Commonwealth of Kentucky

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ANNUAL PERFORMANCE REPORT

for

Invasive Carp Management in Kentucky

Tennessee and Cumberland River Basin

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Geographic Location: Tennessee and Cumberland rivers and the northern section of the Tennessee-Tombigbee Waterway (Divide Cut and Bay Springs Lake).

Lead Agency: Tennessee Wildlife Resources Agency (TWRA)

Participating Agencies: TWRA; Kentucky Department of Fish and Wildlife Resources (KDFWR); Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP); Alabama Department of Conservation & Natural Resources, Wildlife & Freshwater Fisheries Division (ALWFF); U.S. Fish and Wildlife Service (USFWS); U.S. Army Corps of Engineers; Tennessee Valley Authority; Tennessee Cooperative Fisheries Research Unit, Tennessee Technological University (TTU); and Mississippi State University.

Introduction:
Same as project plan.

Project Objectives:

1. Estimate Asian carp relative abundance, and population demographics in the Tennessee and Cumberland River basins to evaluate management actions.
2. Examine Asian carp impacts on native fish communities.
3. Target and remove Asian carp to suppress populations and reduce propagule pressure in the Tennessee and Cumberland River basins.

Agency: *Murray State University*

Objective 1: Estimate Asian Carp Relative Abundance and Population Demographics
Work was not completed towards this objective in 2020 but is being planned for fall of 2021.

Objective 2: Examine Asian Carp Impacts on Native Fish Communities
Work was not completed towards this objective in 2020, but data will be collected during efforts in 2021 and used in future analysis.

Objective 3: Target and Remove Asian Carp
In December of 2020 Murray State University worked with KDFWR, the USGS Columbia Environmental Research Center, and private contractor SilverFin Solutions to prepare a seine site in Pisgah Bay of Kentucky Lake. This seine site will be used by the USGS for conducting Modified-Unified Method efforts, by SilverFin Solutions conducting work as described in their contract with Murray State University, and by contractors utilizing seines as an experimental method of Asian carp harvest in conjunction with KDFWR. Preparation of additional seine sites and other work under this objective will be completed in 2021.

Agency: *Kentucky Department of Fish and Wildlife Resources*
Project Highlights:

- In 2020 data from standard sampling with gill nets indicated silver carp from Lake Barkley had a mean catch per unit effort (CPUE) of 0.008 fish/yard whereas silver carp from Kentucky Lake had a mean CPUE of 0.007 fish/yard. No significant difference was detected when comparing CPUE between lakes or between habitat types within a lake. A significant downward trend in mean CPUE was detected for both lakes from 2018 through 2020 (July & October data only),

however an inverse trend has been observed in the commerical harvest of silver carp in that same timeframe.

- In 2020 silver carp ages ranged from 4 to 7 years old within Lake Barkley and from 4 to 9 years old within Kentucky Lake, with age-5 silver carp being the most abundant in both lakes. Data suggested that the 600mm size class of silver carp dominated commercial harvest in both lakes in 2020.
- In the fall of 2020 the mean Wr for silver carp in Lake Barkley was 94 (N=112, S.E.=±0.73) and the mean Wr for silver carp in Kentucky Lake was 96 (N=67, S.E.=±0.89).
- Gizzard shad collected in the fall of 2020 from Lake Barkley were estimated to have a mean Wr of 93 (N=47, S.E.=0.7) and gizzard shad from Kentucky Lake were estimated to have a mean Wr of 92 (N=95, S.E.=0.8)
- From October 2018 through Feburary 2021, KDFWR received 36 tag returns from commercial fishing efforts of the 1292 (Barkley=619, Kentucky=673) fish marked for the Mark-Recapture effort. Twenty-seven came from Lake Barkley and nine from Kentucky Lake. Eight of the harvested fish were double tagged. Data analysis is ongoing.
- Community sampling with electrofishing in the Kentucky Tailwater resulted in the capture of 3,204 total fish comprised of 35 species during 4.0 hrs of effort. CPUE of threadfin shad increased from previous years, but CPUE of many other species declined. Mean relative weights for gizzard shad, largemouth and smallmouth bass increased compared to previous years.
- Community sampling in the Barkley Tailwater resulted in the capture of 5,149 total fish comprised of 36 species in 3.75 hrs of effort. CPUE increased significantly from 2019 for threadfin shad. Mean relative weights for many species collected increased compared to previous years.
- Commercial fishers removed over 6.5 million pounds of bigheaded carps through the KDFWR Asian Carp Harvest Program in 2020. CPUE (fish/yard) was highest in 3.5” bar mesh gill nets.
- KDFWR staff conducted 30 ride-alongs with commercial fishers to monitor catch and bycatch data.
- Bycatch of sport fish reported by commercial fishers using the ACHP continued to be minimal (<1% of total bycatch), however, survival rates decreased slightly from 2019 (92.5%).
- Bycatch of paddlefish reported by commercial fishers using the ACHP decreased in 2020 (203 individuals) and survival rates increased (85.7%).
- Reported bycatch by commercial fishers and observations of KDFWR staff during ride alongs continues to be significantly different.
- Commercial fishers registered with the Tennessee and Cumberland rivers contract fishing program received $453,925.21 for over 4.54 million pounds of Asian carp harvested from Kentucky Lake, Lake Barkley, and their respective tailwaters.
- KDFWR established a Master Agreement contract with two private entities to test Asian carp experimental gears in Kentucky waters. During 2020, one entity was active in the program and harvested approximatley 180,443 lbs of Asian carp over 16 days.
- KDFWR hosted the USGS to conduct the Modified-Unified Method for removal of Asian carp in two bays of Kentucky Lake over 16 days. Approximately 69,228 lbs of fish were removed during those efforts.
- KDFWR conducted targeted sampling for Asian carp removal with gill nets and electrofishing. Targeted electrofishing for silver carp removed 19,321 lbs of Asian carp from the Barkley

Tailwaters and lower Cumberland River (CPUE = 815 fish/hr). Gill netting efforts in Kentucky Lake and Lake Barkley removed approximately 7,043 lbs of Asian carp.

- KDFWR continued to retrieve and process black carp captured by commercial fishers. One Black Carp was reported caught in Lake Barkley on the Cumberland River. No captures were reported from the Tennessee River in 2020.

Methods:

Objective 1. Estimate Asian Carp Relative Abundance and Population Demographics

Standard Sampling

KDFWR used a combination of standardized sampling, mark-recapture efforts, and monitoring of commercial harvest to evaluate relative changes in Asian carp abundance in Kentucky and Barkley lakes. Standard sampling with gill nets was conducted at sixteen sites in Kentucky waters of Barkley and Kentucky lakes. These standard sites were selected to provide adequate sampling parameters, decrease conflict with anglers, and provide static locations to monitor changes in catch per unit effort (CPUE). Four embayment and four main channel sites were selected on each lake. These sites were sampled once during spring (April), summer (July), and fall (October) (Figure 1). During each sampling period a total of four nets were fished at each location and in orientations specific to each location. Sampling occurred when lake levels were greater than 354', and nets were set where water depths were a minimum of 13'. Nets were deployed one hour before sunset and retrieved one hour after sunrise the following morning (USA Sunrise Sunset Calendars, 2019). Specific Global Positioning System (GPS) coordinates were determined for all sets, and nets were set at the same locations each season and year of gill netting effort. Sinking gill nets (12' deep) were tied down to 10' every 8 linear feet. Each 100' panel of webbing was hung with 30" stretch in 16" ties. The mesh sizes included: 3" square with 5 meshes per 16 linear inches of net; 4" square with 4 meshes per 16 linear inches of net; and 5" square with 3 meshes per 16 linear inches of net.

All webbing was constructed of 8 ply with 0.2-mm twist mesh. Cross ties for the nets were constructed with #15 white bonded twine through the webbing. Catch rates were analyzed by species and gill net mesh size.

Additionally, targets were set to record total length (mm), weight (g), gender, and gonad weight (g) measurements from subsamples consisting of 10 silver carp and 10 bighead carp at each discrete sample site. During fall sampling, pectoral fin rays were collected from a subsample of silver carp for aging. Due to COVID restrictions and the low sample size of silver carp collected through the standard sampling project no gonadosomatic index was developed in 2020. Demographics were recorded for Asian carp collected during other KDFWR sampling efforts and included in analyses.

Asian Carp Harvest Program

Commercial fishers participating in the Asian Carp Harvest Program (ACHP) are required to provide KDFWR with daily reports including fishing effort, type of gear, pounds harvested, and bycatch information. KDFWR staff occasionally accompanied commercial fishers (ride-along) to verify their harvest reports and collect information additional to that required on a standard commercial fishing report. After each ride-along was completed, data was taken from a random subsample of approximately 20 harvested silver carp, including weights, total lengths, and gender (using the pectoral fin ray).

Black Carp

Although black carp was not specifically included in the project's study plan, commercial fishers have continued to capture them as bycatch in small numbers in the Tennessee and Cumberland River systems. Therefore, it is pertinent that this information be reported.

Objective 2. Examine Asian carp impacts on native fish communities.

Standard Sampling

During standard sampling described above (Objective 1), total length and weight data were collected from bigmouth buffalo (*Ictiobus cyprinellus*) and paddlefish (*Polyodon spathula*) to assess relative weights. The values will be compared over time to asses if Asian carp negatively impact condition of these native fishes. These species are of greatest interest to this study because they are often caught in gill nets and have been documented to compete for resources with Asian carp species (Irons et al. 2007, Schrank et al. 2003).

Standard Sport Fish Sampling

KDFWR staff collected length-weight data to monitor condition of black crappie (*Pomoxis nigromaculatus*), white crappie (*Pomoxis annularis*), largemouth bass (*Micropterus salmoides*), and blue catfish (*Ictalurus furcatus*) in Kentucky Lake and Lake Barkley. Sampling methods are standardized and described in KDFWR's 2020 annual report. Relative weights were compared to harvest rates of Asian carps to identify trends that may be associated with the increasing Asian carp harvest.

Asian Carp Harvest Program Monitoring

Commercial fishing reports and data collected during ride-alongs with commercial fishers were compiled to provide a summary for 2020 data and to determine if yearly trends are related to bycatch numbers, species caught, and survival rates.

Tailwater Electrofishing

Sampling was conducted in the Kentucky Dam tailwater of the Tennessee River (hereafter referred to as the Kentucky Tailwater) and Barkley Dam tailwater of the Cumberland River (hereafter referred to as the Barkley Tailwater) with pulsed DC electrofishing. Historically, sampling in the Kentucky Tailwater consisted of three 15-minute runs on each bank of the river. However, due to construction of the new lock chamber at Kentucky Lock and Dam, one of these runs is no longer possible. Additionally, fluctuating water levels increased the difficulty for sampling in November and only 2 runs were completed. Sampling in the Barkley Tailwater continued as previous years with two 15-minute runs on each bank. Electrofishing was conducted in a downstream direction along the banks (Figure 2). Spring sampling in each Tailwater was scheduled for one day each month (April, May, and June). However, due to high water events in 2020 (elevation >315ft), spring sampling only occurred in June. Fall sampling was conducted as scheduled in each Tailwater on one day of each month (September, October, and November). Two dippers were utilized to collect stunned fish, which were identified to the lowest taxonomic level possible, and total lengths (inches) were recorded. Weights (pounds) were also recorded during fall sampling. When large numbers (> 100) of any species were collected, random subsamples were utilized. With the exception of Asian carp species, all fish were released immediately after processing. Data collected in 2020 was compared to historical data to assess changes in the fish community over time.

Objective 3: Target and Remove Asian Carp

Asian Carp Harvest Program Monitoring

Commercial fishers participating in the Asian Carp Harvest Program are required to provide daily reports including fishing effort, type of gear, pounds harvested, and bycatch information. Ride-alongs were also conducted with commercial fishers occasionally to verify reports. Observers collected all data required on commercial harvest logs with the addition of GPS fishing locations and net soak time (Figure 3). Staff observed 16 different commercial fishers on 30 ride-alongs throughout the year. Ride alongs were conducted when the fishermen were pulling their nets and harvesting fish, unless commercial fishers were using short net soak times or were drifting net sets. On those occasions, KDFWR staff observed the commercial fishers from start to finish. Ride alongs were conducted while onboard with commercial fishers or from a department boat closely following the commercial fishers to record catch. After each ride-along was completed, data was recorded from a random subsample of approximately 20 silver carp harvested including weights, total length, and gender (using the pectoral fin ray). Observations were analyzed both in aggregate with fishers' daily reports and separately (i.e. ride-along data). Data was analyzed to determine number of fishing trips, amount and disposition of bycatch by species, and total pounds of Asian carp harvested.

Experimental Gears

KDFWR coordinated with other agencies and private entities to test the efficacy of experimental gear types for capturing Asian carp in Kentucky Lake, the Ohio River and the Mississippi River. Testing of the Modified-Unified Method (MUM) was led by the USGS Columbia Environmental Research Center, and was conducted in Pisgah Bay and Smith Bay of Kentucky Lake. This was the first use of the MUM in the state of Kentucky and in a reservoir of comparable size. KDFWR hosted these efforts and provided lodging, food, and coordination of staff and equipment needs. Many other agencies provided assistance throughout the project including the USFWS, TVA, USFS, TWRA, MDFWP, INDNR. A total of 16 days of effort was expended between the two sites. Specific methods were determined by the USGS as the project lead. Fish harvested were disposed of by SilverFin Solutions.

In 2020, KDFWR established a Master Agreement contract with two private entities to test Asian carp experimental gears in Kentucky waters. Through this program, contracted entities are able to use experimental methods for harvesting Asian carp, in an effort to increase removal efficiencies. However, contractors are required to accommodate KDFWR observers during all gear testing. KDFWR staff are responsible for data collection and monitoring of bycatch. One contractor was active in the program in 2020, utilizing various seining methods in Kentucky Lake, the Ohio River, and the Mississippi River.

Sampling with the USFWS Columbia, MO Fish and Wildlife Conservation Office Paupier net was not possible in 2020 due to restrictions associated with COVID 19. However, KDFWR plans to continue coordination with the USFWS and other partners to develop standardized and targeted sampling with the Paupier net and electrified dozer trawl in the Tennessee and Cumberland River basins (Towne et al. 2020).

In 2020, KDFWR used targeted electrofishing to remove Asian carp in the Cumberland River below Lake Barkley Dam. Particular locations for the effort were determined from angler reports of high silver carp densities and high catch rates during previous removal efforts. Additionally, certain areas below Lake Barkley Dam routinely attract fish at certain water levels, which lends it to very successful sampling for silver carp.

Electrofishing runs were not standardized, and typically lasted until the boat was laden with fish. Fish were then transferred to a chase boat. Settings varied between 15-120 pps and voltage was adjusted as needed to achieve approximately 8 amps. Depending on the density of fish in an area and presence of recreational fishers, electrofishing runs in the tailwaters extended the length of the dam and down either bank. Electrofishing runs in the tributaries were conducted in either a back-and-forth pattern from bank to bank or straight down the channel depending on the width of the tributaries. Tributaries sampled were never wider than 50 feet at the mouth and generally much narrower.

KDFWR conducted experimental gill net sampling targeting Asian carp in Kentucky and Barkley lakes. Gill nets ranged from 3", 3.5", 4", and 5" bar mesh. Net lengths and depths ranged from 100' to 2400' and 10' to 16', respectively. The technique used during these removal efforts did not require webbing to be tied down to create bags. All removal efforts were conducted during the day and utilized active methods of circling large schools of fish or blocking them in a cove at a depth where gill nets covered the entire water column. Subsequent to net deployment, boat motor noise was used to herd fish toward the nets. Crews typically proceeded to pull nets within an hour of setting them.

Results and Discussion:

Objective 1: Estimate Asian carp relative abundance and population demographics

Standard sampling data indicated no clear trend in overall catch rates for Asian carp (silver, bighead, and grass), in either lake unlike previous years (Table 1). Data for silver carp suggested that mean catch per unit effort (CPUE), reported as number of fish per linear yard of gill net, was highest on Lake Barkley in July but only slightly higher than October. Whereas, Kentucky Lake's CPUE was highest in October followed by April (Table 2). Overall Asian carp CPUE through standard sampling was low. In 2020, Lake Barkley had a mean CPUE of 0.008 fish/yard whereas Kentucky Lake had a mean CPUE of 0.007 fish/yard, no significant difference was detected when comparing CPUE between lakes ($N=24$, $T_{18}=0.39$, $P=0.70$).

Catch rates were compared between habitat types (main channel & embayment) within lakes. No significant difference in CPUE was detected for Lake Barkley ($N=24$, $T_{11}=0.21$, $P=0.42$) or Kentucky Lake ($N=24$, $T_{15}=1.61$, $P=0.13$). Catch rates were also compared between 2018, 2019 and 2020 for each lake separately; only data from July and October was included in the analysis, as no data was available for April in 2018. A significant difference was detected for both lakes, Barkley ($F(2,21) = 25.16$ $P = <0.001$) and Kentucky ($F(2,21) = 11.35$, $P = <0.001$; Table 2). Data suggested that catch rates of silver carp have been decreasing since 2018, however an inverse trend has been observed in commercial harvest in that time frame (Figure 4).

A length-frequency histogram was created for silver carp collected from Barkley and Kentucky lakes from all capture methods in 2020. Data suggested the 600mm size class of silver carp dominated harvest from both lakes (Figure 5 & 6). However, smaller size classes of silver carp were not collected in 2020 due to the absence of data from Paupier net sampling that had been conducted in the fall of previous years. The USFWS Paupier net crew was unable to sample in Kentucky waters in 2020 as a result of COVID restrictions.

Age & Growth

Pectoral fin rays were collected from silver carp in Barkley and Kentucky lakes in the fall of 2020 for aging. Ages ranged from 4 to 7 years old within Lake Barkley (N=55) and from 4 to 9 years old within Kentucky Lake (N=61), with age 5 silver carp being the most abundant in both lakes (Figures 7 & 8). This data indicates that the 2015 cohort still dominates the silver carp population in the lakes.

Mortality

Catch-curve regressions were developed for the 2015 cohort of silver carp by lake. This cohort of silver carp is the only documented cohort known to occupy the lakes at age-0. Data for age frequencies were $\log_{10}(x+1)$ transformed to compensate for heteroscedasticity. A Chapman-Robson analysis was performed to estimate annual mortality (Â) and instantaneous mortality (Z). Annual mortality for silver carp from Lake Barkley was estimated at 63% and instantaneous mortality was estimated at 0.99 (N= 196, $F_{1,1}$=11.75, P=0.181, R^2=0.92: Figure 9). Annual mortality for silver carp from Kentucky Lake was estimated at 53% and instantaneous mortality was estimated at 0.75 (N=166, $F_{1,1}$=3.78, P=0.302, R^2=0.79: Figure 10). The higher mortality rate estimate for Lake Barkley is consistent with previous years and may be a result of greater Asian carp commercial fishing effort and harvest occurring in Lake Barkley compared to Kentucky Lake.

Condition

Linear regressions were constructed to describe the $\log_{10}$ length-$\log_{10}$ weight relationship for silver carp in Barkley and Kentucky lakes. The length-weight equation for Lake Barkley was estimated at $\text{Log}_{10}(\text{weight(g)}) = 2.6535*\text{Log}_{10}(\text{length(mm)})-3.9907$ (Figure 11). The length-weight equation for Kentucky Lake was estimated at $\text{Log}_{10}(\text{weight(g)}) = 2.8261*\text{Log}_{10}(\text{length(mm)})-4.5043$ (Figure 12). Weights were predicted for Lake Barkley: 450mm (1121g), 650mm (2974g) and 800mm (5160g) and Kentucky Lake: 450mm (986g), 650mm (2788g) and 800mm (5018g) (Table 3). Predicted weights remain higher for Lake Barkley than for Kentucky Lake, consistent with analysis from previous years.

Data collected from sampling in the fall of 2020 was used to analyze relative weights (*W*r). Relative weight was calculated using the equation $\text{Log}_{10}(W_s)= -5.15756 + 3.06842(\text{Log}_{10}\text{TL})$ for silver carp and $\text{Log}_{10}(W_s)= -4.65006 + 2.88934(\text{Log}_{10}\text{TL})$ for bighead carp (Lamer, 2015). The mean *W*r for silver carp in Lake Barkley was 94 (N=112, S.E.=±0.73) and the mean *W*r for silver carp in Kentucky Lake was 96 (N=67, S.E.=±0.89). These values are consistent with data collected from previous years. The mean *W*r for bighead carp in Kentucky Lake was 97 (N=3), no bighead carp were collected in Lake Barkley in the fall of 2020.

Gonadosomatic Index (GSI):

Due to COVID restrictions and the low sample size of silver carp collected through the standard sampling project, no gonadosomatic index was developed in 2020.

Sex ratios were calculated for silver carp in both lakes from aggregated data in 2020. Lake Barkley was calculated to be comprised of 51% males (N=271) and 49% females (N=258), a 0.95:1 ratio. Kentucky Lake was calculated to be comprised of 46% males (N=107) and 54% females (N=128), a 0.84:1 ratio. The values for Lake Barkley have been consistent since monitoring began remaining near a 1:1 ratio. However, Kentucky Lake's ratio was observed to skew towards females in 2020 but the data set was smaller than in previous years.

Mark-Recapture Effort:

KDFWR worked with personnel from Tennessee Wildlife Resources Agency (TWRA), Tennessee Tech University (TTU), U.S. Fish and Wildlife Service (USFWS), United States Geological Service (USGS), Murray State University (MSU), and volunteers from United States Forest Service at Land Between the Lakes (LBL) to tag silver carp in Barkley and Kentucky lakes in late September 2018. Fish were tagged with a Floy Tag Company, FT-4 Lock-on tag, with a unique identification number. Initially the targeted sample size was 500 fish per lake, with a subset of 20% of tagged fish receiving a secondary tag. The primary tag was placed posterior of the dorsal fin and the secondary tag was placed anterior of the dorsal fin. Fish were collected using short set gill nets (<4 hours) and D.C. electrofishing. Tagging effort occurred over eight days (four on each lake), and 1,292 silver carp were tagged. A total of 619 silver carp were tagged from Lake Barkley with a mean length of 684mm and a mean weight of 3,830 grams. In Kentucky Lake, 673 silver carp were tagged and had a mean length of 627mm and a mean weight of 2,570 grams.

From October 2018 through February 2021, KDFWR received 36 tag returns from commercial fishing efforts. Twenty-seven came from Lake Barkley and nine from Kentucky Lake (Figure 13). Eight of the returned fish were double tagged. The higher frequency of returned fish from Lake Barkley compared to Kentucky Lake is not surprising given the majority of commercial fishing pressure occurs on Barkley (Reported under Objective 3).

Data collected from harvested fish indicated that all fish grew from the time of initial tagging to the point when they were harvested. Inspection of tag insertion locations indicated good healing of the marked fish. All recovered fish exhibited localized redness around the tag insertion, however none showed signs of infection. The majority of fish were collected in approximately the same embayment where they were tagged. This is an interesting observation because telemetry data has shown that a portion of the silver carp population in the lakes exhibit large scale movement patterns at certain times (USFWS 2019). The tag return data suggests that the majority of the fish returned have developed site fidelity, however, we have not distinguished specific behavioral or environmental characteristics that draw them to a constricted geographic area, relative to the area that is available for use. Although, there have been a few tag returns from bow-fishers harvesting tagged fish hundreds of river miles away from their release locations after tagging.

Asian Carp Harvest Program Monitoring

Length and weight data was collected on 595 silver carp harvested by commercial fishers. Silver carp ranged from 4.2 – 20.7 lbs with an average of 8.5 lbs (Table 4). If this metric is used in correlation with the total pounds of silver carp harvested by commercial fishers through the ACHP in 2020, that would produce a rough estimate of 761,378 individual silver carp being removed from Kentucky waters through the ACHP in 2020 (6,471,718 lbs; Table 5). During ride-alongs, commercial fishers were observed using gill nets with a range of bar mesh sizes to target Asian carp (3” – 5” bar mesh: Table 6). Catch per unit effort of gill nets used to harvest silver carp were highest in gill nets with a bar mesh size of 3.5” (0.68 fish/yard), followed by 3.25” bar mesh which had a CPUE of 0.50 fish/yard. This is similar to the previous two years when the highest CPUE was in 3.25” and 3.5” bar mesh nets. However, no ride-alongs were conducted with commercial fishers utilizing gill nets with smaller sizes of bar mesh prior to 2019 (Table 6). Information collected from fish harvested through the ACHP was also used in the above demographics analysis.

Black Carp

In 2020, one black carp was harvested from Lake Barkley by a commercial fisher using gill nets set to target silver carp. According to the commercial fisher, the gill net that the black carp was caught in was set in approximately 20ft of water and on a ridge containing shells. The net mesh size was 4.5" bar mesh. The black carp was a female and had a total length of 43.3 inches and weighed 36.0 lbs, making it the largest black carp collected from Lake Barkley to date.

Additionally, in 2020, KDFWR verified 11 black carp harvested by commercial fishers in the Ohio River (Figure 14). Gear types where black carp were caught included hoop nets (2 fish) and gill nets (9 fish). Two of the black carp recovered by KDFWR were frozen and therefore sent directly to the USGS Columbia Environmental Research Center for data collection. The remaining nine black carp recovered by KDFWR staff included, 6 males and 3 females, with a total length range of 36.0 – 43.5 inches, and weight range of 20.0 – 40.7 lbs. All black carp collected by KDFWR staff were dissected, and sections were shipped on ice to the respective laboratories for analysis (USGS and USFWS, 2017). Additional black carp were captured in Kentucky waters of the Ohio and Mississippi Rivers during 2020, that were reported to or collected by staff at Southern Illinois University at Carbondale. A complete listing of black carp captures and reported locations is kept by the USGS on the Nuisance Aquatic Species data base (https://nas.er.usgs.gov/). Illinois DNR and SIU-Carbondale continue to administer a $100.00 bounty for black carp captured in waters adjacent to the state of Illinois.

Objective 2: Examine Asian carp impacts on native fish communities

Standard Sampling

Capture rates of species with potential direct competition from bigheaded carp (silver and bighead) were observed to be low in the 2020 standard sampling, which continues the trend observed in previous years (Tables 7 & 8). Bigmouth buffalo were observed to have a mean *W*r of 88 (N=5) in Kentucky Lake and paddlefish catch rates through standard sampling were not significant enough to be reported at this time. These species will continue to be monitored and data will be collected opportunistically. Increased data collection through a gear such as the Paupier net and increased ride alongs with commercial fishers targeting paddlefish, would be very valuable in future assessments of these native species.

Bycatch frequency during standard sampling in 2020 was similar to the frequencies observed in 2019. In Lake Barkley catfish spp. (*Ictaluridae*) comprised 33.9% of the bycatch, followed by freshwater drum (*Aplodinotus grunniens*) (25.5%) and smallmouth buffalo (*Ictiobus bubalus*) (19.4%). In Kentucky Lake catfish spp. comprised 26.9% of the bycatch, followed by smallmouth buffalo (32.5%) and freshwater drum (15.6%) (Tables 7 & 8).

Gizzard shad (*Dorosoma cepedianum*) collected by traditional boat electrofishing in October 2020, were measured and used to estimate relative weight values (*W*r), using the formula presented in Blackwell et al. 2000. Gizzard shad from Lake Barkley were estimated to have a mean *W*r of 93 (N=47, S.E.=0.7) and gizzard shad from Kentucky Lake were estimated to have a mean *W*r of 92 (N=95, S.E.=0.8). Data suggests that relative weights have been increasing in Lake Barkley since 2017. Gizzard shad from Kentucky Lake have also exhibited an increase in relative weight since 2017 (Table 9).

Standard Sport Fish Sampling

As Asian carp populations perpetuate in the reservoirs, the potential of competition for resources between these invasive species and economically important sport fish remains. Relative weights (*W*r) were calculated for black bass, crappie, and blue catfish caught through routine sampling performed by the KDFWR Western Fisheries District in Kentucky and Barkley lakes (KDFWR 2020).

In Kentucky Lake, 450 black crappie, 273 white crappie, 190 largemouth bass, and 19 blue catfish were measured and used for relative weight analysis (Table 10). Black and white crappie both exhibited higher relative weights for all length groups than observed since 2017. Some length groups had the highest *W*r since the ACHP began in 2013. Similarly, largemouth bass *W*r in 2020 was higher than most previous years for all length groups. Blue catfish *W*r was higher than values recorded in 2019 for both the 12-19 inch and 20-29 inch length groups (Table 10). Harvest of Asian carp from Kentucky Lake through the ACHP has varied over the years, but was greatest in 2020 with 1,646,900 lbs of Asian carp harvested (Table 5). This increased harvest pressure on Kentucky Lake is partially due to Kentucky making changes to the contract fishing program on Kentucky and Barkley lakes in 2019 to further incentivize harvest of smaller silver carp. KDFWR now provides an additional $0.10 / lb to contracted fishers for silver carp less than 7 lbs, in place of the standard $0.05 / lb that was offered previously. Additionally, commercial fishers are becoming more efficient in their efforts targeting Asian carp, increasing averages catch rate per trip in 2020 from previous years (ACHP section of this report).

In Lake Barkley, 133 black crappie, 424 white crappie, 146 largemouth bass, and 113 blue catfish were measured and used for relative weight analysis (Table 11). Relative weights for both black and white crappie were higher than those recorded in 2019. Largemouth bass average *W*r values were greater than most previous years for all length groups, with largemouth bass in the 12-14 inch and $\geq$ 15 inch length groups exhibiting the highest *W*r since 2013.Only blue catfish in the 12-19 inch group were collected for *W*r analysis in 2020. Those fish had the highest *W*r value recorded for the length group since 2013 (Table 11). Harvest of Asian carp from Lake Barkley decreased slightly in 2020 (4,790,350 lbs) from 2019 (5,364,200 lbs), but still remained the second highest harvest on record (Table 5). Commercial fishers generally prefer to fish Lake Barkley over other water bodies for multiple reasons and harvest efforts are expected to continue increasing as markets for Asian carp continue to develop. Sport fish condition in the reservoirs is highly variable and cannot be directly correlated to Asian carp harvest at this time. Therefore, sport fish condition will continue to be monitored in following years.

Asian Carp Harvest Program Bycatch

According to the ACHP regulation (301:KAR 1:152), commercial fishers are allowed to harvest a ratio of 65% Asian carp to 35% scaled rough fish per month. All other fish caught in commercial gear must be released. Commercial fishers are required to submit daily reports that include bycatch species, number caught, number harvested, number released, and disposition upon release (moribund or alive). In previous years, increased effort by commercial fishers fishing under the ACHP has translated into a growing amount of bycatch (Table 12). However, in 2020, the total number of bycatch decreased from 2018 and 2019 (18,592 fish) even though commercial fishing effort remained similar (2,052 trips: Table 5). This reduction in bycatch may be attributed to changing practices of commercial fishers as most fishers have transitioned from passive setting to active setting of gill nets. Scaled rough fish, primarily buffalo (*Ictiobus*) species, make up majority of reported bycatch in commercial gill nets fished under the ACHP (Table 12). Harvest of scaled rough fish decreased in 2019 and again in 2020 (78.8% of fish caught were harvested), which is largely reflective of market demand for those species. The number of catfish caught in commercial nets under the ACHP decreased in 2020 (N = 768) from 2019 (N = 1512), and the survival rate of this taxa remained high at 99.2%. Total number of sport fish in the bycatch of the ACHP decreased in 2020 from 2019, but remained higher than all other previous years (n=148). The survival rate for sport fish species in 2020 remained similar to 2019 (92.5%: Table 12). This high survival rate is likely due to the change in commercial fishing methods that began in 2019. Previously, the majority of commercial fishers would fish overnight, passive sets for Asian carp, leaving nets out for 6-8 hrs between harvests.

In 2019, most commercial fishers began utilizing more active methods of fishing for Asian carp, targeting large schools, encircling them with nets, and chasing the fish into the gill nets by making loud noises. This active method of fishing resulted in decreased bycatch per fishing trip for most native species (Table 13). The number of paddlefish reported captured as bycatch decreased in 2020 (n=222) from 2019 (n=296), and remains lower than most previous years. Additionally, the mean survival rate of paddlefish reported by commercial fishers increased slightly to 85.7% in 2020 (Table 12).

Survival rates of all bycatch caught during ride-alongs in 2020 was documented by KDFWR observers and was analyzed independent of commercial fishers reporting (Table 14). During ride-alongs, the survival rate of sport fish in bycatches decreased from 2019, and still remained lower than what was reported by commercial fishers (81%). However, in relation to total bycatch, the number of sport fish captured was low (4% during ride-alongs in 2020). Survival rates of catfish species observed as bycatch during ride-alongs was the highest recorded, since 2016, and was similar to values reported by commercial fishers in 2020 (100%: Tables 12 & 14). Paddlefish survival rates observed during ride-alongs in 2020 were higher than observed in 2019, but still remained significantly lower than what commercial fishers reported (50%: Tables 12 & 14).

A comparison for bycatch of paddlefish, catfish species, and sport fish species reported by commercial fishers through daily reports and information collected during ride-alongs shows a decrease since 2015 in number of sport fish captured per trip for most species (Table 13). However, bycatch reported captured per trip for recreationally and commercially important species such as paddlefish and catfish spp. is higher during ride-alongs than from commercial fishing reports (Figure 15). Data suggests 50-75% of bycatch is likely not reported in daily logs submitted to KDFWR by commercial fishers. However, ride-alongs account for a small percentage of the total number of trips made by commercial fishers (<2%). To better identify and monitor under reporting of bycatch, KDFWR will continue to increase the number of ride-alongs conducted with commercial fishers targeting Asian carp. To date, there is no indication of negative impacts on the sport fishery resulting from the ACHP.

Bycatch of Paddlefish

As KDFWR monitors sport fish bycatch through the ACHP it also provides the opportunity to monitor other species that compete directly with Asian carp such as paddlefish. Paddlefish are considered a species of conservation need as 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 closely monitor impacts of the ACHP on paddlefish. Generally, experienced commercial fishers can avoid capturing large numbers of paddlefish when they are targeting Asian carp by carefully selecting fishing locations. The number of paddlefish captured is variable over time, but did show an increasing trend that is now declining even though effort is increasing (Tables 5 & 12).

Paddlefish survival was observed to be low in 2020 (50% during ride-alongs, 85.7% total ACHP) in relation to other species in the bycatch (Tables 12 & 14). 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 have been recorded during ride-alongs conducted since 2016 (Table 15). Another factor identified as possibly affecting paddlefish survival in gill nets was length of time the nets are left in the water (i.e. soak time), and has been recorded since 2017 (Table 15). 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. Although sample sizes are small, observations from ride-alongs in 2019 and 2020 indicate that paddlefish survival rates decrease as water temperature increases.

It has also been suggested that since paddlefish have an elongated operculum, it may be more likely for a gill net to restrict the water flow over their gills than other fish species. There did not appear to be a difference in the survival rate of paddlefish based on soak time of nets in 2020. However, commercial fishers are more frequently using active methods for targeting Asian carp with gill nets and soak times of nets decreased overall in 2020. To increase the sample size, water temperature and soak times will continue to be recorded during ride-alongs in 2021.

Kentucky and Barkley Tailwaters Electrofishing

Spring sampling with electrofishing in the Kentucky Tailwater was conducted only in the month of June. This sampling effort resulted in the collection of 211 individual fish comprised of 21 species through 1.25 hrs of electrofishing. Sunfish species made up the highest percent of the catch (31.9%), followed by Catostomidae species (24.8%: Figure 16). Largemouth and smallmouth bass produced lower catch rates than most previous survey years with CPUE of 14 fish/hr and 2 fish/hr, respectively. However, this decline may be due to the reduced sampling effort in 2020 compared to previous survey years. Silver carp CPUE in the Kentucky Tailwater during spring sampling remained similar to 2018 (3 fish/hr: Table 16). Spring sampling for 2020 in the Barkley Tailwaters was also only conducted in June, and resulted in the collection of 326 individual fish, comprised of 22 species, through 1.0 hr of effort. Similar to Kentucky Tailwater, sunfish species made up the highest percentage of the total catch with 46.8% (Figure 17). Black bass species made up the second highest percentage of the catch at 14.8%, which is in accordance with previous spring surveys at Barkley Tailwater (Figure 17). Flathead catfish catch rates increased in 2020 compared to all previous survey years (26 fish/hr: Table 17). Silver carp CPUE declined from the 2018 survey and remained similar to catch rates produced in 2017 (13 fish/hr: Table 17).

Fall sampling with electrofishing in the Kentucky Tailwater resulted in the capture of 2,293 total fish comprised of 28 species during 2.75 hrs of effort in 2020. This is a decrease in effort from previous years due to reasons stated above. Similar to previous years, Clupeid species were the most abundant group collected, comprising 88.6% of the total catch during sampling in 2020 (Figure 18). Threadfin shad (*Dorsoma petenense*), made up the majority of Clupeids caught, indicating a higher presence than in 2019 (Tables 18 & 19). In 2019, sampling produced the highest percent of total catch and CPUE (510 fish/hr) of skipjack herring (*Alosa chrysochloris*) since the survey began in 2015 (Table 19), sampling in 2020 produced the second highest CPUE for skipjack with 89 fish/hr (Table 19). CPUE of sunfish species including bluegill and longear sunfish, decreased from the high numbers collected in 2019, and was low compared to most previous year as well comprising only 3.6% of the total catch (Figure 18 & Table 19). Largemouth and smallmouth bass (*Micropterus dolomieu*) were the most prominent sport fish species collected in the Kentucky Tailwater during fall sampling in 2020 with a CPUE of 15 fish/hr and 10 fish/hr, respectively (Table 18). However, CPUE for bass and most other sport fish species in 2020 declined compared to CPUE in 2019. A new species, striped mullet (*Mugil cephalus*), was collected during sampling efforts in the Kentucky Tailwater in 2020. A total of 4 striped mullet were collected through electrofishing, pictures were taken, and the fish were released alive. Silver carp retained a similar CPUE and portion of the percent total catch as was documented in previous years (Figure 18 & Table 19).

Fall sampling in the Barkley Tailwater resulted in the capture of 4,824 total fish comprised of 33 species in 2.75 hrs of effort in 2020. Complementary to previous years, Clupeid species, were still the most abundant species group collected in Barkley Tailwater during fall sampling in 2020, comprising 87.1% of the total catch (Figure 19). Similar to the Kentucky Tailwater, threadfin shad made up the majority of Clupeids caught, producing the highest CPUE since 2016 (1298 fish/hr; Table 20).

Indicating a rebound in the threadfin shad population from low CPUE in 2019. Sunfish species such as bluegill (*Lepomis macrochirus*) and longear sunfish (*Lepomis megalotis*) produced low catch rates in comparison to previous years and made up only 4.6% of the total catch (Table 20 & Figure 19). Black bass (largemouth, smallmouth, and spotted) catch rates declined from 2019, but remained similar to other survey years (Table 20). Silver carp CPUE during fall sampling in Barkley Tailwaters decreased in 2020 from surveys conducted in 2018 and 2019 (23 fish/hr; Table 21).

Length frequency distribution for silver carp collected in Kentucky Tailwater during fall sampling in 2020 ranged from 17-28 inches (N=26; Table 18). Silver carp lengths from Barkley Tailwater during fall sampling ranged from 18-29 inches, and was dominated by the 23-27 inch classes (N=64; Table 21). These ranges are similar to silver carp collected during fall sampling in 2018 and 2019, with the exception of the dominant inch classes increasing slightly.

Silver carp and grass carp were collected in both tailwaters during fall sampling efforts, however no bighead carp were collected in either season. Electrofishing for this project resulted in removal of 26 silver carp from Kentucky Tailwater and 64 silver carp from Barkley Tailwater in 2020. Targeted electrofishing sampling for silver carp conducted by KDFWR removed over 2,800 silver carp from the Barkley Tailwaters and lower Cumberland River in 2020.

Relative weights (*Wr*) were calculated for selected species collected during fall sampling to monitor fish condition (Tables 22 & 23). 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 (Blackwell et al. 2000). However, ideal target ranges of *W*r values have not been identified for all species and in every habitat type. Therefore, the *W*r values compiled through this study will be used to assess changes in the Tailwater fish community over time. In the Kentucky Tailwater, the mean *W*r of gizzard shad remained at a value of 85, the highest observed since the survey began in 2015 (Table 22). The mean relative weight for largemouth bass (*W*r = 113) and smallmouth bass (*W*r = 100) in 2020 was also the highest recorded since 2015. Silver carp mean relative weight declined slightly from 2019 (*W*r = 76: Table 22). Mean relative weight values for other species in the Kentucky Tailwater remained similar to previous years. In the Barkley Tailwaters the mean *W*r for silver carp decreased compared to previous years (*W*r = 77; Table 23). This decline is a factor that will continue to be monitored as a low mean relative weight for silver carp could also be an indication of increased competition for resources in the tailwaters as the silver carp population grows. During sampling in the Barkley Tailwater in 2019, mean relative weight values observed for gizzard shad (*W*r = 96), channel catfish (*W*r = 111), white bass (*W*r = 115), and largemouth bass (*W*r = 101) were the highest recorded since the survey began in 2016. Mean relative weight values for other species remained similar to those observed in previous years (Table 23).

