Control and Removal of Asian carp in the Ohio River

Geographic Location: Ohio River basin, extending from the Cannelton Lock and Dam (RM 720.7) to the Racine Lock and Dam (RM 237.5).

Participating Entities: Kentucky Department of Fish and Wildlife Resources (KDFWR), Indiana Department of Natural Resources (INDNR), West Virginia Department of Natural Resources (WVDNR),

Introduction:
Eradication of an invasive species after establishment is often difficult and prevention or immediate response to an introduction is likely the most successful form of invasion control. Since the introduction of Asian carp (Silver, Bighead, Grass, and Black carp) into US waters, much has been done in an attempt to limit their expansion. Despite these efforts, invasive carps have steadily increased their range (Kolar et al. 2005) and some species densely colonized rivers, potentially affecting the native food webs (Irons et al. 2007, Freedman et al. 2012) and disrupting human connections to natural resources (i.e. fishing, boating, navigation, and aesthetics). With prevention and early responses no longer possible, physical removal of Asian carp in the Ohio River basin may be one tool to slow upriver expansion.

Consistent removal applied where the established population meets the invasion front may decrease upriver immigration, lower pressure on existing barriers, and reduce numbers of carp in places with species of conservation concern, or valued sport fisheries. Cannelton Pool currently marks the establishment front for Silver Carp populations within the ORB. In addition, there are several locations above Cannelton Locks and Dam where Grass and bigheaded carps can be consistently targeted. The purpose of this project is to utilize basin-wide knowledge to control and contain populations in the Ohio River basin (ORB). Removal efforts also provide an opportunity to collect data on Asian carp in pools where data is limited, and evaluation efforts may not provide information on population statuses.

Objectives:
1. Target and remove Asian Carp to suppress populations and reduce propagule pressure in the Ohio River.
2. Implement a removal program using contracted fishers within an intensive management zone to reduce carp numbers below Markland Locks and Dam.
3. Develop an Ohio River contingency response plan.

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.
- Approximately 59 hours of electrofishing effort was used to remove approximately 1,060 kg (~2,337 lbs) of invasive carp from the Ohio River in 2020.
- Approximately 4,662 meters of gill netting was used to remove approximately 273 kg (~601 lbs) of invasive carp from the Ohio River in 2020.
- Contract fishing efforts have substantially increased the removal of invasive carps in the Ohio

Methods:
Clarification of Terminology Referenced in This Document
With the current rate of Asian carp expansion and the massive effort to study and adaptively manage carp impacts across a broad range of Mississippi River sub-basins, it is important to clarify terminology used in technical documentation and annual reports. Therefore, a list of terms and their respective definitions used in this report are provided.

Bigheaded Carps – Silver (Hypophthalmichthys molitrix), Bighead (Hypophthalmichthys nobilis), and their hybrids.
Establishment Front – the furthest upriver range of Asian carp populations that demonstrates natural recruitment.
Invasion Front – the furthest upriver extent where reproduction has been observed (eggs, embryos, or larvae), but recruitment to young-of-year fish has not been observed.
Invasive Carp – one of four species (i.e., Silver Carp, Bighead Carp, feral Grass Carp, and Black Carp) originating from the continent of Asia.
Presence Front – The furthest upstream extent where invasive carp occur, but reproduction is not likely.
Targeted Sampling – Gear and/or techniques used to specifically target invasive carp and exclude native species.

Agency Removal of Asian Carps
Removal efforts using electrofishing and gill netting were significantly reduced in 2020 and only conducted over approximately 16 weeks from late June through September. Electrofishing was not rigorously standardized, but total effort (hours) was recorded. Typical settings utilized pulsed DC electrofishing on an MLES box at 40% duty-cycle and 80 pulses per second. Electrofishing was frequently paired with gill nets so that crews could work in tandem to push groups of fish into entanglement gears. Gill nets were constructed of large bar-mesh (3.0" – 6.0" square) and fished a minimum 60 minutes with fish being driven toward the nets using boat noise or electricity.

Efforts were focused primarily on tributaries and embayments where carp have prolonged residency times and fish are more susceptible to capture gears. There are several locations where carp can be targeted outside of tributaries and embayments (e.g., McAlpine Locks and Dam tailwater) and maps have been created to aid both agency crews and contract fishers when targeting fish for removal in Cannelton Pool (Figure 1).

Carp and all bycatch were identified in the field to the lowest possible taxonomic level. All bycatch was immediately released. Asian carp were inspected for tags before being euthanized for population control. Any tagged fish captured was released if its transmitter had sufficient battery life and it was in good post capture condition. Total length, sex, presence of spawning patches, and capture location was recorded for each fish. Supplemental data was collected infrequently and included otoliths for aging, ovary condition and weight, and recapture information if previously tagged fish were removed.

