Control and Containment of Asian carp in the Ohio River

Geographic Location: Ohio River basin, extending from the Cannelton Lock and Dam (RM 720.7) to the Markland Lock and Dam (RM 531.5) along with some limited removal in the Smithland pool, below Cannelton.

Participating Agencies: Kentucky Department of Fish and Wildlife Resources (KDFWR), Indiana Department of Natural Resources (INDNR), US Fish and Wildlife Service (USFWS), West Virginia Department of Natural Resources (WVDNR)

Introduction:
Eradication of invasive species after establishment is difficult and often limited by available resources. Since their introduction in the Mississippi River basin, Asian carp (Silver Carp, Bighead Carp, and Grass Carp) have steadily increased their range (Kolar et al. 2005) and may densely colonize river reaches, affecting the native food webs in large river ecosystems (Irons et al. 2007, Freedman et al. 2012) in addition to disrupting human connections to natural resources (i.e. fishing, boating, navigation, aesthetics, etc). Prevention and rapid response are the best tools for limiting establishment of costly invasive species and physical removal of Asian carp in the Ohio River basin may be one tool that can slow their upriver expansion. In addition, contingency planning can aid in preparing agencies and many other stakeholder groups for managing changes in invasion status.

Recent studies on Asian carp harvest programs in the Illinois River show that the collapse of Silver and Bighead Carp populations are possible if all fish sizes are targeted (Tsehaye et al. 2013). Consistent removal efforts in portions of the Ohio River where Asian carp are established may disrupt upriver movement of Asian carp, decrease pressure on existing barriers, and reduce numbers of Asian carp in sensitive areas to protect species of conservation need or important sport fisheries. Removal efforts also provide an opportunity to collect data on the populations of Asian carp in higher density pools of the Ohio River Basin (ORB). This data provides an assessment tool that aids in guiding decisions about monitoring, barrier defense, and population control efforts in future years.

Objectives:
1. Target and remove Asian Carp to suppress populations and reduce propagule pressure in the Ohio River.
2. Develop an Ohio River contingency response plan.

Methods:
Removal efforts in 2018 focused on Cannelton and McAlpine pools with limited effort in the RC Byrd pool (Figure 1). Cannelton pool currently marks the accepted establishment front for Silver Carp populations within the ORB. In previous years, the McAlpine Dam appeared to be a bottleneck for Silver Carp advancement upriver with few fish tagged near the tailwater known to pass the dam. However, with recent evidence indicative of crowding populations in the Cannelton pool in addition to some limited dam passages seen in the past two years, it is likely that fish are beginning to expand upriver in response to density increases.

Clarification of Terminology Referenced in This Document
With the current rate of Asian carp expansion and the massive effort to study and adaptively manage carp populations across several Mississippi River sub-basins, it is important to clarify terminology used in technical documentation and annual reports. Currently, there may be inconsistent terminology used across the basins when talking about basin-specific invasions. With this in mind, below is a list of terms used in this report that are solely for internal reference.

Bigheaded Carps – a term used to reference the collection of the bigheaded carps (*Hypophthalmichthys spp.*) and their hybrids, found in the Ohio River basin.
Establishment Front – the farthest upriver range expansion of Asian carp populations that demonstrates the presence of natural recruitment.
Invasion Front – the farthest upriver extent where reproduction has been observed (eggs, embryos, or larvae) but recruitment to young-of-year fish has is not been observed.
Macrohabitat – One of four habitat types used to describe the variety of fixed sites within a pool (e.g. Tributary/Embayment, Tailwater, Island Back-Channel, and Main Stem River).
Presence Front – The farthest upstream extent where Asian carp populations occur, but reproduction is not likely taking place.
Targeted Sampling – sampling that uses gear and/or techniques intended to specifically target one species and exclude others (i.e. silver carp and bighead carp).

Targeting and Removal of Asian Carps
Electrofishing and gill netting for removal in 2017 were conducted over approximately 15 weeks from May through September. In 2018, this was expanded while taking advantage of the high water conditions on the river. When fixed monitoring sites could not be accessed due to hazardous conditions, high water tended to force large schools of carp into flooded tributaries and embayments. Those that provided access were used to conduct removal. Because removal is the primary objective, electrofishing was not rigorously standardized, but total effort (hours) was recorded. Pulsed DC electricity at 40% duty-cycle and 80 pulses per second was used most often and voltage was adjusted to target a maximum power goal for each run. Large mesh (4.0" – 6.0" square) gill nets were used with each set consisting of a minimum 180 minutes of soak time with fish being driven toward the nets with boat noise at 30-minute intervals. Nets were occasionally set overnight throughout the season in areas where they did not create hazards to navigation. However, in the warmer months this was avoided to decrease paddlefish by-catch. Often electrofishing crews were paired with netting crews so that they could work in tandem to push large schools of into netting gears

Sampling efforts focused on tributaries and embayments where densities of Asian carp are highest and fish are easiest to capture. The majority of these locations were discovered from accessing early monitoring sampling sites in 2015 - 2016. Additional sites were identified using map study, recommended by agency biologists, or were in areas that contained characteristics of typical carp habitat. The majority of effort was spent in known, high-density locations where carp were consistently captured.