The Western Fisheries District branch of the KDFWR fisheries division collected some data on sportfish in the Kentucky and Barkley tailwaters previous to this study. Data was collected from fish in both tailwaters in the fall of 2002, and 2011 (KDFWR, 2003 and 2012). Fish were collected through standardized electrofishing runs, measured, and weighed. Using this historical data, comparisons of sport fish catch rates and condition were made to the information presented in this report. These comparisons did not reveal any appreciable declines in sport fish numbers or condition since Asian carp have become abundant in the tailwaters.

Recreationally important fish species in the Kentucky and Barkley tailwaters including: catfish, *Morone* spp. (white bass, yellow bass, striped bass, and hybrid striped bass), black bass, sunfish, and crappie, still exhibit good condition despite the high densities of Asian carp in these areas.

Objective 3: Target and Remove Asian carp

Asian Carp Harvest Program Monitoring

The Asian Carp Harvest Program (ACHP) created by KDFWR allows commercial fishers to target Asian carp in waters where commercial fishing with gill nets is otherwise restricted. The data in this section is compiled from daily and monthly reports submitted by commercial fishers participating in the ACHP. Implementation of the ACHP has been a key element in the increased harvest of Asian carp from Kentucky waters, especially Kentucky Lake and Lake Barkley.

Since 2013, commercial fishers in Kentucky harvested a total of 18,425,995 lbs of Asian carp through the ACHP (18,110,738 lbs silver carp, 204,067 lbs bighead carp, 111,190 lbs grass carp [2020 only]: Table 5). Total harvest would be higher if grass carp were included for all years, however commercial fishing reports prior to 2020 did not delineate grass carp from common carp. Therefore, only grass carp harvest from 2020 is included in the total. Grass carp harvest will continue to be included in future reports. The majority of Asian carp harvested in Kentucky are from Lake Barkley (Table 5). Commercial fishers prefer fishing Lake Barkley over Kentucky Lake as it is shallower, has more embayments to corral fish, less recreational traffic, and the fishers believe the silver carp are larger. Number of commercial fishers in Kentucky and associated trips under the ACHP program has varied annually. A decrease in fishing effort (numbers of trips) and Asian carp harvest in 2015 and 2017 was due to inconsistent market demands. In 2019, the number of fishers targeting Asian carp doubled, and fishing effort more than doubled. In 2020, 48 commercial fishers made 2,052 trips through the ACHP, which is a decrease in both fishers and effort through the program from 2019. However, it was an increase in effort per commercial fisher (approximately 43 trips/fisher). Additionally, commercial fishers harvested an excess of 6.6 million pounds of Asian carp through the ACHP in 2020, indicating an increase in harvest efficiency for commercial fishers targeting Asian carp (Table 5, Figure 4). Factors affecting the increased efficiency are likely a combination of the 2015 Asian carp year class becoming fully recruited to the fishery and improved commercial practices. However, large numbers of Asian carp harvested by commercial fishers were too small for food-grade processing (< 7 lbs), and several regulatory and incentive adjustments have been made since 2018 to compel fishers to harvest all sizes of Asian carp, and to attract more commercial fishers in general.

In August, 2018, KDFWR installed an industrial flake ice machine to provide free ice to ACHP fishers. In 2019, the state adjusted the Asian carp cost-share contract program to better compensate fishers for lower prices offered for small fish (< 7 lbs). Additionally, free Asian carp commercial fishing licenses were made available. Another significant effort that induced the increase in commercial fishing interest and harvest in 2019 was Kentucky's public-private partnership established to create a fish buyer/distributor. The new business is compelled by substantial incentives to meet aggressive Asian carp purchase and sales goals. The new project created increased demands for Asian carp in 2019, and in combination with the other incentives, more fishers from Kentucky and other states were attracted to the ACHP. However, in 2020, the new business struggled to meet the incentive goals.

Concerning the regulatory changes to compel harvest of smaller Asian carp, it is important to note that KDFWR collected data in 2017 that lead to the regulatory amendments allowing 3" gill nets for commercial fishing. A very strong year class of silver carp was apparent in 2015 in Kentucky Lake, Lake Barkley, and their associated tailwaters. This cohort was initially observed in commercial nets in 2016 when 8 to 14-inch size fish were incidentally caught. Sampling in Lake Barkley in 2017, KDFWR consistently collected the smaller fish in experimental gill nets with 3" bar mesh. At that time, commercial fishers were restricted to using 3.25" or greater bar mesh. KDFWR sampling revealed there was no increased risk to sport fish with 3" bar mesh, and in 2018, the state passed an emergency regulation allowing commercial fishers in the ACHP to use the smaller mesh size. Similar to KDFWR's data in 2017, decrease in mesh size has not resulted in an appreciable increase of sportfish bycatch by commercial fishers (Table 12). Commercial fishers' adjustments in net sizes during the past several years helped facilitate the 2020 record harvest, and the highest CPUE of silver carp during ride-alongs (0.68 fish/yard: Table 6, Figure 20).

Asian carp harvest data was summarized by month from January 2013 to December 2020 (Figures 25 & 26). Historically, the number of trips made by commercial fishers under the ACHP decreased during paddlefish season (November-March) and increased again when paddlefish season ended (Figure 21). This shift was expected as many commercial fishers' 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. However, in late 2018 and through 2020, this trend was not apparent as commercial fishers are now targeting Asian carp year round, and are allowed to receive funds through the contract program administered by KDFWR for Asian carp harvested while fishing on their net permit. The highest number of commercial fishing trips recoded in a single month was 302 in January 2020, followed by 300 trips in February 2020. Total pounds of silver carp harvested per month closely follows the trend of number of trips made with February of 2020 having the highest weight recorded (859,783 lbs). Average pounds of silver carp harvested per trip has varied by year. Except in July, the average pounds of silver carp harvested per trip was higher in every month of 2020 than in 2019 (Figure 22). Market demand for food grade fish decreased after February of 2020 due to COVID 19, and therefore impacted effort and harvest by commercial fishers for the majority of the year.

Water conditions routinely affect Asian carp harvest rates, but seasonality is also a factor. KDFWR and MSU telemetry studies indicate that movement rates of silver carp increase in water temperatures between 61.5 ^{o}F and 86.0 ^{o}F (USFWS 2019). Fish become more active with rising water temperatures in the spring, and they become less susceptible to harvest when moving to the main channels from embayments. Commercial harvest rates also vary among fishers. The most successful fishers understand silver carp tendencies better, and they use higher quality gear with larger boats that have higher weight capacities. In 2020, the average number of pounds harvested per trip was calculated for all fishers who made 10 or more fishing trips (N=34), and average pounds of silver carp harvested varied from 133 lbs/trip to 6,956 lbs/trip. Interestingly, not all fishermen with high catch rates fished frequently (Figure 23).

Ride-Alongs

KDFWR conducted 30 ride-alongs with 16 different commercial fishers utilizing the ACHP January through December 2020 (Figure 3). During ride-alongs 30,208 yards of gill net were fished and 145,855 lbs of Asian carp were harvested. The majority of fishing effort observed during ride alongs was in Lake Barkley (N=24), which is similar to fishing effort in general. Ride-alongs were also conducted in Kentucky Lake (N=5), and the Ohio River (N=1). Commercial fishers set nets primarily along secondary channels, on flats in the main lake, and in embayments.

The northern end of Lake Barkley received the most fishing pressure. This may be a result of the ease of access, as it is shorter distance for commercial fishers to drive and transport fish. Another factor may be the sinuosity of Lake Barkley at this location which reduces impacts from high winds. Additionally, in 2020, Lyon County, KY continued offering a subsidy for Asian carp harvested from Lake Barkley waters within the county boundaries, which encompasses the northern portion of Lake Barkley. The county's subsidy program was independent of KDFWR contract incentives, and commercial fishers could participate in both programs.

In Lake Barkley, average total weight of silver carp harvested per trip increased during 2020 (5,094 lbs) from all previous years (Table 24). Average total weight of silver and bighead carp harvested per trip during all ride-alongs in 2020 (4,775 lbs and 41 lbs respectively) was also higher than those averages for the ACHP as a whole in 2020 (Table 25). After each ride along total length and weight was recorded for 20 randomly selected silver carp. Average weight of individual silver carp harvested during all ACHP ride-alongs in 2020 was similar to 2019 (Table 4).

Asian Carp Contract Fishing Program in the Tennessee and Cumberland Rivers Systems

Interest and participation in the KDFWR contract fishing program for Asian carp has varied greatly since it began in 2016. However, refinements to the system in 2019 increased participation in the program. In 2020, contractors received $453,925.56 for Asian carp harvested from Kentucky Lake, Lake Barkley, and their respective tailwaters. This equates to over 4.5 million pounds of Asian carp harvested through the program in 2020 (Table 26). Refinements to the program to allow for varying pay out based on size of fish harvested have made it more difficult to track the exact weight of fish removed.

Experimental Gears

Modified-Unified Method

Conducting the MUM in Kentucky Lake required significant time, personnel, and equipment. However, the efforts did result in the removal of 69,228 lbs of fish, most of which were Asian carp. Additionally, great insight was gained through the process regarding improvements in efficiencies and interagency coordination. The MUM event on Kentucky Lake was also capitalized upon by an interagency media event that garnered national attention towards the efforts being expended towards controlling Asian carp.

Contracted Experimental Efforts

The only active contractor (Robbins Construction LTD) in the experimental gears program conducted efforts with experimental methods a total of 16 days in 2020. Two days on Kentucky Lake, two days on the Ohio River and twelve days on the Mississippi River. Approximately 206,052 lbs. of fish were harvested during these events in 2020. Of the total harvest, 87% were silver carp, 0.6% were other Asian carp species (bighead and grass crap) and the remaining 12.4% were comprised of rough fish species (primarily buffalo species and common carp). Sport fish bycatch and other fish species that were not harvested were observed to have an 87% survival rate at the time of release.

Electrofishing

Five sampling trips were made in the Barkley Tailwater area and associated tributaries. A total of 19,321 lbs of Asian carp were removed in 3.4 hours of electrofishing. The average CPUE was estimated at 815 fish/hr. A random sample of 20 silver carp were individually weighed and measured from all other days of effort. Mean total length and weight of these fish was 27.05 inches and 6.75 lbs, respectively.

Gill netting

During 2020, KDFWR crews fished a total of 4,400 linear yards of gill nets during targeted removal efforts, and harvested approximately 7,043 lbs of Asian carp. Gill nets were fished during 2 trips to Kentucky Lake, and 7 species were captured. Asian carp comprised 97% of fish numbers collected (8 grass carp and 363 silver carp). Gill nets were fished during 4 trips in Lake Barkley, and 4 species were collected. Asian carp totaled 98% of the fish collected (1 grass carp, 598 silver carp). Asian carp CPUE differed by bar mesh size yielding the following; 3" (0.038 fish/yd.), 3.5" (0.445 fish/yd.), 4" (0.047 fish/yd.), and 5" (0.000 fish/yd.), respectively for both reservoirs combined. In 2020 KDFWR staff were able to expand the variety of mesh size and depth of gill nets for use, however due to the limited number of staff and restrictions associated with COVID 19, targeted removal effort was much lower in 2020, than in previous years.

Recommendation:

Additional funding has been requested to significantly increase efforts of KDFWR and TWRA efforts to monitor Asian carp populations. Standardized gill netting methods will be continued in 2021. To increase capture rates and sample sizes in the variable habitats found in the basin, additional gears types are being planned as funding allows. Methods for these gears will be clearly outlined and should be standardized across the basin. Data collected by KDFWR has been useful for identifying trends in demographics of Asian carp populations in the lower reaches of Kentucky and Barkley lakes, and this type of data collection will be expanded throughout the basin. As basin partners begin sampling or continue efforts currently in place, data should be compiled and analyzed congruently to more succinctly identify trends in Asain carp populations characteristics throughout the basin. This information will also be utilized to inform removal efforts. It is reccommended that targeted removal of Asian carp be continued through 2021. KDFWR also suggests that increased observations of commercial fishers through ride alongs be conducted to reduce differences in reporting. Commercial fishing effort throughout the basin is increasing, but relies almost entirely on gill nets as their method of harvest. Gill nets are size selective and the mesh sizes used do not capture all year classes of Asian carp present in the basin. Therefore, effort towards identifying and testing other methods for removing Asian carp should be expanded. Commercial seining shows considerable promise for efficinetly removing carp at rates higher than traditional gill netting, and Asian carp harvest areas and associated regualtions are planned to facilitate that gear type in Kentucky. KDFWR plans to significantly increase efforts with experimental gear types in Kentucky and Barkley lakes, including research to broaden the scope of the USGS Modified Unified Method, testing promising new pelagic harvest techniques, and initiating a research project with MSU and the USGS in the Kentucky tailwater to investigate consistent harvest efforts as a potential deterrence to interpool movment. KDFWR will partner with federal agencies, universities, and other contracted entities on these projects. Impacts of Asian carp and associated removal efforts on native species will continue to be assessed. If it is determined that native fishes are being impacted by Asian carp or removal efforts, then additional actions may need to be taken.

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Tables and Figures:

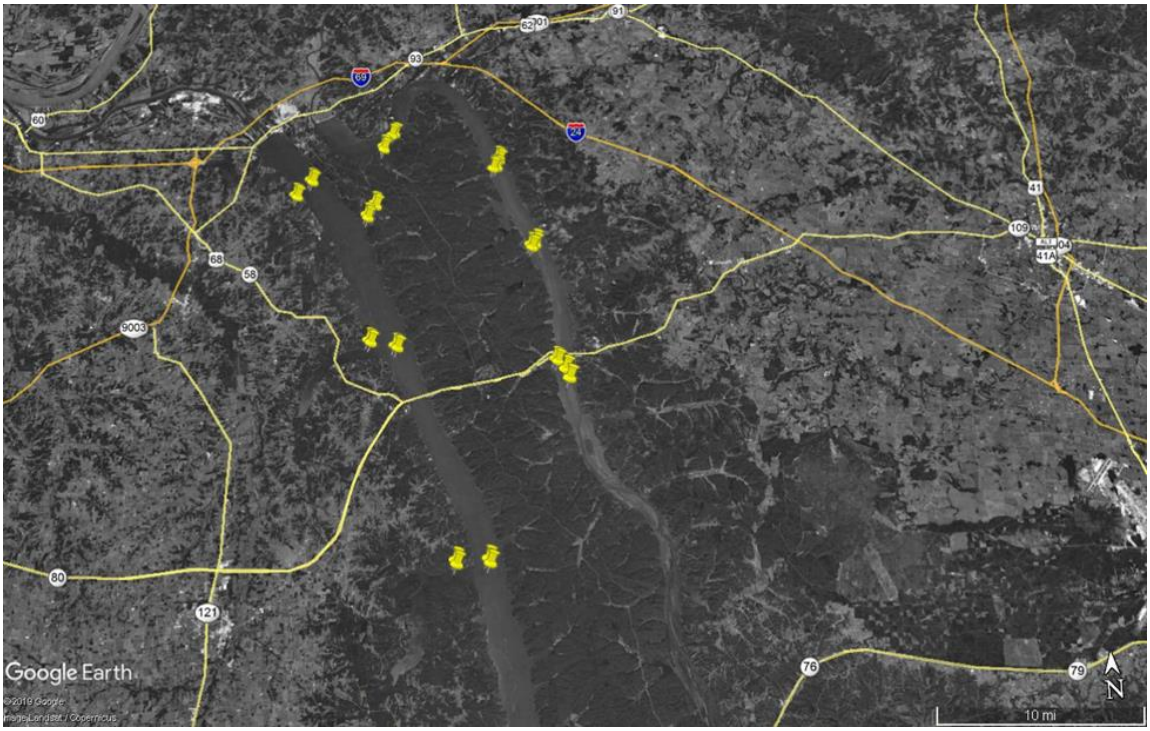

Figure 1. Location of standard sampling sites, where gill nets were fished by Kentucky Department of Fish and Wildlife Resources in 2020.

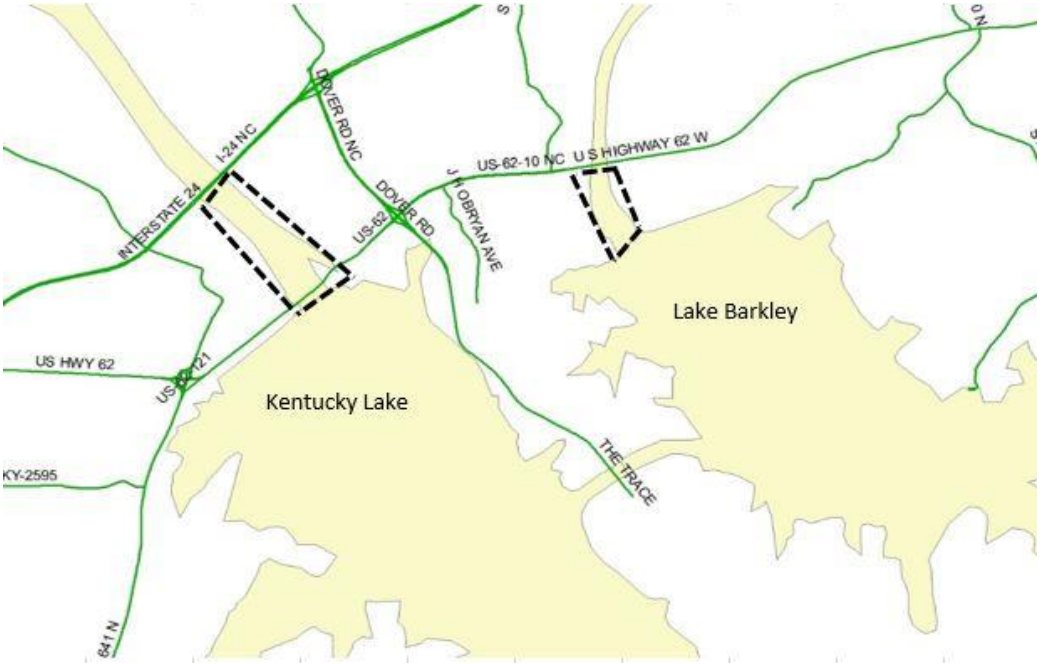

Figure 2. The tailwater electrofishing at Kentucky Tailwater extended from the dam downstream to the Interstate 24 bridge. The electrofishing at Barkley Tailwater extended from the dam downstream to the US Hwy 62 bridge. Sample areas are outlined by dashed line.

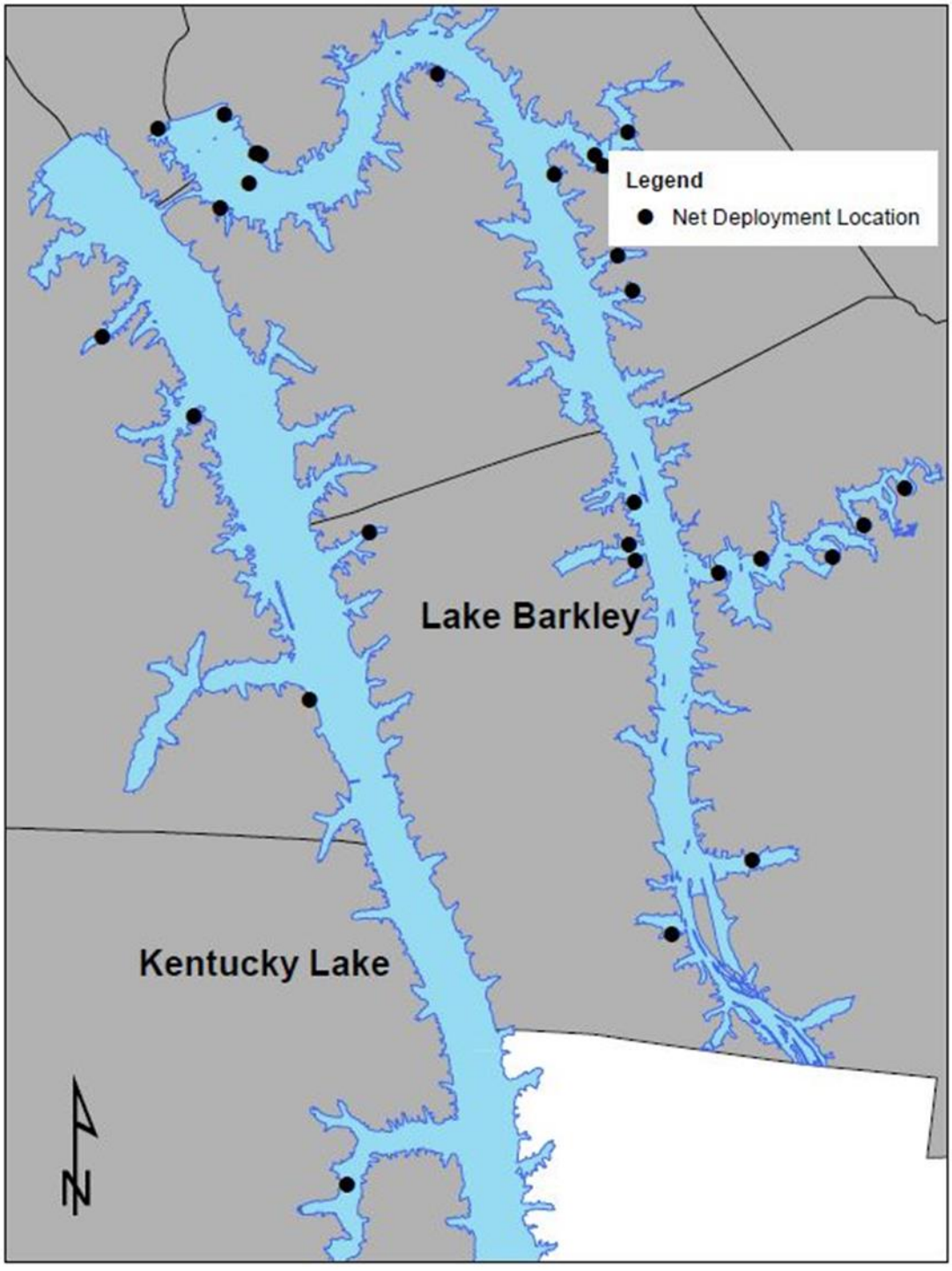

Figure 3. Locations where nets were deployed by commercial fishermen during ride-alongs conducted by KDFWR staff in 2020.

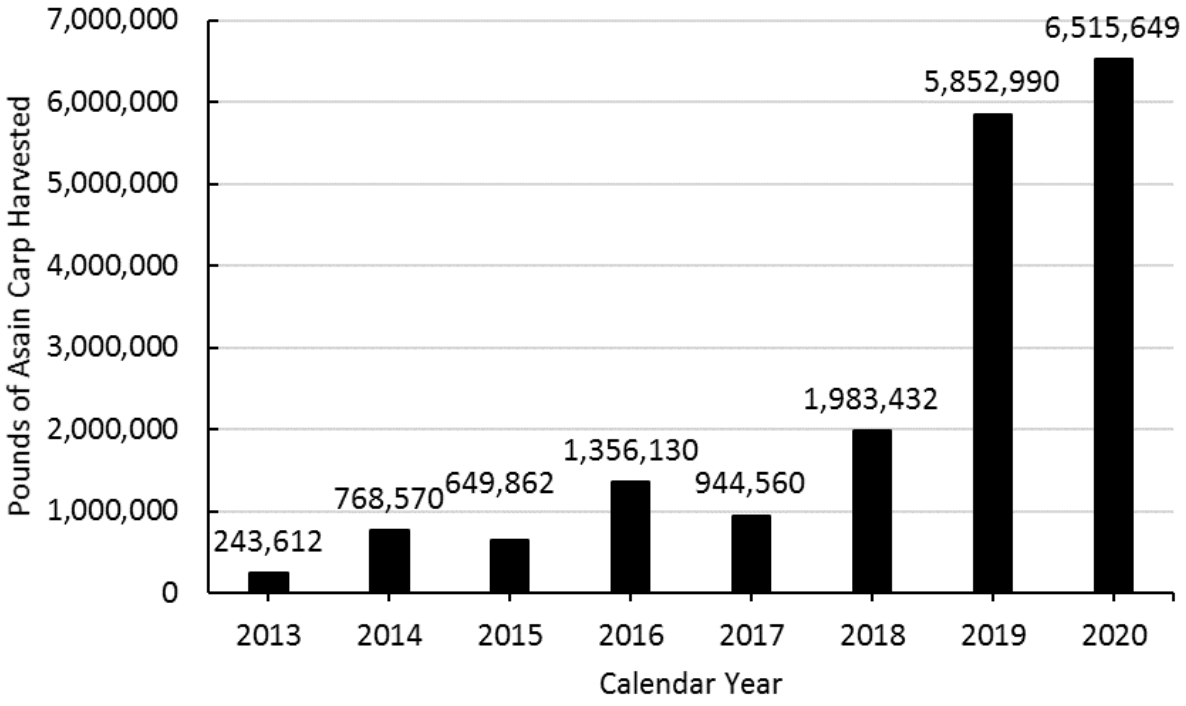

Figure 4. Pounds of Bigheaded carp harvested through the Asian Carp Harvest Program by calendar year. 2020 was the first year that grass carp harvest was tracked through the ACHP and accounted for an additional 111,190 lbs of Asian carp species harvested through the ACHP in 2020.

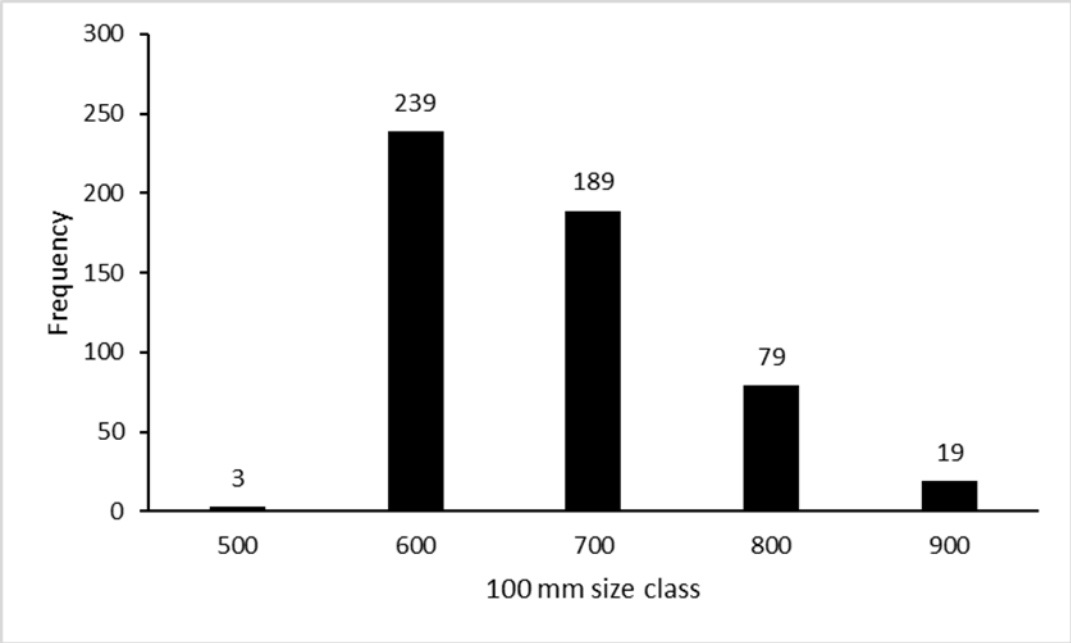

Figure 5. Length-frequency distribution of silver carp collected from Lake Barkley, from all methods in 2020 (N=529).

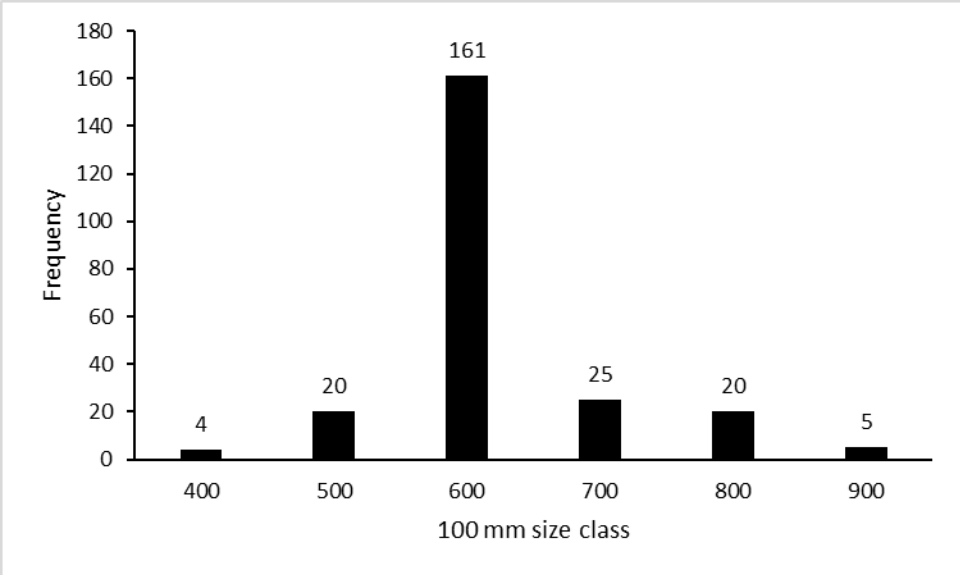

Figure 6. Length-frequency distribution of silver carp collected from Kentucky Lake, from all methods in 2020 (N=235).

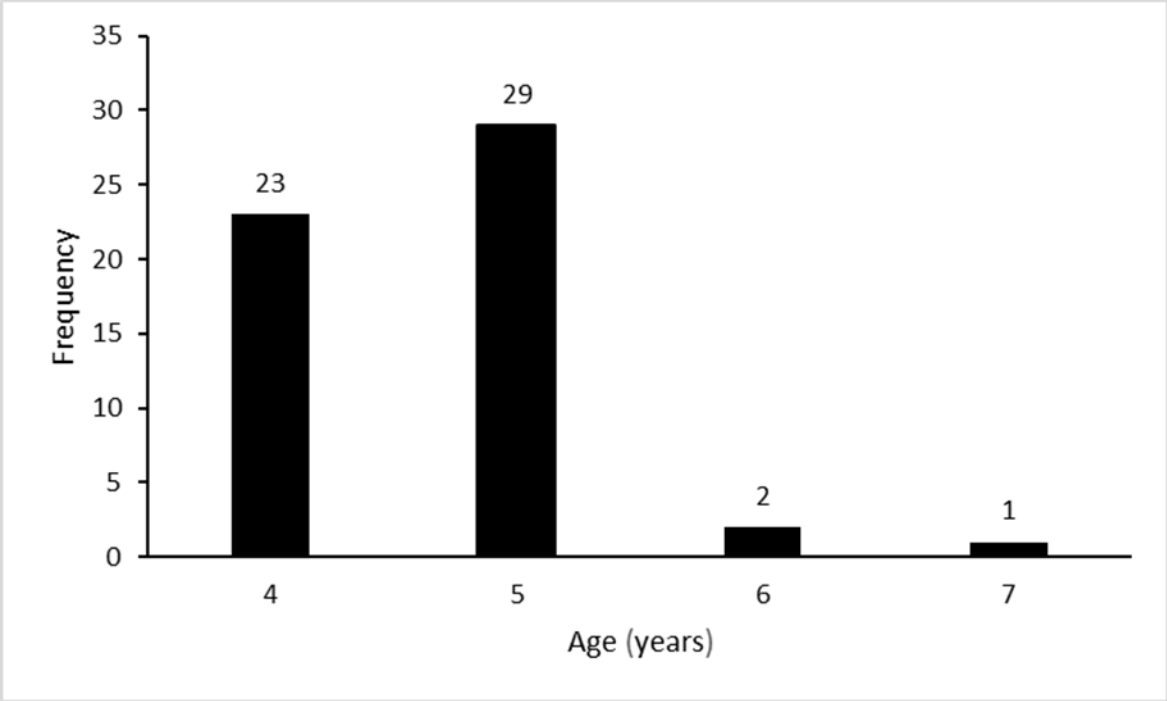

Figure 7. Age-frequency distribution for silver carp collected from Lake Barkley in 2020 (N=55).

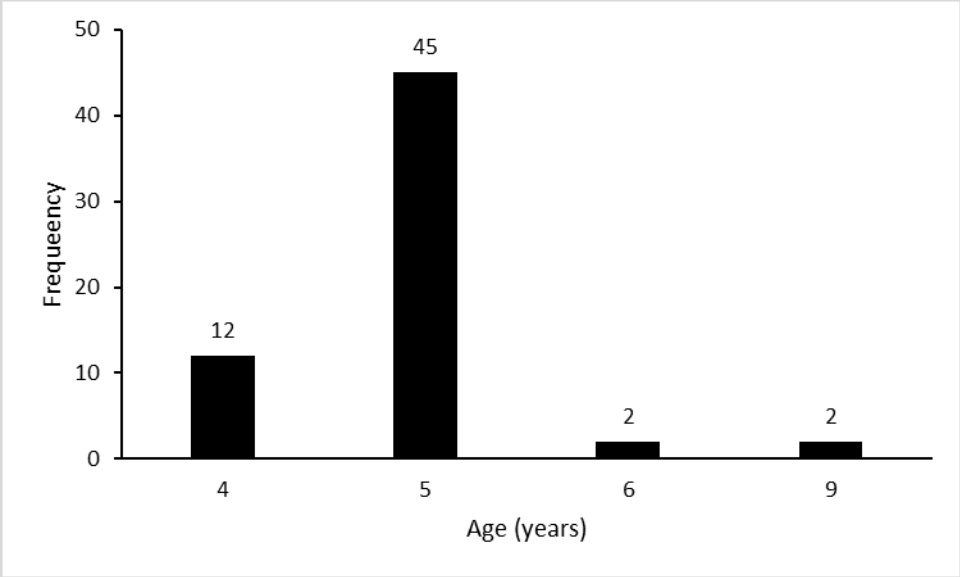

Figure 8. Age-frequency distribution for silver carp collected from Kentucky Lake in 2020 (N=61).

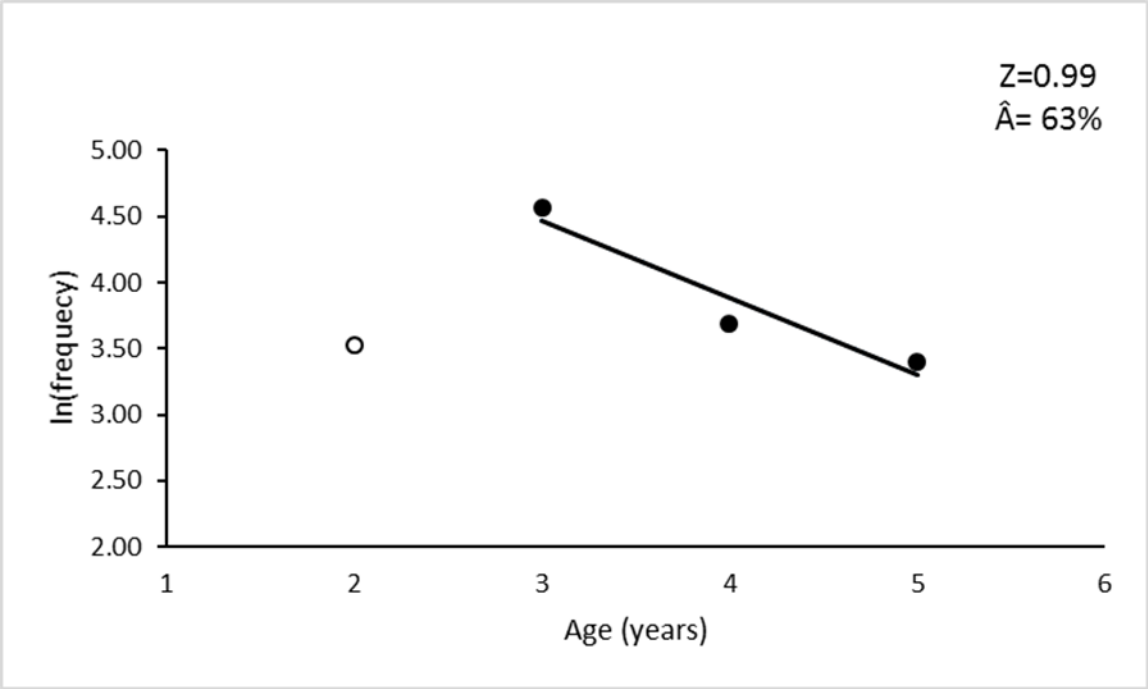

Figure 9. Catch-curve regression estimating mortality of the 2015 cohort of silver carp in Lake Barkley in 2020 (N=196, F1,1=11.75, P=0.180, R2= 0.92). The open circle represnets fish not considered fully recruited to the gears used for data collection and thus not used to estimate A or Z.

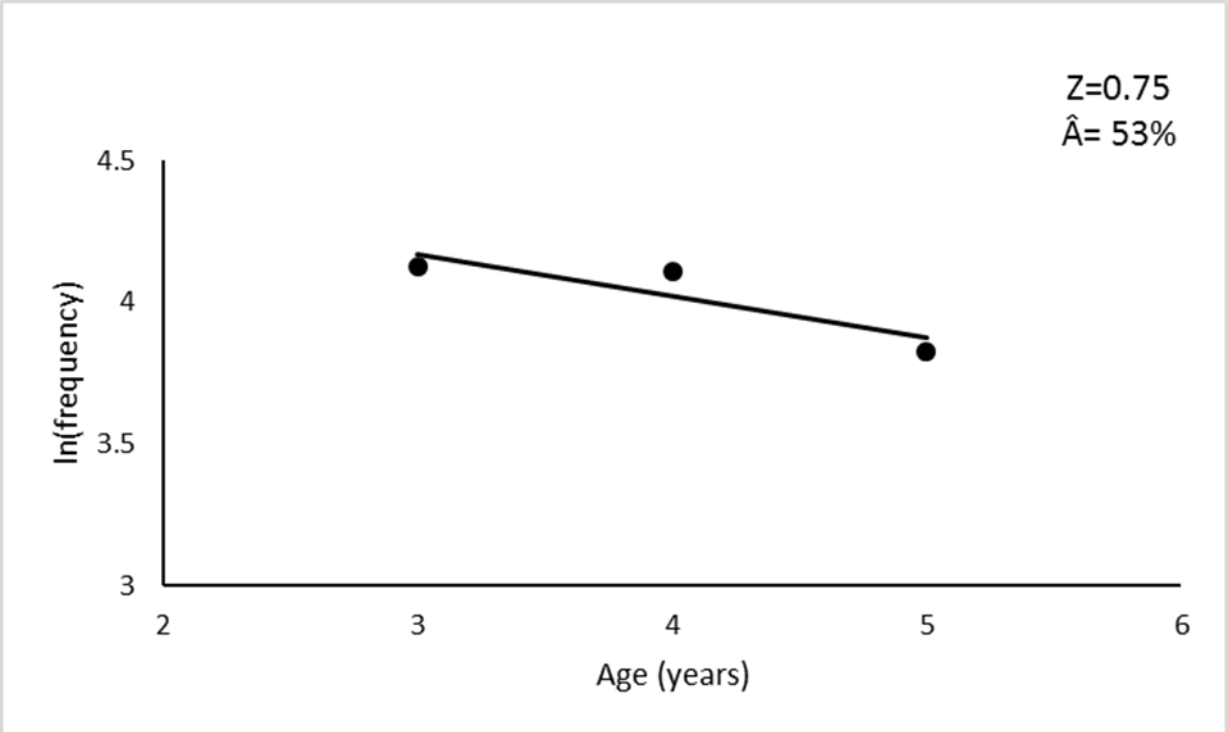

Figure 10. Catch-curve regression estimating mortality of the 2015 cohort of silver carp in Kentucky Lake in 2020 (N=166, F1,1=3.78, P=0.302, R2= 0.79).

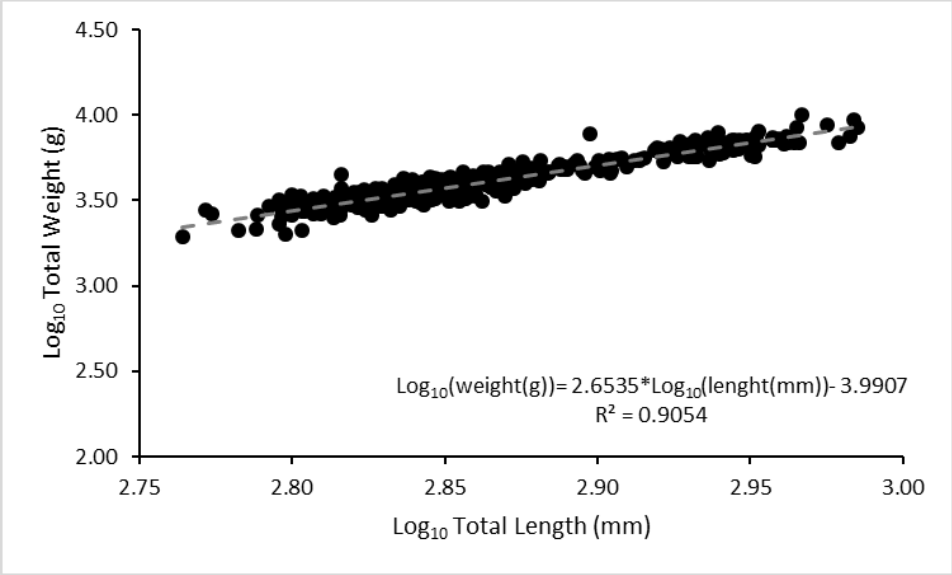

Figure 11. A scatterplot of Log10 transformed lengths and weights for silver carp collected from Lake Barkley in 2020 with a regression line describing the relationship between lengths and weights (N=530).