Contract Fishing Program
The newly established contract fishing program began in July of 2019. In 2020 eight fishers participated in the program and fishing was shut down for a portion of the year due to COVID-19 precautions and in some cases lack of staffing. When fishing resumed in the summer months, effort was bottlenecked until catches began to increase in the fall. Once harvest numbers began to climb and staffing of on-board observers to record data on harvest and bycatch was possible, program efforts increased. Contracted fishers were given access to mainstem river, tributaries, and embayments to target Asian carp species. All bycatch was recorded and released immediately while tracking morbidity of non-target species. On-board observers collected additional data including total length, sex, and weights on 20 randomly subsampled Silver and Bighead carp each day.

Contingency and Response Planning
The current framework established in the ORB uses information from basin projects to form recommendations on management actions designed to reduce abundances of invasive carp. KDFWR reviewed draft and invasion statuses and added information about their logistics and resources assumptions for response measures in addition to a section highlighting priority waters.

Results:

Physical Removal of Asian Carps

Approximately 59 hours were spent electrofishing in four pools of the Ohio River and its tributaries between Cannelton and R.C. Byrd Locks and Dam (Table 1). Five hundred and forty-eight carp were removed using boat electrofishing over these four pools in 2020. The highest level of effort was expended in the McAlpine pool where 272 carps, weighing approximately 1,060 kg (2,337 lbs), were removed. Electrofishing provided the most success between gears but was most successful when paired with gill nets.

A total of 4,662 meters (15,300 ft) of large mesh (4" – 6" square) gill nets were used to capture 45 invasive carps in four pools of the Ohio River (Cannelton – Markland; R.C. Byrd) (Table 2). This amounted to 273 kg (~ 601 lbs) of Bighead, Silver, and Grass Carp combined. The largest amount of effort was expended in the McAlpine Pool with 2,377 meters (7,798 ft) of net fished to remove 44% of total net catches. Gill netting has been less productive than boat electrofishing for agency crews, but it is an effective gear for targeting Bighead carp using either dead-set nets (left overnight) or as an entrapment gear paired with electrofishing or sound herding.

Bycatch was rarely taken with boat electrofishing, however, species resembling young carp were dipped to ensure they were not invasive juvenile fish. Gill net bycatch was tracked extensively. The most common non-target species encountered in the 2020 gill net effort were Smallmouth Buffalo (~ 37% overall bycatch), Paddlefish (~ 29% overall bycatch), and Freshwater Drum (~ 15% overall bycatch). The additional 19% of remaining bycatch consisted of Blue Catfish, Channel Catfish, Common Carp, Flathead Catfish, Longnose Gar, Sauger, and a Silver Redhorse (Table 3). Fish were rarely moribund and the number of fish that were dead on arrival was negligible due to sets being fished for less than two hours.

In efforts to refine agency Asian carp removal techniques, determine the best locations for future expanded contract removal within Indiana, and utilize the remainder of previous funding allotments, INDNR conducted seven removal events in 2020, primarily in the White River. The most productive sites were located within oxbows still connected to the river proper. Total effort included 14.25 hours of boat electrofishing and 1,051 meters (3,450 ft) of gill net webbing. A combined 2,230 Asian carp were removed, totaling approximately 19,180 pounds. In future efforts, a multi-boat approach and the use of block nets will increase efficiency and removal capabilities.

Contract Fishing Program

Contract harvest between January 2020 and February 2021 aided removal success through 2020 despite limitations from COVID-19. Disposal of harvest was not rigorously tracked, but many fishers indicated that harvest was typically sold when possible. However, facilitation of harvests from the middle Ohio River to markets remains one of the largest hurdles in the program. Coordination between KDFWR and other established distribution chains is ongoing. Illinois DNR and Tetra Tech have been valuable resources in supplying information and possible solutions. After their guidance and further investigation, it has become evident that a drop-off point close to the intensive management zone in the Ohio River is unlikely sustainable without weekly harvest amounting to around 13,600kg (30,000lbs). Weekly landings at this level are currently not possible under the current program structure, but several strategies are being explored to provide this level of harvest during highly productive months of the year.

Individual average daily catch rates for fishers were highest in the month of January 2020 (Figure 2) and daily harvest appears to be well correlated with river gauge height and cooler water temperatures. Gill nets were the only capture gear used over the thirteen-month period, but some fishers also deployed block nets to aid in concentrating fish before harvest. Netting effort varied and depended on catch, but fishers

would typically lay around 1,000 meters (~3,200 ft) of webbing per day. Silver Carp catch ranged in total length from 511 mm to 1100 mm with the greatest frequency of catch falling between 800 – 850 mm (Figure 3). Bighead and Grass carp catches were far more infrequent, but both were most commonly around 800 to 1000 mm in total length.

Bycatch from contract effort was highest in March 2020 and January 2021 with most other months showing that non-target species made up less than 45% of total catch (Figure 4). All bycatch was immediately released and any fish that was dead-on-arrival (DOA) or appeared moribund was noted. Ictiobid species were the most common bycatch making up 84% of non-target catch with Common Carp (*Cyprinus*) and Freshwater Drum (*Aplodinotus*) being the second and third most commonly encountered bycatch in contract net sets (Figure 5). Paddlefish were the seventh most frequent bycatch encountered and made up approximately 0.5% of all the bycatch recorded by contract observers. However, only two individuals of all Paddlefish captured were either DOA or close to death after being pulled from nets. This was far lower when compared to post-capture condition for paddlefish captured in 2019. In fact, numbers of moribund fish for all bycatch species decreased in 2020 when compared to the previous year.