All Asian carps and by-catch were identified to the lowest taxonomic level possible. Asian carp were inspected for tags (both jaw and ultrasonic VEMCO tags) before being euthanized for population control or tagged for the Ohio River Telemetry project. All by-catch was immediately returned to the water upon recovery. Asian carp species (Bighead Carp, Silver Carp, and Grass Carp) from each sampling location were measured for total length (mm) and weight (g) to provide estimates of the minimum total weight harvested. When possible, supplemental data including sex, fin spines, and otoliths were collected for each Silver or Bighead Carp captured (Williamson and Garvey 2005, Seibert and Phelps 2013).

Contingency Planning Effort and Document
In 2017, a need was identified for a consistent procedure that ORB member agencies and management groups could follow in an effort to respond to changes in the Asian Carp conditions in any of the six pools of the Ohio River. The Upper Illinois Waterway Contingency Response Plan was a major source for template design and many of the components of the current draft mimic that document. The goal of the contingency plan was identified in the context of the ORB and reviewed at the beginning of the document. Information on relevant pool characteristics was accumulated and paired with information on carp population status for two of the four invasive species (i.e. Bighead Carp and Silver Carp) across pools currently being monitored. This information was organized into a "decision matrix" and assigned

an urgency level that would help facilitate a response. Then a "Response Matrix" was designed with possible actions tied to each of the different changes in urgency level. A flowchart showing the process for initiating a response was laid out and provides a general suggestion for initiating any coordinated basin effort. The draft will be introduced to the basin partners for comment, edits, and augmentation.

Results:

Physical Removal of Asian Carps

Approximately 87 hours were spent electrofishing in five pools of the Ohio River and its tributaries between Cannelton and RC Byrd Locks and Dam (Table 1). Four thousand and sixty-nine carp were removed using boat electrofishing over these four pools in 2018. The highest level of effort was expended in the Cannelton pool where a total number of 3,726 carps, weighing approximately 23,446 kg (51,690 lbs), were removed. Electrofishing provided the most success between sampling gears, but is aided with the use of barrier structures such as nets. Thus, many electrofishing efforts were conducted in tandem with gill netting. In addition, some tributaries consistently hold schools of invasive carp and can be regularly targeted and produce yields.

A total of 6,309 meters (20,700 ft) of large mesh (4" – 6" square) gill nets were used in capturing 505 invasive carps in five pools of the Ohio River (Cannelton – RC Byrd) (Table 2). This amounted to 3,281 kg (~7,233 lbs) of Bighead, Silver, and Grass Carp combined. The largest amount of effort was expended in the Cannelton pool with 3,109 meters (10,200 ft) of gill net fished to remove 494 fish, weighing approximately 3,056 kg (~6,737 lbs). Gill netting has been less effective than boat electrofishing, but it is useful in creating structure and obstacles that are difficult for carp to maneuver around. This has aided in increasing capture success when used in addition to boat electrofishing.

By-catch was rarely taken with boat electrofishing. Small minnow and herring species were occasionally dipped to ensure they were not juvenile carp, but were released upon inspection. When gill netting, by-catch was a concern because it usually impacts native fauna and can severely reduce set times. The most common non-target species encountered when gill netting in 2018 were Smallmouth Buffalo (~20% overall catch), Paddlefish (~ 5%), Common Carp (~ 4%), and Blue Catfish (~ 4%) with all other species comprising an additional 7% (Table 3) with accounts of fish rarely being DOA. Targeted invasive carp make up ~ 60% of the total catch by number and it often benefits crews to use short sets and remove them from nets quickly to prevent capture loss.

Total effort and capture numbers accounted for in this report include some time and effort placed into targeted monitoring from the basin's evaluation project. However, this report does not contain all removal efforts contributing to population control in the basin. For example, some additional work has been conducted by INDNR in the White and Wabash rivers, which are free-flowing tributaries of the Ohio River. In 2018, Indiana removed 39 kg (86.4 lbs) of Bighead Carp and 723 kg of Silver Carp captured as by-catch during paddlefish gill net and catfish hoop net sampling. These fish were used in outreach events where carp fillets were provided for the public to sample and generated interest in the targeting and consumption of the invasive species. Also, through juvenile sampling, adult fish are removed on an annual basis; for more detail on effort and removal conducted during juvenile sampling in 2018, please refer to that report.