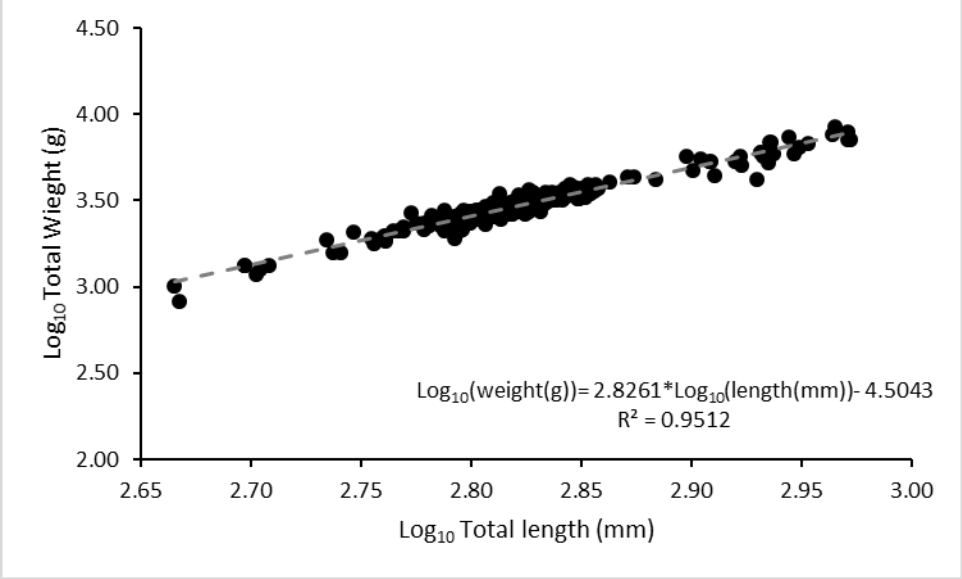

Figure 12. A scatterplot of Log10 transformed lengths and weights for silver carp collected from Kentucky Lake in 2020 with a regression line describing the relationship between lengths and weights (N=236).

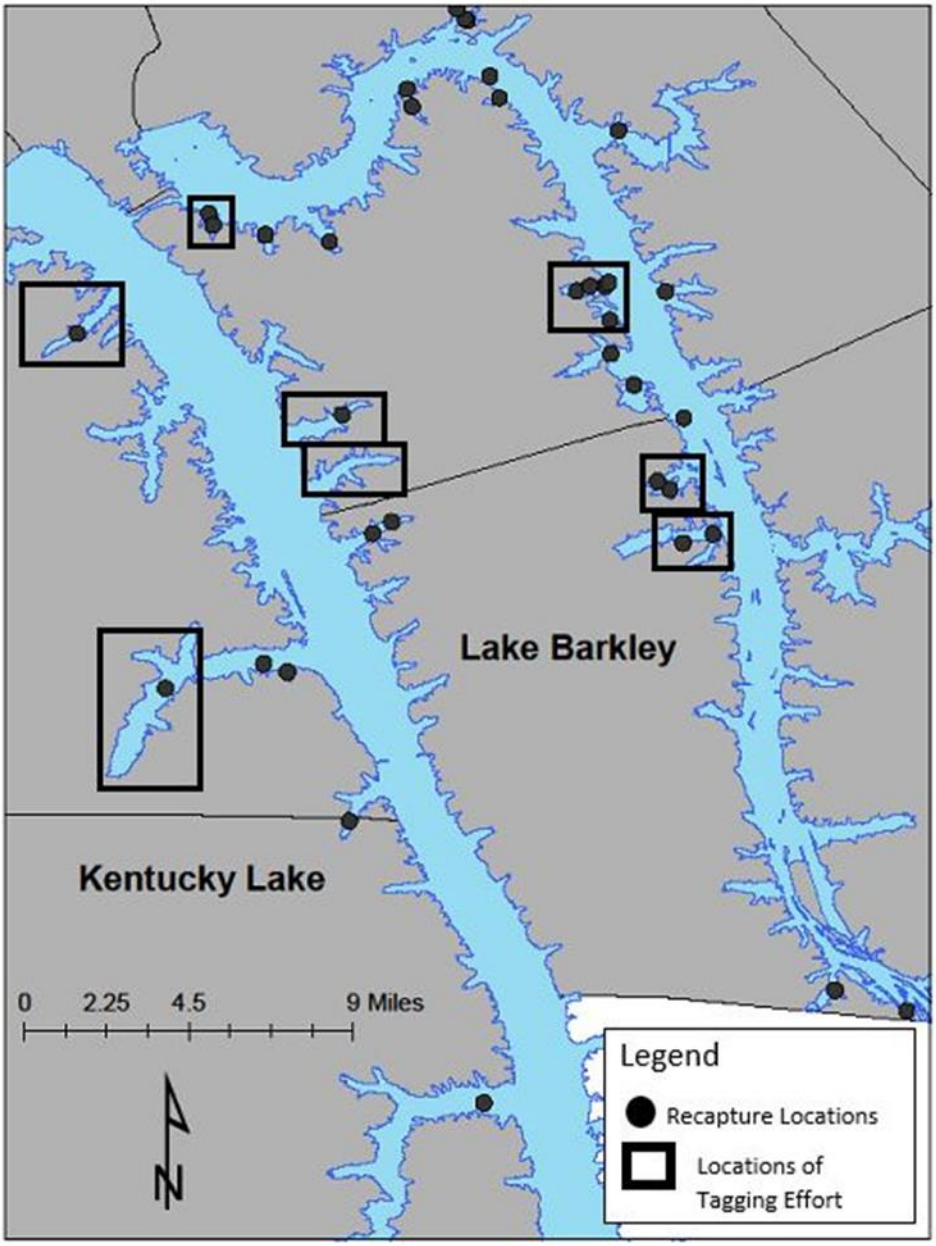

Figure 13. Locations of recaptured silver carp that were tagged as part of the mark-recapture effort to estimate abundance of silver carp in Barkley and Kentucky lakes.

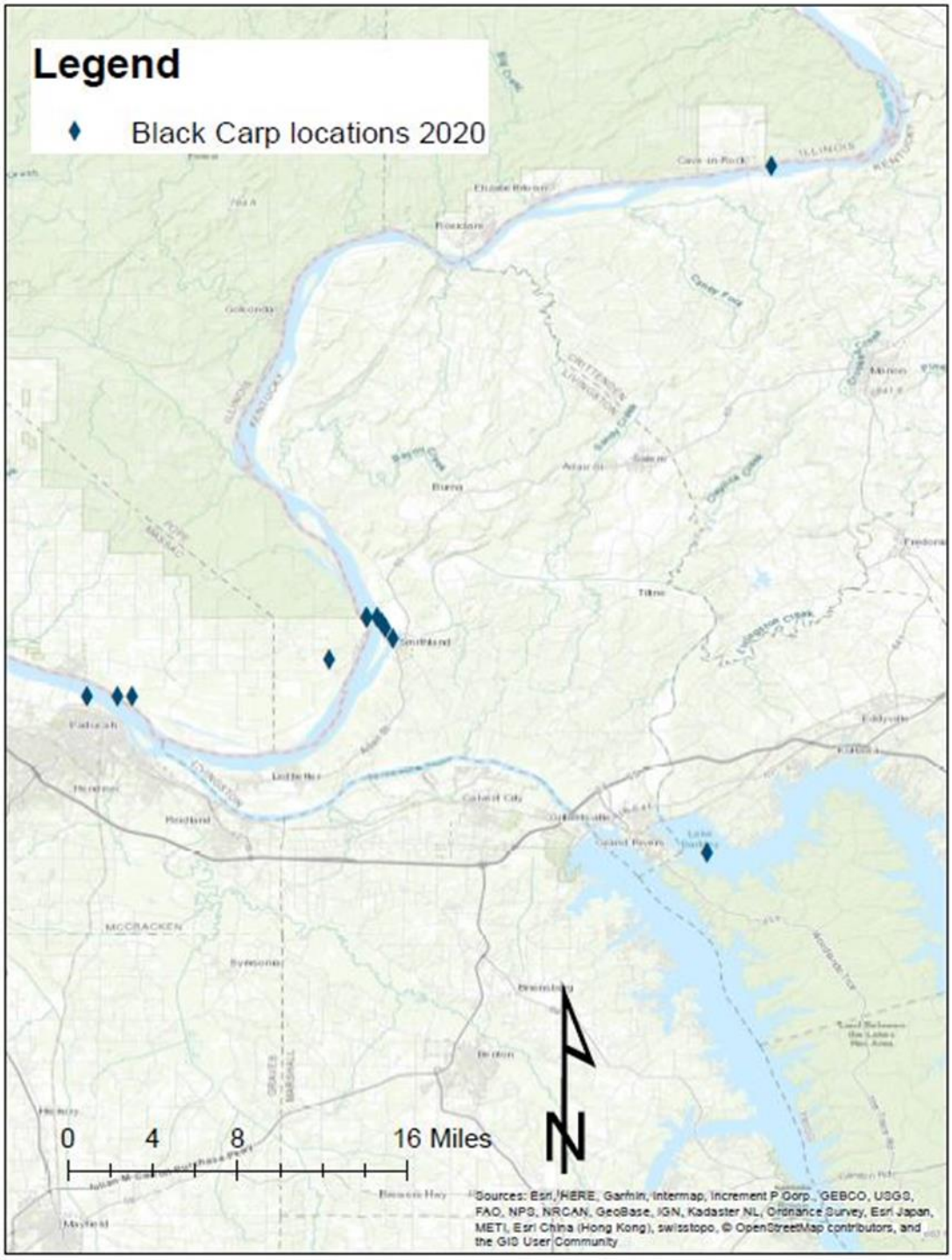

Figure 14. Locations of black carp captures reported in 2020 by commecial fishers to KDFWR. Additional fish from the Ohio and Mississippi rivers were captured and sent to Illinois or the USGS by commercial fishers.

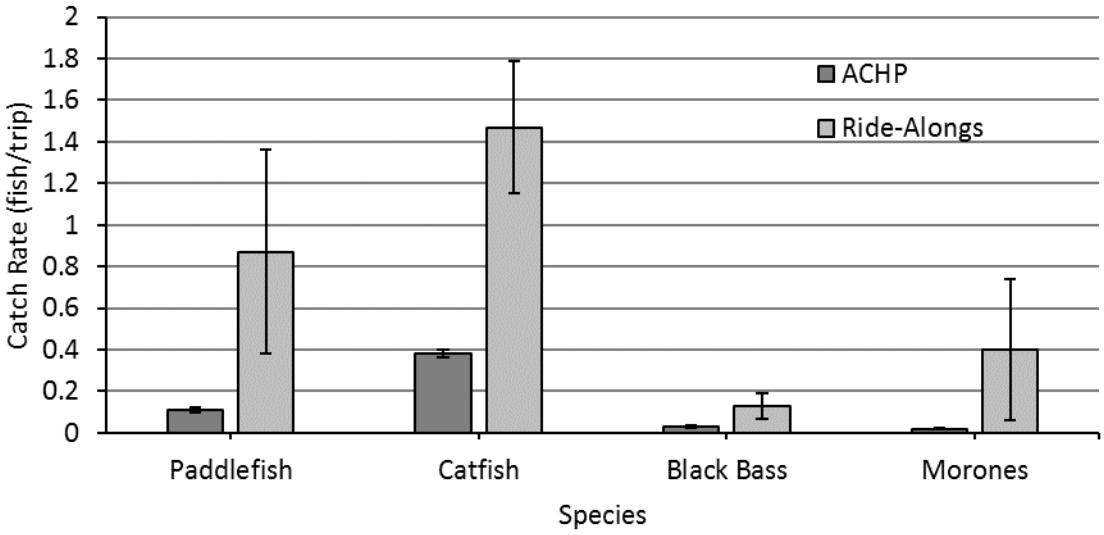

Figure 15. Comparison of catch rates (fish/trip) for some commercially and recreationally important species reported as bycatch by commercial fishers utilizing the Asian Carp Harvest Program (ACHP) and through KDFWR ride-alongs with commercial fishermen. Error bars represent Standard Error values.

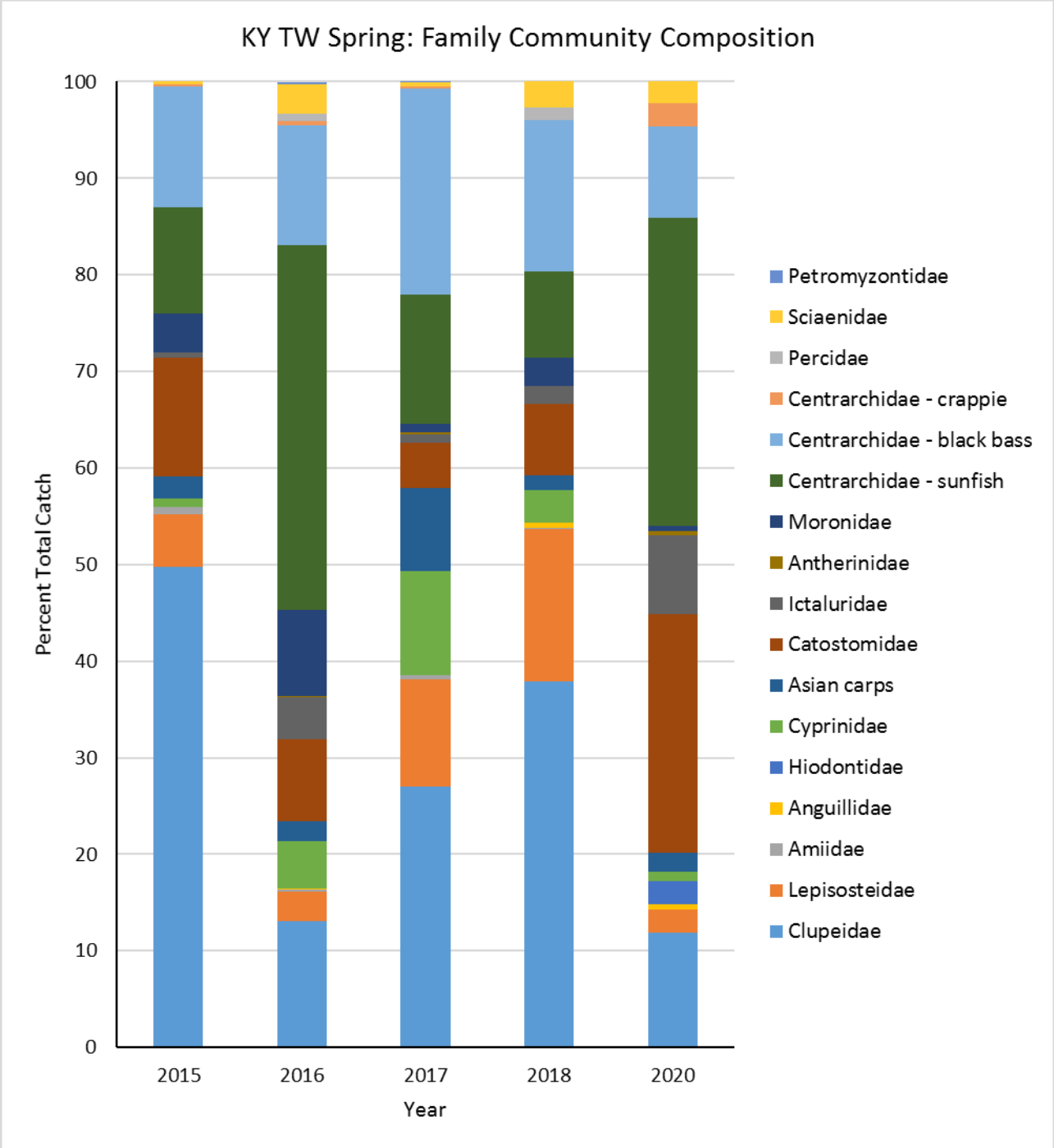

Figure 16. Comparison of percent total catch by number of each family identified from spring community sampling via electrofishing in the Kentucky Tailwater 2015-2020. Spring sampling was not conducted in 2019.

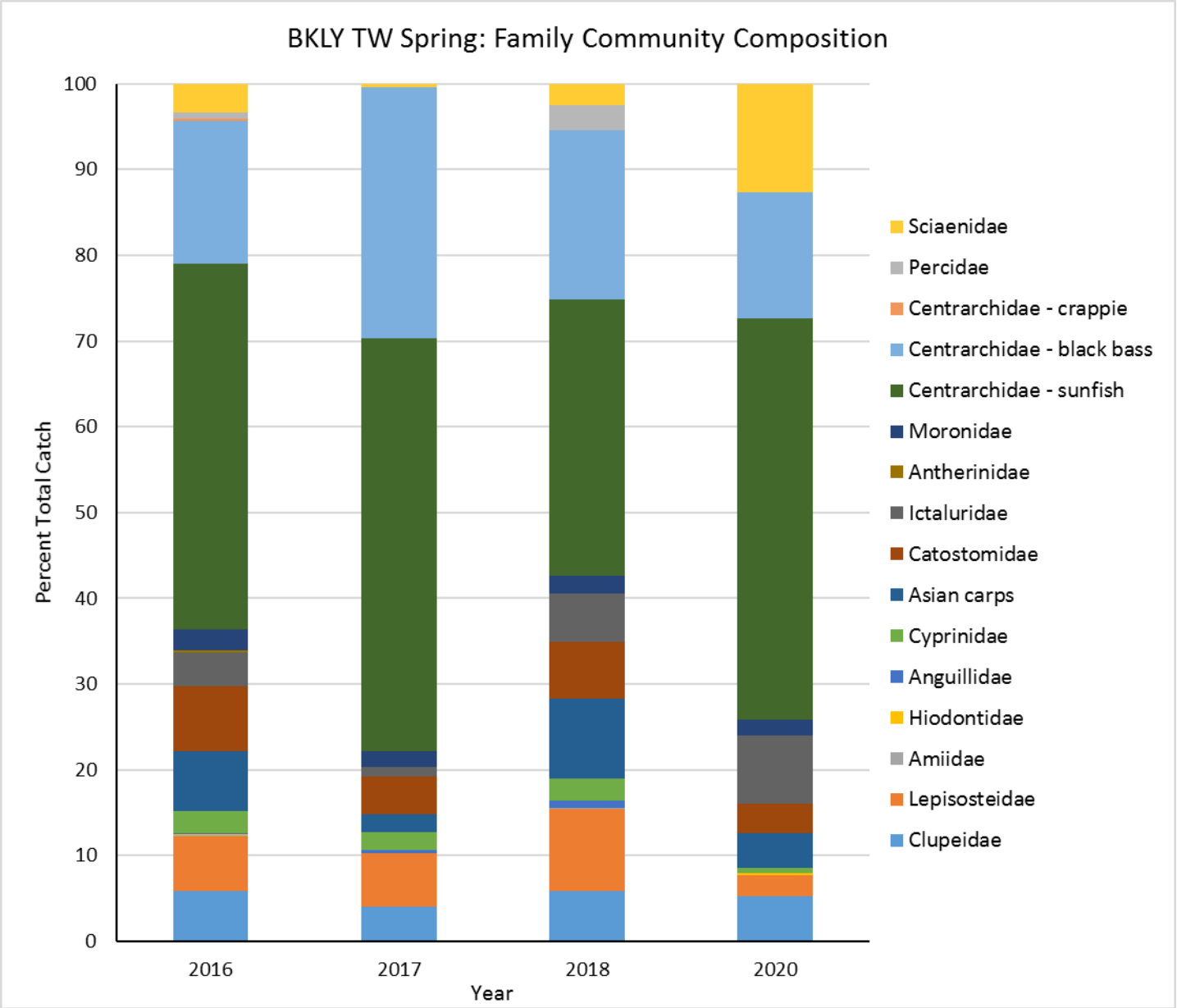

Figure 17. Comparison of percent total catch by number of each family identified from spring community sampling via electrofishing in the Barkley Tailwater 2016-2020. Spring sampling was not conducted in 2019.

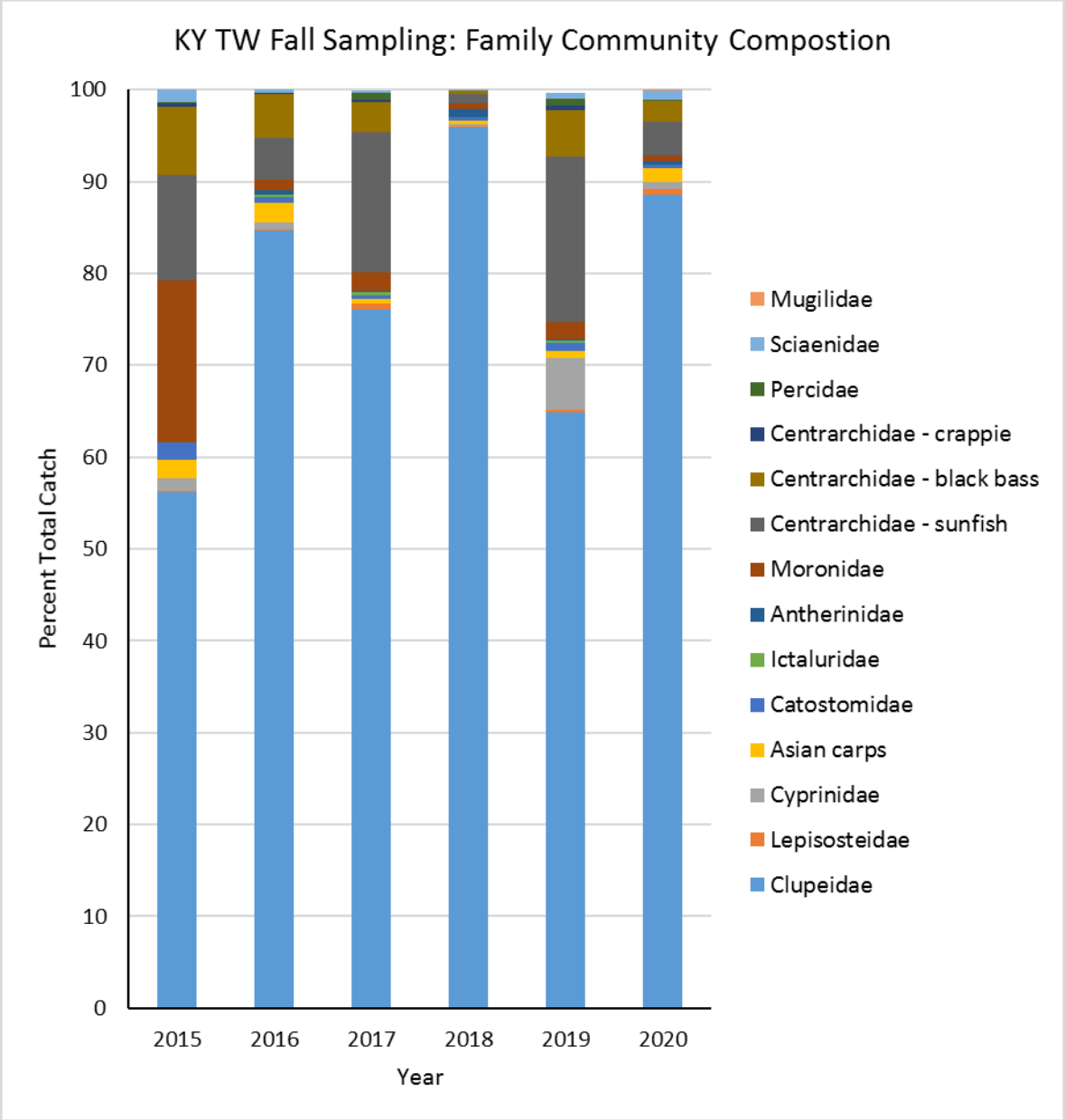

Figure 18. Comparison of percent total catch by number of each family identified from fall community sampling via electrofishing in the Kentucky Tailwater 2015-2020.

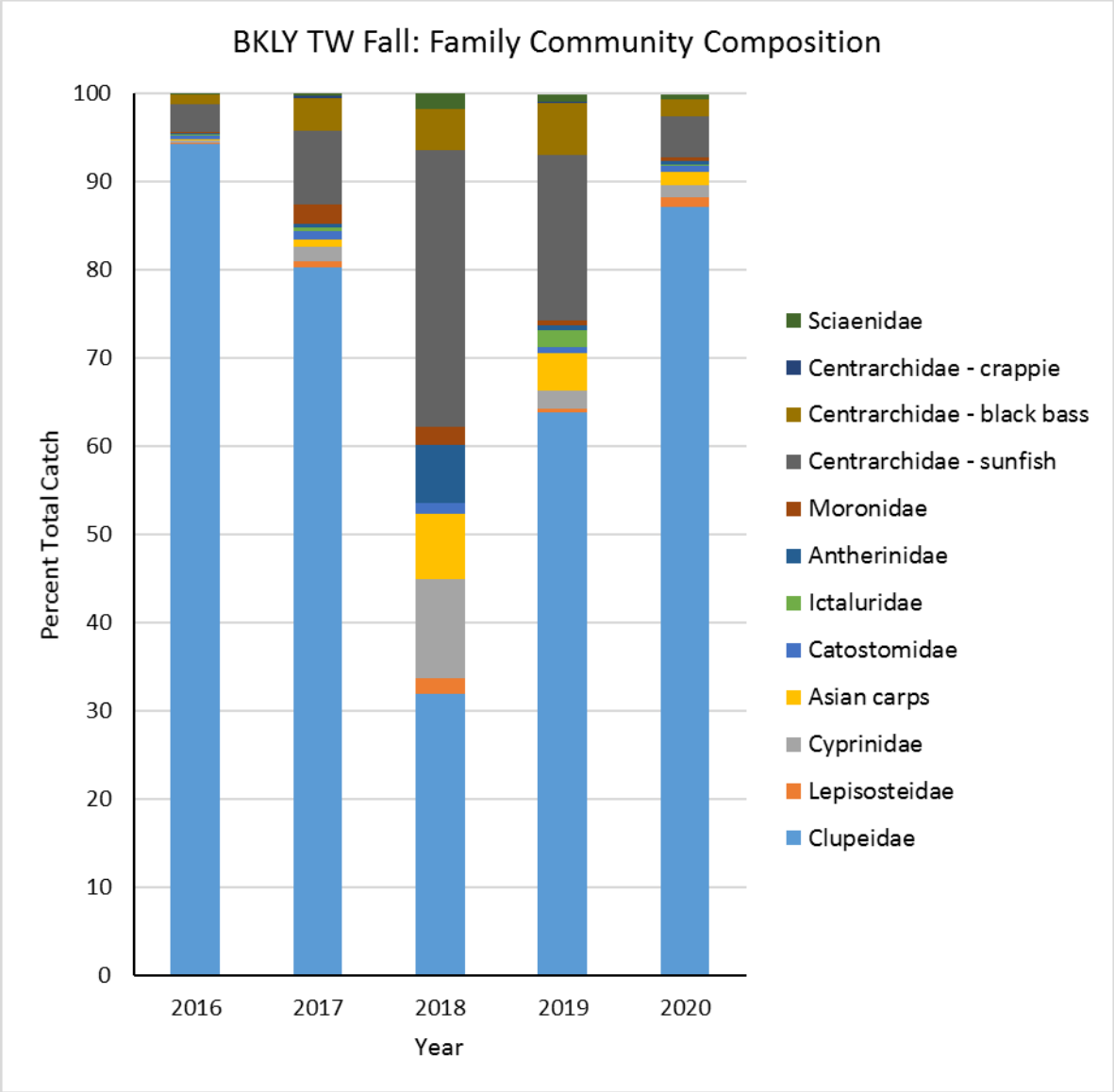

Figure 19. Comparison of percent total catch by number of each family identified from fall community sampling via electrofishing in the Barkley Tailwater 2016-2020.

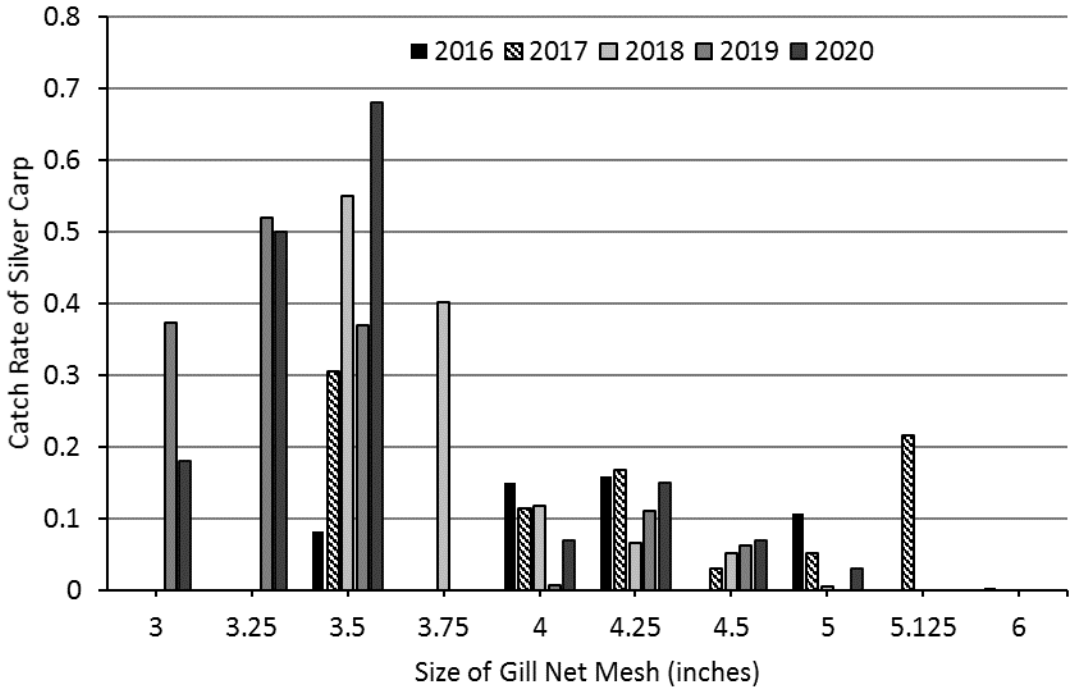

Figure 20. Catch rates (number of fish / yard of net) of silver carp by gill net mesh size during ride-alongs with commercial fishers fishing under the Asian Carp Harvest Program 2016-2020.

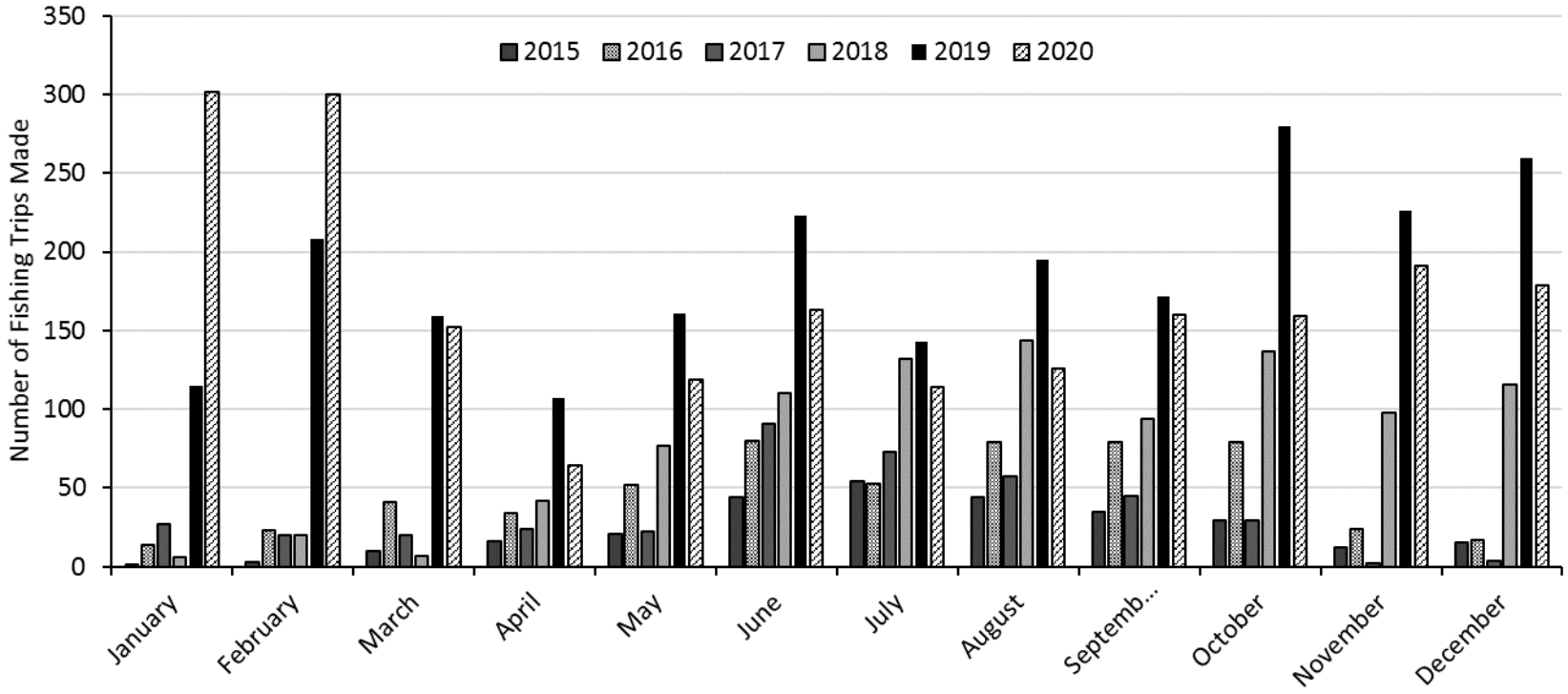

Figure 21. Number of fishing trips made monthly by commercial fishers fishing under the Asian Carp Harvest Program from January 2015 - December 2020.

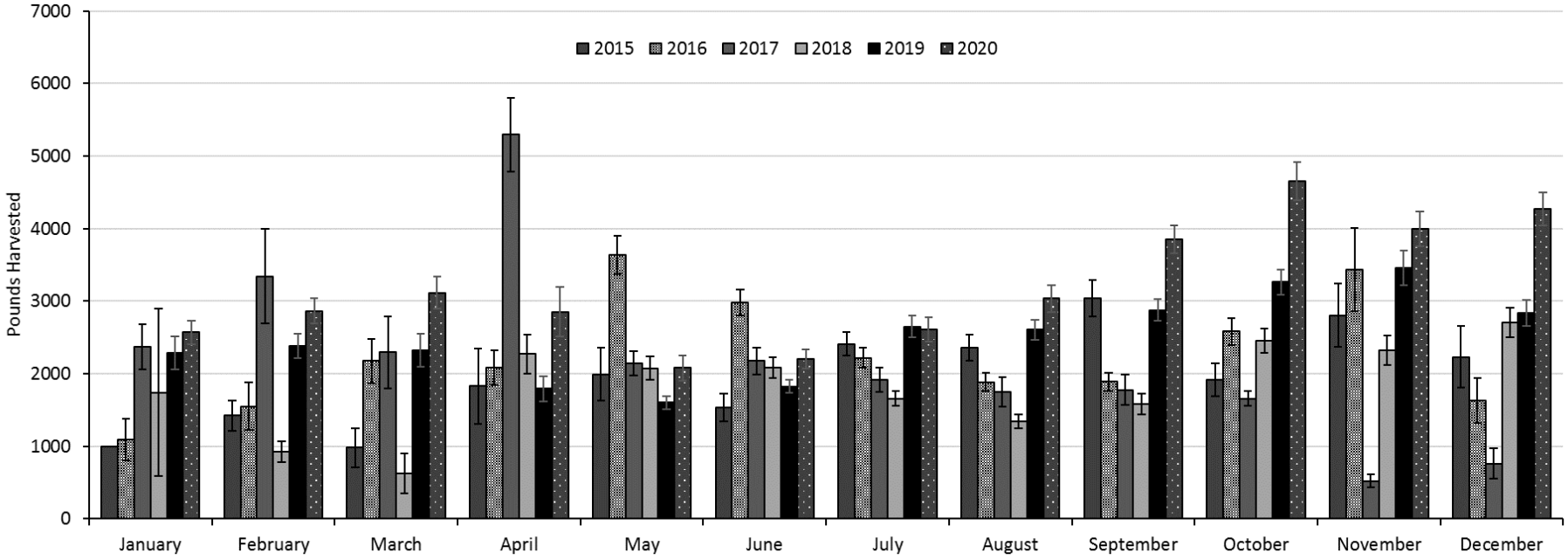

Figure 22. Monthly average total weight (lbs) of silver carp harvested per trip by commercial fishers fishing under the Asian Carp Harvest Program January 2015 - December 2020. Error bars represent standard error values.

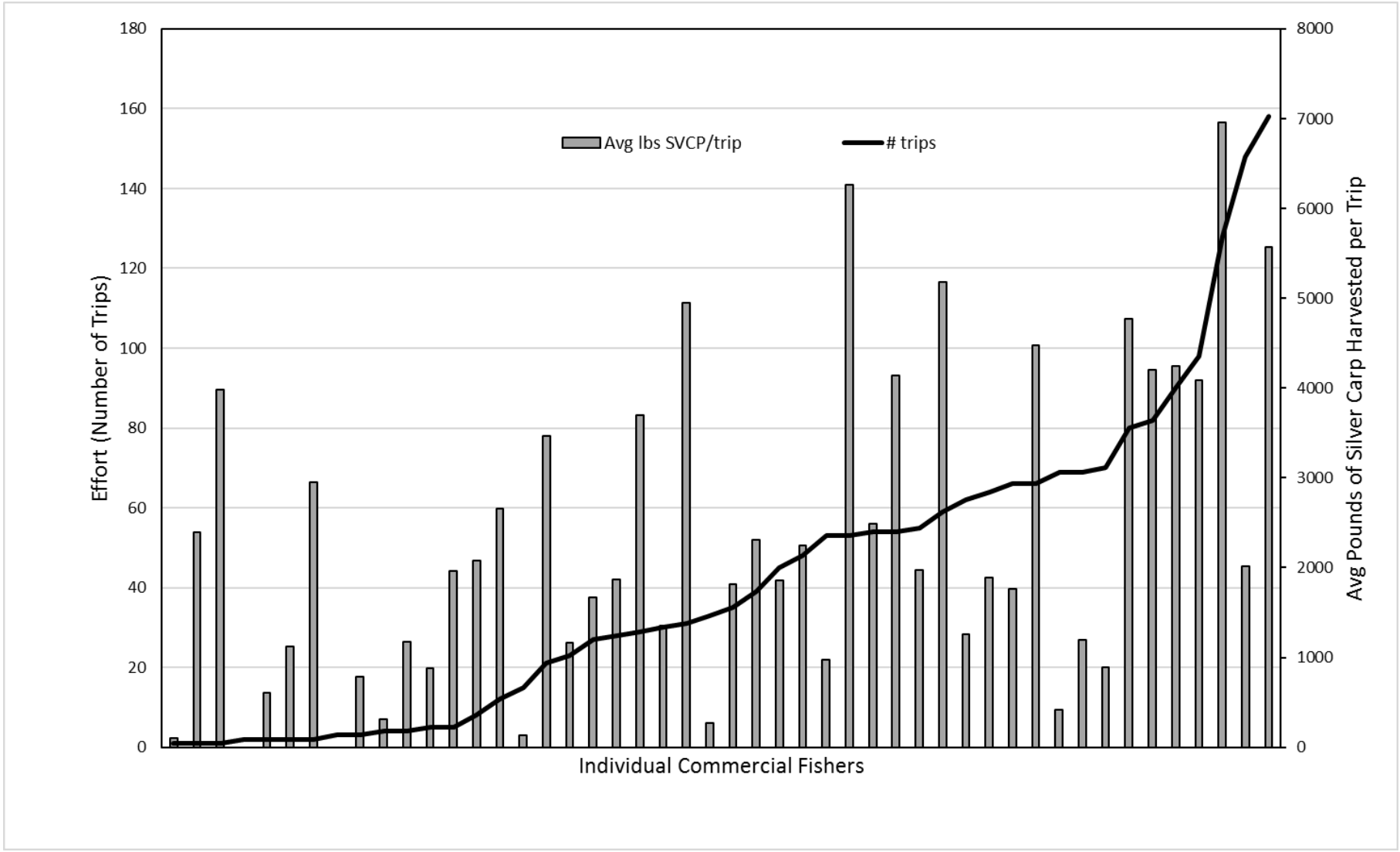

Figure 23. Average weight harvested per trip by individual commercial fishers compared to the number of trips taken by those fishers under the Asian Carp Harvest Program in 2020.

Table 1. The number of Asian carp collected during each standard sampling period by lake in 2018-2020.