Contingency Planning Effort and Document

The ORB contingency plan draft was updated after basin feedback and information on state priority waters was added in 2020. A redirection of effort, funding, and state resources was not specifically outlined in reference to each change in population status, but simply identified as a priority. This document is expected to be finalized in 2021, and a draft of this document is included in Appendix C below.

Discussion:

Dams along the Ohio River likely provide some barrier to dispersal for invasive carp species. Data acquired from monitoring efforts have repeatedly shown that the average sizes and body condition of Silver Carp increase while catch rates decrease as you move upriver. This is an indication that fish further up the system are not only fewer in number, but likely older. With Cannelton being the furthest upriver pool where fish less than 400 mm have been regularly observed, it is considered the farthest upriver pool within the establishment zone. Although young-of-year recruits have never been observed in Cannelton, it is currently prioritized as a major target for implementing population control actions and densities of fish are high enough to suggest that intense, regular fishing pressure is needed.

In 2020, 10 fishers were placed on contract to provide this necessary fishing effort and observers were hired to record harvest success and bycatch impacts. Overall, fishers showed the most success when focusing efforts in tributaries, where netting gears are typically more effective due to decreased water depth. Invasive carps were difficult for contract crews to target during summer months and effort was bottlenecked by only allowing one contract fisher on the water per week. This allowed KDFWR and INDNR to monitor harvest rates throughout the less productive months while preserving funding and continuing to gain information on harvest potential during this time. As daily landings increased and more staff was available to observe, the number of fishermen utilized per week was increased. Insights into aggregate movements of carp into or out of accessible waters are important points of information for fishers on contract and can increase harvest success. Additional years of data are necessary; however, information herein suggests that a decrease or suspension in fishing effort may help control impacts to bycatch and preserve fishing effort for larger harvests and greater impacts during months with higher water levels and cooler water temperatures.

Agency crews were able to supply recommendations based off of previous years' experience and monitoring efforts. Suggestions on where to target fish and gear specifications that would maximize success seemed to be the most helpful; however, fishers were allowed to use gears they felt were best

during each fishing event. Gill nets with webbing constructed of 3.50-inch to 4.25-inch bar-mesh were preferred and appeared to provide the best results when considering Silver Carp harvest numbers. On several instances, block nets were used to wall off embayments so that fish could not escape if they evaded gill net capture. This allowed fishers to continually catch until the embayment was cleared out. Additional recommendations by fishermen include combining effort in tributaries and embayments where exits can be sufficiently blocked and harvest potential exceeds the capabilities of one fishing crew. Thus, if fishers and agency personnel coordinate well, additional boats could be deployed to locations where large numbers of fish are still held captive until numbers are reduced below catchable levels.

Most bycatch was reported as released unharmed by on-board observers and the frequency of Paddlefish morbidity was greatly reduced compared to numbers seen in 2019. Ictiobids appear to be the most common bycatch followed by Common Carp and Freshwater Drum. In all three cases, the vast majority of fish appeared unhurt or minimally injured after release. Low mortality was likely aided by the rapid setting and pulling of gill nets, a style of fishing which seems more effective when targeting Asian carp because of their tendency to move often and evade capture.

Currently, pairing electrofishing with gill nets has produced the most success for agency crews when targeting invasive carp for removal efforts. Groups of carp can be found with side-scan technology while schools can be targeted using electricity and herding techniques to move fish into netting gears. However, capture success is highly dependent on the experience of the driver and dipper and nets often have to be fished in sets with several different mesh sizes. Targeting tributary waters gives removal crews an advantage because gears are typically more effective in shallower systems and the tributary banks keep fish from scattering when being pushed into entanglement gear.

The contingency planning document was edited without recommendations from basin partners in 2019. The document points out several gaps in knowledge about population statuses for invasive carps in the Ohio River and provides a starting point for future investigation. This document is intended to be completed in 2021 and will hopefully provide a framework for responses to changes in carp invasion statuses for all pools throughout the river.

Recommendations:

It is imperative that fishing pressure increases substantially and is sustained throughout the course of our control efforts in the Cannelton Pool to help protect and reduce immigration of invasive carps further up the Ohio River. Contract fishing should continue to support population control efforts and should be closely monitored so that recommendations can be made to increase efficiency and successful harvest. Agency crews should continue to pursue removal in lower density pools and internal waters to reduce numbers of mature fish and place additional effort into multi-agency removal efforts in hotspots like Raccoon Creek in R.C. Byrd Pool. Outreach and efforts to spur public and commercial interest within the ORB should continue and will be important in contributing necessary population control efforts as well as providing a useful means for disposal for contract harvests. Further work in aiding facilitation of harvests to markets should also be considered as weekly yields approach levels capable of contributing significant numbers to processors. River and have not appeared to cause substantial impacts to native fish populations. It is imperative that fishing pressure increases in the Cannelton Pool and efforts upriver remain in place to reduce the number of fish capable of reproducing.