Contingency Planning Effort and Document

The contingency document has progressed and is a rough approximation of what an ORB contingency plan should look like. The plan is short, but identifies the known range statuses for Bighead and Silver carp in the ORB. The response matrix currently contains seven potential actions that can be expanded on by additional partners. The draft is currently missing a section that clearly defines a chain of command within the ORB Asian Carp Coordination Committee and a section that includes logistics and resource

limitations (i.e. the speed at which state permits could be obtained or how money would be leveraged to complete actions, etc…).

Discussion:
Dams along the Ohio River likely provide some barrier to dispersal for invasive carps migrating up river. Data acquired from monitoring sampling efforts in 2018 show that the average sizes of Silver Carp increase (Figure 2) as you move up river, while catch rates decrease (Figures 3 – 4). This has been a consistent pattern in data gathered since 2015 and is an indication that fish further up river are not only fewer in number, but likely older. Older and larger fish likely have greater ability to disperse in addition to more time to move up the establishment and invasion fronts. With Cannelton being the furthest upriver pool where fish < 400 mm have been observed consistently, it must be prioritized as a major target in terms of population control. Numbers of fish are high enough to suggest that intense, regular fishing pressure is needed at a level higher than current agency crews can maintain. Also, with the presence of juvenile fish that may have been newly recruited in that pool, it is likely the most adjacent source-population contributing to upriver population expansion. Focus on the higher density pools like Cannelton that may be important reservoirs for propagules can alleviate pressure for upriver expansion and decrease efforts expended upriver, where low densities make it difficult to catch and suppress carp populations.

The McAlpine pool itself has several areas where fish accumulate and most fish appear to be mature adults which average 28mm larger than fish caught in the Cannelton pool below. This pattern is more indicative of a migrant population, but with potential increases in population size over the past two years it is important to continue removal efforts in this pool as well to reduce the overall population size and the potential for successful recruitment.

Currently, electrofishing has produced the most success in capturing Silver Carp due to their transient nature and explosive reaction to electricity. Silver Carp can be sought out quickly with boat electrofishing techniques and schools can easily be targeted when found. Driving the boat in aggressive and sinuous patterns is often used to pin fish against the bank when targeting Silver and Grass Carp and can be effective at getting fish to surface. However, because they are difficult to catch when airborne, CPUE is often highly variable and dependent on the experience of the driver and dipper. Targeting of tributary waters and tributary mouths gives removal crews an advantage because gears are typically more effective in these shallower waters and fish appear to prefer these slower moving waters. In all cases, the use of side-scan imaging can greatly increase success and the ability of a crew to move between multiple tributaries from one launch location increases the likelihood of success. Future removal efforts should be designed to take advantage of periods of increased movement when fish are actively moving in or out of contiguous tributaries to maximize catch. The late 2018 and early 2019 seasons have been very high water periods and have made access to the river challenging, but additional exploratory efforts have led to the discovery of winter aggregations of carp in certain tributaries like Clover Creek. When water is accessible, fish should be targeted during cooler months when they are more susceptible to netting gears.

By-catch is always a concern when considering impacts of targeting and removing bigheaded and grass carps from the Ohio River. Overnight sets during productive sampling months were decreased substantially and only utilized a handful of times. Overnight sets have the potential to produce low increases in Bighead Carp captures, but come at the cost of increased by-catch during warmer water months. Typically paddlefish are found to be dead on arrival (DOA) if caught in nets overnight in warmer conditions and often it has been more effective to target sites known to produce previous Bighead Carp captures. When utilizing short active net sets, by-catch can be dealt with while continuing to fish netting gears and catch rates of native species is rather low.

When compared to previous years, larger yields in 2018 are primarily due to the shifting of effort downstream where densities of Silver Carp are higher. However, there has been no indication that removal efforts have made any measurable impact on carp numbers. In fact, some evidence suggests that numbers have increased in Cannelton (frequent large schools now common, decreasing Bighead Carp body condition, small increases in dam passages, and relatively larger yields anecdotally being reported by removal crews). With Cannelton pool being such a strategic area for removal, additional effort is now necessary to begin placing heavier fishing pressures on carp populations in that pool. Contract fishing planned for 2019 will greatly increase fishing pressure and free up resources for agency personnel to shift additional effort into the McAlpine pool and potentially aid in lowering numbers of fish in that section of the Ohio before they become established in the pool. With the existing monitoring efforts we hope to be able to identify if the increase in pressure does lead to a measurable impact in carp numbers.

