tags detected), river mile 541 (n = 75 unique tags), river mile 533 (n = 71 unique tags) and then two actual Markland L&D sites, which included the downriver approach at river mile 531.5 (n = 22 unique tags) and the lock chamber at river mile 531 (n = 3 unique tags). These results indicate that the majority of tagged carp are not readily using lock chambers to move between pools. This was rather surprising since Markland L&D has a substantially lower density of Asian Carp competing for a level of resources that is very similar to what is found in the McAlpine Pool. The 2016 telemetry database is likely to contain more scenarios like these that can help in identifying specific behaviors and/or trends of tagged Asian Carp that are located throughout the Ohio River array. Hence, a more thorough analysis of the 2016 telemetry data will continue even as additional detections are added to the database in 2017.

Table 1. The number of VR2W receivers that have been deployed to each Ohio River pool in 2015 and 2016 for the Asian Carp telemetry project.

Pool	Pool Length (RM)	2015				2016				Change in # Mainstem Receivers	Change in # Tributary Receivers	Change in # Total Receivers
		# Mainstem Receivers	# Tributary Receivers	# Total Receivers	RM per Receiver	# Mainstem Receivers	# Tributary Receivers	# Total Receivers	RM per Receiver			
Willow Island	35.0	1	0	1	35.00	1	0	1	35.00	0	0	0
Belleville	42.2	11	1	12	3.52	11	1	12	3.52	0	0	0
Racine	33.6	7	0	7	4.80	7	0	7	4.80	0	0	0
RC Byrd	41.7	9	4	13	3.21	10	5	15	2.78	+1	+1	+2
Greenup	61.8	11	2	13	4.75	10	1	11	5.62	-1	-1	-2
Meldahl	95.2	44	6	50	1.90	29	9	38	2.51	-15	+3	-12
Markland	95.3	15	0	15	6.35	14	3	17	5.61	-1	+3	+2
McAlpine	75.3	8	0	8	9.41	13	2	15	5.02	+5	+2	+7
Cannelton	55.0	0	0	0	n/a	7	0	7	7.86	+7	0	+7
Totals	480.1	106	13	119	4.03	102	21	123	4.35	-4	+8	+4

Table 2. Total Numbers of Bighead Carp and Silver Carp implanted with ultrasonic transmitters in each pool of the Ohio River from 2013 - 2016.

Year	AC Species	Pool					Totals
		Cannelton	McAlpine	Markland	Meldahl	RC Byrd	
2013	Silver Carp	-	-	0	6	-	6
	Bighead Carp	-	-	0	13	-	13
2014	Silver Carp	-	115	6	10	-	131
	Bighead Carp	-	4	4	0	-	8
2015	Silver Carp	-	22	3	5	-	30
	Bighead Carp	-	1	1	5	-	7
2016	Silver Carp	92	94	6	0	0	192
	Bighead Carp	4	1	4	2	3	14
	Totals	96	237	24	41	3	401

Table 3. A summary of the hourly detections for Mainstem Receiver Stations (MRS), Tributary Receiver Stations (TRS), and All Receiver Stations (ARS) during 2016.

Pool	Mainstem Receiver Stations (*MRS*)						Tributary Receiver Stations (*TRS*)					
	Total # of *MRS*	# *MRS* with detections	% *MRS* with detections	# unique AC detected	# of hourly detections	% of total detections	Total # of *TRS*	# *TRS* with detections	% *TRS* with detections	# unique AC detected	# of hourly detections	% of total detections
Willow Island	1	0	0.0	0	0	0.0	0	---	---	---	---	---
Belleville	11	0	0.0	0	0	0.0	1	0	0.0	0	0	0.0
Racine	7	6	85.7	1	49	< 0.1	0	---	---	---	---	---
RC Byrd	10	5	50.0	3	166	0.2	5	0	0.0	0	0	0.0
Greenup	10	0	0.0	0	0	0.0	1	0	0.0	0	0	0.0
Meldahl	29	26	89.7	21	29046	23.6	9	4	44.4	16	4013	4.4
Markland	14	12	85.7	12	3963	3.2	3	2	66.7	4	331	0.4
McAlpine	13	13	100.0	169	75672	61.4	2	2	100.0	118	85699	95.2
Cannelton	7	6	85.7	67	14271	11.6	0	---	---	---	---	---
Total	102	68	66.7	267	123167	100.0	21	8	38.1	138	90043	100.0

Table 3. Continued.