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Table 1. Electrofishing effort (hours) and resulting catch of Asian carp (catch and weight) for three pools of the Ohio River during Asian carp control efforts in 2020.

		Capture Number (N)					Total Weight (kg)				
Pool	Electro Effort (hr)	Bighead Carp	Hybrid Bigheaded Carp	Silver Carp	Grass Carp	Total	Bighead Carp	Hybrid Bigheaded Carp	Silver Carp	Grass Carp	Total
Cannelton	22	0	0	264	3	267	0	0	1,064	34	1,098
McAlpine	29	0	13	259	0	272	0	79	1,060	0	1,139
Markland	8	0	0	9	0	9	0	0	70	0	70
Total	59	0	13	532	3	548	0	79	2,191	34	2,307

Table 2. Netting effort (meters) and resulting catch of Asian carp (number and weight) for four pools of the Ohio River during Asian carp control efforts in 2020.

		Capture Number (N)					**Total Weight (kg)**				
Pool	Net Effort (m)	Bighead Carp	Hybrid Bigheaded Carp	Silver Carp	Grass Carp	Total	Bighead Carp	Hybrid Bigheaded Carp	Silver Carp	Grass Carp	Total
Cannelton	1920	0	0	23	1	24	0	0	128	10	138
McAlpine	2377	1	0	18	0	19	6	0	95	0	95
Markland	274	0	0	0	0	0	0	0	0	0	0
R.C. Byrd	91	1	0	0	1	2	25	0	0	9	
Total	4662	2	0	41	2	45	31	0	223	19	273

Table 3. Gill netting bycatch (N) by species for four pools of the Ohio River during Asian carp control efforts in 2020.

	Ohio River Pools in 2019					
Species	Cannelton	McAlpine	Markland	R.C. Byrd	Totals	Percent Total
Bigmouth Buffalo	1	2	2		5	0.03
Blue Catfish	2			1	3	0.02
Channel Catfish		1			1	< 0.01
Common Carp	1	3		2	6	0.04
Flathead Catfish	1	1	2	3	7	0.05
Freshwater Drum	19	2			21	0.15
Longnose Gar		4			4	0.03
Paddlefish	25	14		2	41	0.29
Sauger		1			1	< 0.01
Silver Redhorse	1				1	< 0.01
Smallmouth Buffalo	27	25	1		53	0.37
Total	77	53	5	8	143	