The contingency planning document has progressed and provides one possible framework for how agencies can prepare for changes in Asian Carp status and respond to that change in the ORB. Future work should focus on providing logistical and resource assumptions in addition to identifying a chain of command that allows for coordinated approaches between basin partners to be implemented in a responsible manner. In addition, work needs to be placed into expanding both the response action and decision matrices. Decision matrices have gaps in knowledge that need to be addressed and pool characteristics need to be added into consideration of the threat level that initiates each action. Finally, an outline defining what "rapid response" efforts should look like and how they should be incorporated into this document is needed.

Recommendations:
It is imperative that fishing pressure increases substantially in the Cannelton pool as it is the reproductive extent of Silver Carp. Future removal effort in the form of contract fishing should augment removal in that pool during the months of May to August when spawning activity and overall movement in and out of tributaries is common. During this time period, special consideration should be given to Clover Creek, Oil Creek, and Yellowbank Creek where juvenile fish have been observed. Sinking Creek, Poison Creek and the Salt River, appear to harbor large groups of fish year around and are important targets for continual removal efforts. Outreach and efforts to spur public and commercial interest within the Cannelton pool should continue and will be important in contributing to the necessary population control efforts for the Ohio River basin.

Project Highlights:

- Prevention and control are currently the best tools for limiting establishment of costly invasive species. Physical removal of Asian carps in the Ohio River basin is one of our few tools to slow their upstream expansion.
- Removal in 2018 was altered from removal conducted in 2017 in order to focus removal effort in higher density pools were larger impacts could be made. However, no reductions on population size are evident.
- Approximately 87 hours of boat electrofishing yielded 23,446 kg (51,690 lbs) of invasive carp removed from the Ohio River
- Gill netting effort accounted for the removal of over 3,200 kg of invasive carp removed from the Ohio River but remains a difficult tool to use when targeting Silver Carp. Yields tend to increase when used in tandem with boat electrofishing and are often more effective in cooler water when known aggregations of fish can be targeted.
- Gill netting efforts in 2018 have produced little strain on native populations and the most common by-catch species removed from net sets are Smallmouth Buffalo and Paddlefish. Targeted carp species make up more than 60% of the total catch by number in netting gears.

- It is imperative that fishing pressure increases substantially in the Cannelton pool. Future removal effort in the form of contract fishing should augment removal efforts in that portion of the Ohio River.
- A contingency plan document is included with this report for basin review and comment. This is a draft document and is currently not being implemented in the ORB.

Literature Cited

Freedman, J. A., S. E. Butler, and D. H. Wahl. 2012. Impacts of invasive Asian carps on native food webs. Page Illinois-Indiana Sea Grant.

Irons, K. S., G. G. Sass, M. A. McClelland, and J. D. Stafford. 2007. Reduced condition factor of two native fish species coincident with invasion of non-native Asian carps in the Illinois River, U.S.A. Is this evidence for competition and reduced fitness? Journal of Fish Biology 71(Supplement D):258–273.

Kolar, C. S., D. C. Chapman, W. R. Courtenay Jr., C. M. Housel, J. D. Williams, and D. P. Jennings. 2005. Asian carps of the genus Hypophthalmichthys (Pisces, Cyprinidae) -- A biological synopsis and environmental risk assessment. Page Report to U.S. Fish and Wildlife Service. Washington, D.C.

Seibert, J. R., and Q. E. Phelps. 2013. Evaluation of Aging Structures for Silver Carp from Midwestern U.S. Rivers. North American Journal of Fisheries Management 33(4):839–844.

Tsehaye, I., M. Catalano, G. Sass, D. Glover, and B. Roth. 2013. Prospects for Fishery-Induced Collapse of Invasive Asian Carp in the Illinois River. Fisheries 38(10):445–454.

Williamson, C. J., and J. E. Garvey. 2005. Growth, Fecundity, and Diets of Newly Established Silver Carp in the Middle Mississippi River. Transactions of the American Fisheries Society 134(6):1423–1430.

Figures:

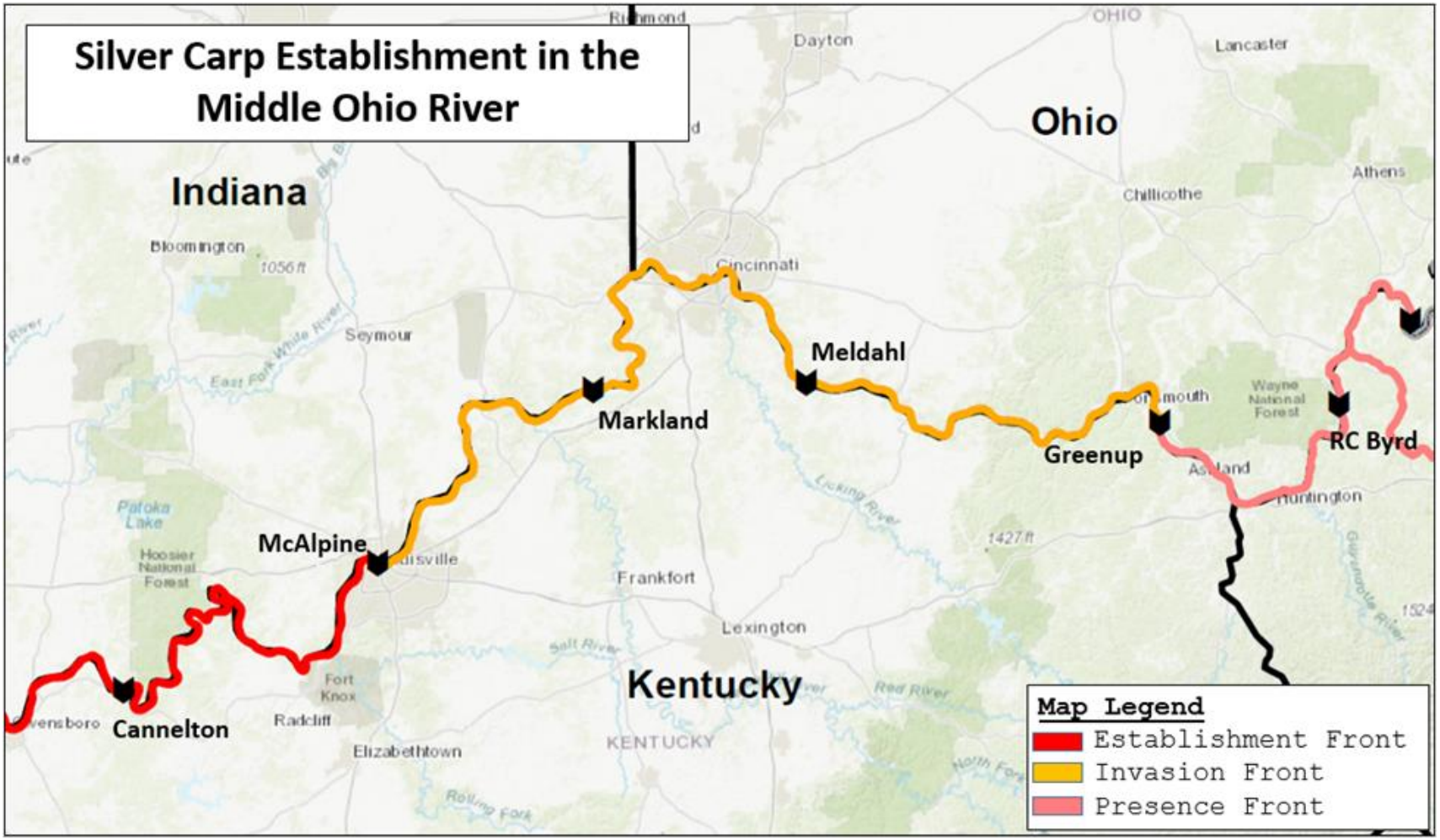

Figure 1. A map depicting the differing levels of Asian carp establishment in the middle Ohio River where targeted sampling and regular suppression is currently being conducted.