2020								
	Lake Barkley				Kentucky Lake			
Species Captured	April	July	October	Total	April	July	October	Totals
Bighead carp	1	7	0	8	7	7	3	17
Grass carp	0	3	1	4	2	5	19	26
Silver carp	12	33	32	77	18	14	36	68
Totals	22	53	35	110	31	30	63	124

2019								
	Lake Barkley				Kentucky Lake			
Species Captured	April	July	October	Totals	April	July	October	Totals
Bighead carp	3	4	2	9	4	12	1	17
Grass carp	0	0	1	1	1	0	4	5
Silver carp	74	64	48	186	109	81	61	251
Totals	100	76	69	245	121	96	70	287

2018								
	Lake Barkley				Kentucky Lake			
Species Captured	April	July	October	Totals	April	July	October	Totals
Bighead carp		13	3	16		11	3	14
Grass carp		4	3	7		4	12	16
Silver carp		305	193	498		477	494	971
Totals		331	212	543		505	522	1027

Table 2. A summation of catch per unit effort (CPUE) for silver carp collected in Barkley and Kentucky lakes, by month and habitat type in 2020. CPUE reported in fish/linear yard of gill net.

			Bar mesh size			
	Site	Month	3"	4"	5"	Mean Total CPUE
Lake Barkley	Main Channel	April	0.004	0.004	0.000	0.003
		July	0.021	0.013	0.006	0.013
		October	0.005	0.013	0.000	0.006
	Embayment	April	0.002	0.011	0.002	0.005
		July	0.000	0.019	0.004	0.008
		October	0.009	0.034	0.004	0.016
			Bar mesh size			
	Site	Month	3"	4"	5"	Mean Total CPUE
Kentucky Lake	Main Channel	April	0.012	0.006	0.000	0.006
		July	0.006	0.002	0.000	0.003
		October	0.003	0.003	0.005	0.003
	Embayment	April	0.017	0.000	0.000	0.006
		July	0.015	0.004	0.000	0.006
		October	0.045	0.013	0.002	0.020

Table 3. A summation of estimated weights at three lengths for silver carp collected from Barkley and Kentucky lakes through all methods from 2018 through 2020.

Lake	Year	Predicted weight(g) at 450mm	Predicted weight(g) at 650mm	Predicted weight(g) at 800mm
Barkley	2018	933	2789	5176
	2019	1076	2881	5024
	2020	1121	2974	5160
Kentucky	2018	950	2733	4963
	2019	930	2720	4987
	2020	986	2788	5018

Table 4. Average length and weight of silver carp harvested during ride-alongs with commercial fishers under the Asian Carp Harvest Program 2015-2019.

Year	Number Sampled	Average total length (inches)	Average weight (lbs)	S. E.
2015	206	33.2	15.2	0.12
2016	448	34.5	17.7	0.10
2017	416	34.0	16.1	0.10
2018	387	31.0	11.6	0.10
2019	924	27.9	8.1	0.09
2020	595	28.0	8.5	0.11

Table 5. Measures of effort and catch reported by commercial fishers fishing under the Asian Carp Harvest Program by calendar year, January -December 2013 - 2020.

Water Body	Year	Number of Days/Trips	Number of fishers	Weight silver carp harvested (lbs)	Weight bighead carp harvested (lbs)	Number of grass carp harvested
Lake Barkley	2013	45	5	187,022		
	2014	61	6	464,003	1,360	
	2015	189	12	472,487	10,278	
	2016	447	22	1,112,585	5,693	
	2017	345	15	826,016	9,669	
	2018*	835	23	1,762,830	25,932	
	2019	1,846	60	5,318,535	45,665	
	2020***	1,431	43	4,700,149	28,714	61,487
Kentucky Lake	2013	21	4	26,400	491	
	2014	82	3	193,786	992	
	2015	59	6	84,190	17,791	
	2016	52	8	96,652	2,884	
	2017	54	8	71,487	11,754	
	2018*	116	8	143,996	11,537	
	2019	140	28	233,806	1,978	
	2020***	426	27	1,601,822	4,196	40,882
Ohio River	2013					
	2014	11	1	74,879		
	2015	16	3	26,864	1,206	
	2016	30	5	90,012	3,216	
	2017	8	4	11,217	713	
	2018	21	4	37,553	70	
	2019	129	9	142,520	521	
	2020***	151	13	137,754	7,402	6,402
Statewide**	2013	76	7	243,121	491	
	2014	160	9	765,768	2,802	
	2015	283	16	617,062	32,800	
	2016	565	24	1,343,464	12,666	
	2017	414	21	921,288	23,272	
	2018*	982	29	1,945,693	37,739	
	2019	2,250	66	5,802,624	50,366	
	2020***	2,052	48	6,471,718	43,931	111,190

*In 2018 KDFWR began allowing commercial fishermen to receive subsidy funds from the Asian Carp Harvest Program while fishing on their net permit, which allows them to harvest catfish and paddlefish. Commercial fishing effort from net permit holders that received subsidy funds is included in this table for 2018 and 2019.

**Effort and harvest occurs under the ACHP in other water bodies to a lesser degree and is included in the statewide totals.

***2020 was the first year that Grass carp harvest was reported seperately from common carp harvest through the ACHP.

Table 6. Number of bighead carp and silver carp captured by gill net mesh size as observed during KDFWR ride-alongs with commercial fishers fishing under the Asian Carp Harvest Program 2016 - 2020. (CPUE = catch per unit effort)

Year	Net Bar Mesh Size (inches)	Effort (yards)	Number of Silver carp	Silver carp CPUE (fish/yard)	Number of Bighead carp	Number of Grass carp
2016	3.5	1883	155	0.08		17
	4	2067	308	0.15		1
	4.25	9300	1469	0.16	8	12
	5	16983	1811	0.11	44	13
	6	1067	3	0.00		
2017	3.5	200	61	0.31	4	1
	4	1983	225	0.11	1	1
	4.25	23400	3918	0.17	19	31
	4.5	2283	68	0.03		
	5	4125	212	0.05	3	1
	5.125	400	86	0.22	4	2
2018	3.5	6883	3778	0.55	8	24
	3.75	167	67	0.40		
	4	3250	381	0.12	4	3
	4.25	14100	920	0.07	54	8
	4.5	2767	145	0.05	4	
	5	867	5	0.01	1	
2019	3	2967	1106	0.37	2	5
	3.25	9600	4979	0.52	10	83
	3.5	39300	14483	0.37	30	177
	4	300	2	0.01	0	0
	4.25	3700	406	0.11	18	3
	4.5	2567	162	0.06	5	1
	5	67	0	0.00	0	0
2020	3	100	18	0.18		
	3.25	3933	1968	0.5003814	2	17
	3.5	21692	14792	0.6819104	33	169
	4	533	38	0.0712946		
	4.25	2100	319	0.1519048	6	
	4.5	1583	104	0.065698	5	
	5	267	9	0.0337079	4	

Table 7. The number of fish captured by species and percent of total by-catch during standard sampling with gill nets from Lake Barkley in 2019 and 2020.

Species Captured	April(20)	July(20)	October(20)	Totals	Percent %
Bigmouth buffalo	0	1	0	1	0.6
Black buffalo	1	0	0	1	0.6
Black crappie	0	1	0	1	0.6
Blue catfish	10	23	6	39	23.6
Channel catfish	2	5	4	11	6.7
Flathead catfish	0	2	4	6	3.6
Freshwater drum	1	30	11	42	25.5
Gizzard shad	0	0	1	1	0.6
Largemouth bass	0	1	1	2	1.2
Paddlefish	1	0	0	1	0.6
Redear sunfish	0	0	2	2	1.2
River carpsucker	0	2	0	2	1.2
Sauger	1	0	0	1	0.6
Shortnose gar	0	1	1	2	1.2
Skipjack herring	0	4	15	19	11.5
Smallmouth buffalo	4	16	12	32	19.4
Stripped bass	0	0	1	1	0.6
Yellow bass	0	1	0	1	0.6
Totals	20	87	58	165	

Species Captured	April(19)	July(19)	October(19)	Totals	Percent %
Bigmouth buffalo	0	1	0	1	0.6
Blue catfish	15	12	16	43	27.6
Channel catfish	0	1	1	2	1.3
Flathead catfish	2	3	2	7	4.5
Freshwater drum	5	22	20	47	30.1
Lake sturgeon	2	0	0	2	1.3
Largemouth bass	0	0	1	1	0.6
Longnose gar	0	0	1	1	0.6
Paddlefish	3	6	0	9	5.8
Redear sunfish	0	0	1	1	0.6
River carpsucker	1	2	2	5	3.2
Shortnose gar	0	2	0	2	1.3
Skipjack herring	0	1	1	2	1.3
Smallmouth buffalo	4	14	13	31	19.9
Striped bass	1	0	0	1	0.6
Yellow bass	0	1	0	1	0.6
Totals	33	65	58	156	

Table 8. The number of fish captured by species and percent of total by-catch during standard sampling with gill nets from Kentucky Lake in 2019 and 2020.

Species Captured	April(20)	July(20)	October(20)	Totals	Percent %
Bigmouth buffalo	0	3	2	5	2.4
Blue catfish	11	8	14	33	15.6
Channel catfish	3	8	5	16	7.5
Flathead catfish	3	2	3	8	3.8
Freshwater drum	3	15	15	33	15.6
Largemouth bass	1	0	3	4	1.9
Longnose gar	6	1	2	9	4.2
River carpsucker	3	8	6	17	8.0
Sauger	2	2	1	5	2.4
Shortnose gar	0	1	0	1	0.5
Skipjack herring	1	0	8	9	4.2
Smallmouth buffalo	2	29	38	69	32.5
Striped bass	0	0	1	1	0.5
Yellow bass	0	0	1	1	0.5
Totals	35	78	99	212	

Species Captured	April(19)	July(19)	October(19)	Totals	Percent %
Bigmouth buffalo	0	2	1	3	1.2
Black Buffalo	0	2	0	2	0.8
Blue catfish	20	11	4	35	14.5
Channel catfish	2	1	2	5	2.1
Flathead catfish	5	1	5	11	4.6
Freshwater drum	6	46	16	68	28.2
Largemouth bass	3	0	2	5	2.1
Longnose gar	2	1	0	3	1.2
Paddlefish	0	1	0	1	0.4
River carpsucker	2	9	7	18	7.5
Shortnose gar	0	1	0	1	0.4
Skipjack herring	0	1	0	1	0.4
Smallmouth buffalo	2	33	50	85	35.3
Striped bass	2	0	0	2	0.8
White crappie	1	0	0	1	0.4
Totals	45	109	87	241	

Table 9. Relative weight (*W*r) values of gizzard shad collected with boat electrofishing from Barkley and Kentucky lakes in October 2017-2020.

Lake Barkley

		Length group								
		7.0-11.0 in			>11.0 in			Total		
Species	Year	No.	Wr	Std err	No.	Wr	Std err	No.	Wr	Std err
Gizzard shad	2020	43	94	0.7	4	91	2.3	47	93	0.7
	2019	60	94	1.1	9	93	2.3	69	94	1.0
	2018	30	90	1.1	1	99		31	90	1.1
	2017	110	83	0.7	0			110	83	0.7

Kentucky Lake

		Length group								
		7.0-11.0 in			>11.0 in			Total		
Species	Year	No.	Wr	Std err	No.	Wr	Std err	No.	Wr	Std err
Gizzard shad	2020	63	93	1.1	32	91	1.1	95	92	0.8
	2019	41	96	0.8	26	93	1.3	80	92	0.9
	2018	57	86	1.1	7	86	2.5	64	86	1.0
	2017	40	84	0.9	4	85	1.1	44	84	0.8

Table 10. Number of fish, mean relative weight (Wr), and standard error values for each length group of sportfish collected during standardized sampling in Kentucky Lake from 2013-2020.

		Length group								
		5.0-7.9 in			8.0-9.9 in			≥10 in		
Species	Year	No.	Wr	Std err	No.	Wr	Std err	No.	Wr	Std err
Black crappie	2020	314	90	0.5	54	99	1.1	82	97	0.8
	2019	123	84	1	255	85	<1	151	85	<1
	2018	76	85	1.6	254	87	0.5	111	89	0.7
	2017	123	87	0.8	332	87	0.4	90	87	0.6
	2016	208	99	0.6	230	98	0.5	81	97	0.7
	2015	625	93	0.4	251	90	0.4	50	92	1.2
	2014	373	86	0.5	105	84	0.8	101	91	0.7
	2013	76	85	1.1	126	93	0.8	176	96	0.6

		Length group								
		5.0-7.9 in			8.0-9.9 in			≥10 in		
Species	Year	No.	Wr	Std err	No.	Wr	Std err	No.	Wr	Std err
White crappie	2020	194	86	0.6	52	101	1.9	27	101	1.9
	2019	143	81	1	33	81	1	92	86	1
	2018	48	84	2.2	56	86	1.8	117	94	0.7
	2017	16	86	2.1	135	90	0.7	84	89	1.0
	2016	23	98	2.2	79	100	0.9	45	97	1.5
	2015	243	89	0.6	255	89	0.5	95	97	1.3
	2014	166	81	0.6	45	87	1.4	91	91	0.9
	2013	37	83	1.6	42	93	1.4	112	96	0.7

		Length group								
		8.0-12.0 in			12.0-15.0 in			≥15 in		
Species	Year	No.	Wr	Std err	No.	Wr	Std err	No.	Wr	Std err
Largemouth bass	2020	42	97	1.2	93	93	1.2	55	96	1.3
	2019	32	94	1	38	90	1	10	93	3
	2018	114	93	0.8	46	92	1.3	26	90	2.2
	2017	91	89	0.9	28	84	1.7	34	89	2.1
	2016	180	105	0.8	87	92	1.0	97	98	0.9
	2015	52	98	1.7	160	102	0.8	72	103	1.5
	2014	185	92	0.7	112	88	1.0	47	91	1.9
	2013	145	91	0.7	85	89	1.1	64	92	1.4

		Length group								
		12.0-19.9 in			20.0-29.9 in			≥30 in		
Species	Year	No.	Wr	Std err	No.	Wr	Std err	No.	Wr	Std err
Blue catfish	2020	8	130	20.7	11	99	1.7			
	2019	15	105	6	2	95	2			
	2018	27	118	2	17	111	2	1	124	
	2017	55	117	2.0	40	115	2.0	7	126	3.0
	2016	203	99	1.0	48	105	2.0	8	119	5.0
	2015	81	102	1.0	32	100		1	108	
	2014	77	106	1.0	21	101	2.0	5	116	4.0

Table 11. Number of fish and the relative weight (Wr) values for each length group of sportfish collected during standardized sampling in Lake Barkley 2013-2020.

		Length group								
		5.0-7.9 in			8.0-9.9 in			≥10 in		
Species	Year	No.	Wr	Std err	No.	Wr	Std err	No.	Wr	Std err
Black crappie	2020	81	93	1.0	36	102	1.5	16	101	1.3
	2019	66	89	1.1	22	88	1.6	17	96	1.9
	2018	68	93	2.5	32	105	2.9	18	103	3.3
	2017	77	95	1.2	75	94	1.4	32	94	1.7
	2016	229	91	0.7	155	96	1.0	49	95	1.0
	2015	135	94	1.0	100	93	0.9	87	100	0.7
	2014	167	92	0.6	97	97	0.8	17	100	2.4
	2013	4	94	3.3	11	93	2.6	48	93	0.8

		Length group								
		5.0-7.9 in			8.0-9.9 in			≥10 in		
Species	Year	No.	Wr	Std err	No.	Wr	Std err	No.	Wr	Std err
White crappie	2020	204	90	0.7	185	101	0.5	35	104	1.3
	2019	347	83	0.5	70	88	1.3	41	99	1.9
	2018	58	89	1.8	88	101	1.1	64	102	1.2
	2017	39	91	2.9	47	94	1.5	116	98	0.9
	2016	261	87	0.5	324	93	0.5	168	97	0.7
	2015	922	87	0.3	328	93	0.7	110	100	1.1
	2014	52	83	1.6	79	96	0.9	97	99	0.9
	2013	27	84	2.0	23	96	1.0	150	99	0.7

		Length group								
		8.0-11.9 in			12.0-14.9 in			≥15 in		
Species	Year	No.	Wr	Std err	No.	Wr	Std err	No.	Wr	Std err
Largemouth bass	2020	39	106	1.8	57	105	1.2	50	103	1.6
	2019	52	98	1.4	7	97	1.7	8	98	1.3
	2018	48	103	1.4	76	103	1.0	55	103	1.2
	2017	47	92	1.2	35	95	1.6	38	95	0.8
	2016	42	95	2.2	72	96	1.2	83	98	0.8
	2015	62	105	1.0	143	102	0.7	117	103	0.5
	2014	107	95	0.8	138	93	0.7	82	98	1.2
	2013	145	110	8.3	167	98	0.7	112	100	0.9

		Length group								
		12.0-19.9 in			20.0-29.9 in			≥30 in		
Species	Year	No.	Wr	Std err	No.	Wr	Std err	No.	Wr	Std err
Blue catfish	2020	113	104	0.8	0			0		
	2019	183	97	0.6	14	101	3.6	1	84	
	2018	269	97	0.6	10	99	4.0	1	111	
	2017	303	98	0.7	14	98	6.0	1	116	
	2016	288	96	0.6	21	103	3.0	0		
	2015	357	96	0.4	4	99	2.8	4	106	8.4
	2014	142	99	0.7	1	111		0		

Table 12. Number and disposition of bycatch from commercial fishing efforts under the Asian Carp Harvest Program by calendar year, January - December. Survival rate is defined as fish that swam away upon being released from the net. Harvest of scaled rough fish is permitted under the Asian Carp Harvest Program.

Year	Sport Fish*		Scaled Rough Fish**		Catfish Species		Paddlefish		Total number of bycatch
	Number	Survival Rate %	Number Caught	% Harvested	Number	Survival Rate %***	Number	Survival Rate	
2013	29	100.0	7,132	93.7	100	97.0	305	90.5	7,566
2014	78	92.3	4,505	75.1	128	99.2	120	65.0	4,831
2015	97	89.7	7,462	80.5	719	95.0	980	65.0	9,258
2016	115	75.7	10,811	76.1	719	95.5	573	68.2	12,218
2017	25	92.0	9,565	91.8	541	95.7	314	75.5	10,445
2018	46	71.7	25,703	86.1	1201	98.3	200	85.5	27,150
2019	171	93.6	32,861	80.7	1512	98.7	296	80.7	34,841
2020	148	92.5	17,394	78.8	768	99.2	222	85.7	18,592

*Sport fish are defined in 301 KAR 1:060

**Scaled Rough fish are defined in 301 KAR 1:152

***In 2018 KDFWR began allowing commercial fishermen to receive subsidy funds from the Asian Carp Harvest Program while fishing on their net permit, which allows them to harvest catfish and paddlefish. Therefore, the survival rates for 2018 - 2020 only account for fish that were dead or alive upon release and not those that were harvested.

Table 13. Comparison for number of paddlefish, catfish, and sport fish caught per trip as reported by commercial fishers fishing under the Asian Carp Harvest Program versus observations made by KDFWR staff during ride-alongs in 2016-2020. (S.E. = standard error).

	2016				2017				2018				2019				2020			
Species	ACHP	S.E.	Ride-alongs	S.E.	ACHP	S.E.	Ride-alongs	S.E.	ACHP	S.E.	Ride-alongs	S.E.	ACHP	S.E.	Ride-alongs	S.E.	ACHP	S.E.	Ride-alongs	S.E.
Paddlefish	1.02	0.08	2.96	0.60	0.90	0.12	2.00	0.95	0.22	0.03	1.54	0.53	0.13	0.02	1.31	0.80	0.11	0.01	0.87	0.49
Blue catfish	0.74	0.06	1.21	0.28	0.63	0.08	1.52	0.33	0.47	0.04	1.75	0.37	0.08	0.01	2.00	0.45	0.19	0.01	1.07	0.34
Channel catfish	0.08	0.02	0.36	0.16	0.06	0.02	0.55	0.20	0.09	0.01	0.50	0.13	0.08	0.03	0.27	0.08	0.05	0.01	0.17	0.11
Flathead catfish	0.38	0.04	0.39	0.17	0.41	0.06	0.61	0.19	0.14	0.02	0.33	0.13	0.06	0.01	0.83	0.21	0.06	0.01	0.23	0.09
Catfish*	0.07	0.02			0.17	0.05			0.23	0.04			0.21	0.03			0.08	0.01		
Largemouth bass	0.08	0.70	0.04	0.04	0.01	<0.01	0.16	0.06	0.01	<0.01	0.08	0.06	0.02	0.01	0.52	0.24	0.02	<0.01		
Smallmouth bass	<0.01												<0.01	<0.01	0.08	0.05	0.02	<0.01	0.13	0.06
Spotted bass	<0.01		0.04	0.04													<0.01	<0.01		
Bass**	0.02	0.02			0.02	0.01			0.01	<0.01			0.02	0.01						
Hybrid striped bass	<0.01		0.07	0.05					<0.01	<0.01	0.04	0.04	<0.01	<0.01	0.10	0.05	<0.01	<0.01	0.07	0.07
Striped bass	0.12	0.03	0.68	0.37	0.02	<0.01	0.03	0.03	0.01	<0.01	0.08	0.06	0.01	0.01	0.10	0.05	0.01	<0.01	0.33	0.33
Yellow bass	0.04	0.02	0.71	0.45	<0.01	<0.01	0.03	0.03	0.01	<0.01	0.25	0.15	<0.01	<0.01	0.08	0.07	<0.01	<0.01		
White bass	<0.01		0.07	0.05									<0.01	<0.01	0.02	0.02	<0.01	<0.01		
Sauger	<0.01		0.04	0.04	<0.01	<0.01	0.06	0.04	<0.01	<0.01	0.13	0.70	<0.01	<0.01	0.08	0.07	0.01	<0.01	0.07	0.05
Crappie	0.01	0.01					0.03	0.03	0.01	0.01	0.29	0.21	<0.01	<0.01	0.06	0.05	<0.01	<0.01	0.03	0.03
Redear sunfish	0.01		0.04	0.04	<0.01	<0.01			<0.01	<0.01	0.04	0.04	<0.01	<0.01	0.13	0.07	<0.01	<0.01		

*Commercial fishers do not always delineate species of catfish on their reports, therefore this row accounts for those catfish that were not identified species

**Commercial fishers do not always delineate what species of black bass they catch, therefore this row accounts for black bass that were not identified to species

Table 14. Species composition, number of individuals captured, and survival rate of species observed in bycatch during KDFWR ride-alongs with commercial fishers fishing under the Asian Carp Harvest Program in 2016 - 2020. Survival rate of fish is defined as fish that swim away after release.

		2016		2017		2018		2019		2020	
	Species	Number captured	Survival rate	Number captured	Survival rate	Number captured	Survival rate	Number captured	Survival rate	Number captured	Survival rate
Sport Fish	White bass	1	<1%					1	100%		
	Yellow bass	20	50%	1	100%	6	33%	4	75%		
	Striped bass	19	79%	1	100%	3	33%	5	80%	10	80%
	Hybrid striped bass	2	100%			1	100%	5	80%	2	100%
	Sauger	1	<1%	2	100%	3	33%	4	75%	2	50%
	Spotted bass	1	100%								
	Largemouth bass	1	100%	5	80%	3	67%	25	80%	4	75%
	Smallmouth bass							4	100%		
	Redear sunfish	1	100%			2	50%	6	83%		
	Black crappie					5	50%	1	100%	1	100%
	White crappie			1	100%	6	67%	2	50%		
	Total	46	88%	10	96%	29	54%	57	82%	19	81%
Catfish species	Blue catfish	27	74%	47	94%	42	91%	96	95%	32	100%
	Channel catfish	10	80%	17	82%	12	100%	13	100%	5	100%
	Flathead catfish	9	89%	19	100%	8	88%	40	100%	7	100%
	Total	46	81%	83	92%	62	93%	149	98%	44	100%
Rough Fish*	Paddlefish	83	48%	62	48%	38	32%	63	48%	26	50%
	Lake sturgeon					1	100%				
	Shovelnose sturgeon									3	100%
	Skipjack herring	23	17%	47	13%	18	<1%	79	<1%	16	<1%
	Smallmouth buffalo	145	99%	13	85%	98	100%	186	98%	103	100%
	Bigmouth buffalo	8	100%	4	100%	7	100%	34	97%	14	100%
	Black buffalo	17	94%			2	100%	4	100%	1	100%
	Common carp	48	98%	33	94%	27	100%	479	84%	36	97%
	Gizzard shad	5	<1%	3	33%			3	<1%	1	100%
	Freshwater drum	76	67%	27	52%	73	71%	71	63%	40	82%
	River carpsucker	3	100%					35	97%	41	100%
	Quillback									1	100%
	Mooneye	3	<1%								
	Chestnut lamprey	1	<1%								
	Threadfin shad	1	<1%								
	Blue sucker	49	80%					2	100%		
	Spotted gar					2	50%	3	100%	1	100%
	Longnose gar	8	88%	9	44%			9	67%	3	100%
	Shortnose gar	9	44%	1	100%	2	50%	11	55%	5	100%
	Total	571	77%	365	72%	392	83%	1277	87%	329	98%

* Rough fish capture numbers only include fish that were released and does not include fish that were harvested.

Table 15. Number and survival rate of paddlefish captured by commercial fishers during KDFWR ride-alongs under the Asian Carp Harvest Program for each month paddlefish were observed caught in 2016 - 2020.

Year	Month	Number paddlefish captured	% released alive	Mean water temp (℉)	Mean soak time (hours)
2016	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	
2017	April	6	0.0%	67.6	13.0
	May	15	33.3%	68.5	10.0
	June	35	60.0%	79.5	8.3
	September	2	50.0%	74	10.0
	December	4	75%	50	21.3
2018	April	4	75.0%	54.9	11.0
	May	9	60.0%	66.1	10.2
	June	12	35.0%	81.7	10.6
	August	12	0.0%	82.9	11.6
2019	February	43	60.5%	46.9	11.4
	March	1	0.0%	49.8	11
	April	3	33.3%	60.25	9.7
	May	7	14.3%	74	6.4
	June	4	0.0%	76.9	11.3
	August	2	0.0%	84.1	8.8
	October	3	66.7%	69.8	8.2
2020	March	9	88.8%	49.1	7.8
	May	5	20%	66.1	6.5
	September	11	36.36%	77	7.25
	October	1	100%	68.6	8.8

Table 16. Comparison of spring electrofishing CPUE values for all species captured in the Kentucky Lake tailwaters during sampling in 2015 (effort = 2.33 hours), 2016 (effort = 4.65 hours), 2017 (effort = 3.0 hours), 2018 (effort = 3.0 hours), and 2020 (effort = 1.25 hours). (CPUE=catch per unit effort; S.E.=standard error)

Species	Kentucky Spring 2015		Kentucky Spring 2016		Kentucky Spring 2017		Kentucky Spring 2018		Kentucky Spring 2020	
	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.
Paddlefish			< 1	0.2						
Skipjack herring	1	0.4	< 1	0.2	1	0.5	1	0.7		
Gizzard shad	24	4.8	52	14.7	122	83.3	126	70.7	20	6.1
Threadfin shad			8	4.1	3	1.6	2	1.7		
Grass carp	< 1	0.3	3	1.1	1	1.0	2	1.2		
Silver carp	1	0.3	6	2.3	38	17.2	3	1.6	3	1.5
Smallmouth buffalo	3	1.0	27	6.1	13	3.3	19	4.6	38	10.5
Bigmouth buffalo	2	1.0	1	0.3	4	1.6	3	1.6		
Black buffalo			2	1.1	1	0.5				
Blue catfish			< 1	0.3						
Channel catfish	< 1	0.2	1	0.7	< 1	0.3	< 1	0.3		
Flathead catfish			19	5.5	4	1.3	6	2.4	14	3.7
White bass	1	0.6	8	2.1	1	0.8	2	1.4		
Yellow bass	1	0.5	31	12.3	3	1.3	5	5.0		
Striped bass									1	0.8
Green sunfish			4	1.5	2	1.3	1	0.5		
Orangespotted sunfish			< 1	0.2	3	1.7	< 1	0.3		
Bluegill	2	0.7	92	16.3	30	5.6	14	3.2	29	8.9
Longear sunfish	3	1.8	74	15.2	25	6.9	15	3.9	22	9.9
Redear sunfish	1	0.3	3	1.1	2	1.2	1	0.5	3	1.5
Smallmouth bass	1	0.8	10	2.5	13	3.2	6	2.6	2	1.6
Spotted bass	< 1	0.3	1	0.5	11	4.2	1	0.5		
Largemouth bass	5	1.6	46	5.2	76	7.9	46	9.2	14	3.3
White crappie			1	0.9	< 1	0.3			3	3.2
Black crappie	< 1	0.1	1	0.3	1	0.5			1	0.8
Sauger			1	0.6			1	0.5		
Freshwater drum	< 1	0.1	14	3.4	2	0.9	9	2.9	4	1.3
White bass/Striped bass hybrid			2	0.8			2	2.3		

Table 17. Comparison of spring electrofishing CPUE values for all species captured in the Lake Barkley tailwaters during sampling in 2016 (effort = 2.75 hours), 2017 (effort = 0.92 hours), 2018 (effort = 2.0 hours), and 2020 (effort = 1.0 hours). (CPUE=catch per unit effort; S.E.=standard error)

Species	Barkley Spring 2016		Barkley Spring 2017		Barkley Spring 2018		Barkley Spring 2020	
	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.
Skipjack herring			4	1.6	2	1.5	1	1.0
Gizzard shad	19	8.1	18	14.1	24.5	18.4	15	1.0
Threadfin shad	6	5.0					1	1.0
Grass carp	7	2.9	1	1.0	0.5	0.5		
Silver carp	24	9.8	10	2.6	42	28.4	13	7.2
Smallmouth buffa	23	3.6	22	3.5	28	6.7	11	3.4
Bigmouth buffalo	1	0.6	2	1.2	1	1.0		
Black buffalo	1	0.8			0.5	0.5		
Channel catfish	1	0.8			0.5	0.5		
Flathead catfish	16	5.5	6	2.6	25	5.4	26	7.8
White bass	8	3.6	6	3.5	7.5	4.2	4	2.8
Yellow bass	2	1.0	4	4.0	2	1.1	2	1.2
Striped bass	1	1.1						
Green sunfish	1	0.8	2	1.2	2	1.1	4	2.8
Bluegill	69	16.1	55	26.9	56.5	31.2	64	15.9
Longear sunfish	110	23.6	183	83.6	80.5	42.4	70	18.5
Redear sunfish	10	2.6	20	5.9	7	2.0	14	6.6
Smallmouth bass	10	2.7	3	3.0	10.5	2.3	10	4.2
Spotted bass	1	0.6					3	1.9
Largemouth bass	64	6.2	155	35.3	79	10.6	35	5.3
White crappie	< 1	0.4						
Black crappie	1	0.7						
Sauger	< 1	0.4						
Freshwater drum	15	3.4	2	2.0	11.5	4.3	41	17.6

Table 18. Length frequency and CPUE (fish/hr) for select species of fish collected during 2.75 hours of electrofishing at Kentucky Tailwater in fall of 2020. (CPUE = catch per unit effort; S. E. = standard error)

Species	Inch Class																										TOTAL	CPUE (fish/hr)	S. E.
	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	27	28 - 33			
Skipjack herring*		32	74	31	21	2																						246	89	22.3
Gizzard shad*		6	61	1	1	6	27	13	7	11	5	2	1															449	163	69.7
Threadfin shad*		57	105	3																								1957	712	241.1
Grass carp																	3	6	2	3				1	1	1	5	22	8	4.7
Silver carp																	3	4	1	2	3	2	4	5		1	1	26	9	4.9
Smallmouth buffalo														1		2	1					2						6	2	0.8
Black buffalo																			1									1	0	0.4
Flathead catfish									1																			1	0	0.4
White bass			1	2	1	2	2	1	1		1			2														13	5	2.5
Yellow bass			2		4			1																				7	3	1.6
Bluegill*	2	28		9	21	9	2																					71	26	5.9
Longear sunfish		4	5	8	10																							27	10	3.9
Redear sunfish			1	1	1	1	1																					5	2	1.1
Smallmouth bass		1	2	3	9	6	2	1		1	1						1											27	10	2.8
Largemouth bass			1	2	2	3	7	7	5	2	2	3	3		1	3												41	15	3.6
Freshwater drum				1	3	2							1	3	3	2	2		3	3	2	1	1	1	1	1		30	11	2.8
Striped mullet																		1	1	1			1					4	1	1.0

* species were randomly subsampled

Table 19. Comparison of fall electrofishing CPUE for selected species collected at Kentucky Tailwater in 2015 (effort = 1.0 hours), 2016 (effort = 1.75 hours), 2017 (effort = 4.5 hours), 2018 (effort = 1.25 hours), 2019 (effort = 3.75 hours), and 2020 (effort = 2.75 hours). (CPUE=catch per unit effort; S.E.=standard error)

Species	2015		2016		2017		2018		2019		2020	
	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.
Skipjack herring	22	8.4	1	0.6	18	9.5	2	1.6	510	200.3	89	22.3
Gizzard shad	275	58.6	184	78.0	163	61.1	22	10.2	240	92.1	163	69.7
Threadfin shad	251	176.3	1690	1251.0	1263	637.0	2557	1845.1	27	14.9	712	241.1
Grass carp	13	1.9	6	2.5	2	0.7			6	2.8	8	4.7
Silver carp	6	2.6	44	22.4	4	1.6	9	6.9	4	2.0	9	4.9
Smallmouth buffalo	10	2.6	9	3.7	5	2.1	1	0.8	8	3.0	2	0.8
Bigmouth buffalo					1	0.4	2	1.0				
Black buffalo	6	2.0	3	1.9	< 1	0.2			1	0.4	< 1	0.4
Blue catfish					< 1	0.2			< 1	0.3		
Channel catfish			1	0.6	1	0.9			< 1	0.3		
Flathead catfish			4	1.2	4	1.4			3	1.4	< 1	0.4
White bass	8	4.3	7	4.0	< 1	0.3	6	5.6	4	1.9	5	2.5
Yellow bass	162	83.5	17	13.3	26	4.1	7	4.3	18	7.8	3	1.6
Striped bass					2	1.0	2	1.0				
Bluegill	96	29.2	41	11.8	128	30.7	20	4.0	127	48.8	26	5.9
Longear sunfish	14	14.0	48	12.0	80	25.0	7	4.8	67	15.4	10	3.9
Redear sunfish	1	1.0	6	2.3	6	1.6			15	3.9	2	1.1
Smallmouth bass	9	2.5	21	5.2	11	3.2	2	1.0	29	12.3	10	2.8
Spotted bass	1	1.0	1	0.6	3	1.4	1	0.8	3	1.4		
Largemouth bass	62	19.8	86	9.4	35	4.3	7	2.9	29	6.2	15	3.6
White crappie	2	2.0	1	0.7	1	0.4			3	1.9		
Black crappie	2	2.0	1	0.6	3	1.7			2	1.5		
Sauger	1	1.0			1	0.4						
Freshwater drum	13	5.7	6	1.5	4	0.7	4	2.2	8	2.5	11	2.8
White bass/Striped bass hybric	1	1.0	1	1.1	1	0.5						
Striped mullet											1	1.0

Table 20. Comparison of fall electrofishing CPUE for selected species collected at Barkley Tailwater in 2016 (effort = 1.99 hours), 2017 (effort = 3.0 hours), 2018 (effort = 1.0 hour), 2019 (effort = 3.0 hours), and 2020 (effort = 2.75 hours). (CPUE=catch per unit effort;

Species	2016		2017		2018		2019		2020	
	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.
Skipjack herring	< 1	0.5	8	2.9	35	18.0	324	158.4	41	10.78
Gizzard shad	209	52.4	104	18.2	23	8.1	362	224.8	189	49.03
Threadfin shad	4598	1818.7	1252	602.1	67	12.8	30	18.8	1298	719.49
Grass carp	5	2.6	1	0.5			6	1.7	3	1.22
Silver carp	4	2.0	14	7.7	29	17.2	42	33.4	23	6.58
Smallmouth buffalo	15	7.6	10	2.7	1	1.0	5	3.2	10	3.75
Bigmouth buffalo	1	0.9	< 1	0.3	1	1.0				
Black buffalo			1	0.7						
Channel catfish	< 1	0.4	1	0.5					1	0.49
Flathead catfish	8	3.6	6	3.1			22	5.9	4	1.57
White bass	7	3.9	3	1.1	3	3.0	1	0.7	1	0.56
Yellow bass	2	0.7	28	16.0			4	3.0	3	1.24
Striped bass	1	0.9	2	1.4	1	1.0	< 1	0.3	2	1.25
Bluegill	46	15.3	56	14.6	70	14.5	50	13.2	37	11.66
Longear sunfish	102	25.0	83	16.8	46	25.4	153	30.5	41	10.06
Redear sunfish	8	2.1	3	1.2	2	1.2	3	1.2	2	0.83
Smallmouth bass	7	2.3	9	1.2	4	1.6	29	7.2	8	1.53
Spotted bass	2	1.0	< 1	0.3	1	1.0	7	2.0	1	1.09
Largemouth bass	48	8.0	55	10.3	13	5.0	30	8.1	26	11.01
White crappie	4	1.5	1	0.7			< 1	0.3	< 1	0.36
Black crappie			2	1.3			< 1	0.3	< 1	0.36
Freshwater drum			5	1.5	7	4.7	9	3.4	8	1.87
White bass / Striped bass	< 1	0.4	3	2.3	4	4.0			1	0.73

Table 21. Length frequency and CPUE (fish/hr) for select species of fish collected during 2.75 hours of electrofishing at Barkley Tailwater in fall of 2020. (CPUE = catch per unit effort; S. E. = standard error)

Species	Inch Class																											TOTAL	CPUE (fish/hr)	S. E.
	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	28 - 30			
Skipjack herring*		15	63	19	3	5	1	1																					114	41	10.8
Gizzard shad*		2	60	6	4	14	29	22	13	5	4			1	1														519	189	49.0
Threadfin shad*	2	34	123	1																									3569	1298	719.5
Grass carp																		1	2	3	1							1	8	3	1.2
Silver carp																		1		1			7	9	12	14	8	12	64	23	6.6
Smallmouth buffalo					1										1	3	4	6	10	1		1							27	10	3.8
Channel catfish																	1							1					2	1	0.5
Flathead catfish						1		1	2	1	1		2	1														1	10	4	1.6
White bass					1							1	1																3	1	0.6
Yellow bass					3	3	1																						7	3	1.2
Striped bass															1		1						1			1		1	5	2	1.3
Bluegill*		8	40	16	18	6	1																						102	37	11.7
Longear sunfish*		6	11	50	40																								113	41	10.1
Redear sunfish	1			1	1					2																			5	2	0.8
Smallmouth bass				2	6	3		4	5		1								1										22	8	1.5
Spotted bass					1				1					1															3	1	1.1
Largemouth bass				1	6	13	10	7	8	3	3	4	3	1	1	7	2		2										71	26	11.0
White crappie									1																				1	0	0.4
Black crappie									1																				1	0	0.4
Freshwater drum													4	2	2	1		7	1	4	1								22	8	1.9
White bass/Striped bass hybrid																					1	1							2	1	0.7

* species were randomly subsampled

Table 22. Mean relative weight (*Wr*) and standard error for a subsample of fish collected during fall electrofishing at Kentucky Tailwaters in 2015 - 2020. (S.E. = standard error)

Species	2015			2016			2017			2018			2019			2020		
	N	Mean *Wr*	S.E.	N	Mean *Wr*	S.E.	N	Mean *Wr*	S.E.	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	215	83	0.7	21	77	2.0	152	85	0.5	66	85	1.6
Blue catfish							1	108					1	99				
Channel catfish				1	102		1	105					1	100				
Flathead catfish				7	98	6.2	19	100	6.3				11	99	6.2	1	106	
Yellow bass	29	74	1.2	29	84	1.8	104	83	2.2	7	90	12.3	33	80	4.6	4	58	11.4
White bass	7	92	4.1	13	99	2.6	2	97	20.4	7	108	1.3	8	90	3.3	9	95	5.1
Striped bass										1	101							
White bass/Striped bass hybrid				2	81	7.5												
Bluegill	69	88	1.7	49	103	3.7	220	93	2.2	18	89	6.4	148	94	0.8	41	93	8.3
Redear sunfish	1	98	0.0	10	85	6.9	28	93	3.3				42	97	2.3	4	85	5.3
Smallmouth bass	6	93	3.1	13	91	2.0	9	92	3.4	1	82		4	92	5.5	6	100	4.9
Spotted bass	1	103	0.0	1	123		6	109	3.1				1	117				
Largemouth bass	42	102	3.2	89	102	1.7	117	97	1.9	7	93	5.5	41	99	1.7	26	113	8.4
White crappie	2	79	0.9	2	90	8.7	3	76	7.3				4	84	3.0			
Black crappie	1	91	0.0				12	90	2.7									
Sauger	1	87	0.0				3	97	21.8									
Freshwater drum	12	91	5.4	11	100	2.7	17	92	3.3	5	89	3.8	21	92	2.9	29	91	3.3
Smallmouth buffalo	10	76	2.9	15	79	1.5	22	77	1.4	1	78		29	100	3.2	6	81	2.7
Bigmouth buffalo							3	86	1	2	75	7.4						
Silver carp	6	84	2.3	75	89	1.6	19	82	2.4	11	73	3.2	15	81	1.2	26	76	1.7

Table 23. Mean relative weight (*Wr*) and standard error for a subsample of fish collected during fall electrofishing at Barkley Tailwaters in 2016 - 2020. (S.E. = standard error)

Species	2016			2017			2018			2019			2020		
	N	Mean *Wr*	S.E.	N	Mean *Wr*	S.E.	N	Mean *Wr*	S.E.	N	Mean *Wr*	S.E.	N	Mean *Wr*	S.E.
Gizzard shad	96	70	1.6	176	80	0.9	18	75	2.5	45	91	1.2	53	96	4.2
Channel catfish	1	67		2	92	1.0							2	111	5.6
Flathead catfish	13	94	1.7	17	106	5.8				66	99	3.8	10	96	3.4
Yellow bass	2	88	8.7	73	79	1.3				11	87	4.5	7	85	4.5
White bass	11	96	3.7	8	86	2.2	3	98	4.9	3	85	7.7	2	115	1.8
Striped Bass				2	90	5.9				1	109		5	108	5.6
White bass/Striped bass hybrid				9	89	2.7	4	103	4.6				2	102	2.8
Bluegill	49	111	3.1	107	104	2.5	31	115	8.3	85	103	1.6	63	102	2.3
Redear sunfish	17	93	2.1	9	97	3.7	2	106	14.6	9	101	3.9	4	101	13.0
Smallmouth bass	4	86	3.6	11	95	3.8	3	87	5.6	22	92	2.5	11	93	2.5
Spotted bass	3	107	11.0				1	125		3	106	10.1	2	103	9.4
Largemouth bass	37	101	1.9	118	95	1.2	10	95	3.4	58	98	1.6	41	101	4.3
White crappie				3	88	6.6				1	92		1	116	
Black crappie				5	86	6.3				1	76		1	85	
Freshwater drum	6	84	4.4	14	97	3.0	7	82	3.5	27	103	2.3	22	96	2.3
Smallmouth buffalo	21	84	1.4	28	84	1.6	1	99		16	92	1.9	27	81	1.4
Bigmouth buffalo	2	88	4.0	1	79		1	84							
Silver carp	9	81	2.9	41	83	2.1	29	83	2.7	70	83	1.5	64	77	1.2

Table 24. Fishing effort and total weight (lbs) of Asian carp harvested during KDFWR ride-alongs with commercial fishers fishing under the Asian Carp Harvest Program on Lake Barkley 2015 - 2020. (S.E. = standard error)

Year	Effort *	Mean effort per trip	S. E.	Number of ride alongs	Number of fishers	Total WT of bighead carp harvested (lbs)	Mean total WT of bighead carp harvested/trip (lbs)	S. E.	Total WT of silver carp harvested (lbs)	Mean total WT of silver carp harvested/trip (lbs)	S. E.
2015	17850	1116	50.5	16	5	1608	101	43.1	35130	2196	256.6
2016	25135	1143	70.4	22	4	704	32	13.7	61533	2797	481.8
2017	30491	1089	90.1	28	8	558	20	6.3	69459	2481	421.3
2018	23260	1108	81.7	21	10	362	17	7.8	49248	2345	477.1
2019	52367	1247	251.8	42	19	838	20	6.7	142102	3383	498.0
2020	23775	990	57.6	24	13	682	28	10.9	122271	5094	796.2

*effort is calculated in yards of gillnet fished.