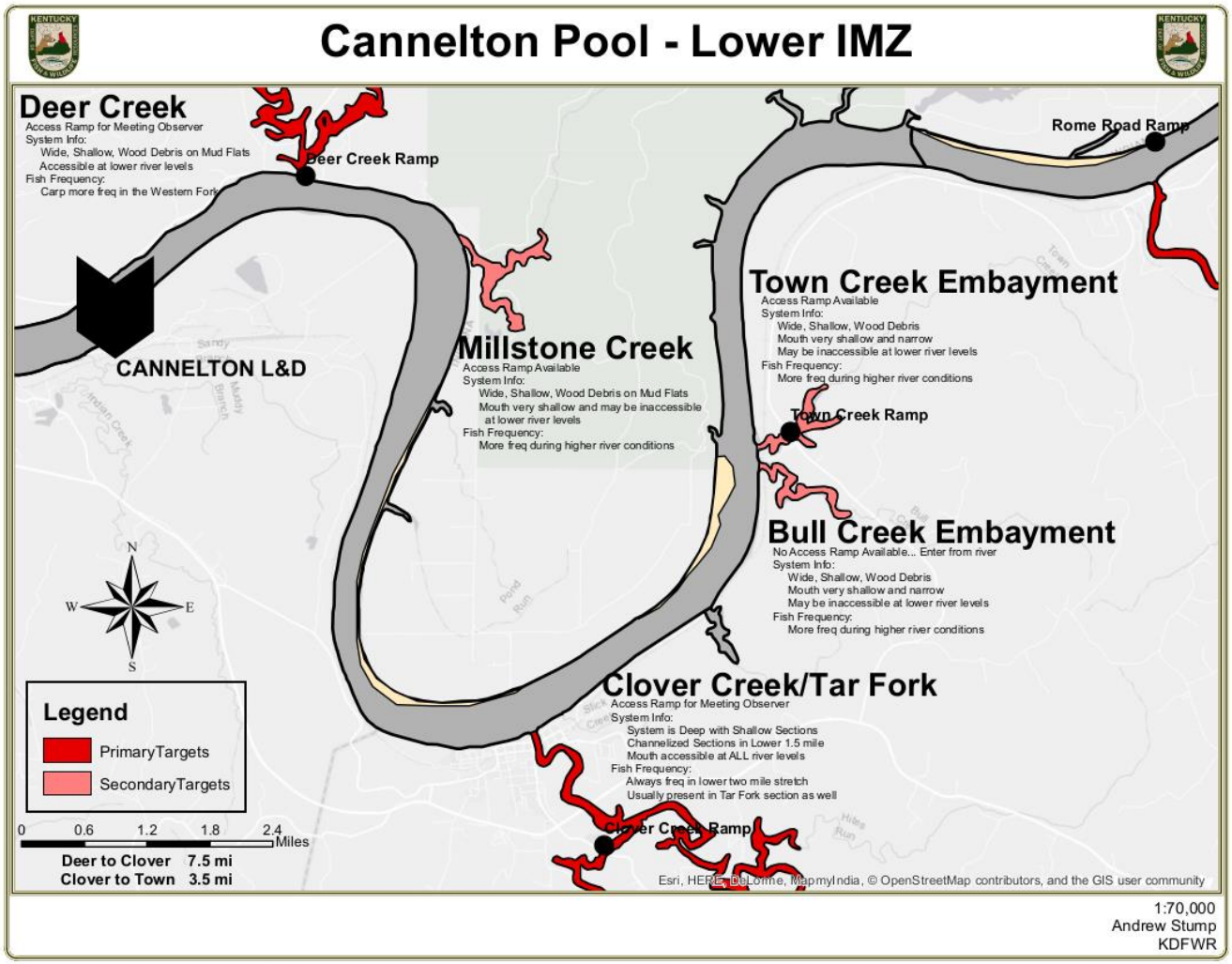

Figure 1. An example of the maps generated to help agency and contract fishing crews prioritize locations under different water conditions when conducting removal in the lower Cannelton Pool. This is one of five maps which were generated using monitoring and removal data collected over the past four years.