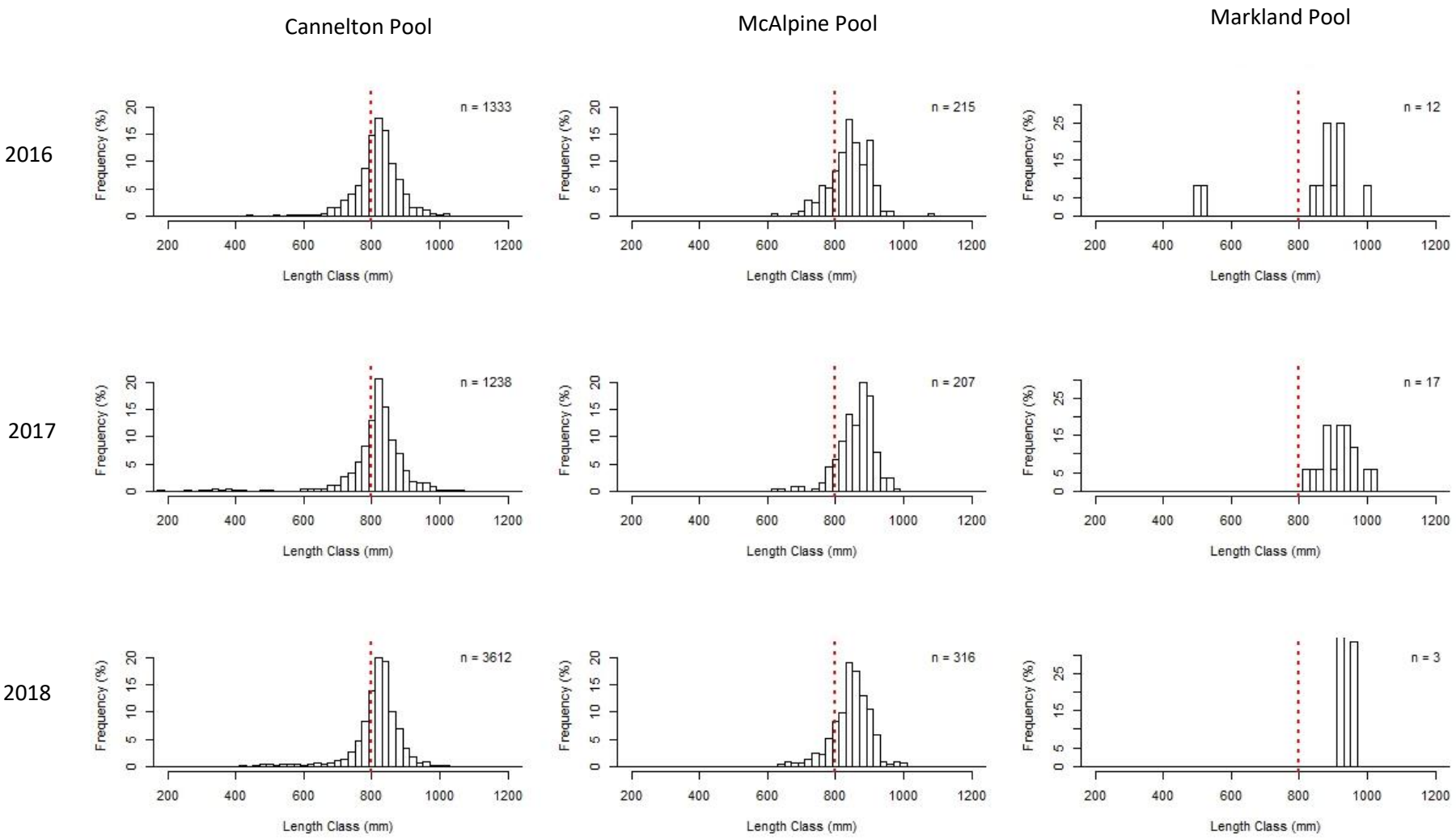

Figure 2. Length frequencies of silver carp captured during sampling efforts in 2016 – 2018. A line at 800mm highlights the change in length-classes from fish captured farther upriver with Cannelton being the farthest pool downstream and Markland the farthest pool upstream.