Table 25. Comparison of the average weight harvested per trip of silver carp and bighead carp during KDFWR ride-alongs, and through commercial fishers reports for the Asian Carp Harvest Program in 2016 - 2020. (S.E. = standard error)

		Silver Carp	S. E.	Bighead Carp	S. E.	Grass Carp	S. E.
2016	Ride Alongs	2,280	402.2	40	12.4	23	10.1
	Commercial Fisher Reports	2,378	70.5	22	3.3		
2017	Ride Alongs	2,386	395.0	25	8.2	24	9.4
	Commercial Fisher Reports	2,225	92.8	56	7.6		
2018	Ride Alongs	2,219	422.6	16	6.9	18.4	8.8
	Commercial Fisher Reports	1,981	54.2	38	4.0		
2019	Ride Alongs	3,353	475.7	23	7.2	60	19.3
	Commercial Fisher Reports	2,580	53.0	22	1.6		
2020*	Ride Alongs	4,775	677.5	41	14.8	46	15.5
	Commercial Fisher Reports	3,186	62.4	22	1.8	55	3.0

*2020 was the first year that Grass Carp harvest through the Asian Carp Harvest Program was recorded.

Table 26. Summary of Asian carp harvest and expenditures of Subsidy funds under the Asian Carp Harvest Program 2016-2020.

Year	Total funds paid out
2016	$4,706.06
2017	$9,596.05
2018	$36,136.98
2019	$210,163.21
2020	$453,925.56

Project Title: Evaluation and Removal of Asian Carp in the Tennessee and Cumberland Basins

Geographic Location: Tennessee and Cumberland rivers and the northern section of the Tennessee-Tombigbee Waterway (Divide Cut and Bay Springs Lake).

Lead Agency: Tennessee Wildlife Resources Agency (TWRA; Cole Harty, cole.r.harty@tn.gov).

Participating Agencies: TWRA; Kentucky Department of Fish and Wildlife Resources (KDFWR); Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP); Alabama Department of Conservation & Natural Resources, Wildlife & Freshwater Fisheries Division (ALWFF); U.S. Fish and Wildlife Service (USFWS); U.S. Army Corps of Engineers; Tennessee Valley Authority; Tennessee Cooperative Fisheries Research Unit, Tennessee Technological University (TTU); Mississippi State University; and Murray State University.

Introduction:

Project Objectives:

1) Estimate Asian carp relative abundance, and population demographics in the Tennessee and Cumberland River basins to evaluate management actions.
2) Examine Asian carp impacts on native fish communities.
3) Target and remove Asian carp to suppress populations and reduce propagule pressure in the Tennessee and Cumberland River basins.

Project Highlights:

KDFWR

- No age-0 silver carp have been collected in either reservoir since 2015, suggesting that these fish continue to immigrate into the reservoirs through the lock systems.
- KDFWR is pursuing analysis of silver carp mark-recapture data with USGS Columbia Environmental Research Center.
- Conducted community sampling in the Kentucky and Barkley Tailwaters to monitor for impacts of invasive carp on the native fish assemlage. Catch per unit effort of several species declined from previous years as did mean relative wieghts, which may indicate negative impacts to the fishery.
- Commercial fishers removed over 8.2 million pounds of invasive carp through the KDFWR Asian Carp Harvest Program in 2021. CPUE (fish/yard) was highest in 3.5” bar mesh gill nets.
- KDFWR staff conducted 59 ride-alongs with commercial fishers to monitor catch and bycatch data.

- Bycatch of sport fish reported by commercial fishers using the ACHP continued to be minimal (<1% of total bycatch), and survival rates were over 98%.
- Commercial fishers registered with the Kentucky Lake and Lake Barkley contract fishing program received $646,072.68 for over 7 million pounds of Asian carp harvested from Kentucky Lake and Lake Barkley.
- KDFWR continued Master Agreement contracts with two private entities to test invasive carp experimental gears in Kentucky waters. During 2021, one entity was active in the program and harvested approximately 238,351 lbs of invasive carp from Kentukcy and Barkley lakes over 16 days.
- KDFWR did not receive any reports of black carp in the Tennessee or Cumberland rivers during 2021.

Methods:

Objective 1

Standard Sampling

KDFWR used a combination of standardized sampling, mark-recapture efforts, and monitoring of commercial harvest to evaluate relative changes in invasive carp abundance in Kentucky and Barkley lakes. Standard sampling with gill nets was conducted at sixteen sites in Kentucky waters of Barkley and Kentucky lakes. These standard sites were selected to provide adequate sampling parameters, decrease conflict with anglers, and provide static locations to monitor changes in catch per unit effort (CPUE). Four embayment and four main channel sites were selected on each lake. These sites were sampled once during spring (April), summer (July), and fall (October) (Appendix B. Figure 1). During each sampling period, a total of four nets were fished at each location and in orientations specific to each location. Sampling occurred when lake levels were greater than 354', and nets were set where water depths were a minimum of 13'. Nets were deployed one hour before sunset and retrieved one hour after sunrise the following morning (USA Sunrise Sunset Calendars, 2021). Specific Global Positioning System (GPS) coordinates were determined for all sets, and nets were set at the same locations each season and year of gill netting effort. Sinking gill nets (12' deep) were tied down to 10' every 8 linear feet. Each 100' panel of webbing was hung with 30" stretch in 16" ties. The mesh sizes included 3" square with 5 meshes per 16 linear inches of net, 4" square with 4 meshes per 16 linear inches of net, and 5" square with 3 meshes per 16 linear inches of net.

All webbing was constructed of 8 ply, 0.2-mm twist mesh. Cross ties for the nets were constructed with #15 white bonded twine through the webbing. Catch rates were analyzed by species and gill net mesh size.

Additionally, targets were set to record total length (mm), weight (g), gender, and gonad weight (g) measurements from subsamples consisting of 10 silver carp and 10 bighead carp at each

discrete sample site. During fall sampling, pectoral fin rays were collected from a subsample of silver carp for aging. Demographics were recorded for invasive carp harvested during other KDFWR sampling efforts and included in analyses.

Asian Carp Harvest Program

Commercial fishers participating in the Asian Carp Harvest Program (ACHP) are required to provide KDFWR with daily reports that include fishing effort, type of gear, pounds harvested, and bycatch information. KDFWR staff occasionally accompanied commercial fishers (ride-along) to verify their harvest reports and collect additional information to that required on a standard commercial fishing report. After each ride-along was completed, data was taken from a random subsample of approximately 20 harvested silver carp, including weights, total lengths, and gender (using the pectoral fin ray).

Objective 2

Standard Sampling

During standard sampling described above (Objective 1), total length and weight data were collected from bigmouth buffalo (*Ictiobus cyprinellus*) and paddlefish (*Polyodon spathula*) to assess relative weights. The values were compared over time to evaluate if invasive carp negatively impact condition of these native fishes. These species are of greatest interest to this study because they are often caught in gill nets and have been documented to compete for resources with invasive carp species (Irons et al. 2007, Schrank et al. 2003).

Standard Sport Fish Sampling

KDFWR staff collected length-weight data to monitor condition of black crappie (*Pomoxis nigromaculatus*), white crappie (*Pomoxis annularis*), largemouth bass (*Micropterus salmoides*), and blue catfish (*Ictalurus furcatus*) in Kentucky Lake and Lake Barkley. Sampling methods are standardized and described in KDFWR's 2021 annual District Fisheries Management report. Relative weights were compared to harvest rates of invasive carps to identify trends that may be associated with the increasing invasive carp harvest.

Asian Carp Harvest Program Monitoring

Commercial fishing reports and data collected during ride-alongs with commercial fishers were compiled to provide a summary of 2021 data and to determine if yearly trends are related to bycatch numbers, species caught, and survival rates.

Tailwater Electrofishing

Sampling was conducted in the Kentucky Dam tailwater of the Tennessee River (hereafter referred to as the Kentucky Tailwater) and Barkley Dam tailwater of the Cumberland River (hereafter referred to as the Barkley Tailwater) with pulsed DC electrofishing. Sampling in the Kentucky Tailwater consisted of three 15-minute runs on the west bank and two 15-minute runs

on the east bank. Sampling in the Barkley Tailwater continued as previous years with two 15-minute runs on each bank. Electrofishing was conducted in a downstream direction along the banks (Appendix B. Figure 2). Spring sampling in each Tailwater was conducted on one day each month (April, May, and June). Fall sampling was conducted as scheduled in each Tailwater on one day of each month (September, October, and November). Two dippers were utilized to collect stunned fish, which were identified to the lowest taxonomic level possible, and total lengths (inches) were recorded. Weights (pounds) were also recorded during fall sampling. When large numbers (> 100) of any species were collected, random subsamples were utilized. Except for invasive carp species, all fish were released immediately after processing. Data collected in 2021 was compared to historical data to assess changes in the fish community over time.

Objective 3

Asian Carp Harvest Program Monitoring

Commercial fishers participating in the Asian Carp Harvest Program are required to provide daily reports including fishing effort, type of gear, pounds harvested, and bycatch information. Ride-alongs were also conducted with commercial fishers occasionally to verify reports. Observers collected all data required on commercial harvest logs with the addition of GPS fishing locations and net soak time (Appendix B. Figure 3). Staff observed 18 different commercial fishers on 59 ride-alongs throughout the year. Ride-alongs were conducted when the fishermen were pulling their nets and harvesting fish, unless commercial fishers were using short net soak times or were drifting net sets. On those occasions, KDFWR staff observed the commercial fishers from start to finish. Ride-alongs were conducted while onboard with commercial fishers or from a department boat closely following the commercial fishers to record catch. After each ride-along was completed, data was recorded from a random subsample of approximately 20 silver carp harvested including weights, total length, and gender (using the pectoral fin ray). Observations were analyzed both in aggregate with fishers' daily reports and separately (ride-along data). Data was analyzed to determine number of fishing trips, amount, and disposition of bycatch by species, and total pounds of Asian carp harvested.

Experimental Gears

KDFWR continued the Master Agreement (M.A.) contract with two vendors to test invasive carp experimental gears in Kentucky waters. Through this program, contracted entities can use experimental methods for harvesting invasive carp, to increase removal efficiencies. However, contractors are required to accommodate KDFWR observers during all gear testing. KDFWR staff are responsible for data collection and monitoring of bycatch, however if the contractor is operating under a scientific collector permit, then data reporting is the responsibility of the contractor in accordance with the permit requirements.

In 2021, Robbins Construction LLC, conducted 16 days of effort on the Lake Barkley and Kentucky Lake, 20 days on the Mississippi river and 4 days on the lower Ohio river. This contractor used various seines and seining methods for harvesting fish.

Silverfin Solutions (SFS) was the other contractor with a M.A. contract in 2021. Silverfin Solution's focus in 2021 was working with the United States Geological Survey (USGS) Columbia Environmental Research Center to remove and dispose of all invasive carp captured in the Modified Unified Method (MUM) work. Silverfin Solutions also assessed sites in Western Kentucky for future work, once equipment is received. The USGS conducted MUM effort in several bays on Kentucky lake in 2021. Field work was refined based on information from field in 2020 and incorporated new approaches and equipment into the process.

Sampling with the USFWS Columbia, MO Fish and Wildlife Conservation Office Paupier net was not possible in 2021 due to restrictions associated with COVID 19 and staff shortages. However, KDFWR plans to continue coordination with the USFWS and other partners to develop standardized and targeted sampling with the Paupier net and electrified dozer trawl in the Tennessee and Cumberland River basins (Towne et al. 2020).

KDFWR conducted gill netting effort targeting invasive carp in Kentucky and Barkley lakes. Gill nets ranged from 3", 3.5", 4" bar mesh. Net lengths and depths ranged from 1200 to 2400' and 16' to 24', respectively. The technique used during these removal efforts did not require webbing to be tied down to create bags. All removal efforts were conducted during the day and utilized active methods of circling large schools of fish or blocking them in a cove at a depth where gill nets covered the entire water column. After net deployment, boat motor noise was used to herd fish toward the nets. Crews typically proceeded to pull nets within an hour of setting them.

Results and Discussion:

Objective 1

Standard Sampling

Standard sampling data continues to be variable across seasons and years in each reservoir. (Appendix B. Table 1). Data for silver carp suggested that mean catch per unit effort (CPUE), reported as number of fish per linear yard of gill net, was highest on Lake Barkley in July but only slightly higher than in April. Whereas Kentucky Lake's CPUE was highest in October followed by July (Appendix B. Table 2). Overall invasive carp CPUE through standard sampling was low. In 2021, Lake Barkley had a mean CPUE of 0.012 silver carp/yard (S.E. ±0.002) whereas Kentucky Lake had a mean CPUE of 0.008 silver carp/yard (S.E. ±0.003).

A length-frequency histogram was created for silver carp harvested from Barkley and Kentucky lakes from all harvest methods in 2021. Data suggested the 600mm size class of silver carp was dominant in Kentucky Lake whereas the 700mm size class was dominant in Lake Barkley (Appendix B. Figures 4 & 5).

Age & Growth

Pectoral fin rays were collected from silver carp in Barkley and Kentucky lakes in the fall of 2021 for aging. Lake Barkley ages ranged from 3 to 7 years old, with age 5 being the most abundant. Kentucky Lake ages ranged from 2 to 10 years old, with age 6 being the most abundant, (Appendix B. Figures 6 & 7). Data suggests a strong presence of two cohorts of silver carp behind the 2015 cohort (6 year old fish). Since no age-0 silver carp have been collected in either reservoir since 2015, logic suggests that these fish continue to immigrate into the reservoirs through the lock systems.

Mortality

Catch-curve regressions were developed for the 2015 cohort of silver carp by lake. This cohort of silver carp is the only documented cohort known to occupy the lakes at age-0. Data for age frequencies were ln(x+1) transformed to compensate for heteroscedasticity. A Chapman-Robson analysis was performed to estimate annual mortality (Â) and instantaneous mortality (Z). Annual mortality for silver carp from Lake Barkley was estimated at 55% and instantaneous mortality was estimated at 0.81 (N= 179, F1,2=48.99, P=0.02, R2=0.96; Appendix B. Figure 8). Annual mortality for silver carp from Kentucky Lake was estimated at 45% and instantaneous mortality was estimated at 0.59 (N=199, F1,2=18.51, P=0.05, R2=0.90; Appendix B. Figure 9).

Condition

Linear regressions were constructed to describe the log10 length-log10 weight relationship for silver carp in Barkley and Kentucky lakes. The length-weight equation for Lake Barkley was estimated at Log10(weight(g)) = 2.8663*Log10(length(mm))-4.5885 (Appendix B. Figure 10). The length-weight equation for Kentucky Lake was estimated at Log10(weight(g)) = 2.909*Log10(length(mm))-4.7207 (Appendix B. Figure 11). Weights were predicted for Lake Barkley: 450mm (1038g), 650mm (2980g) and 800mm (5403g) and Kentucky Lake: 450mm (994g), 650mm (2848g) and 800mm (5301g) (Appendix B. Table 3). Predicted weights remain higher for Lake Barkley than for Kentucky Lake, both lakes indicate an upward trend.

Data collected from sampling in the fall of 2021 was used to analyze relative weights (Wr). Relative weight was calculated using the equation Log10(Ws)= -5.15756 + 3.06842(Log10TL) for silver carp and Log10(Ws)= -4.65006 + 2.88934(Log10TL) for bighead carp (Lamer 2015). The mean Wr for silver carp in Lake Barkley was 94 (N=183, S.E.=±0.81) and the mean Wr for silver carp in Kentucky Lake was 93 (N=132, S.E.=±1.20).

These values are consistent with data collected from previous years. The mean Wr for bighead carp in Kentucky Lake (n=15) and Lake Barkley (n=1) was 106 (S.E.=±2.72).

Mark-Recapture Effort

KDFWR worked with personnel from Tennessee Wildlife Resources Agency (TWRA), Tennessee Tech University (TTU), U.S. Fish and Wildlife Service (USFWS), United States Geological Service (USGS), Murray State University (MSU), and volunteers from United States Forest Service at Land Between the Lakes (LBL) to tag silver carp in Barkley and Kentucky lakes in late September 2018. Fish were tagged with a Floy Tag Company, FT-4 Lock-on tag, with a unique identification number. Initially the targeted sample size was 500 fish per lake, with a subset of 20% of tagged fish receiving a secondary tag. The primary tag was placed posterior of the dorsal fin and the secondary tag was placed anterior of the dorsal fin. Fish were collected using short set gill nets (<4 hours) and D.C. electrofishing. Tagging effort occurred over eight days (four on each lake), and 1,292 silver carp were tagged. A total of 619 silver carp were tagged from Lake Barkley with a mean length of 684mm and a mean weight of 3,830 grams. In Kentucky Lake, 673 silver carp were tagged and had a mean length of 627mm and a mean weight of 2,570 grams.

From October 2018 through February 2022, KDFWR received 43 tag returns from commercial fishing efforts. Thirty-three came from Lake Barkley and ten from Kentucky Lake (Appendix B. Figure 12). Eight of the returned fish were double tagged. The higher frequency of returned fish from Lake Barkley compared to Kentucky Lake is not surprising given most of the commercial fishing pressure occurs on Barkley (Reported under Objective 3).

Data collected from harvested fish indicated that all fish grew from the time of initial tagging to the point when they were harvested. Inspection of tag insertion locations indicated good healing of the marked fish. All recovered fish exhibited localized redness around the tag insertion, however none showed signs of infection. Many fish were harvested in the same embayment where they were tagged. This is an interesting observation because telemetry data has shown that a portion of the silver carp population in the lakes exhibit large scale movement patterns at certain times (USFWS 2019). The tag return data suggests that most of the fish returned have developed site fidelity, however, we have not distinguished specific behavioral or environmental characteristics that draw them to a constricted geographic area, relative to the area that is available for use. Although, there have been three tag returns from bow-fishers harvesting tagged fish outside of the reservoirs where they were tagged and released. Data analysis is in progress with the assistance of the USGS CERC staff.

Asian Carp Harvest Program Monitoring

Length and weight data was collected on 949 silver carp harvested by commercial fishers in 2021. Silver carp lengths ranged from 15.5 - 38.0 inches with an average of 27.9 inches, and weights ranged from 4.0 – 21.3 lbs with an average of 8.9 lbs (Appendix B. Table 4). If this metric is used in correlation with the total pounds of silver carp harvested by commercial fishers through the ACHP in 2021, that would produce a rough estimate of 915,516 individual silver carp being removed from Kentucky waters through the ACHP in 2021 (8,148,093 lbs; Appendix B. Table 5). During ride-alongs, commercial fishers were observed using gill nets with a range of bar mesh sizes to target invasive carp (3.25" – 4.5" bar mesh; Appendix B. Table 6, Figure 13). Catch per unit effort of gill nets used to harvest silver carp were highest in gill nets with a bar mesh size of 3.5" (0.58 fish/yard), followed by 3.25" bar mesh which had a CPUE of 0.40 fish/yard. This is similar to the previous three years when the highest CPUE was in 3.25" and 3.5" bar mesh nets. However, no ride-alongs were conducted with commercial fishers utilizing gill nets with smaller sizes of bar mesh prior to 2019 (Appendix B. Table 6). Information collected from fish harvested through the ACHP was also used in the above demographics analysis.

Objective 2

Standard Sampling

Capture rates of species with potential direct competition from bigheaded carp (silver and bighead) were observed to be low in the 2021 standard sampling, which continues the trend observed in previous years. Bigmouth buffalo were observed to have a mean Wr of 87 (N=3, S.E. ±15) in Kentucky Lake. Paddlefish were observed to have a mean Wr of 95 (N=16, S.E. ±5). These species will continue to be monitored and data will be collected opportunistically. Increased data collection through a gear such as the Paupier net and increased ride alongs with commercial fishers targeting paddlefish, would be very valuable in future assessments of these native species.

During standard sampling in 2021, bycatch in Lake Barkley was comprised of 68% scaled rough fish (Buffalo spp., Freshwater drum, Gar spp., etc.), 22% catfish spp. (Ictaluridae), 8% paddlefish and 2% sportfish. Bycatch in Kentucky lake was comprised of 59% scaled rough fish, 38% catfish spp., 4% paddlefish and 2% sportfish.

Gizzard shad (Dorosoma cepedianum) collected by traditional boat electrofishing in October 2021, were measured and used to estimate relative weight values (Wr), using the formula presented in Blackwell et al. 2000. Gizzard shad from Lake Barkley were estimated to have a mean Wr of 90 (N=34, S.E.=1.0) and gizzard shad from Kentucky Lake were estimated to have a mean Wr of 92 (N=85, S.E.=0.5). Data suggests that relative weights for gizzard shad are remain at or above 90 over the past several years (Appendix B. Table 7). No gizzard shad greater than 11.0 inches were collected from Lake Barkley in 2021.

Standard Sport Fish Sampling

In Kentucky Lake, relative weight analysis was conducted for black crappie, white crappie, blue catfish, and largemouth bass (KDFWR 2020). Black and white crappie both exhibited mean relative weights that were lower than 2020, but were not outside of historical norms with *W*r of 85.31 and 83.73 respectively (Appendix B. Figure 14). Largemouth bass average *W*r also remained similar to values calculated for the previous four years (*W*r = 91.04). Sampling for blue catfish began in 2004 and has been inconsistent. However, in 2021 blue catfish average *W*r was within the range of values calculated for previous years (*W*r = 102.0). Historical mean relative weight values were charted along with pounds of invasive carp removed from Kentucky Lake through the commercial fishery (Appendix B. Figure 14). Harvest of invasive carp from Kentucky Lake through the ACHP increased significantly in 2020 from previous years, and again in 2021 to 2,366,990 pounds harvested. However, the impacts to sport fish condition associated with this increased removal of invasive carp requires more years of data and will continue to be monitored. Many factors are known to impact sport fish condition and values recorded since invasive carp have become established in Kentucky Lake have not fluctuated outside of historical variations.

In Lake Barkley, relative weight analysis was conducted for black crappie, white crappie, largemouth bass, and blue catfish (KDFWR 2020). Mean relative weights for both black and white crappie decreased slightly from 2020, but remained similar to previous years having *W*r of 96.8 and 92.6, respectively (Appendix B. Figure 15). Mean *W*r value for largemouth bass in 2021 was 102.1, which is higher than most previous years. Sampling for blue catfish in Lake Barkley began in 2004, but has been inconsistent. Mean *W*r for blue catfish collected in 2021 was similar to previous years (Wr = 102.0). Historical relative weight values were charted along with pounds of invasive carp removed from Lake Barkley through the commercial fishery (Appendix B. Figure 15). Harvest of invasive carp from Lake Barkley has increased almost every year since the ACHP began in 2013 spiking in 2021 to over 6.2 million pounds. Similar to Kentucky Lake, the sharp rise in harvest of invasive carp in 2019 corresponds with lower condition factors of sportfish species, which may be an indicator of high densities of adult invasive carp competing with these sport fish for resources. Therefore, the increase in condition of sport fish in Lake Barkley in subsequent years, may be influenced by a reduced competition with invasive carp as they are continually harvested. However, sport fish condition in the reservoirs is highly variable due to a variety of factors and will continue to be monitored in following years.

Asian Carp Harvest Program Bycatch

According to the KDFWR ACHP regulation (301:KAR 1:152), commercial fishers are allowed to harvest a ratio of 65% Asian carp to 35% scaled rough fish per month. All other fish caught in commercial gear must be released. Commercial fishers are required to submit daily reports that include bycatch species, number caught, number harvested, number released, and disposition upon release (moribund or alive).

In previous years, increased effort by commercial fishers fishing under the ACHP has translated into a growing amount of bycatch. In 2021, the total number of bycatch reported increased slightly from 2020, but still remained lower than numbers reported in 2018 and 2019 (Appendix B. Table 8). This reduction in bycatch per trip is attributed to changing practices of commercial fishers as most fishers have transitioned from passive setting to active setting of gill nets targeting schools of carp identified via their boat electronics. Scaled rough fish, primarily buffalo (*Ictiobus*) species, make up the majority of reported bycatch in commercial gill nets fished under the ACHP (Appendix B. Table 8). In 2021, the percentage of scaled rough fish harvested by ACHP fishers increased almost 10% from 2020 (Appendix B. Table 8). This is likely a result of processors utilizing these fish, as well as invasive carp, for other products such as fertilizer or fish meal instead of only food items as in previous years. Although commercial fishers on the ACHP are limited to how much of their bycatch they can harvest, KDFWR will continue to monitor this trend in future years. The number of sport fish, catfish, and paddlefish collected as bycatch all decreased in 2021 compared to recent years. Survival rates of sportfish (98.4%) and catfish (87.7%) increased in comparison to previous years, and the survival rate of paddlefish remained similar (81.0%) (Appendix B. Table 8).
Survival rates of all bycatch caught during ride-alongs in 2021 was documented by KDFWR observers and was analyzed independent of commercial fishers reporting (Appendix B. Table 9). During ride-alongs, the survival rate of sport fish in bycatches increased from previous years to a high of 100%. Survival rates of catfish species observed as bycatch during ride-alongs was similar to previous years at 95%. Paddlefish survival rates observed during ride-alongs in 2021 were the highest observed since 2016, but still remained significantly lower than what commercial fishers reported (69%; Appendix B. Tables 8 & 9).

A comparison for bycatch of paddlefish, catfish species, and sport fish species reported by commercial fishers through daily reports and information collected during ride-alongs shows a decrease since 2015 in number of sport fish captured per trip for most species (Appendix B. Table 10). However, bycatch reported captured per trip for recreationally and commercially important species such as paddlefish and catfish spp. is higher during ride-alongs than from commercial fishing reports (Appendix B. Figure 16). Data suggests 50-75% of bycatch is likely not reported in daily logs submitted to KDFWR by commercial fishers. However, ride-alongs account for a small percentage of the total number of trips made by commercial fishers (2.5% in 2021). To better identify and monitor under reporting of bycatch, KDFWR will continue to increase the number of ride-alongs conducted with commercial fishers targeting Asian carp. To date, there is no indication of negative impacts on the sport fishery resulting from the ACHP.

Bycatch of Paddlefish

As KDFWR monitors sport fish bycatch through the ACHP it also provides the opportunity to monitor other species that compete directly with Asian carp such as paddlefish. Paddlefish are considered a species of conservation need as 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 closely monitor impacts of the ACHP on paddlefish. Generally, experienced commercial fishers can avoid capturing large numbers of paddlefish when they are targeting Asian carp by carefully selecting fishing locations. The number of paddlefish captured is variable over time, but did show an increasing trend that is now declining even though effort is increasing throught the ACHP (Appendix B. Tables 5 & 8).

Paddlefish survival was observed to be low in 2021 (69% during ride-alongs, 81% total ACHP) in relation to other species in the bycatch (Appendix B. Tables 8 & 9). Since much of the ACHP effort is during the summer months (i.e. warmer water temperatures), paddlefish are vulnerable bycatch in this fishery. Another factor identified as possibly affecting paddlefish survival in gill nets is length of time the nets are left in the water (i.e. soak time). From conducting ride-alongs, it has been observed that the soak time of nets varies among fishers and depends on the location being fished, weather, and water temperature. Overall, fishers tend to leave nets in the water longer when water temperatures are cooler as it increases catch rates and like most fish, invasive carp will survive longer in the cooler temperatures. Therefore, water temperature and soak time have been recorded during ride alongs since 2017. Figure 17 (Appendix B) exhibits data from each trip where paddlefish were observed as bycatch and indicates a trend of declining survival rates associated with rising water temperatures. However, it is also important to note that the majority of paddlefish are caught in nets with soak times of over 8 hours (Appendix B. Figure 18). Therefore, the combination of soak times greater than 8 hours and rising water temperatures attributes to higher catch rates of paddlefish and lower survival rates. However, commercial fishers are more frequently using active methods for targeting invasive carp with gill nets and soak times of nets decreased overall in 2021. To increase the sample size, water temperature and soak times will continue to be recorded during ride-alongs in 2022.

Kentucky and Barkley Tailwaters Electrofishing

Spring sampling with electrofishing in the Kentucky Tailwater resulted in the collection of 942 individual fish comprised of 28 species through 3.75 hrs of electrofishing. Gar, black bass, and cyprinid species made up the highest percentages of the catch with 22%, 20%, and 19% respectively (Appendix B. Figure 19). Smallmouth bass catch rate was the highest since the survey began in 2015 with a CPUE of 34 fish/hour (Appendix B. Table 11). However, most other sportfish had catch rates lower than or similar to previous years. The majority of rough fish exhibited catch rates within the range of previous surveys, with the exception of gizzard shad which had the lowest catch rate since 2015 when the survey began (16 fish/hr; Appendix B. Table 11). Silver carp CPUE in the Kentucky Tailwater during spring sampling remained similar to the previous two survey years (5 fish/hr; Appendix B. Table 11).

Spring sampling for 2021 in the Barkley Tailwaters resulted in the collection of 1,271 individual fish, comprised of 34 species, through 3.0 hours of effort. Cyprinid species made up the highest percentage of the total catch with 37%, followed by gar species with 17%, and sunfish species

with 11% (Appendix B. Figure 20). Similar to Kentucky Tailwaters, the smallmouth bass catch rate was the highest since the survey began in 2016 (16 fish/hr; Appendix B. Table 12). However, catch rates for largemouth bass, bluegill, and redear sunfish declined from previous survey years. In contrast to Kentucky Tailwaters, gizzard shad catch rates in the Barkley Tailwaters were the highest recorded since the survey began in 2016 with 27 fish/hr. Silver carp CPUE increased slightly from 2020, but remained similar to catch rates produced in previous years (20 fish/hr; Appendix B. Table 12).

Although spring sampling in the Kentucky and Barkley tailwaters has been conducted in most years during the survey's history, 2015-2021, the amount of effort has been variable (Tables 11 & 12). The Tailwaters can be volatile and often produce conditions in which sampling is not possible due to high water levels and high flows, especially in the spring months of this survey. Additionally, the utility of data collected in the spring months is limited to catch rates and length frequencies of species collected, which are highly impacted by time of year and sampling effort. Therefore, KDFWR is considering discontinuing spring sampling efforts after the 2022 field season, to best utilize funding and staff time for projects that will inform management strategies.

Fall sampling with electrofishing in the Kentucky Tailwater resulted in the capture of 3,133 total fish comprised of 29 species during 3.75 hours of effort in 2021. Like previous years, Clupeid species were the most abundant group collected, comprising 90% of the total catch during sampling in 2021 (Appendix B. Figure 21). Threadfin shad (Dorsoma petenense), made up the majority of Clupeids caught (Appendix B. Tables 13 & 14). Catch rates for other bait fish including gizzard shad and skipjack herring declined from the 2020 survey but remained within the range of previous years (Appendix B. Table 14). CPUE of sunfish species including bluegill and longear sunfish, were the lowest since the survey began in 2016 with a CPUE of 4 fish/hr and 2 fish/hr, respectively. Largemouth and smallmouth bass were the most prominent sport fish species collected in the Kentucky Tailwater during fall sampling in 2021 with 19 and 21 fish collected, respectively. However, the CPUE for largemouth bass in 2021 was the lowest since the survey began in 2015 (5 fish/hr; Appendix B. Table 13). CPUE for Morone spp. and bluegill also declined in 2021 compared to previous years. Interestingly, for the second year in a row, striped mullet (*Mugil cephalus*) was collected during sampling efforts in the Kentucky Tailwater in 2021. A total of 5 striped mullet were collected ranging from 19 – 22 inches in total length, whereas 4 fish were collected in 2020 (Appendix B. Table 14). Silver carp retained a similar CPUE and portion of the percent total catch as was documented in the previous four years (Appendix B. Figure 21 & Table 14).

Fall sampling in the Barkley Tailwater resulted in the capture of 1,721 total fish comprised of 27 species over 3.0 hours of effort in 2021. Complementary to previous years, Clupeid species, were still the most abundant species group collected in Barkley Tailwater during fall sampling in 2021, comprising 72% of the total catch (Appendix B. Figure 22). Similar to the Kentucky Tailwater, threadfin shad made up the majority of Clupeids caught. However, gizzard shad catch rates were the lowest recorded with a CPUE of 8 fish/hr (Appendix B. Tables 15 & 16).

Sunfish species such as bluegill and longear sunfish produced the lowest catch rates for those species since the survey began in 2016 with a CPUE of 21 fish/hr and 14 fish/hr, respectively (Appendix B. Table 15). Largemouth bass catch rates in 2021 were near the lowest observed, but smallmouth bass catch rates remained higher than most previous years (Appendix B. Table 15). Silver carp CPUE during fall sampling in Barkley Tailwaters remained similar to 2020 (24 fish/hr; Appendix B. Table 15).

Length frequency distribution for silver carp collected in Kentucky Tailwater during fall sampling in 2021 ranged from 18-35 inches (N=32; Appendix B. Table 13). Silver carp lengths from Barkley Tailwater during fall sampling ranged from 18-32 inches (N=71; Appendix B. Table 16). These ranges are much wider compared to silver carp collected during fall sampling in 2018 and 2019 and may indicate more mixing of the silver carp population in the Tailwaters, or that fish from a variety of locations are arriving at the tailwaters and looking for passage upstream.

Silver carp and grass carp were collected in both tailwaters during fall sampling efforts, and a single bighead carp was collected in the Kentucky Tailwater. Electrofishing for this project resulted in removal of 32 silver carp from Kentucky Tailwater and 71 silver carp from Barkley Tailwater in 2021.

Relative weights (Wr) were calculated for selected species collected during fall sampling to monitor fish condition (Appendix B. Tables 17 & 18). 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 Invasive carp densities in the tailwaters. Low relative weight is generally characteristic of fish in poor health, whereas high values indicate fish in excellent health (Blackwell et al. 2000). 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 increased to a value of 92, the highest observed since the survey began in 2015 (Appendix B. Table 17). However, the mean relative weight for largemouth bass (Wr = 87), white bass (Wr = 86), and sauger (Wr = 78) all decreased to the lowest values recorded for those species since the survey began (Appendix B. Table 17. Figure 23). Silver carp mean relative weight remained the same as observed in 2020 (Wr = 76: Appendix B. Table 17). Mean relative weight values for other species in the Kentucky Tailwater remained similar to previous years. In the Barkley Tailwaters the mean Wr for silver carp remained similar to the low observed in 2020 (Wr = 77; Appendix B. Table 18). This decline is a factor that will continue to be monitored as a low mean relative weight for silver carp could also be an indication of increased competition for resources in the tailwaters as the silver carp population grows. During sampling in the Barkley Tailwater in 2021, mean relative weight values also remained low for gizzard shad (Wr = 73), yellow bass (Wr = 74), smallmouth bass (Wr = 81), and smallmouth buffalo (Wr = 78) (Appendix B. Table 18, Figure 24). Conversely, the mean relative weight values for largemouth bass (Wr = 101), redear sunfish (Wr = 101), and bluegill (Wr = 118) remained high compared to those observed in previous years (Appendix B.

Table 18, Figure 24). Sampling in fall of 2021 produced more low mean relative weight scores than most previous surveys which may be an indication of increased competition with silver carp for both space and food in the tailwaters. Therefore, continued data collection and further analysis with currently available data is warranted and will be pursued by KDFWR. Additionally, the creel survey to be conducted in the tailwaters in 2022, will yield important data from anglers regarding catch rates for comparison to previous years.

Objective 3

Asian Carp Contract Fishing Program in Kentucky Lake and Lake Barkley

Interest and participation in the KDFWR contract fishing program for invasive carp has varied greatly since it began in 2016. However, in 2019, refinements were made to the program and the number of fishers targeting invasive carp in Kentucky and Barkley lakes increased, which heightened participation in the program. In 2021, contractors received $646,072.68 for invasive carp harvested from Kentucky Lake and Lake Barkley. This equates to over 7 million pounds of Asian carp harvested through the contract program in 2021, the largest harvest to date (Appendix B. Table 19). Refinements to the program were made in 2021 which removed the varying pay out based on size of fish harvested. As of October 2021, the program now pays contractors $0.08 / lb for invasive carp harvested from Kentucky waters of the lakes regardless of the size of those fish.

Asian Carp Harvest Program Monitoring

The Asian Carp Harvest Program (ACHP) created by KDFWR allows commercial fishers to target invasive carp in waters where commercial fishing with gill nets is otherwise restricted. The data in this section is compiled from daily and monthly reports submitted by commercial fishers participating in the ACHP. Implementation of the ACHP has been a key element in the increased harvest of invasive carp from Kentucky waters, especially Kentucky Lake and Lake Barkley.

Since 2013, commercial fishers in Kentucky have harvested a total of 26,673,217 lbs of invasive carp through the ACHP (26,258,831 lbs silver carp, 228,766 lbs bighead carp, 185,620 lbs grass carp [2020-2021 only]; Appendix B. Table 5). Total harvest would be higher if grass carp were included for all years, however commercial fishing reports prior to 2020 did not delineate grass carp from common carp. The majority of invasive carp harvested in Kentucky are from Lake Barkley (Appendix B. Table 5). Commercial fishers typically prefer fishing Lake Barkley over Kentucky Lake as it is shallower, has more embayments to corral fish, less recreational traffic, and the fishers believe the silver carp are larger. However, the amount of effort by commercial fishers and harvest of invasive carp from Kentucky Lake has increased substantially in 2020 and 2021 (Appendix B. Table 5). Number of commercial fishers in Kentucky and associated trips under the ACHP program has varied annually. A decrease in fishing effort (numbers of trips) and invasive carp harvest in 2015 and 2017 was due to inconsistent market demands. In 2019, the number of fishers targeting Asian carp doubled, and fishing effort more than doubled.