Pool	All Receiver Stations (*ARS*)					
	Total # of *ARS*	# *ARS* with detections	% of *ARS* with detections	# unique AC detected	# of hourly detections	% of total detections
Willow Island	1	0	0.0	0	0	0.0
Belleville	12	0	0.0	0	0	0.0
Racine	7	6	85.7	1	49	< 0.1
RC Byrd	15	5	33.3	3	166	0.1
Greenup	11	0	0.0	0	0	0.00
Meldahl	38	30	79.0	23	33059	15.5
Markland	17	14	82.4	12	4294	2.0
McAlpine	15	15	100.0	180	161371	75.7
Cannelton	7	6	85.7	67	14271	6.7
Total	123	76	61.8	279	213210	100.0

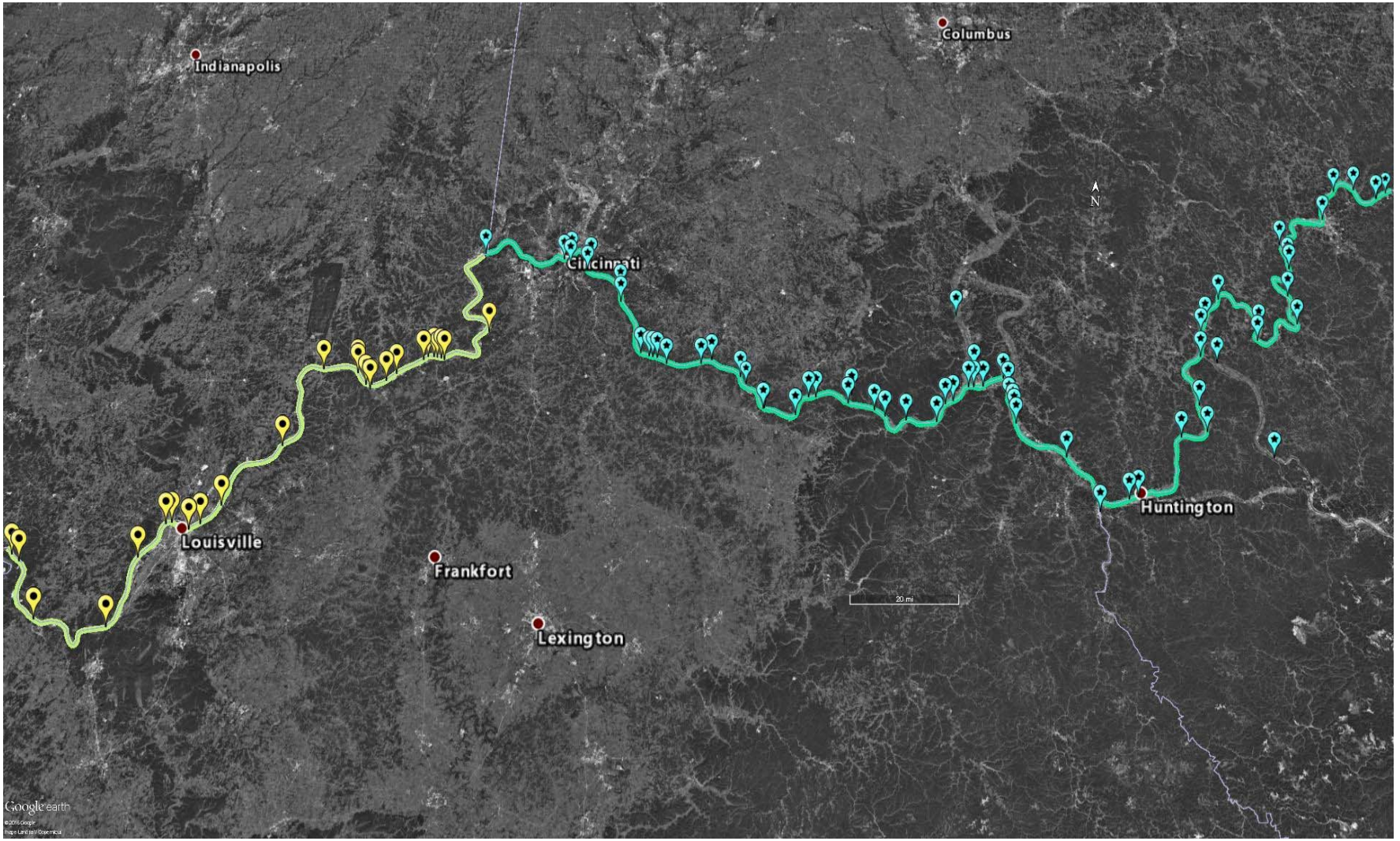

Figure 1. A map showing the Ohio River receiver array for the project as it appeared at the end of 2016. A new protocol used in 2016 gave the KDFWR responsibility for receiver stations within the first 170 miles of the array (Yellow) while the USFWS and ODNR split the receiver work conducted over the upper 330 miles of the array (Blue).