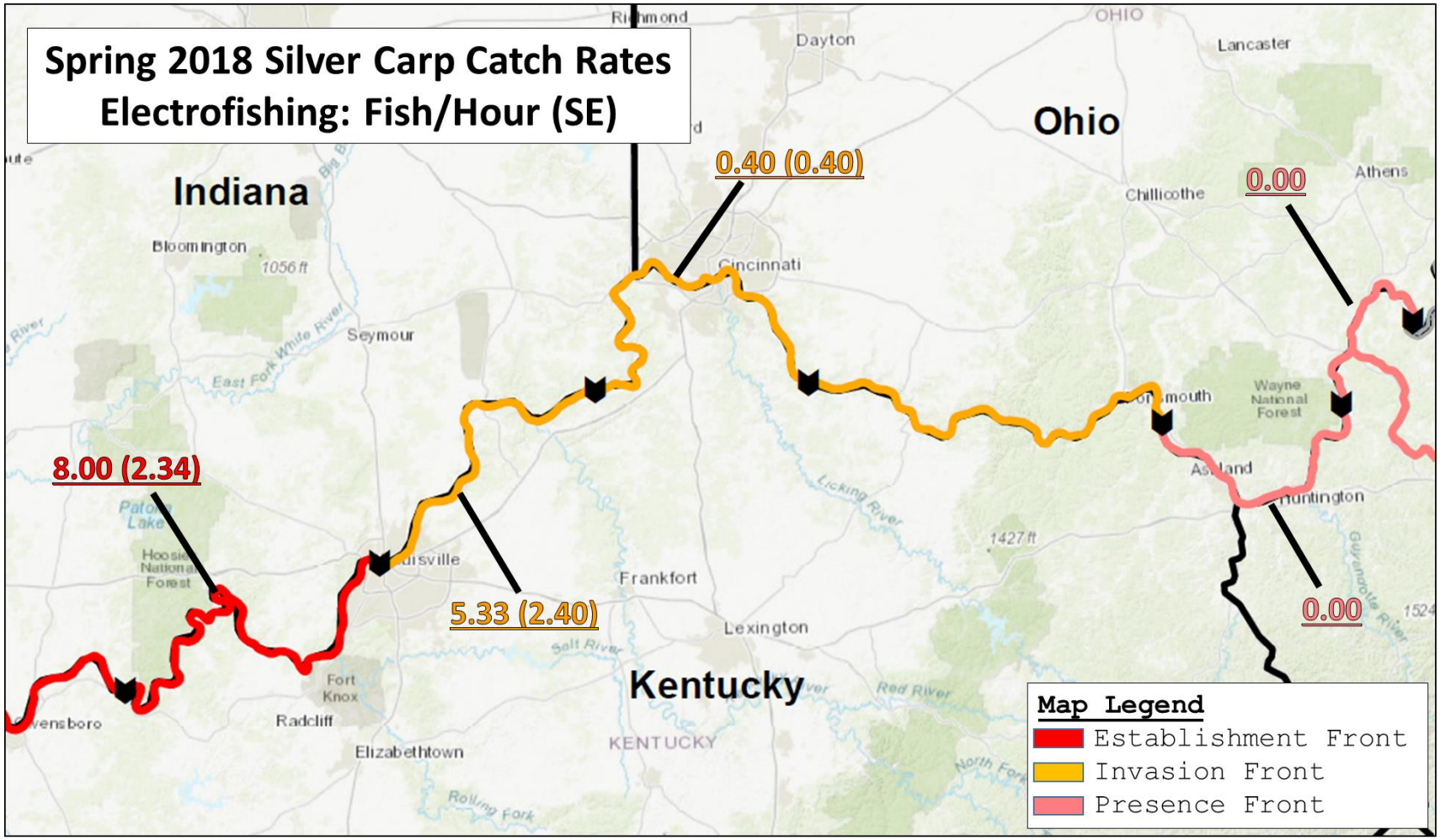

Figure 3. Mean Silver Carp catch rates in fish per hour by navigation pool using boat electrofishing during targeted sampling in 2018. Standard errors are in parenthesis.