In 2021, the number of commercial fishers participating in the ACHP decreased to 38 individuals. However, those fishers made the most trips ever recorded through the ACHP with 2,373 days of effort. This translates to an increase in effort per commercial fisher (approximately 62 trips/fisher) indicating that commercial fishers in Kentucky are transitioning to full time fishing for invasive carp rather than inconsistent efforts as seen in previous years. Additionally, commercial fishers harvested an excess of 8.2 million pounds of invasive carp through the ACHP in 2021, indicating an increase in harvest efficiency for commercial fishers targeting invasive carp (Appendix B. Table 5 & Figure 25). Factors affecting the increased efficiency are likely a combination of the 2015 silver carp year class becoming fully recruited to the fishery and improved commercial practices. Commercial fishers' adaptation in net sizes during the past several years helped facilitate the 2021 record harvest as well as improvements to equipment such as boats, trucks, net rollers, cranes, and electronics. KDFWR also continues to maintain an industrial flake ice machine to provide free ice to ACHP fishers to help keep their catch fresh.

Invasive carp harvest data was summarized by month from January 2015 to December 2021 (Appendix B. Figures 26 & 27). Historically, the number of trips made by commercial fishers under the ACHP decreased during paddlefish season (November-March) and increased again when paddlefish season ended (Appendix B. Figure 26). This shift was expected as many commercial fishers 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. However, in late 2018 and through 2021, this trend was not apparent as commercial fishers are now targeting invasive carp year round, and are allowed to receive funds through the contract program administered by KDFWR for invasive carp harvested while fishing on their net permit. The highest number of commercial fishing trips recorded in a single month was 302 in January 2020, however, effort was much more consistent through 2021 with number of trips ranging from 126 – 276 per month (Appendix B. Figure 26). Total pounds of silver carp harvested per month closely follows the trend of number of trips made and ranged from 2,652 – 4,142 pounds per month in 2021 (Appendix B. Figure 27). Market demand for food grade fish has decreased since February of 2020, however, other markets for non-food products such as fish meal, fertilizer, and lobster bait have increased.

Water conditions routinely affect invasive carp harvest rates, but seasonality is also a factor. KDFWR and MSU telemetry studies indicate that movement rates of silver carp increase in water temperatures between 61.5 ^{o}F and 86.0 ^{o}F (USFWS 2020). Fish become more active with rising water temperatures in the spring, and they become less susceptible to harvest when moving to the main channels from embayments. Commercial harvest rates also vary among fishers. The most successful fishers understand silver carp behavior better, and they use higher quality gear with larger boats that have higher weight capacities.

In 2021, the average number of pounds harvested per trip was calculated for all ACHP fishers (N=38), and average pounds of silver carp harvested varied from 396 lbs/trip to 7,431 lbs/trip. Interestingly, not all fishermen with high catch rates fished frequently (Appendix B. Figure 28).

Ride-Alongs

KDFWR conducted 59 ride-alongs with 18 different commercial fishers utilizing the ACHP January through December 2021 (Appendix B. Table 20 & Figure 3). During ride-alongs 42,193 yards of gill net were fished and 201,159 lbs of invasive carp were harvested. The majority of fishing effort observed during ride alongs was in Lake Barkley (N=39), which is similar to fishing effort in general. Ride-alongs were also conducted in Kentucky Lake (N=20). Commercial fishers set nets primarily along secondary channels, on flats in the main lake, and in embayments. In previous years, the northern end of Lake Barkley received the most fishing pressure. However, in 2021 the fishing pressure observed through ride alongs was more evenly distributed throughout Lake Barkley and Kentucky Lake (Appendix B. Figure 3). The mean effort per trip (yards of net fished) decreased in 2021 compared to all previous years, which is reflective of the changing strategies that commercial fishers are employing to catch silver carp (active setting vs. dead setting nets) (Appendix B. Table 20). Average total weight of silver carp harvested per trip during ride-alongs in 2021 (3,389 lbs) was lower than 2020 (appendix B. Table 21). This is also reflective of changing strategies as commercial fishers may not expend effort of deploying and retrieving nets if they do not find schools of silver carp to target. This occurred on three occasions during ride alongs, and may also be an indication of changing population dynamics or densities of silver carp in the lakes. Average weight of individual silver carp harvested during ACHP ride-alongs in 2021 was similar to 2020 (Appendix B. Table 4).

Experimental Gears

Contracted Experimental Efforts

Robbins Construction LTD harvested approximately 238,351 lbs of invasive carp from Barkley and Kentucky Lakes in 2021 (14,896 lbs/day). 99% of the invasive carp harvested were silver carp and >1% were bighead carp. Sport fish bycatch and other fish species that were not harvested were observed to have an 95% survival rate at the time of release. While outside the scope of this report it is worth noting that Robbins Construction LTD also harvested 501,637 lbs (26,401 lbs/day) of silver carp from the Mississippi River and 56,271 lbs (14,067 lbs/day) of silver carp from the Ohio River in 2021 through the contracted experimental efforts.

Robbins Construction LTD continued to modify equipment to improve harvest efficiencies. Such modifications included the addition of two power blocks for pulling gear and reducing personnel fatigue. These power blocks were installed on a custom-built boat, that was modified for hauling and rapidly deploying seine nets. This equipment adds to their previous investment of net reels and a boat mounted crane.

Furthermore, Robbins Construction LTD was able to acquire additional netting to lengthen their seine used in 2020 and invest in material for a new seine with a bag to hold fish and further modify their gear from 2020. Their seines ranged from 900’ to 2400’ in length with a bar mesh of 2” to 2.5”.

Electrofishing

Due to staffing shortages, n trips were made in 2021 for targeted electrofishing removal of invasive carp in either Barkley or Kentucky Lake tailwaters.

Gill netting

During 2021, KDFWR staff did not conduct any targeted gill netting for invasive carp, solely for removal purposes. However, through the course of collecting invasive carp in support of the deterrents project and additional demographic collections KDFWR harvested 6,056 lbs. of silver carp and 87 lbs. of grass carp over 5 days of effort (Kentucky n=2, Barkley n=3).

Recommendations:

All Partners

-Partners in the Tennessee and Cumberland River Basin have initiated substantial efforts to take on invasive carp. New programs being developed by partners are largely dependent on funding provided through the USFWS Invasive carp grants. Continued funding opportunities will be required for partners to advance their efforts.

-Recognize need to standardize collections as possible and working together in the basin.

-As basin partners begin sampling or continue efforts currently in place, data should be compiled and analyzed congruently to more succinctly identify trends in invasive carp population characteristics throughout the basin and inform removal efforts.

-Continue and increase harvest efforts, with identified need for expansion to leading edge populations.

-Need for linking information/data collection back to potential or current management actions.

Agency: KDFWR

-To increase capture rates and sample sizes in the variable habitats found in the basin, additional gear types are being planned as funding allows. Methods for these gears will be clearly outlined and should be standardized across the basin.

Data collected by KDFWR has been useful for identifying trends in demographics of invasive carp populations in the lower reaches of Kentucky and Barkley lakes, and this type of data collection will be expanded throughout the basin.

-KDFWR will be pursuing assisitance with data anlysis to identify trends within the fish communities of Kentukcy and Barkley tailwaters that may be associated with invasive carp densities and determining management strategies.

-It is recommended that targeted removal of invasive carp be continued through 2022.

-KDFWR also suggests that increased observations of commercial fishers through ride-alongs be conducted to reduce differences in reporting.

-Commercial fishing effort throughout the basin is increasing, but relies almost entirely on gill nets as their method of harvest. Gill nets are size selective and the mesh sizes used do not capture all year classes of invasive carp present in the basin. Therefore, effort towards identifying and testing other methods for removing invasive carp should be expanded. Commercial seining shows considerable promise for efficiently removing carp at rates higher than traditional gill netting, and invasive carp harvest areas and associated regulations are planned to facilitate that gear type in Kentucky. KDFWR plans to significantly increase efforts with experimental gear types in Kentucky and Barkley lakes.

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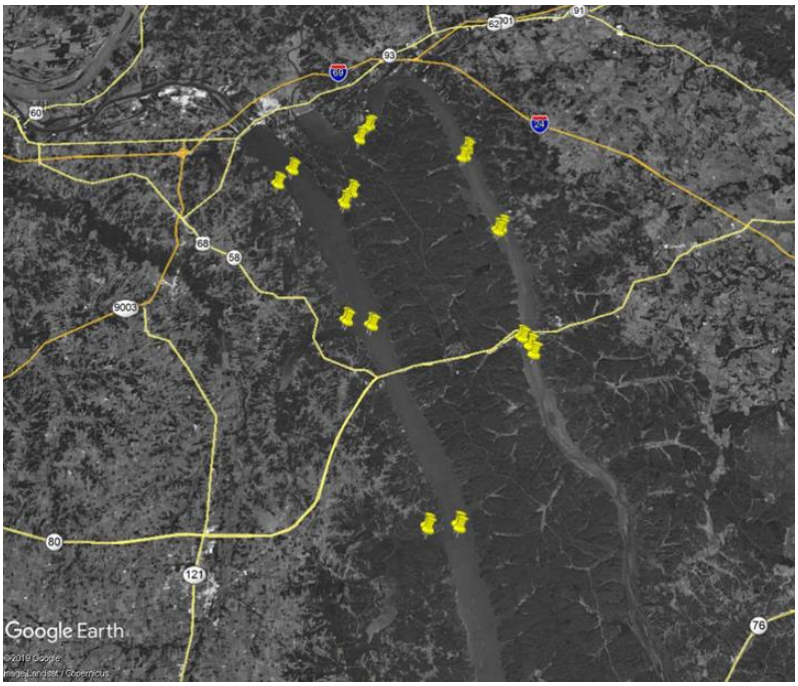

Figure 1. Location of standard sampling sites, where gill nets were fished by Kentucky Department of Fish and Wildlife Resources in 2021.

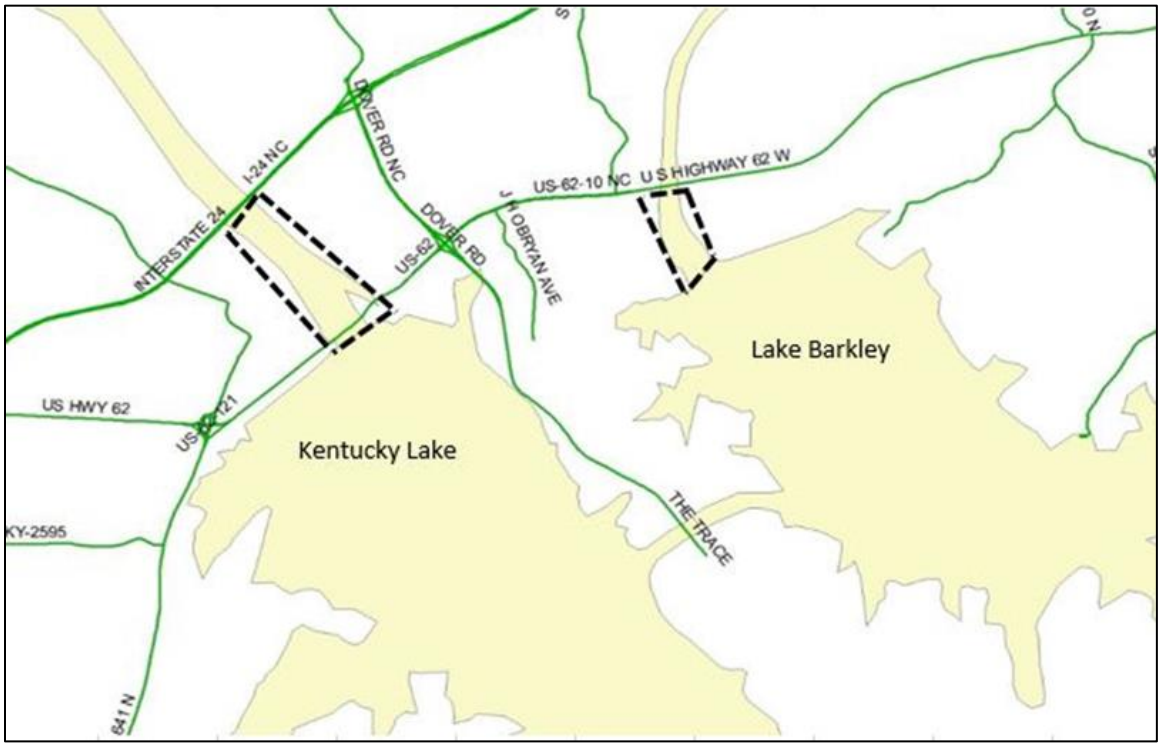

Figure 2. The tailwater electrofishing at Kentucky Tailwater extended from the dam downstream to the Interstate 24 bridge. The electrofishing at Barkley Tailwater extended from the dam downstream to the US Hwy 62 bridge. Sample areas are outlined by dashed line.

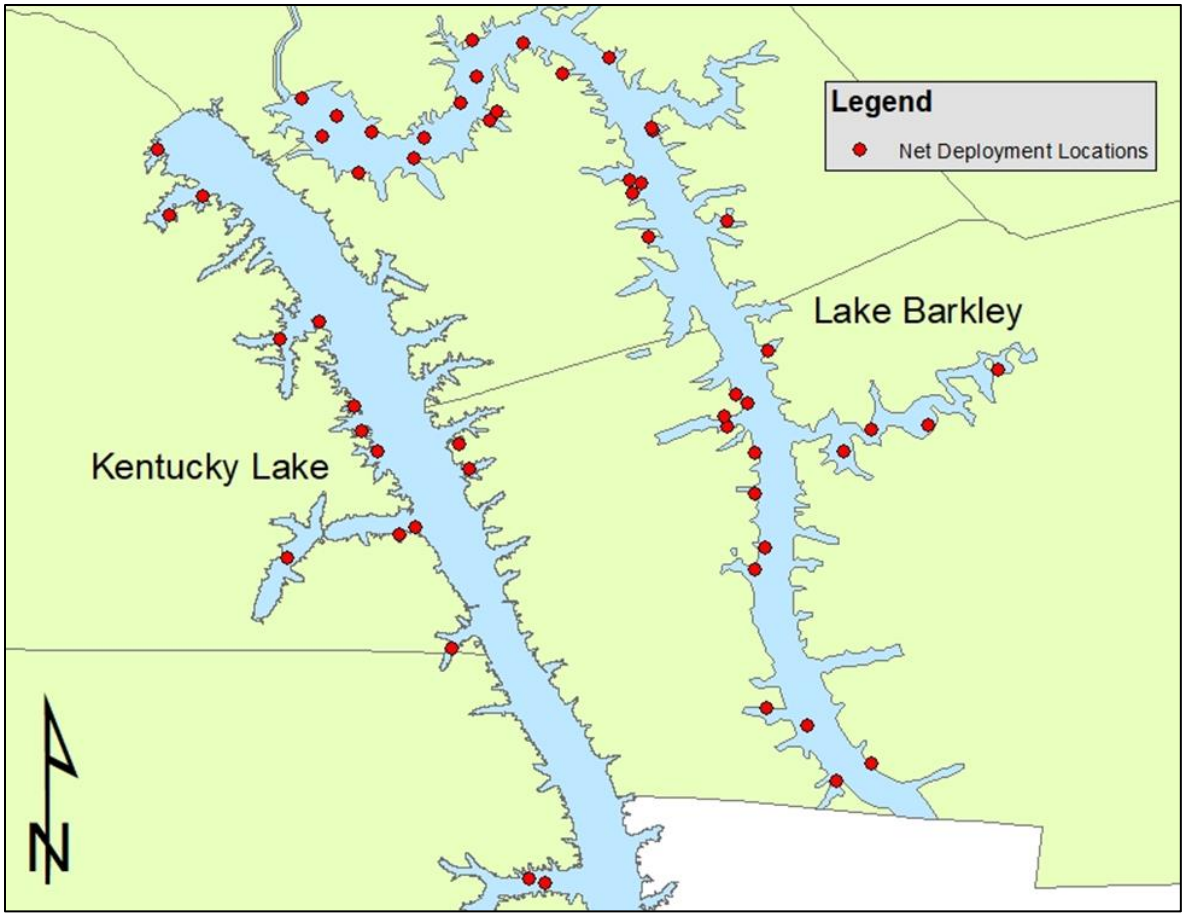

Figure 3. Locations where nets were deployed by commercial fishermen during ride-alongs conducted by KDFWR staff in 2021.

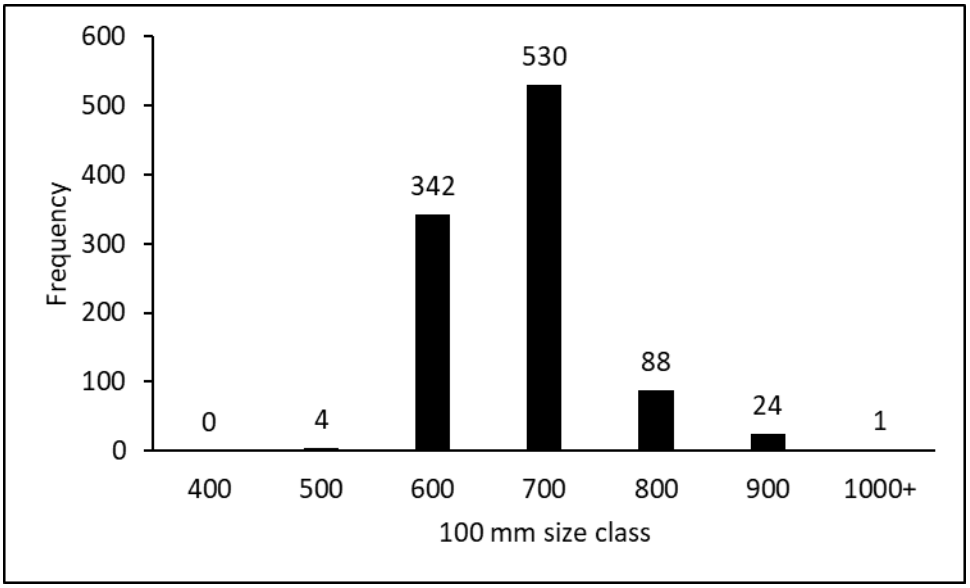

Figure 4. Length-frequency distribution of silver carp collected from Lake Barkley, from all methods in 2021 (N=989).

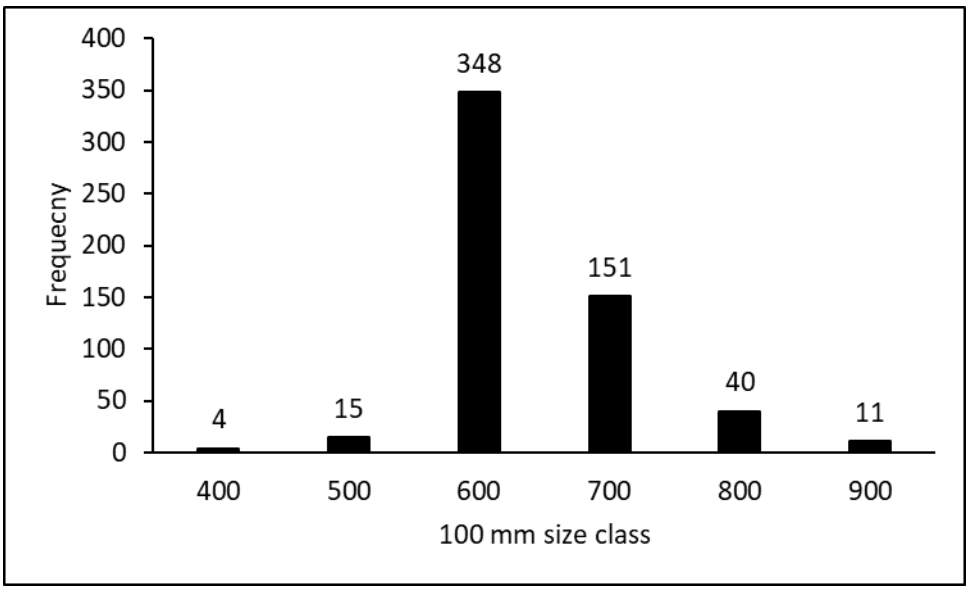

Figure 5. Length-frequency distribution of silver carp collected from Kentucky Lake, from all methods in 2021 (N=569).

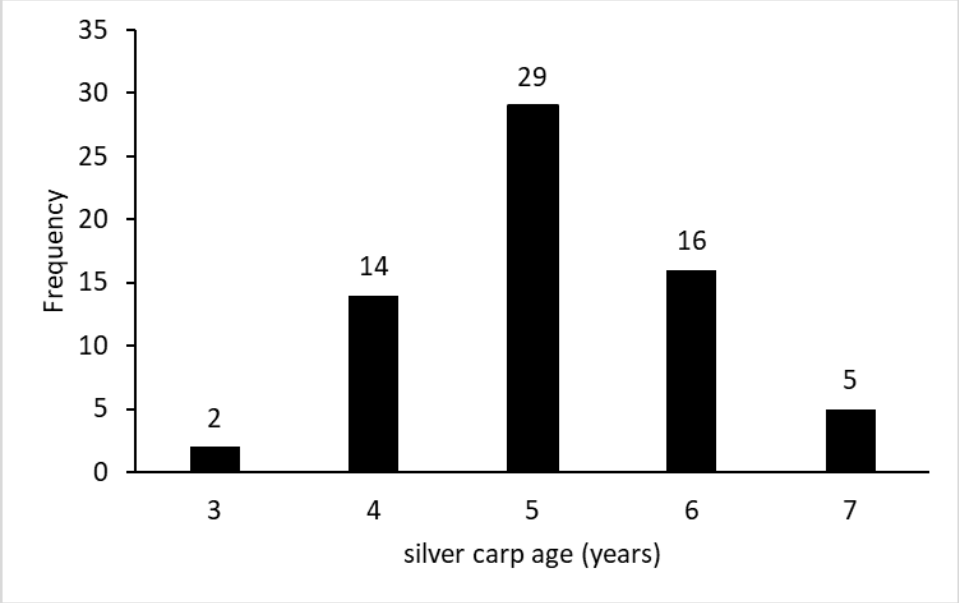

Figure 6. Age-frequency distribution for silver carp collected from Lake Barkley in 2021 (N=66).

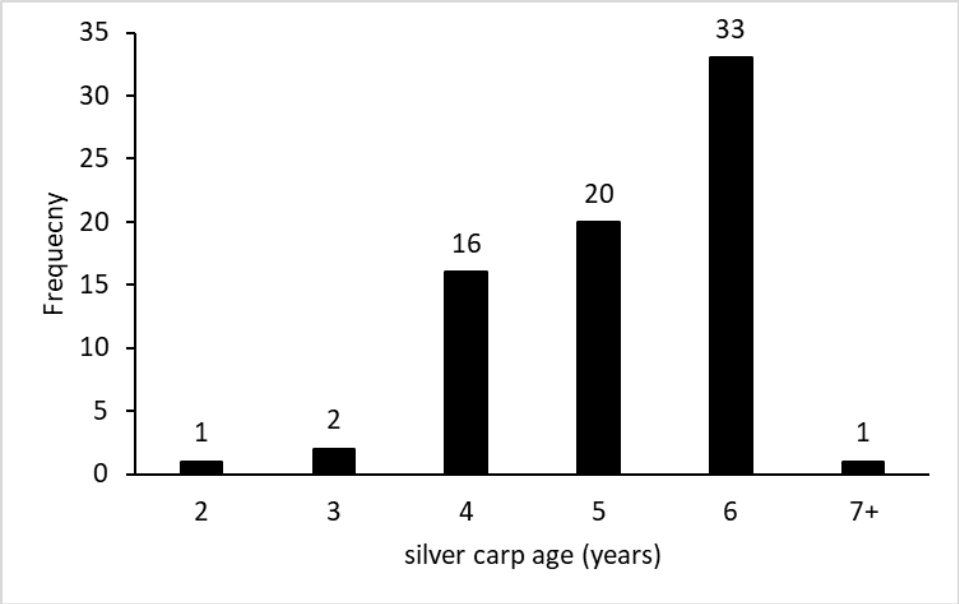

Figure 7. Age-frequency distribution for silver carp collected from Kentucky Lake in 2021 (N=73).

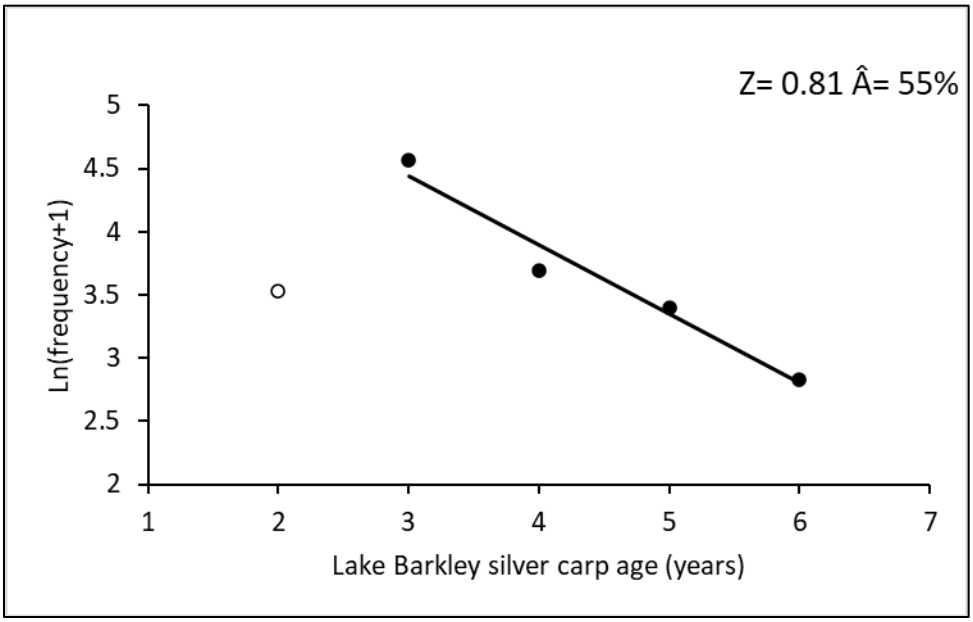

Figure 8. Catch-curve regression estimating mortality of the 2015 cohort of silver carp in Lake Barkley in 2021 (N=179, F1,2=48.99, P=0.02, R2= 0.96). The open circle represents fish not considered fully recruited to the gears used for data collection and thus not used to estimate A or Z.

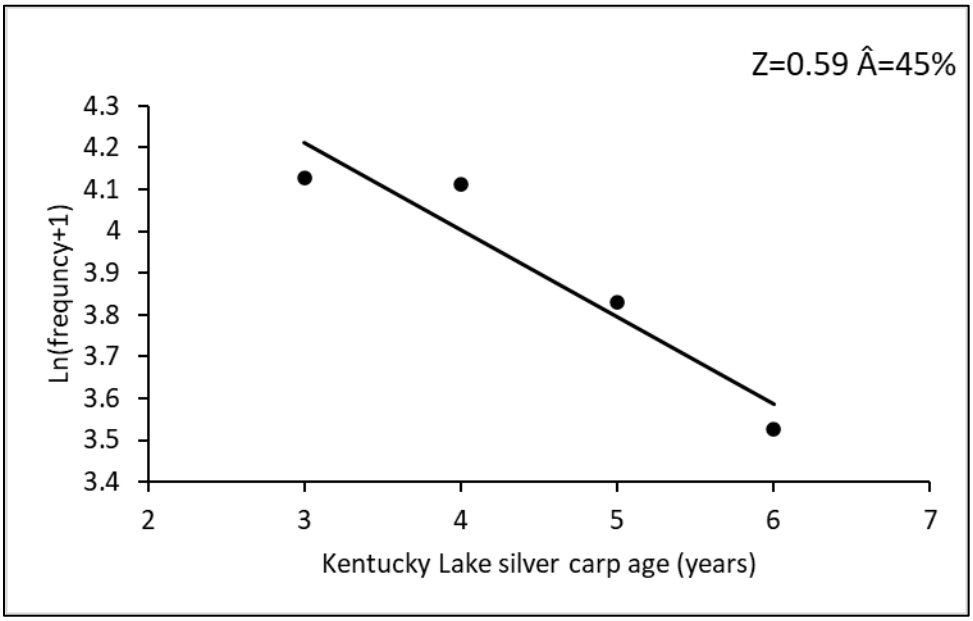

Figure 9. Catch-curve regression estimating mortality of the 2015 cohort of silver carp in Kentucky Lake in 2021 (N=199, F1,2=18.51, P=0.05, R2=0.90).

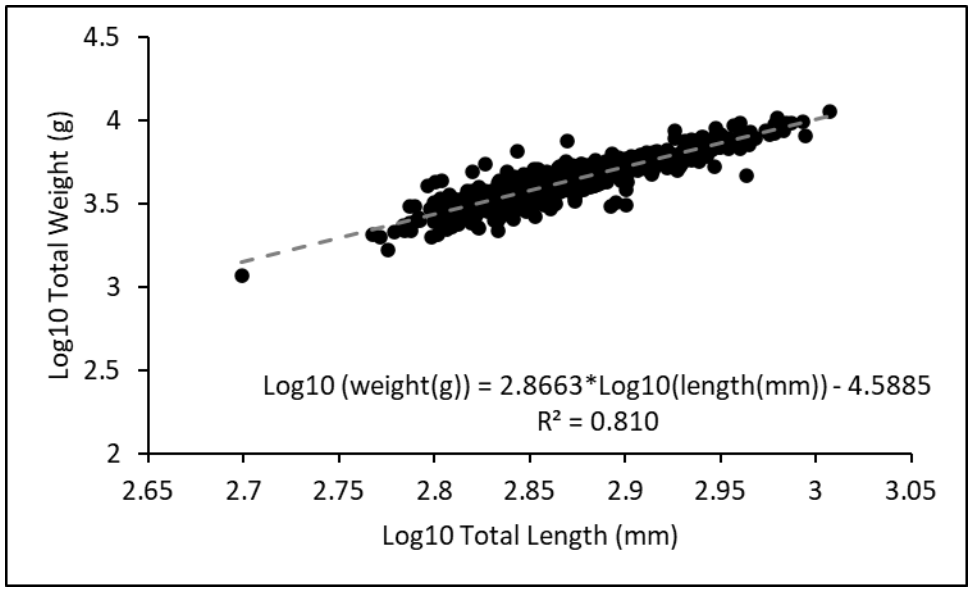

Figure 10. A scatterplot of Log10 transformed lengths and weights for silver carp harvested from Lake Barkley in 2021 with a regression line describing the relationship between lengths and weights (N=986).

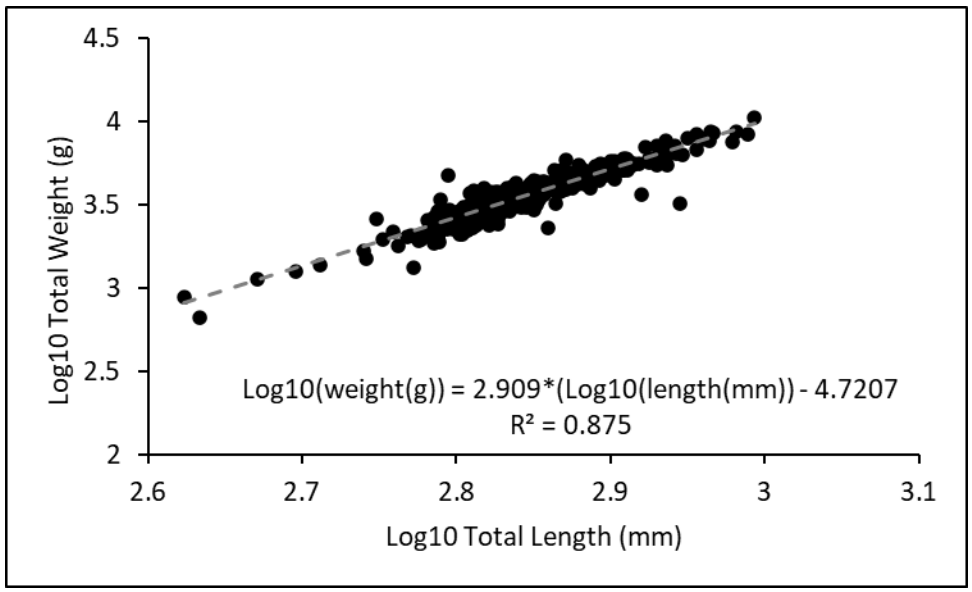

Figure 11. A scatterplot of Log10 transformed lengths and weights for silver carp harvested from Kentucky Lake in 2021 with a regression line describing the relationship between lengths and weights (N=569).

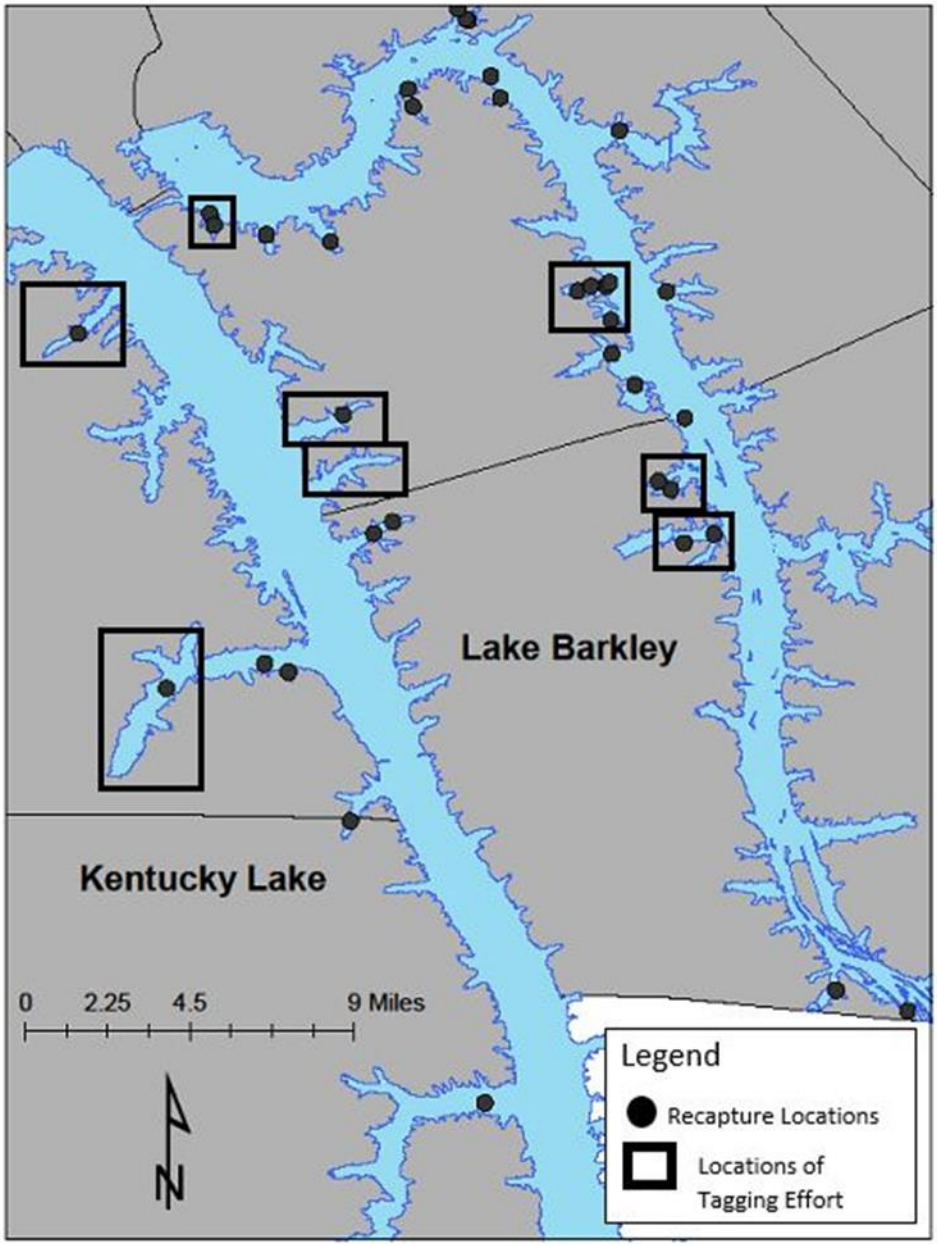

Figure 12. Locations of recaptured silver carp that were tagged as part of the mark-recapture effort to estimate abundance of silver carp in Barkley and Kentucky lakes.

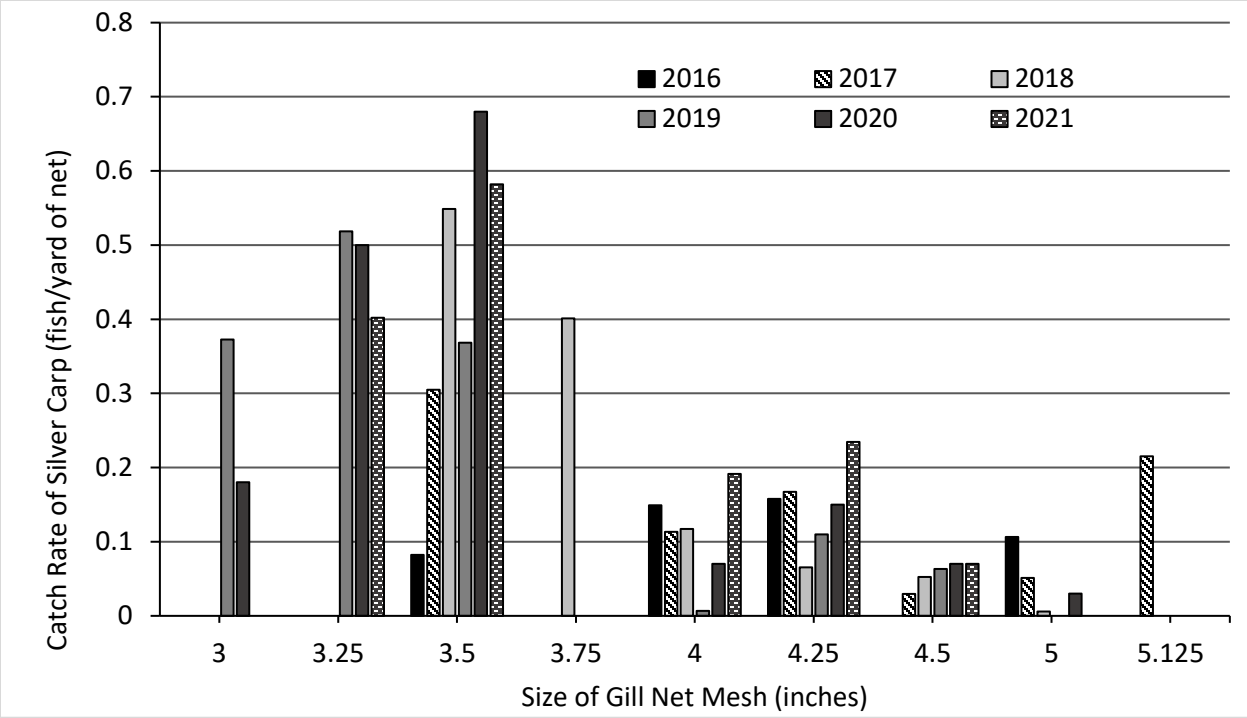

Figure 13. Catch rates (number of fish/yard of net) of silver carp by gill net mesh size during ride-alongs with commercial fishermen fishing under the Asian Carp Harvest Program.

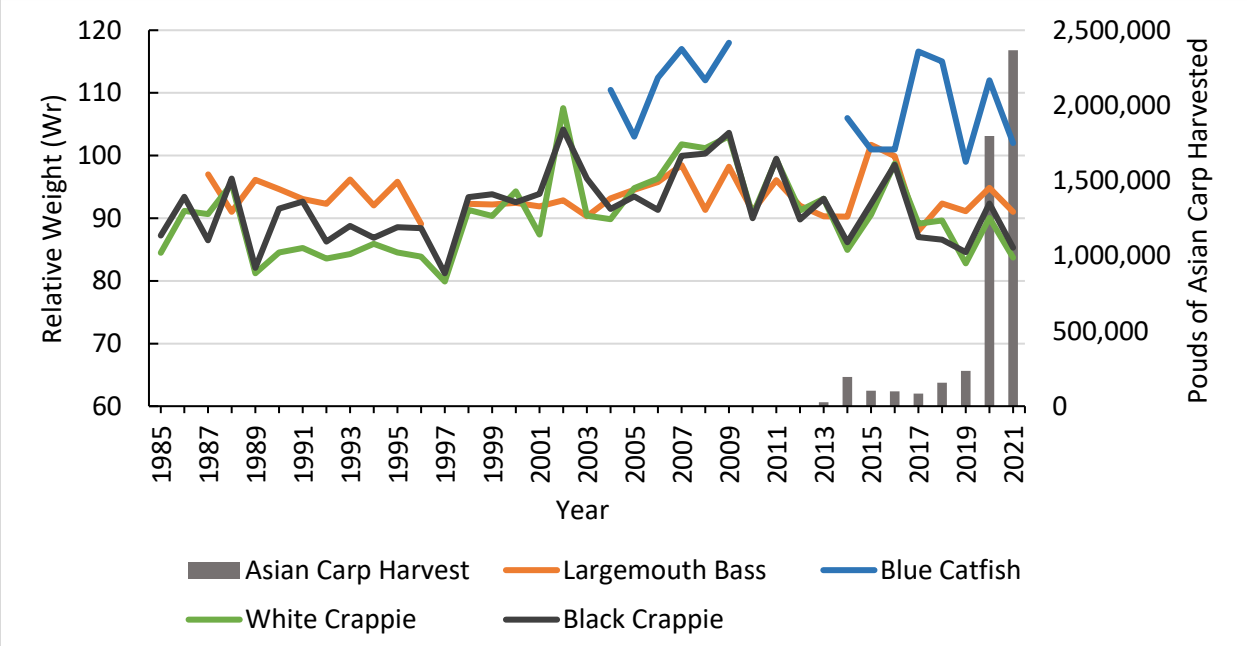

Figure 14. Mean relative weights of popular sport fish species sampled in Kentucky Lake annually, plotted against pounds of invasive carp harvested from Kentucky Lake by commercial fishers under the Asian Carp Harvest Program since the program began in 2013.