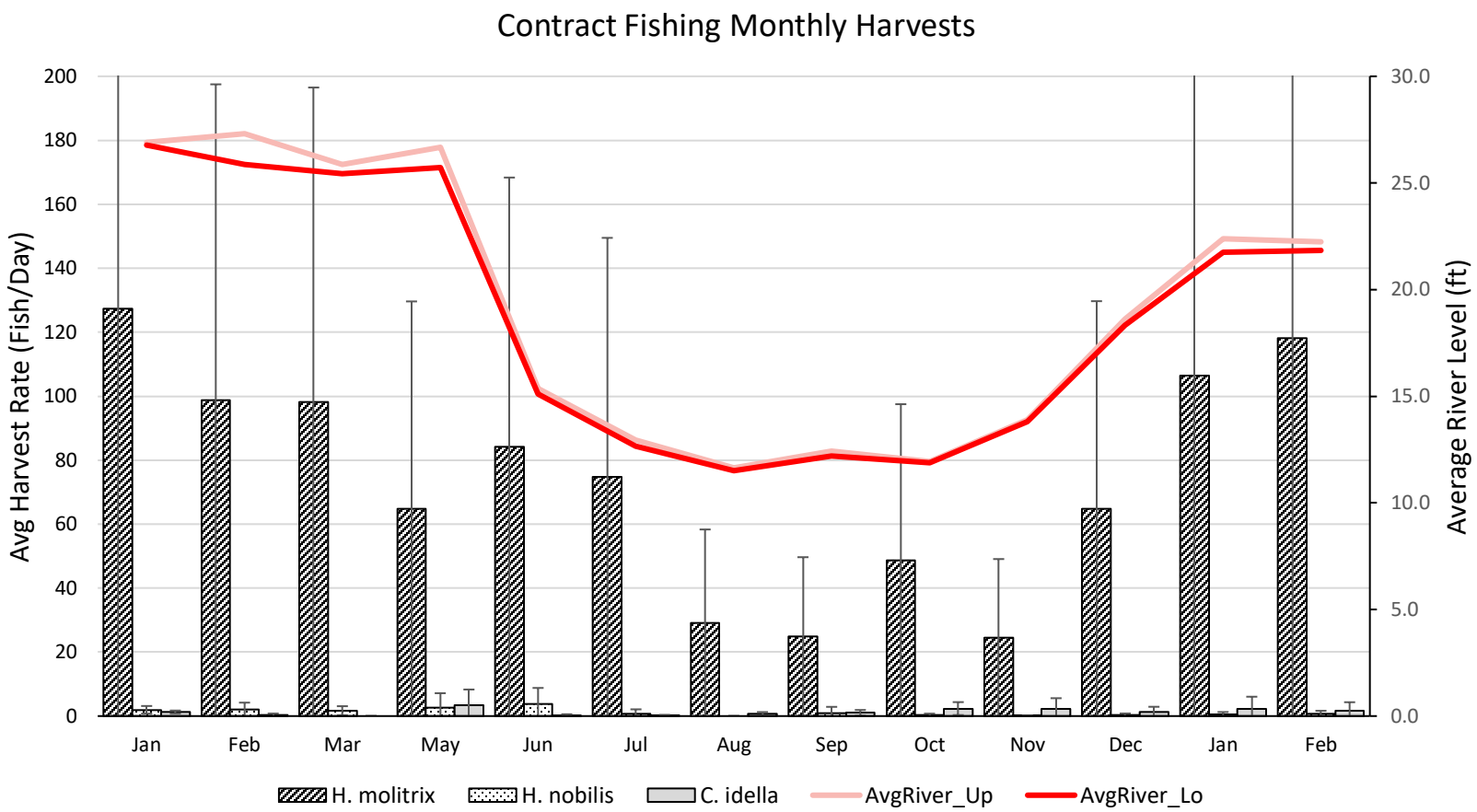

Figure 2. The average daily harvest rates (Fish/Day) by contract fishers for each month employed from January 2020 through February 2021 with error bars representing the standard deviation in daily catchs. In addition, upper and lower bounds for the river level is shown using data collected from gauge height measurements reported on the USGS WaterWatch site (https://waterwatch.usgs.gov, 2020). Increases in average daily landings correlate with higher river levels and cooler months.

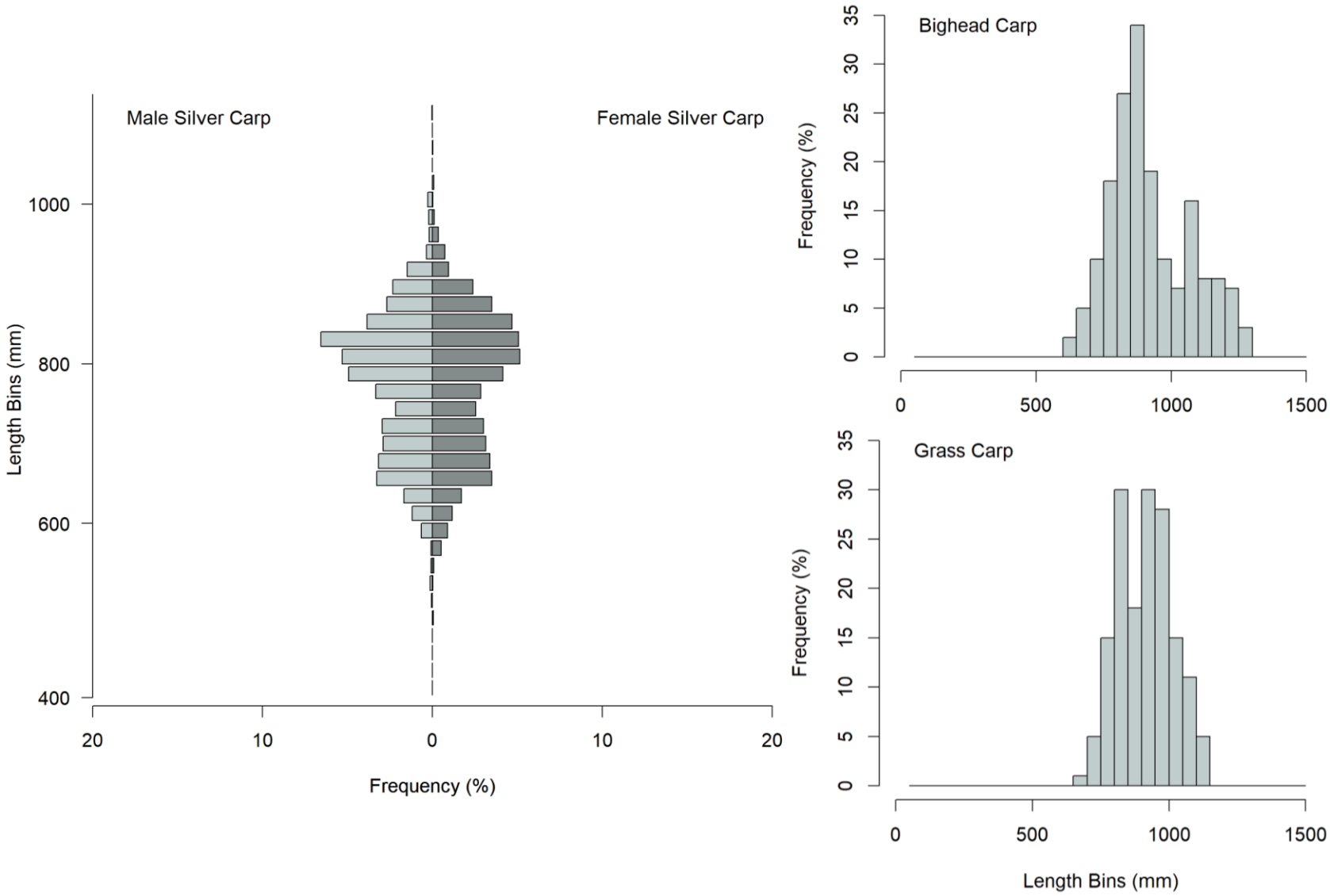

Figure 3. Histograms of the distribution in total lengths for fish captured in the Cannelton Pool by contract fishers and agency crews.