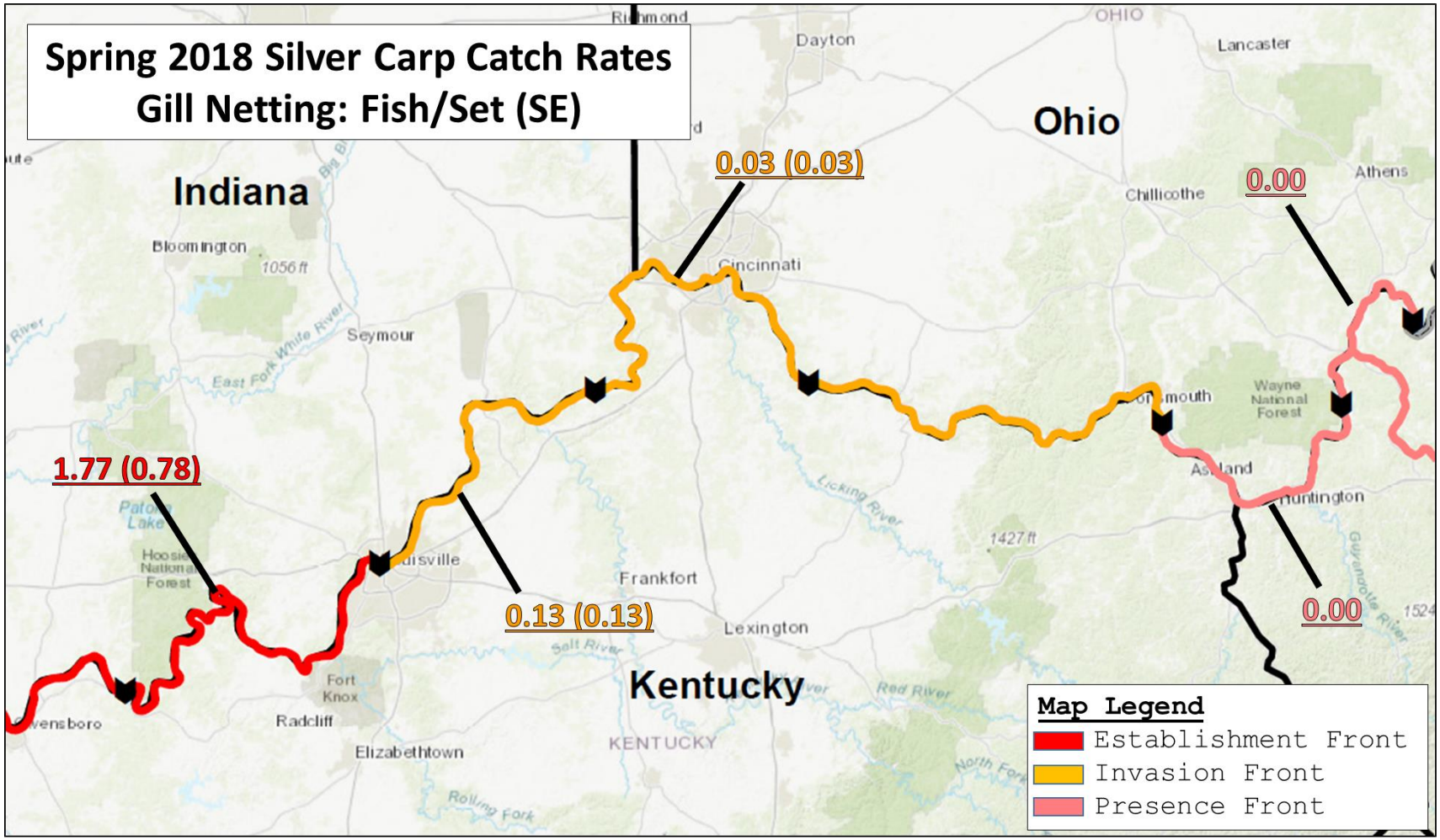

Figure 4. Mean Silver Carp catch rates in fish per net-set by navigation pool using gill netting during targeted sampling efforts in Spring 2018. Standard errors are in parenthesis.

Tables:

Table 1. Electrofishing effort (hours) and resulting catch of three species of Asian carp (number and weight) for three pools of the Ohio River during Asian carp removal efforts in 2018.

Pool	Electro Hours (hr)	Bighead Carp (N)	Hybrid Bigheaded Carp (N)	Silver Carp (N)	Grass Carp (N)	Total (N)	Bighead Carp (kg)	Hybrid Bigheaded Carp (kg)	Silver Carp (kg)	Grass Carp (kg)	Total (kg)
Cannelton	53.70	16	16	3682	12	3726	218.40	108.80	21010.70	108.30	21446.20
McAlpine	18.75	1	5	330	0	336	13.65	34.00	1894.20	0.00	1941.85
Markland	6.00	0	0	3	2	5	0.00	0.00	17.20	17.00	34.20
Greenup	4.50	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
RC Byrd	3.85	0	0	0	2	2	0.00	0.00	0.00	24.00	24.00
Total	86.8	17	21	4015	16	4069	232.05	142.80	22922.10	149.30	23446.25

Table 2. Gill netting effort (meters) and resulting catch of three species of Asian carp (number and weight) for two pools of the Ohio River during Asian carp removal efforts in 2018.

Pool	Total Net Length (m)	Bighead Carp (N)	Hybrid Bigheaded Carp (N)	Silver Carp (N)	Grass Carp (N)	Total (N)	Bighead Carp (kg)	Hybrid Bigheaded Carp (kg)	Silver Carp (kg)	Grass Carp (kg)	Total (kg)
Cannelton	3109	37	2	454	1	494	404.67	39.00	2605.96	6.35	3055.98
McAlpine	366	0	0	1	1	2	0.00	0.00	5.74	12.90	18.64
Markland	1463	0	0	1	5	6	0.00	0.00	5.74	58.90	64.64
Greenup	457	0	0	0	0	0	0.00	0.00	0	0.00	0.00
RC Byrd	914	3	0	0	0	3	142.00	0.00	0	0.00	142.00
Total	6309	40	2	456	7	505	546.67	39.00	2617.44	78.15	3281.26

Table 3. A table indicating by-catch of species during 2018 sampling, excluding records from Community Monitoring samples taken during the fall season. Numbers indicate total catch (n) of fish species. Targeted carp species include Bighead Carp, Silver Carp, and Grass Carp.

	Cann	McAlp	Mark	Green	RCByrd	Total	Percent
TargetedCarpSpecies	389	2	6	0	2	399	60.3%
BigmouthBuffao	7	0	0	0	0	7	1.1%
BlackBuffalo	1	1	1	0	0	3	0.5%
BlueCatfish	22	0	2	2	0	26	3.9%
ChannelCatfish	0	0	0	2	0	2	0.3%
CommonCarp	4	2	17	0	3	26	3.9%
FlatheadCatfish	2	0	7	0	0	9	1.4%
FreshwaterDrum	8	1	1	0	2	12	1.8%
LongnoseGar	5	0	0	0	0	5	0.8%
Paddlefish	32	0	1	0	2	35	5.3%
RiverCarpsucker	2	0	2	0	0	4	0.6%
SmallmouthBuffalo	94	6	32	0	0	132	19.9%
StripedBass	1	0	0	1	0	2	0.3%
Total	567	12	69	5	9	662	