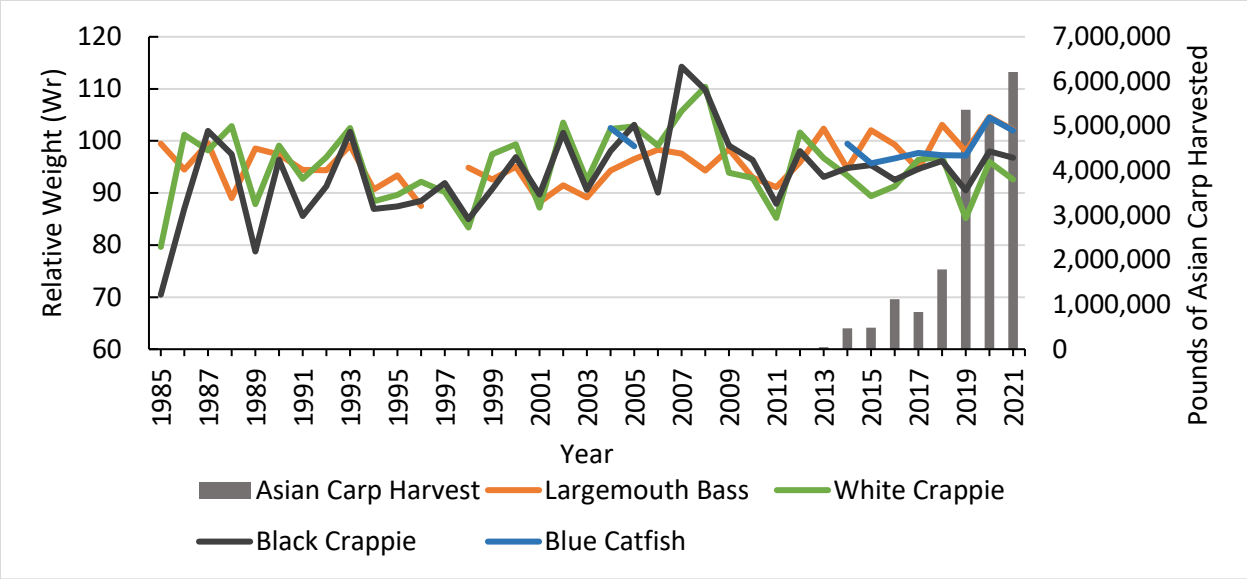

Figure 15. Mean relative weights of popular sport fish species sampled in Lake Barkley annually, plotted against pounds of invasive carp harvested from Lake Barkley by commercial fishers under the Asian Carp Harvest Program since the program began in 2013.

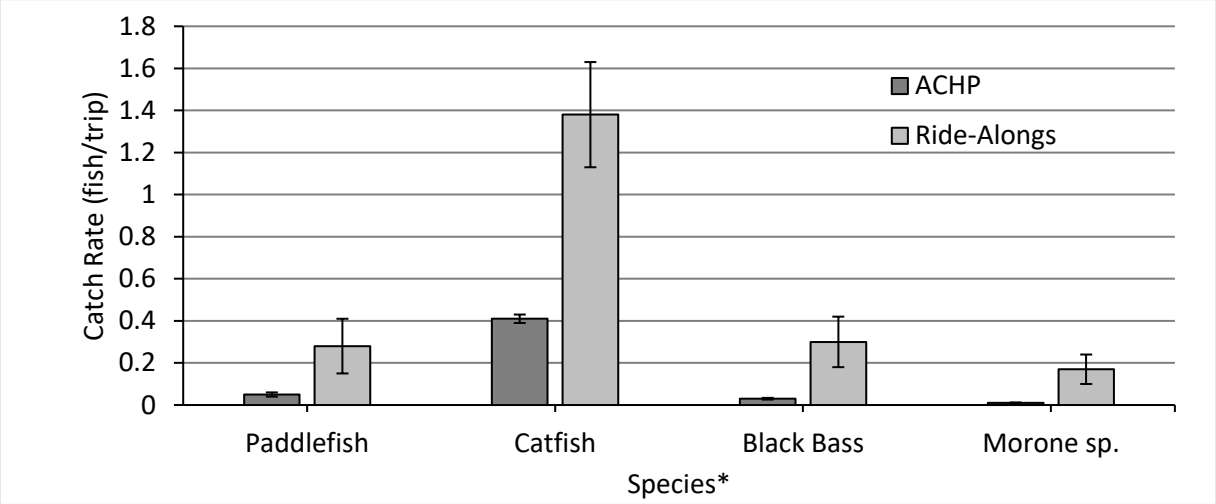

Figure 16. Comparison of catch rates (fish/trip) for some common bycatch species as reported by commercial fishers utilizing the Asian Carp Harvest Program (ACHP) and through KDFWR ride-alongs with commercial fishers in 2021. Error bars represent Standard Error values.

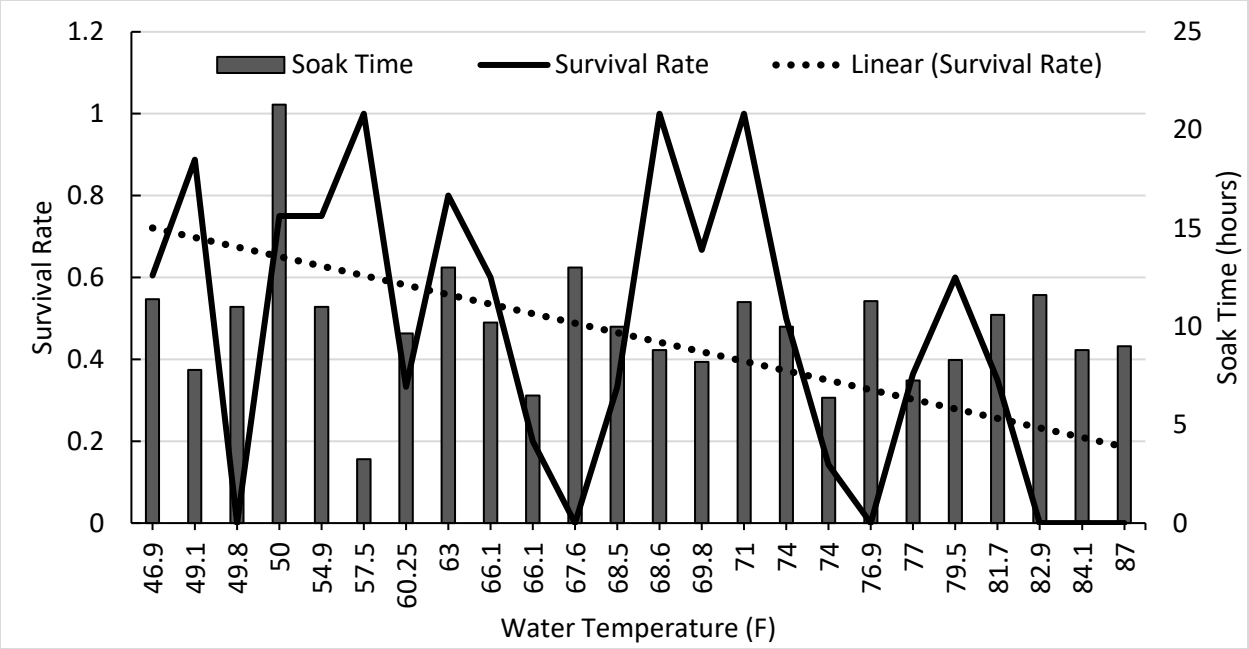

Figure 17. Survival rates of paddlefish observed caught as bycatch during ride alongs with commercial fishers on the Asian Carp Harvest Program.

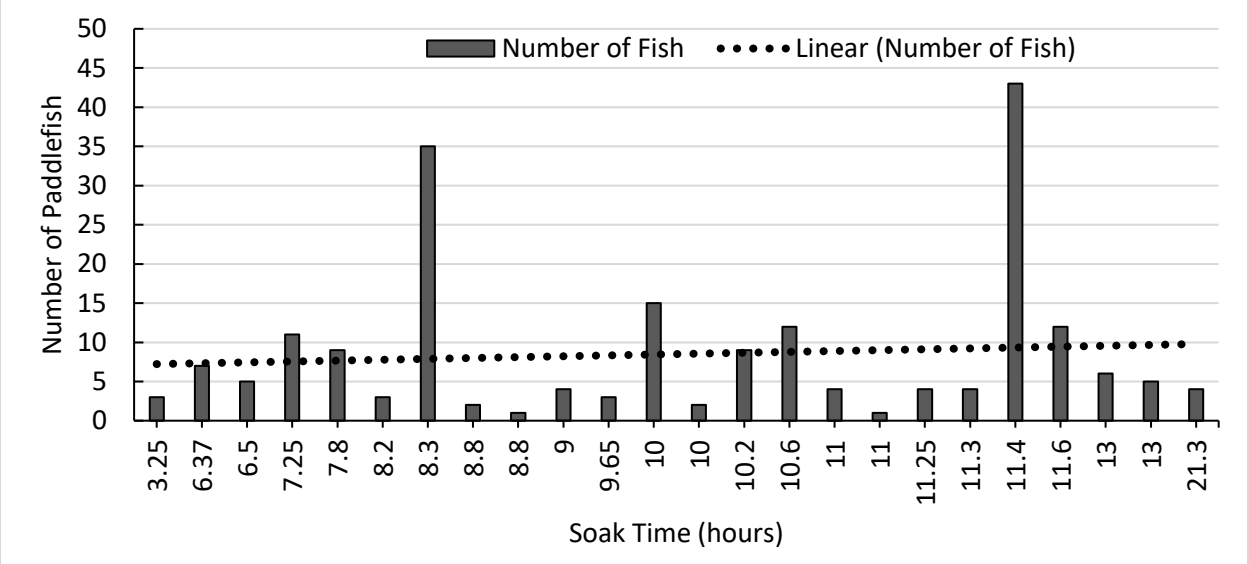

Figure 18. Number of paddlefish observed caught as bycatch during ride alongs with commercial fishers under the Asian Carp Harvest Program 2017 - 2021.

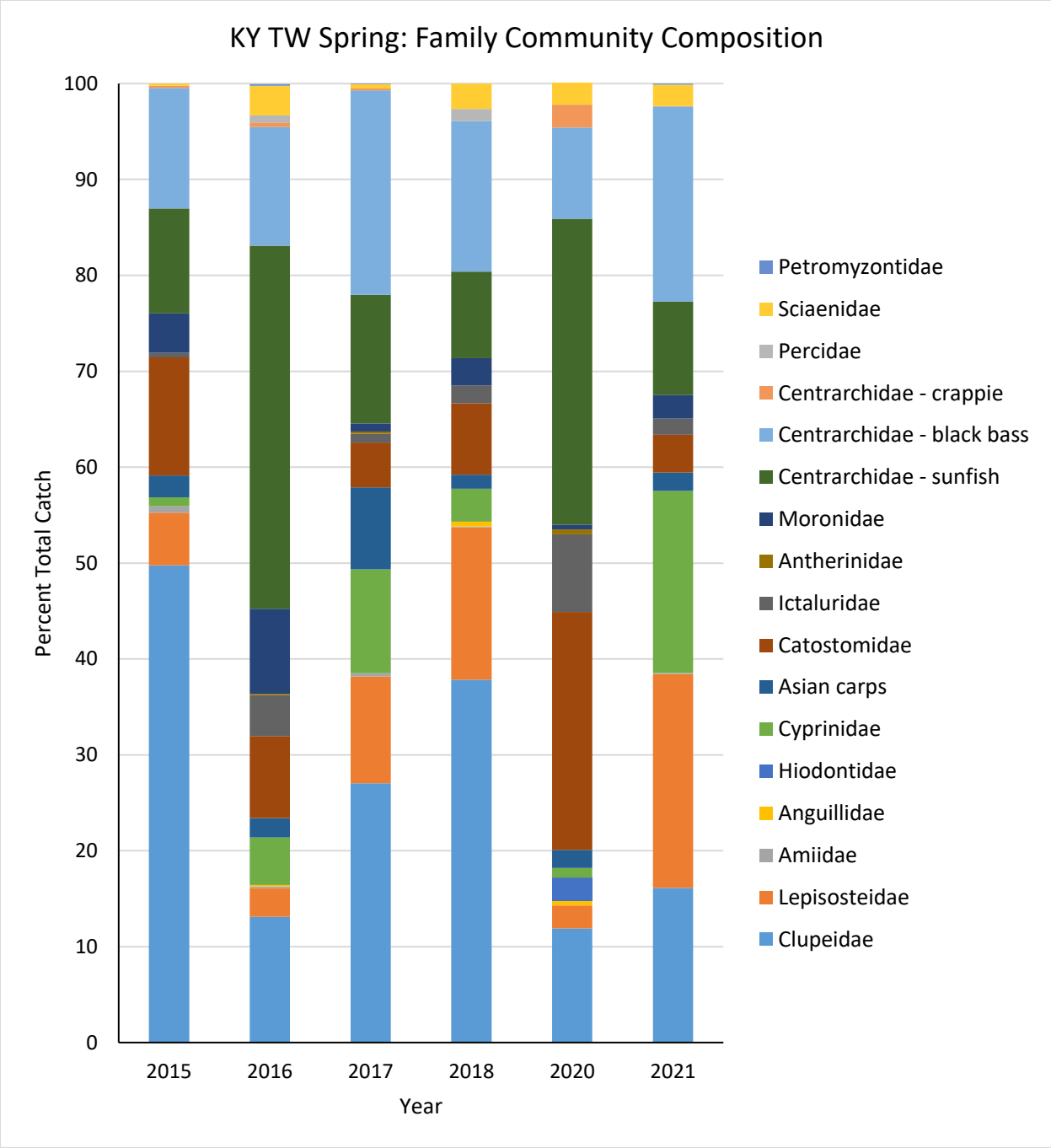

Figure 19. Comparison of percent total catch by number of each family identified from spring community sampling via electrofishing in the Kentucky Tailwater 2015-2021. Spring sampling was not conducted in 2019.

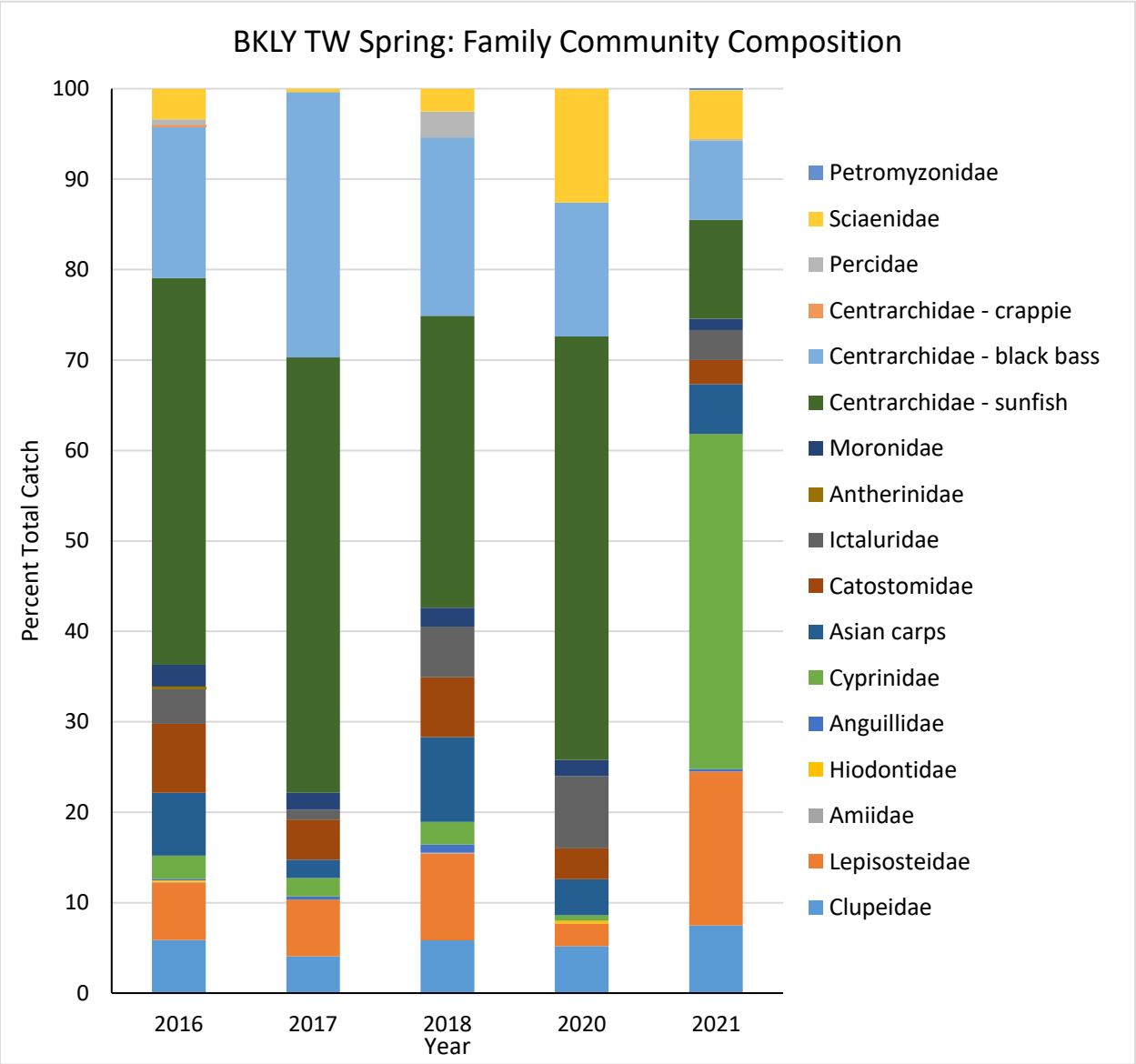

Figure 20. Comparison of percent total catch by number of each family identified from spring community sampling via electrofishing in the Barkley Tailwater 2016-2021. Spring sampling was not conducted in 2019.

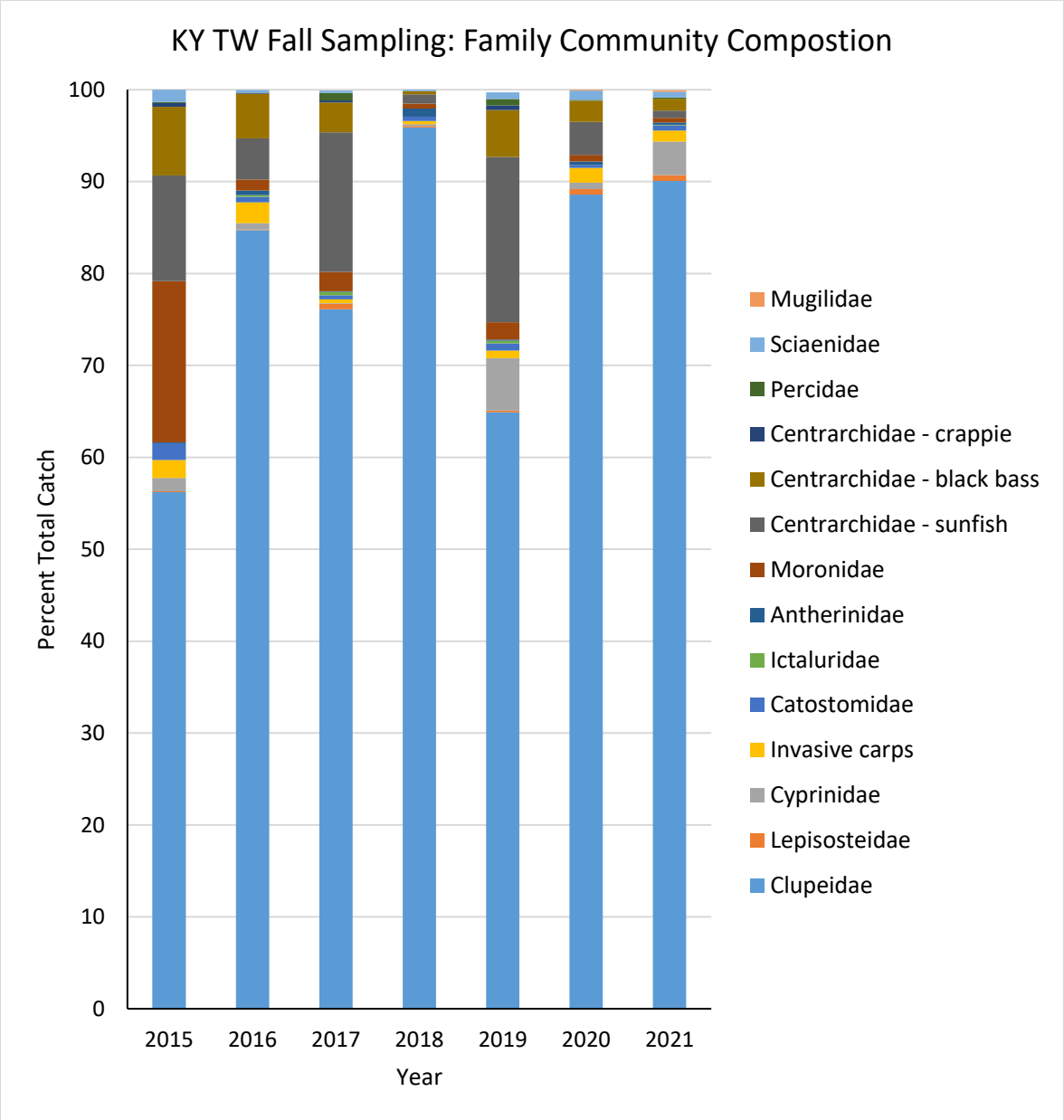

Figure 21. Comparison of percent total catch by number of each family identified from fall community sampling via electrofishing in the Kentucky Tailwater 2015-2021.

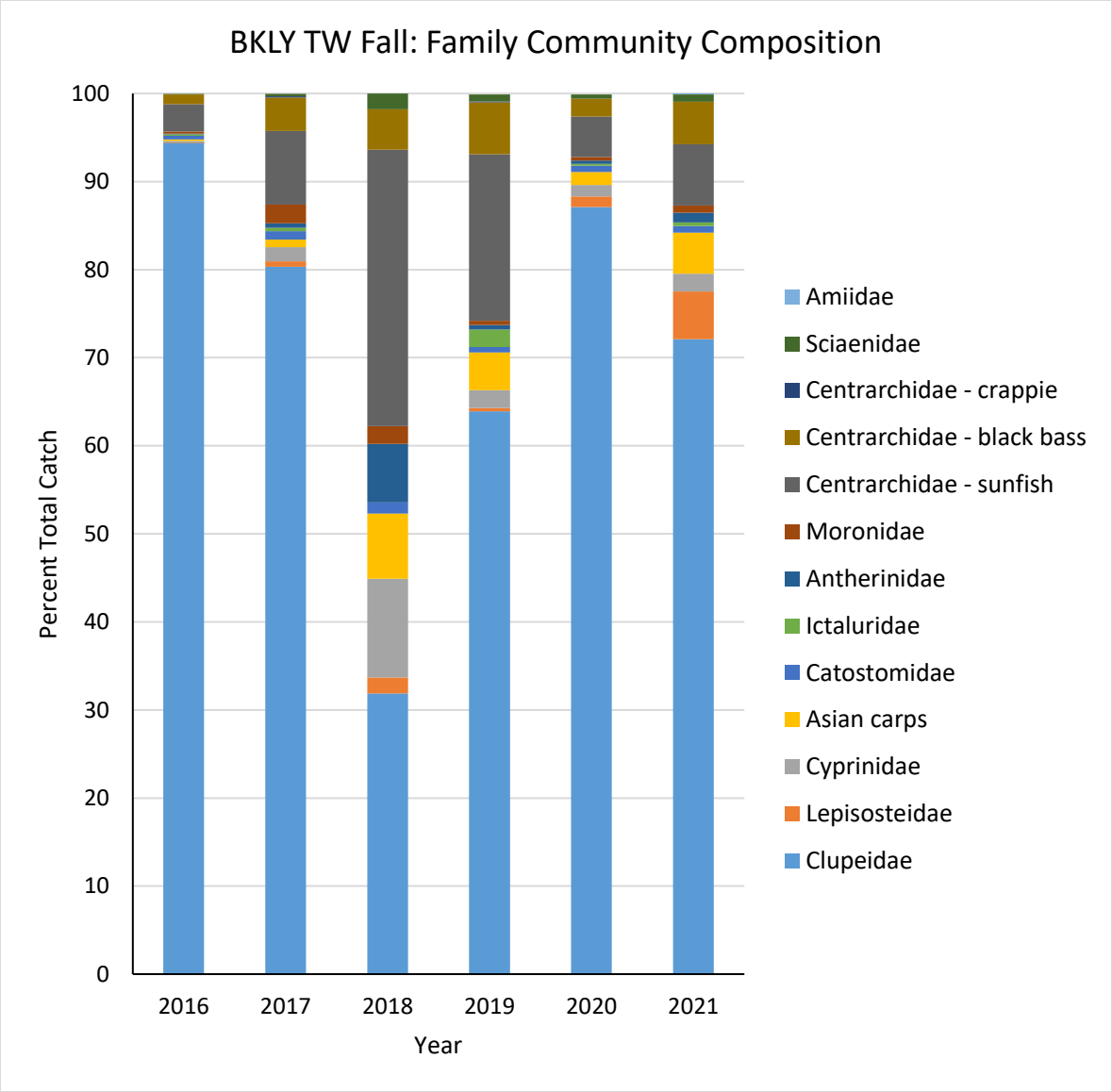

Figure 22. Comparison of percent total catch by number of each family identified from fall community sampling via electrofishing in the Barkley Tailwater 2016-2021.

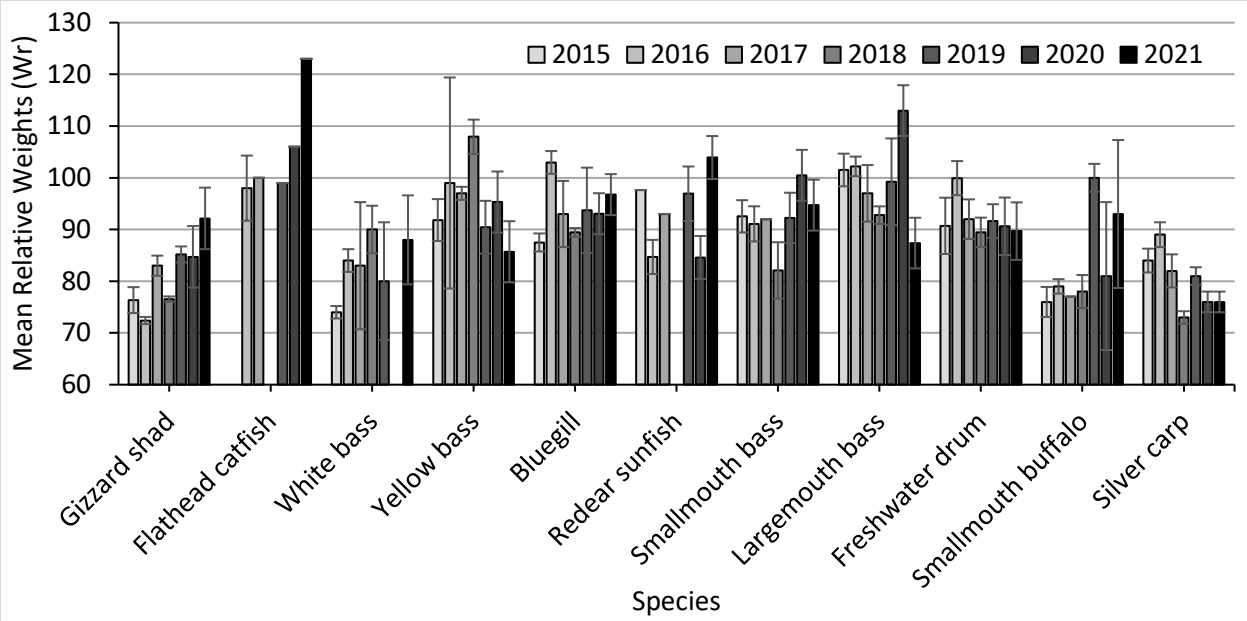

Figure 23. Mean relative weights (*W*r) of select species sampled through shoreline electrofishing in the Kentucky Tailwaters during the fall season 2015-2021.

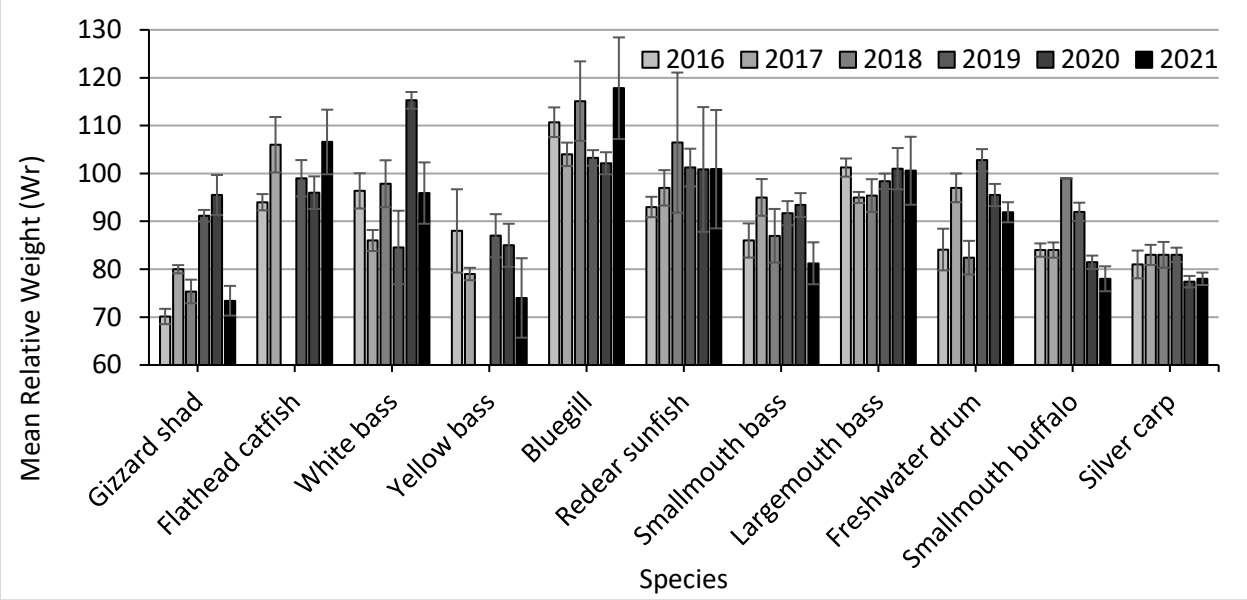

Figure 24. Mean relative weights (*W*r) of select species sampled through shoreline electrofishing in the Barkley Tailwaters during the fall season 2016-2021.

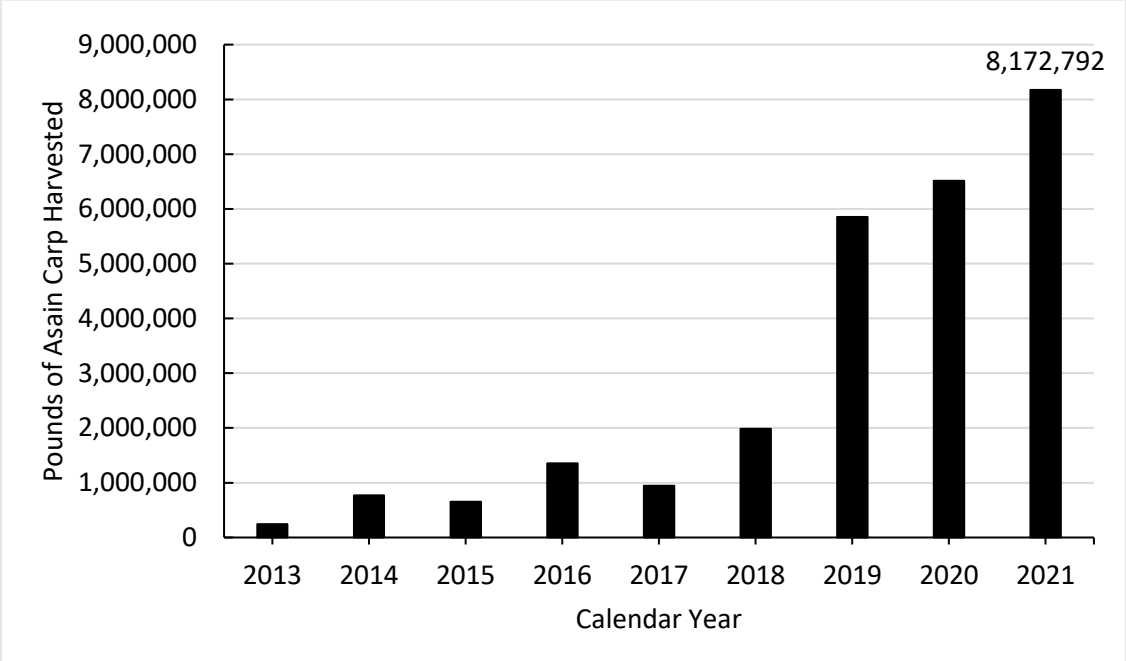

Figure 25. Pounds of Bigheaded carp harvested through the Asian Carp Harvest Program by calendar year. *2020 was the first year that grass carp harvest was tracked through the ACHP and accounted for an additional 111,190 lbs of invasive carp species harvested through the ACHP in 2020 and 74,430 lbs in 2021.

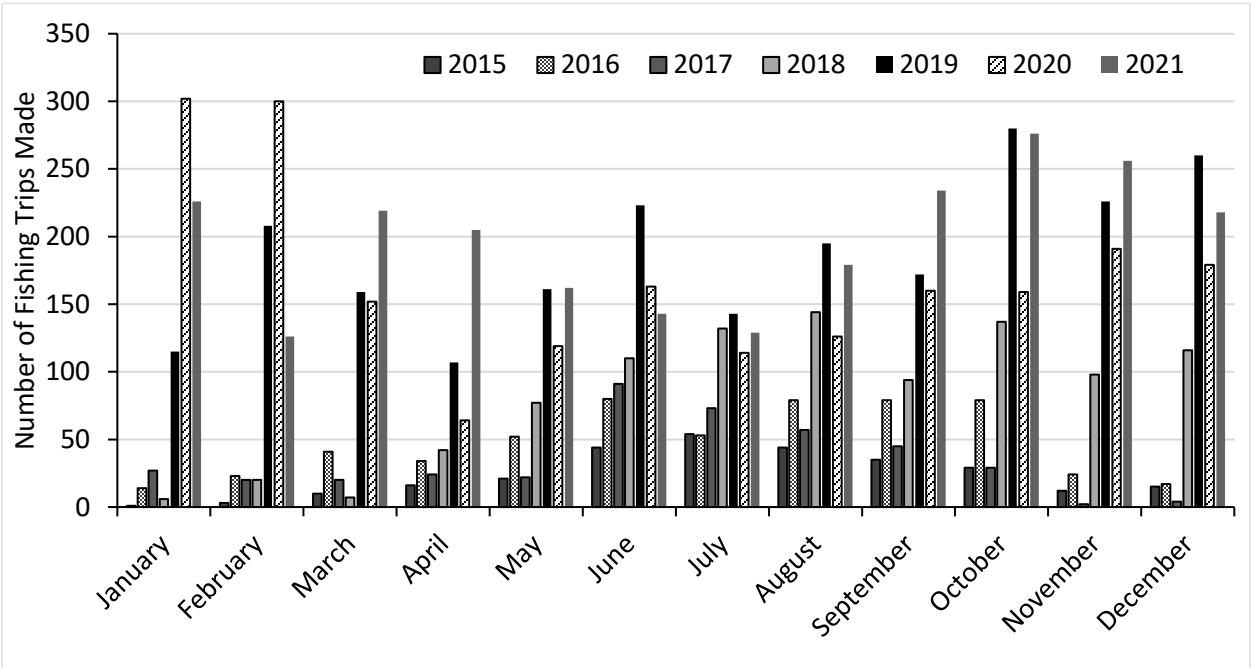

Figure 26. Number of fishing trips made monthly by commercial fishers fishing under the Asian Carp Harvest Program from January 2015 - December 2021.

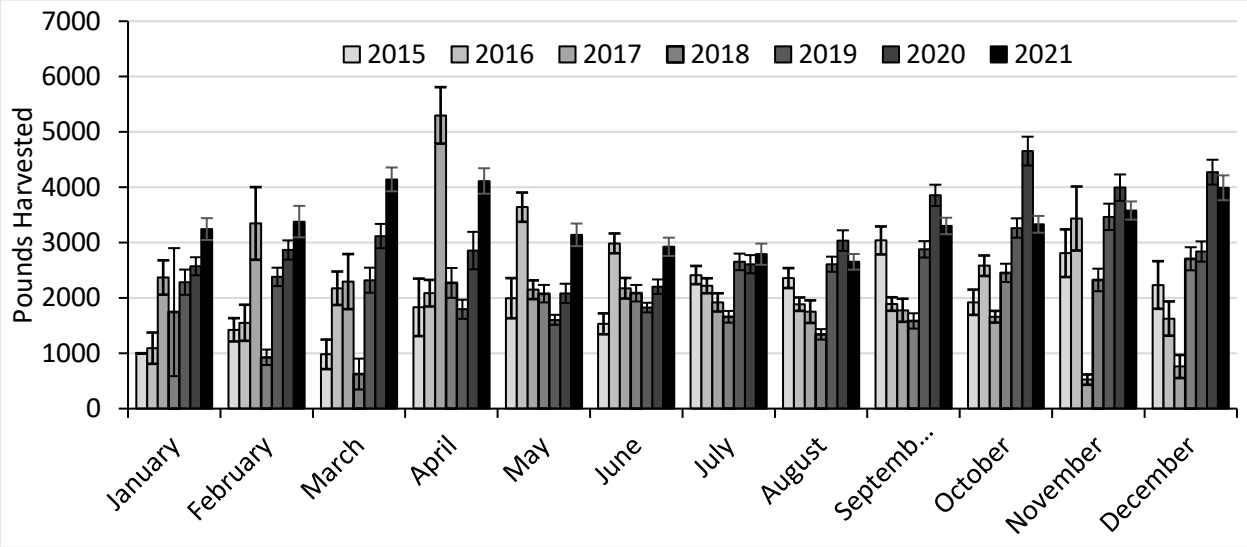

Figure 27. Monthly average total weight (lbs) of silver carp harvested per trip by commercial fishers fishing under the Asian Carp Harvest Program January 2015 - December 2021. Error bars represent standard error values.