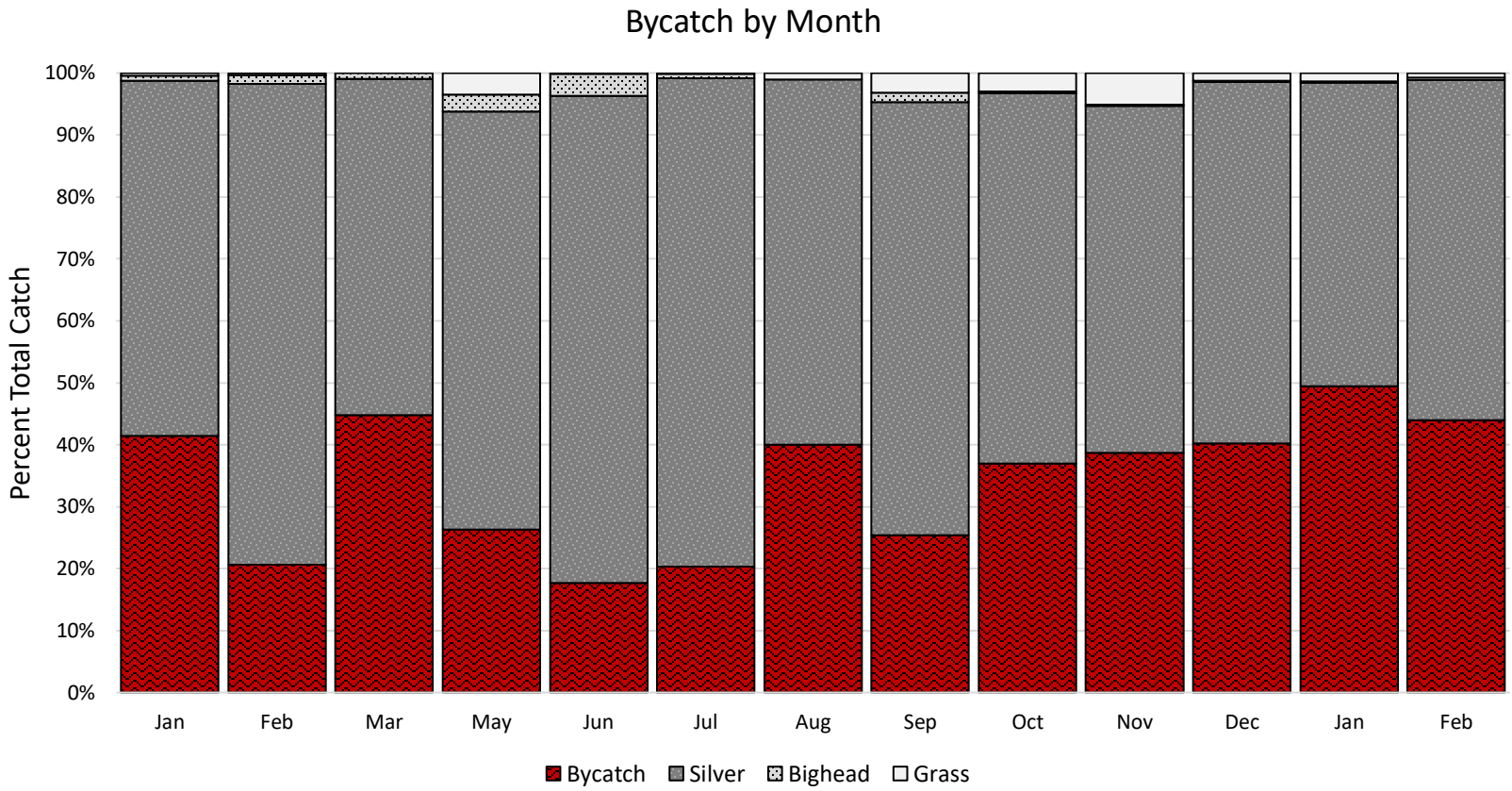

Figure 4. The percent of total catch for contract fishing efforts when considering all bycatch species in relation to the three of the target species of Asian carps from January 2020 through February 2021.