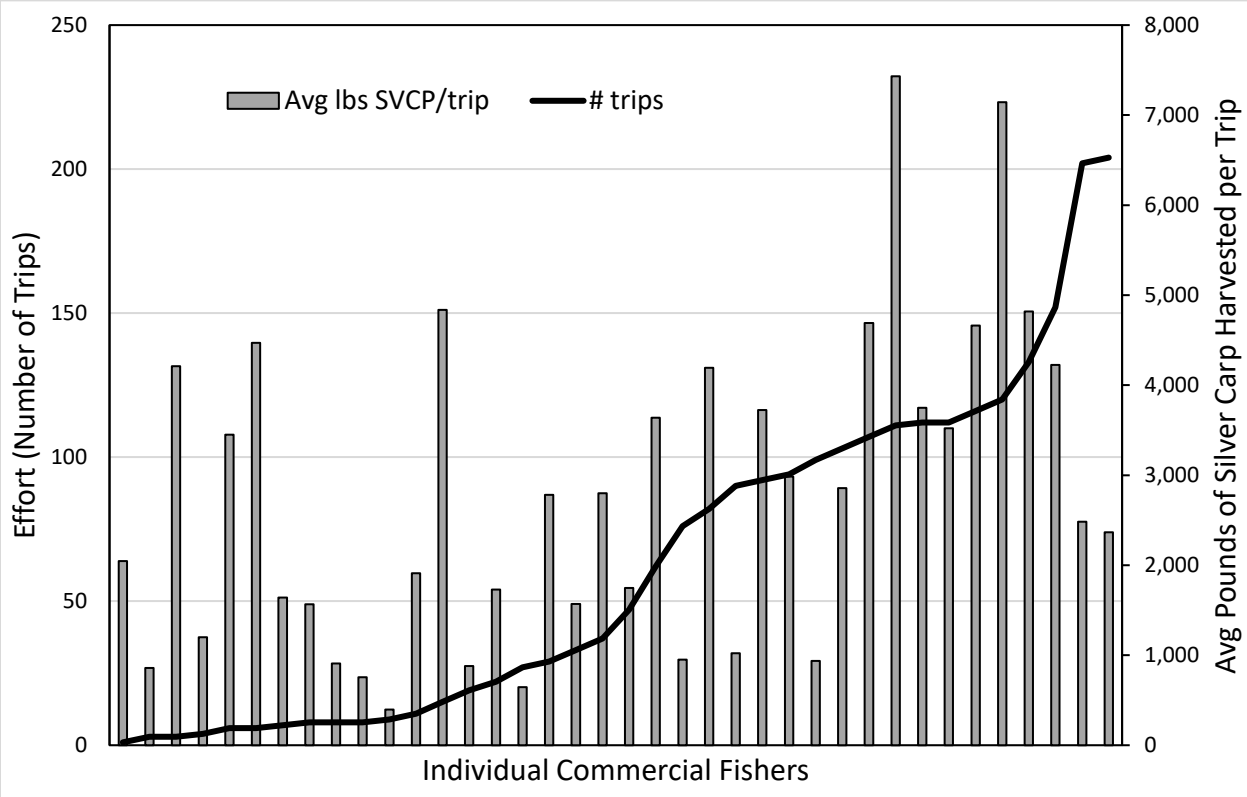

Figure 28. Average weight harvested per trip by individual commercial fishers compared to the number of trips taken by those fishers under the Asian Carp Harvest Program in 2021.

Table 1. The number of invasive carp collected during each standard sampling period by lake in 2018-2021.

2021								
	Barkley Reservoir				Kentucky Reservoir			
Species Captured	April	July	October	Total	April	July	October	Totals
Bighead carp	3	16	1	20	0	10	15	25
Grass carp	0	4	0	4	0	6	3	9
Silver carp	39	43	31	113	12	25	38	75
Totals	42	63	32	137	12	41	56	109

2020								
	Barkley Reservoir				Kentucky Reservoir			
Species Captured	April	July	October	Total	April	July	October	Totals
Bighead carp	1	7	0	8	7	7	3	17
Grass carp	0	3	1	4	2	5	19	26
Silver carp	12	33	32	77	18	14	36	68
Totals	13	43	33	89	27	26	58	111

2019								
	Barkley Reservoir				Kentucky Reservoir			
Species Captured	April	July	October	Totals	April	July	October	Totals
Bighead carp	3	4	2	9	4	12	1	17
Grass carp	0	0	1	1	1	0	4	5
Silver carp	74	64	48	186	109	81	61	251
Totals	77	68	51	196	114	93	66	273

2018								
	Barkley Reservoir				Kentucky Reservoir			
Species Captured	April	July	October	Totals	April	July	October	Totals
Bighead carp		13	3	16		11	3	14
Grass carp		4	3	7		4	12	16
Silver carp		305	193	498		477	494	971
		322	199	521		492	509	1001

Table 2. A summation of catch per unit effort (CPUE) for silver carp collected in Barkley and Kentucky lakes, by month and habitat type in 2021. CPUE reported in fish/linear yard of gill net.

			Bar mesh size			
	Site	Month	3"	4"	5"	Mean Total CPUE
Lake Barkley	Main Channel	April	0.004	0.038	0.006	0.016
		July	0.004	0.023	0.004	0.010
		October	0.002	0.008	0.000	0.003
	Embayment	April	0.002	0.023	0.002	0.009
		July	0.006	0.041	0.004	0.017
		October	0.004	0.043	0.002	0.016
			Bar mesh size			
	Site	Month	3"	4"	5"	Mean Total CPUE
Kentucky Lake	Main Channel	April	0.000	0.000	0.000	0.000
		July	0.000	0.004	0.000	0.001
		October	0.009	0.019	0.000	0.009
	Embayment	April	0.006	0.011	0.006	0.008
		July	0.009	0.028	0.006	0.014
		October	0.011	0.028	0.004	0.014

Table 3. A summation of estimated weights at three lengths for silver carp collected from Barkley and Kentucky lakes through all methods from 2018 through 2021.

Reservoir	Year	Predicted weight(g) at 450mm	Predicted weight(g) at 650mm	Predicted weight(g) at 800mm
Barkley	2018	933	2789	5176
	2019	1076	2881	5024
	2020	1121	2974	5160
	2021	1038	2980	5403
Kentucky	2018	950	2733	4963
	2019	930	2720	4987
	2020	986	2788	5018
	2021	994	2848	5301

Table 4. Average length and weight of silver carp harvested during ride-alongs with commercial fishers under the Asian Carp Harvest Program 2015-2021.

Year	Number Sampled	Average total length (inches)	Average weight (lbs)	S. E.
2015	206	33.2	15.2	0.12
2016	448	34.5	17.7	0.10
2017	416	34.0	16.1	0.10
2018	387	31.0	11.6	0.10
2019	924	27.9	8.1	0.09
2020	595	28.0	8.5	0.11
2021	949	27.9	8.9	0.07

Table 5. Measures of effort and catch reported by commercial fishers fishing under the Asian Carp Harvest Program by calendar year, January -December 2013 - 2021.

Water Body	Year	Number of Days/Trips	Number of fishers	Weight silver carp harvested (lbs)	Weight bighead carp harvested (lbs)	Weight grass carp harvested (lbs)
Lake Barkley	2013	45	5	187,022		
	2014	61	6	464,003	1,360	
	2015	189	12	472,487	10,278	
	2016	447	22	1,112,585	5,693	
	2017	345	15	826,016	9,669	
	2018*	835	23	1,762,830	25,932	
	2019	1,846	60	5,318,535	45,665	
	2020***	1,431	43	4,700,149	28,714	61,487
	2021	1,707	32	5,918,405	18,669	43,213
Kentucky Lake	2013	21	4	26,400	491	
	2014	82	3	193,786	992	
	2015	59	6	84,190	17,791	
	2016	52	8	96,652	2,884	
	2017	54	8	71,487	11,754	
	2018*	116	8	143,996	11,537	
	2019	140	28	233,806	1,978	
	2020***	426	27	1,601,822	4,196	40,882
	2021	587	28	2,154,845	4,227	27,514
Ohio River	2013					
	2014	11	1	74,879		
	2015	16	3	26,864	1,206	
	2016	30	5	90,012	3,216	
	2017	8	4	11,217	713	
	2018	21	4	37,553	70	
	2019	129	9	142,520	521	
	2020***	151	13	137,754	7,402	6,402
	2021	56	7	60,741	1,286	3,028
Statewide**	2013	76	7	243,121	491	
	2014	160	9	765,768	2,802	
	2015	283	16	617,062	32,800	
	2016	565	24	1,343,464	12,666	
	2017	414	21	921,288	23,272	
	2018*	982	29	1,945,693	37,739	
	2019	2,250	66	5,802,624	50,366	
	2020***	2,052	48	6,471,718	43,931	111,190
	2021	2,373	38	8,148,093	24,699	74,430

*In 2018 KDFWR began allowing commercial fishermen to receive subsidy funds from the Asian Carp Harvest Program while fishing on their net permit, which allows them to harvest catfish and paddlefish.

**Effort and harvest occurs under the ACHP in other water bodies to a lesser degree and is included in the statewide totals.

***2020 was the first year that Grass carp harvest was reported seperately from common carp harvest through the ACHP.

Table 6. Number of bighead carp and silver carp captured by gill net mesh size as observed during KDFWR ride-alongs with commercial fishers fishing under the Asian Carp Harvest Program 2016 - 2021. (CPUE = catch per unit effort)

Year	Net Bar Mesh Size (inches)	Effort (linear yards of net)	Number of Silver carp	Silver carp CPUE (fish/yard)	Number of Bighead carp	Number of Grass carp
2016	3.5	1,883	155	0.08		17
	4	2,067	308	0.15		1
	4.25	9,300	1,469	0.16	8	12
	5	16,983	1,811	0.11	44	13
	6	1,067	3	0.00		
2017	3.5	200	61	0.31	4	1
	4	1,983	225	0.11	1	1
	4.25	23,400	3,918	0.17	19	31
	4.5	2,283	68	0.03		
	5	4,125	212	0.05	3	1
	5.125	400	86	0.22	4	2
2018	3.5	6,883	3,778	0.55	8	24
	3.75	167	67	0.40		
	4	3,250	381	0.12	4	3
	4.25	14,100	920	0.07	54	8
	4.5	2,767	145	0.05	4	
	5	867	5	0.01	1	
2019	3	2,967	1,106	0.37	2	5
	3.25	9,600	4,979	0.52	10	83
	3.5	39,300	14,483	0.37	30	177
	4	300	2	0.01	0	0
	4.25	3,700	406	0.11	18	3
	4.5	2,567	162	0.06	5	1
	5	67	0	0.00	0	0
2020	3	100	18	0.18		
	3.25	3,933	1,968	0.50	2	17
	3.5	21,692	14,792	0.68	33	169
	4	533	38	0.07		
	4.25	2,100	319	0.15	6	
	4.5	1,583	104	0.07	5	
	5	267	9	0.03	4	
2021	3.25	2,117	851	0.40		6
	3.5	35,093	20,416	0.58	73	134
	4	2,583	494	0.19	17	3
	4.25	1,100	258	0.23	17	
	4.5	1,450	102	0.07	4	

Table 7. Relative weight (Wr) values of gizzard shad collected with boat electrofishing from Barkley and Kentucky lakes in October 2017-2021.

	Lake Barkley								
	Length group								
	7.0-11.0 in			>11.0 in			Total		
Year	No.	Wr	S.E.	No.	Wr	S.E.	No.	Wr	S.E.
2021	34	91	0.9				34	90	1
2020	43	94	0.7	4	91	2.3	47	93	0.7
2019	60	94	1.1	9	93	2.3	69	94	1
2018	30	90	1.1	1	99		31	90	1.1
2017	110	83	0.7	0			110	83	0.7

	Kentucky Lake								
	Length group								
	7.0-11.0 in			>11.0 in			Total		
Year	No.	Wr	S.E.	No.	Wr	S.E.	No.	Wr	S.E.
2021	36	93	0.6	49	91.31	1	85	92	0.5
2020	63	93	1.1	32	91	1.1	95	92	0.8
2019	41	96	0.8	26	93	1.3	80	92	0.9
2018	57	86	1.1	7	86	2.5	64	86	1
2017	40	84	0.9	4	85	1.1	44	84	0.8

Table 8. Number and disposition of bycatch from commercial fishing efforts under the Asian Carp Harvest Program by calendar year, January - December. Survival rate is defined as fish that swam away upon being released from the net. Harvest of scaled rough fish is permitted under the Asian Carp Harvest Program.

Year	Sport Fish*		Scaled Rough Fish**		Catfish Species		Paddlefish		Total number of bycatch
	Number	Survival Rate %	Number Caught	% Harvested	Number	Survival Rate %***	Number	Survival Rate %***	
2013	29	100.0	7,132	93.7	100	97.0	305	90.5	7,566
2014	78	92.3	4,505	75.1	128	99.2	120	65.0	4,831
2015	97	89.7	7,462	80.5	719	95.0	980	65.0	9,258
2016	115	75.7	10,811	76.1	719	95.5	573	68.2	12,218
2017	25	92.0	9,565	91.8	541	95.7	314	75.5	10,445
2018	46	71.7	25,703	86.1	1201	98.3	200	85.5	27,150
2019	171	93.6	32,861	80.7	1512	98.7	296	80.7	34,841
2020	148	92.5	17,394	78.8	768	99.2	222	85.7	18,592
2021	126	98.4	19,433	87.7	733	99.0	126	81.0	20,418

*Sport fish are defined in 301 KAR 1:060

**Scaled Rough fish are defined in 301 KAR 1:152

***In 2018 KDFWR began allowing commercial fishermen to receive subsidy funds from the Asian Carp Harvest Program while fishing on their net permit, which allows them to harvest catfish and paddlefish. Therefore, the survival rates for 2018 - 2021 only account for fish that were dead or alive upon release and not those that were harvested.

Table 9. Species composition, number of individuals captured, and survival rate of species observed in bycatch during KDFWR ride-alongs with commercial fishers fishing under the Asian Carp Harvest Program in 2016 - 2021. Survival rate of fish is defined as fish that swim away after release.

		2016		2017		2018		2019		2020		2021	
	Species	Number captured	Survival rate	Number captured	Survival rate	Number captured	Survival rate	Number captured	Survival rate	Number captured	Survival rate	Number captured	Survival rate
Sport Fish	White bass	1	<1%					1	100%			2	100%
	Yellow bass	20	50%	1	100%	6	33%	4	75%			1	100%
	Striped bass	19	79%	1	100%	3	33%	5	80%	10	80%	1	100%
	Hybrid striped bass	2	100%			1	100%	5	80%	2	100%	1	100%
	Sauger	1	<1%	2	100%	3	33%	4	75%	2	50%	3	100%
	Spotted bass	1	100%										
	Largemouth bass	1	100%	5	80%	3	67%	25	80%	4	75%	9	100%
	Smallmouth bass							4	100%				
	Redear sunfish	1	100%			2	50%	6	83%			1	100%
	Black crappie					5	50%	1	100%	1	100%		
	White crappie			1	100%	6	67%	2	50%			1	100%
	Total	46	88%	10	96%	29	54%	57	82%	19	81%	19	100%
Catfish species	Blue catfish	27	74%	47	94%	42	91%	96	95%	32	100%	38	92%
	Channel catfish	10	80%	17	82%	12	100%	13	100%	5	100%	16	96%
	Flathead catfish	9	89%	19	100%	8	88%	40	100%	7	100%	26	100%
	Total	46	81%	83	92%	62	93%	149	98%	44	100%	80	95%
Rough Fish*	Paddlefish	83	48%	62	48%	38	32%	63	48%	26	50%	16	69%
	Lake sturgeon					1	100%					1	100
	Shovelnose sturgeon									3	100%		
	Skipjack herring	23	17%	47	13%	18	<1%	79	<1%	16	<1%	25	36
	Smallmouth buffalo	145	99%	13	85%	98	100%	186	98%	103	100%	173	99%
	Bigmouth buffalo	8	100%	4	100%	7	100%	34	97%	14	100%	12	75%
	Black buffalo	17	94%			2	100%	4	100%	1	100%		
	Common carp	48	98%	33	94%	27	100%	479	84%	36	97%	17	100%
	Gizzard shad	5	<1%	3	33%			3	<1%	1	100%		
	Freshwater drum	76	67%	27	52%	73	71%	71	63%	40	82%	54	94%
	River carpsucker	3	100%					35	97%	41	100%	5	100%
	Quillback									1	100%		
	Mooneye	3	<1%									1	100
	Chestnut lamprey	1	<1%										
	Threadfin shad	1	<1%										
	Blue sucker	49	80%					2	100%				
	Spotted sucker											1	100
	Spotted gar					2	50%	3	100%	1	100%	2	100%
	Longnose gar	8	88%	9	44%			9	67%	3	100%	3	100%
	Shortnose gar	9	44%	1	100%	2	50%	11	55%	5	100%	5	100%
	Total	571	77%	365	72%	392	83%	1277	87%	329	98%	299	92%

* Rough fish capture numbers only include fish that were released and does not include fish that were harvested.

Table 10. Comparison for number of paddlefish, catfish, and sport fish caught per trip as reported by commercial fishers fishing under the Asian Carp Harvest Program versus observations made by KDFWR staff during ride-alongs in 2016-2021. (S.E. = standard error).

	2016				2017				2018				2019				2020				2021			
Species	ACHP	S.E.	Ride-alongs	S.E.	ACHP	S.E.	Ride-alongs	S.E.	ACHP	S.E.	Ride-alongs	S.E.	ACHP	S.E.	Ride-alongs	S.E.	ACHP	S.E.	Ride-alongs	S.E.	ACHP	S.E.	Ride-alongs	S.E.
Paddlefish	1.02	0.08	2.96	0.60	0.90	0.12	2.00	0.95	0.22	0.03	1.54	0.53	0.13	0.02	1.31	0.80	0.11	0.01	0.87	0.49	0.05	0.01	0.28	0.13
Blue catfish	0.74	0.06	1.21	0.28	0.63	0.08	1.52	0.33	0.47	0.04	1.75	0.37	0.08	0.01	2.00	0.45	0.19	0.01	1.07	0.34	0.15	0.01	0.66	0.2
Channel catfish	0.08	0.02	0.36	0.16	0.06	0.02	0.55	0.20	0.09	0.01	0.50	0.13	0.08	0.03	0.27	0.08	0.05	0.01	0.17	0.11	0.05	0.01	0.28	0.08
Flathead catfish	0.38	0.04	0.39	0.17	0.41	0.06	0.61	0.19	0.14	0.02	0.33	0.13	0.06	0.01	0.83	0.21	0.06	0.01	0.23	0.09	0.04	0.01	0.45	0.19
Catfish*	0.07	0.02			0.17	0.05			0.23	0.04			0.21	0.03			0.08	0.01			0.16	0.01		
Largemouth bass	0.08	0.70	0.04	0.04	0.01	<0.01	0.16	0.06	0.01	<0.01	0.08	0.06	0.02	0.01	0.52	0.24	0.02	<0.01			0.02	<0.01	0.16	0.06
Smallmouth bass	<0.01												<0.01	<0.01	0.08	0.05	0.02	<0.01	0.13	0.06	<0.01	<0.01		
Spotted bass	<0.01		0.04	0.04													<0.01	<0.01						
Bass**	0.02	0.02			0.02	0.01			0.01	<0.01			0.02	0.01							<0.01	<0.01		
Hybrid striped bass	<0.01		0.07	0.05					<0.01	<0.01	0.04	0.04	<0.01	<0.01	0.10	0.05	<0.01	<0.01	0.07	0.07			0.02	0.02
Striped bass	0.12	0.03	0.68	0.37	0.02	<0.01	0.03	0.03	0.01	<0.01	0.08	0.06	0.01	0.01	0.10	0.05	0.01	<0.01	0.33	0.33	<0.01	<0.01	0.02	0.02
Yellow bass	0.04	0.02	0.71	0.45	<0.01	<0.01	0.03	0.03	0.01	<0.01	0.25	0.15	<0.01	<0.01	0.08	0.07	<0.01	<0.01			<0.01	<0.01	0.02	0.02
White bass	<0.01		0.07	0.05									<0.01	<0.01	0.02	0.02	<0.01	<0.01			<0.01	<0.01	0.03	0.02
Sauger	<0.01		0.04	0.04	<0.01	<0.01	0.06	0.04	<0.01	<0.01	0.13	0.70	<0.01	<0.01	0.08	0.07	0.01	<0.01	0.07	0.05	0.01	<0.01	0.05	0.03
Crappie	0.01	0.01					0.03	0.03	0.01	0.01	0.29	0.21	<0.01	<0.01	0.06	0.05	<0.01	<0.01	0.03	0.03	<0.01	<0.01	0.02	0.02
Redear sunfish	0.01		0.04	0.04	<0.01	<0.01			<0.01	<0.01	0.04	0.04	<0.01	<0.01	0.13	0.07	<0.01	<0.01			<0.01	<0.01	0.02	0.02

*Commercial fishers do not always delineate species of catfish on their reports, therefore this row accounts for those catfish that were not identified to species

**Commercial fishers do not always delineate what species of black bass they catch, therefore this row accounts for black bass that were not identified to species

Table 11. Comparison of spring electrofishing CPUE values for select species captured in the Kentucky Lake tailwaters during sampling in 2015 (effort = 2.33 hours), 2016 (effort = 4.65 hours), 2017 (effort = 3.0 hours), 2018 (effort = 3.0 hours), 2020 (effort = 1.25 hours), and 2021 (effort = 3.75). (CPUE=catch per unit effort; S.E.=standard error)

Species	Kentucky Spring 2015		Kentucky Spring 2016		Kentucky Spring 2017		Kentucky Spring 2018		Kentucky Spring 2020		Kentucky Spring 2021	
	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.
Paddlefish			< 1	0.2								
Spotted gar	< 1	0.1	3	2.1			1	0.7			1	0.6
Skipjack herring	1	0.4	< 1	0.2	1	0.5	1	0.7			25	21.2
Gizzard shad	24	4.8	52	14.7	122	83.3	126	70.7	20	6.1	16	4.6
Threadfin shad			8	4.1	3	1.6	2	1.7				
Grass carp	< 1	0.3	3	1.1	1	1.0	2	1.2				
Silver carp	1	0.3	6	2.3	38	17.2	3	1.6	3	1.5	5	1.3
Smallmouth buffalo	3	1.0	27	6.1	13	3.3	19	4.6	38	10.5	8	1.6
Bigmouth buffalo	2	1.0	1	0.3	4	1.6	3	1.6			1	0.4
Black buffalo			2	1.1	1	0.5						
Blue catfish			< 1	0.3								
Channel catfish	< 1	0.2	1	0.7	< 1	0.3	< 1	0.3			1	0.8
Flathead catfish			19	5.5	4	1.3	6	2.4	14	3.7	3	1.1
White bass	1	0.6	8	2.1	1	0.8	2	1.4			6	3.0
Yellow bass	1	0.5	31	12.3	3	1.3	5	5.0				
Striped bass									1	0.8	< 1	0.3
Bluegill	2	0.7	92	16.3	30	5.6	14	3.2	29	8.9	14	4.6
Longear sunfish	3	1.8	74	15.2	25	6.9	15	3.9	22	9.9	9	4.1
Redear sunfish	1	0.3	3	1.1	2	1.2	1	0.5	3	1.5	1	0.5
Smallmouth bass	1	0.8	10	2.5	13	3.2	6	2.6	2	1.6	34	8.0
Spotted bass	< 1	0.3	1	0.5	11	4.2	1	0.5			<1	0.3
Largemouth bass	5	1.6	46	5.2	76	7.9	46	9.2	14	3.3	17	5.3
White crappie			1	0.9	< 1	0.3			3	3.2		
Black crappie	< 1	0.1	1	0.3	1	0.5			1	0.8		
Sauger			1	0.6			1	0.5				
Freshwater drum	< 1	0.1	14	3.4	2	0.9	9	2.9	4	1.3	6	1.7
White bass / Striped bass hybrid			2	0.8			2	2.3				

Table 12. Comparison of spring electrofishing CPUE values for select species captured in the Lake Barkley tailwaters during sampling in 2016 (effort = 2.75 hours), 2017 (effort = 0.92 hours), 2018 (effort = 2.0 hours), 2020 (effort = 1.0 hours), and 2021 (effort = 3.0 hours). (CPUE=catch per unit effort; S.E.=standard error)

Species	Barkley Spring 2016		Barkley Spring 2017		Barkley Spring 2018		Barkley Spring 2020		Barkley Spring 2021	
	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.
Skipjack herring			4	1.6	2	1.5	1	1.0	4	1.2
Gizzard shad	19	8.1	18	14.1	24.5	18.4	15	1.0	27	17.4
Threadfin shad	6	5.0					1	1.0	1	1.0
Grass carp	7	2.9	1	1.0	0.5	0.5			2	0.6
Silver carp	24	9.8	10	2.6	42	28.4	13	7.2	20	3.8
Smallmouth buffalo	23	3.6	22	3.5	28	6.7	11	3.4	8	2.4
Bigmouth buffalo	1	0.6	2	1.2	1	1.0			1	0.5
Black buffalo	1	0.8			0.5	0.5				
Shorthead redhorse									< 1	0.3
Channel catfish	1	0.8			0.5	0.5				
Flathead catfish	16	5.5	6	2.6	25	5.4	26	7.8	14	3.5
White bass	8	3.6	6	3.5	7.5	4.2	4	2.8	5	2.7
Yellow bass	2	1.0	4	4.0	2	1.1	2	1.2		
Striped bass	1	1.1							< 1	0.3
White bass / Striped bass hybrid									< 1	0.3
Green sunfish	1	0.8	2	1.2	2	1.1	4	2.8	1	0.5
Bluegill	69	16.1	55	26.9	56.5	31.2	64	15.9	20	6.1
Longear sunfish	110	23.6	183	83.6	80.5	42.4	70	18.5	24	4.7
Redear sunfish	10	2.6	20	5.9	7	2.0	14	6.6	2	0.8
Smallmouth bass	10	2.7	3	3.0	10.5	2.3	10	4.2	16	3.5
Spotted bass	1	0.6					3	1.9	< 1	0.3
Largemouth bass	64	6.2	155	35.3	79	10.6	35	5.3	21	4.2
White crappie	< 1	0.4								
Black crappie	1	0.7								
Sauger	< 1	0.4								
Freshwater drum	15	3.4	2	2.0	11.5	4.3	41	17.6	23	6.2

Table 13. Length frequency and CPUE (fish/hr) for select species of fish collected during 3.75 hours of electrofishing at the Kentucky Tailwater in fall of 2021. (CPUE = catch per unit effort; S. E. = standard error)

Species	Inch Class																																TOTAL	CPUE (fish/hr)	S. E.
	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	28	30	31	33	34	35	37	40			
Skipjack herring*		16	76	15	2						1																							165	44	17.6
Gizzard shad*		5	3	2	3	2	7	7	15	16	11	11	7	2		1																		165	44	21.4
Threadfin shad*	6	163	85																															2492	665	291.6
Grass carp																		1	1					2				1						5	1	0.8
Silver carp																	1		2	4		3	3	6	6	3	1		1	1	1			32	9	3.1
Bighead Carp																																1		1	<1	0.3
Smallmouth buffalo										1		3		5	3	1		1															1	15	4	1.3
Bigmouth Buffalo														1																				1	<1	0.3
Flathead catfish							1	1																										2	1	0.4
White bass	2	1	1	1	1	1	1	3	1				1																					13	3	1.8
Yellow bass					1	1	1																											3	1	0.4
Bluegill	4			2	6	3																												15	4	2.1
Longear sunfish			3	5																														8	2	1.2
Redear sunfish										2																								2	1	0.4
Smallmouth bass			3	6	3		5	2				2																						21	6	2.6
Largemouth bass				1					2	2	3			3	3	2	1	1				1												19	5	1.7
Sauger						1								2	1																			4	1	0.5
Freshwater drum			1	2	2			1						1	1	3	1		2	2	2	1	1											20	5	1.4
Striped mullet																		1	2	1	1													5	1	0.8

* species were randomly subsampled

Table 14. Comparison of fall electrofishing CPUE for selected species collected in Kentucky Lake tailwaters in 2015 (effort = 1.0 hours), 2016 (effort = 1.75 hours), 2017 (effort = 4.5 hours), 2018 (effort = 1.25 hours), 2019 (effort = 3.75 hours). 2020 (effort = 2.75 hours), and 2021 (effort = 3.75 hours). (CPUE=catch per unit effort; S.E.=standard error)

Species	2015		2016		2017		2018		2019		2020		2021	
	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.
Skipjack herring	22	8.4	1	0.6	18	9.5	2	1.6	510	200.3	89	22.3	44	17.6
Gizzard shad	275	58.6	184	78.0	163	61.1	22	10.2	240	92.1	163	69.7	44	21.4
Threadfin shad	251	176.3	1690	1251.0	1263	637.0	2557	1845.1	27	14.9	712	241.1	665	291.6
Grass carp	13	1.9	6	2.5	2	0.7			6	2.8	8	4.7	1	0.8
Silver carp	6	2.6	44	22.4	4	1.6	9	6.9	4	2.0	9	4.9	9	3.1
Bighead Carp													< 1	0.3
Smallmouth buffalo	10	2.6	9	3.7	5	2.1	1	0.8	8	3.0	2	0.8	4	1.3
Bigmouth buffalo					1	0.4	2	1.0					< 1	0.3
Black buffalo	6	2.0	3	1.9	< 1	0.2			1	0.4	< 1	0.4		
Blue catfish					< 1	0.2			< 1	0.3				
Channel catfish			1	0.6	1	0.9			< 1	0.3				
Flathead catfish			4	1.2	4	1.4			3	1.4	< 1	0.4	1	0.4
White bass	8	4.3	7	4.0	< 1	0.3	6	5.6	4	1.9	5	2.5	3	1.8
Yellow bass	162	83.5	17	13.3	26	4.1	7	4.3	18	7.8	3	1.6	1	0.4
Striped bass					2	1.0	2	1.0						
Bluegill	96	29.2	41	11.8	128	30.7	20	4.0	127	48.8	26	5.9	4	2.1
Longear sunfish	14	14.0	48	12.0	80	25.0	7	4.8	67	15.4	10	3.9	2	1.2
Redear sunfish	1	1.0	6	2.3	6	1.6			15	3.9	2	1.1	1	0.4
Smallmouth bass	9	2.5	21	5.2	11	3.2	2	1.0	29	12.3	10	2.8	6	2.6
Spotted bass	1	1.0	1	0.6	3	1.4	1	0.8	3	1.4				
Largemouth bass	62	19.8	86	9.4	35	4.3	7	2.9	29	6.2	15	3.6	5	1.7
White crappie	2	2.0	1	0.7	1	0.4			3	1.9				
Black crappie	2	2.0	1	0.6	3	1.7			2	1.5				
Sauger	1	1.0			1	0.4							1	0.5
Freshwater drum	13	5.7	6	1.5	4	0.7	4	2.2	8	2.5	11	2.8	5	1.4
White bass/Striped bass hybrid	1	1.0	1	1.1	1	0.5								
Striped mullet											1	1.0	1	0.8

Table 15. Comparison of fall electrofishing CPUE for all species collected in Lake Barkley tailwaters in 2016 (effort = 1.99 hours), 2017 (effort = 3.0 hours), 2018 (effort = 1.0 hour), 2019 (effort = 3.0 hours), 2020 (effort = 2.75 hours), and 2021 (effort = 3.0 hours). (CPUE=catch per unit effort; S.E.=standard error)

Species	2016		2017		2018		2019		2020		2021	
	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.	CPUE (fish/hr)	S.E.
Skipjack herring	< 1	0.5	8	2.9	35	18.0	324	158.4	41	10.78	28	10.9
Gizzard shad	209	52.4	104	18.2	23	8.1	362	224.8	189	49.03	8	5.0
Threadfin shad	4598	1818.7	1252	602.1	67	12.8	30	18.8	1298	719.49	378	182.4
Grass carp	5	2.6	1	0.5			6	1.7	3	1.22	3	0.7
Silver carp	4	2.0	14	7.7	29	17.2	42	33.4	23	6.58	24	6.4
Smallmouth buffalo	15	7.6	10	2.7	1	1.0	5	3.2	10	3.75	3	1.6
Bigmouth buffalo	1	0.9	< 1	0.3	1	1.0						
Black buffalo			1	0.7								
Channel catfish	< 1	0.4	1	0.5					1	0.49		
Flathead catfish	8	3.6	6	3.1			22	5.9	4	1.57	2	1.2
White bass	7	3.9	3	1.1	3	3.0	1	0.7	1	0.56	2	1.4
Yellow bass	2	0.7	28	16.0			4	3.0	3	1.24	2	1.0
Striped bass	1	0.9	2	1.4	1	1.0	< 1	0.3	2	1.25		
Bluegill	46	15.3	56	14.6	70	14.5	50	13.2	37	11.66	21	5.9
Longear sunfish	102	25.0	83	16.8	46	25.4	153	30.5	41	10.06	14	4.7
Redear sunfish	8	2.1	3	1.2	2	1.2	3	1.2	2	0.83	3	1.2
Smallmouth bass	7	2.3	9	1.2	4	1.6	29	7.2	8	1.53	13	3.0
Spotted bass	2	1.0	< 1	0.3	1	1.0	7	2.0	1	1.09		
Largemouth bass	48	8.0	55	10.3	13	5.0	30	8.1	26	11.01	15	5.1
White crappie	4	1.5	1	0.7			< 1	0.3	< 1	0.36		
Black crappie			2	1.3			< 1	0.3	< 1	0.36	<1	0.3
Freshwater drum			5	1.5	7	4.7	9	3.4	8	1.87	5	1.7
White bass/ Striped bass	< 1	0.4	3	2.3	4	4.0			1	0.73	1	1.0

Table 16. Length frequency and CPUE (fish/hr) for select species of fish collected during 3.0 hours of electrofishing at the Barkley Tailwater in fall of 2021. (CPUE = catch per unit effort; S. E. = standard error)

Species	Inch Class																																TOTAL	CPUE (fish/hr)	S. E.
	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	28	29	30	31	32	35			
Skipjack herring			19	42	20		2	1	1																								85	28	10.9
Gizzard shad						3	1	4	2	1	4	3	4	1																			23	8	5.0
Threadfin shad*		6	68	106	1	3	1																										1133	378	182.4
Grass carp																												1	3	1	2	1	1	9	3	0.7
Silver carp																		1	1	2	1	3	2	6	8	13	18	7	5	1	2	1		71	24	6.4
Smallmouth buffalo													2				2	3		1	1													9	3	1.6
Flathead catfish											1				2		1					1				1			1					7	2	1.2
White bass			3			1	1	1																									6	2	1.4
Yellow bass			2	1		1	1																										5	2	1.0
Bluegill	1	8	23	2	12	9	8																										63	21	5.9
Longear sunfish			3	14	25	1																											43	14	4.7
Redear sunfish		1	1	1	1				1	3																							8	3	1.2
Smallmouth bass				7	16	9	1	2		1		1		1		1																	39	13	3.0
Largemouth bass				1	2	13	8	1	1	4	4	2		1	1	2		1	2		1												44	15	5.1
Black crappie									1																								1	<1	0.3
Freshwater drum														1		6	2		3		1				1								14	5	1.7
White bass/Striped bass hybrid																1			1					1										3	1	1.0

* species were randomly subsampled

Table 17. Mean relative weight (*Wr*) and standard error for a subsample of fish collected during fall electrofishing at Kentucky Tailwaters in 2015 - 2021. (S.E. = standard error)

Species	2015			2016			2017			2018			2019			2020			2021		
	N	Mean *Wr*	S.E.	N	Mean *Wr*	S.E.	N	Mean *Wr*	S.E.	N	Mean *Wr*	S.E.	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	215	83	0.7	21	77	2.0	152	85	0.5	66	85	1.6	79	92	6.0
Blue catfish							1	108					1	99							
Channel catfish				1	102		1	105					1	100							
Flathead catfish				7	98	6.2	19	100	6.3				11	99	6.2	1	106		1	123	
Yellow bass	29	74	1.2	29	84	1.8	104	83	2.2	7	90	12.3	33	80	4.6	4			3	88	8.6
White bass	7	92	4.1	13	99	2.6	2	97	20.4	7	108	1.3	8	90	3.3	9	95	5.1	8	86	5.9
Striped bass										1	101										
White bass/Striped bass hybrid				2	81	7.5															
Bluegill	69	88	1.7	49	103	3.7	220	93	2.2	18	89	6.4	148	94	0.8	41	93	8.3	11	97	4.0
Redear sunfish	1	98	0.0	10	85	6.9	28	93	3.3				42	97	2.3	4	85	5.3	2	104	4.2
Smallmouth bass	6	93	3.1	13	91	2.0	9	92	3.4	1	82		4	92	5.5	6	100	4.9	9	95	4.9
Spotted bass	1	103	0.0	1	123		6	109	3.1				1	117							
Largemouth bass	42	102	3.2	89	102	1.7	117	97	1.9	7	93	5.5	41	99	1.7	26	113	8.4	17	87	4.9
White crappie	2	79	0.9	2	90	8.7	3	76	7.3				4	84	3.0						
Black crappie	1	91	0.0				12	90	2.7												
Sauger	1	87	0.0				3	97	21.8										4	78	4.2
Freshwater drum	12	91	5.4	11	100	2.7	17	92	3.3	5	89	3.8	21	92	2.9	29	91	3.3	18	90	5.6
Smallmouth buffalo	10	76	2.9	15	79	1.5	22	77	1.4	1	78		29	100	3.2	6	81	2.7	14	93	14.3
Bigmouth buffalo							3	86	1	2	75	7.4									
Silver carp	6	84	2.3	75	89	1.6	19	82	2.4	11	73	3.2	15	81	1.2	26	76	1.7	32	76	2.0

Table 18. Mean relative weight (Wr) and standard error for a subsample of fish collected during fall electrofishing at Barkley Tailwaters in 2016 - 2021. (S.E. = standard error)

Species	2016			2017			2018			2019			2020			2021		
	N	Mean *Wr*	S.E.	N	Mean *Wr*	S.E.	N	Mean *Wr*	S.E.	N	Mean *Wr*	S.E.	N	Mean *Wr*	S.E.	N	Mean *Wr*	S.E.
Gizzard shad	96	70	1.6	176	80	0.9	18	75	2.5	45	91	1.2	53	96	4.2	20	73	3.1
Channel catfish	1	67		2	92	1.0							2	111	5.6			
Flathead catfish	13	94	1.7	17	106	5.8				66	99	3.8	10	96	3.4	6		6.8
Yellow bass	2	88	8.7	73	79	1.3				11	87	4.5	7	85	4.5	3	74	8.3
White bass	11	96	3.7	8	86	2.2	3	98	4.9	3	85	7.7	2	115	1.8	3	96	6.4
Striped Bass				2	90	5.9				1	109		5	108	5.6			
White bass/Striped bass hybrid				9	89	2.7	4	103	4.6				2	102	2.8	3	73	5.0
Bluegill	49	111	3.1	107	104	2.5	31	115	8.3	85	103	1.6	63	102	2.3	29	118	10.6
Redear sunfish	17	93	2.1	9	97	3.7	2	106	14.6	9	101	3.9	4	101	13.0	4	101	12.4
Smallmouth bass	4	86	3.6	11	95	3.8	3	87	5.6	22	92	2.5	11	93	2.5	7	81	4.4
Spotted bass	3	107	11.0				1	125		3	106	10.1	2	103	9.4			
Largemouth bass	37	101	1.9	118	95	1.2	10	95	3.4	58	98	1.6	41	101	4.3	20	101	7.1
White crappie				3	88	6.6				1	92		1	116				
Black crappie				5	86	6.3				1	76		1	85		1	93	
Freshwater drum	6	84	4.4	14	97	3.0	7	82	3.5	27	103	2.3	22	96	2.3	14	92	2.1
Smallmouth buffalo	21	84	1.4	28	84	1.6	1	99		16	92	1.9	27	81	1.4	9	78	2.6
Bigmouth buffalo	2	88	4.0	1	79		1	84										
Silver carp	9	81	2.9	41	83	2.1	29	83	2.7	70	83	1.5	64	77	1.2	70	78	1.3

Table 19. Summary of invasive carp harvest and expenditures of Subsidy funds under the Asian Carp Harvest Program 2016-2021.

Year	Total funds paid out
2016	$4,706.06
2017	$9,596.05
2018	$36,136.98
2019	$210,163.21
2020	$453,925.56
2021	$646,072.68

Table 20. Fishing effort and total weight (lbs) of invasive carp harvested during KDFWR ride-alongs with commercial fishers fishing under the Asian Carp Harvest Program 2015 - 2021.

Year	Effort *	Mean effort per trip	S. E.	Number of ride alongs	Number of fishers	Total WT of bighead carp harvested (lbs)	Total WT of silver carp harvested (lbs)	Total WT of grass carp harvested (lbs)
2015	31,583	1,053	78.4	32	8	4,086	68,139	855
2016	30,700	1,096	73.2	28	4	1,067	69,765	630
2017	32,225	1,040	88.6	31	9	763	73,958	746
2018	32,193	1,238	86.1	26	11	957	60,938	583
2019	57,433	1,197	79.8	48	19	1,123	160,981	2,916
2020	30,208	1,007	58.0	30	16	1,226	143,257	1,372
2021	42,193	728	53.0	59	18	1,780	198,249	1,130

*effort is calculated in yards of gillnet fished.

Table 21. Comparison of the average weight harvested per trip of silver carp and bighead carp during KDFWR ride-alongs, and through commercial fishers reports for the Asian Carp Harvest Program in 2016 - 2021. (S.E. = standard error)

Year		Silver Carp	S. E.	Bighead Carp	S. E.	Grass Carp	S. E.
2016	Ride Alongs	2,280	402.2	40	12.4	23	10.1
	Commercial Fisher Reports	2,378	70.5	22	3.3		
2017	Ride Alongs	2,386	395.0	25	8.2	24	9.4
	Commercial Fisher Reports	2,225	92.8	56	7.6		
2018	Ride Alongs	2,219	422.6	16	6.9	18.4	8.8
	Commercial Fisher Reports	1,981	54.2	38	4.0		
2019	Ride Alongs	3,353	475.7	23	7.2	60	19.3
	Commercial Fisher Reports	2,580	53.0	22	1.6		
2020*	Ride Alongs	4,775	677.5	41	14.8	46	15.5
	Commercial Fisher Reports	3,186	62.4	22	1.8	55	3.0
2021	Ride Alongs	3,389	353.2	31	9.4	20	4.0
	Commercial Fisher Reports	3,434	56.9	10	1.2	31	1.9

*2020 was the first year that grass carp harvest through the Asian Carp Harvest Program was required on commercial fishing reports.