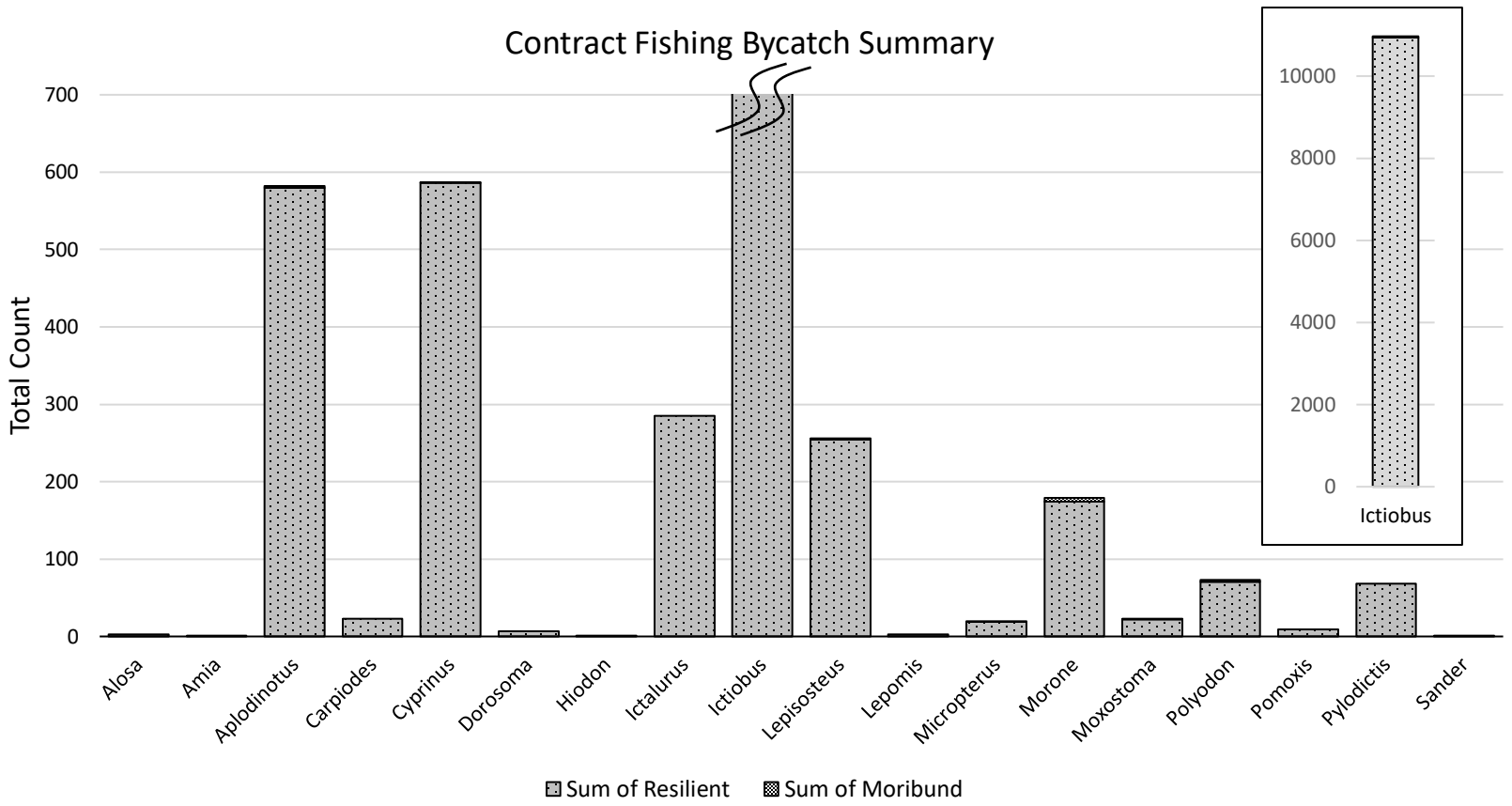

Figure 5. The total counts for all contract fishing bycatch recorded from January 2020 to February 2021. Each bar is broken down by the recorded status of fish removed from contract fishing nets. Fish were marked moribund if it appeared to have suffered significant damage or could not swim off after release. Fish were marked resilient if they recovered quickly and swam off under their own power.

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Appendix:

Ohio River Contingency Response Plan

Participating Agencies: KDFWR, WVDNR (List Additional Groups HERE…)

Introduction and Need:
This contingency plan is intended to develop response protocols for controlling and responding to changes in invasion status for invasive carps in the Ohio River Basin (ORB). The plan utilizes the current information gathered about invasive carp populations in the middle Ohio River. Recommendations on responses to changes in population status are organized by severity of change detected. If no changes in status are observed, the plan should be reviewed every three years to ensure that it remains up to date and takes into consideration changes in policy or protocols implemented by the basin states.

In the event that a change in population status is detected, this document is intended to aid basin partners in determining the severity of the change and help provide a structure for coordinated basin-wide response. It is acknowledged that actions and responses contained in this document are intended to be recommendations to unite basin efforts to respond to changes in invasion statuses of carp species and in no way supersedes the authorities of individual state or federal jurisdictions.

Purpose:
The Ohio River Fisheries Management Team (ORFTM) developed a document in 2014 assessing the current status of Bighead and Silver Carp species in the Ohio River. This "Control Strategy Framework" was intended to outline actions and recommendations the basin should take in order to control, prevent, monitor, and respond to changes in invasive carp expansion in the ORB. This document became the sub-basin's guide in establishing projects to monitor and control Asian carp populations under the greater, national framework: The Management and Control Plan for Bighead, Black, Grass, and Silver Carps in the United States. The purpose of this document is to fulfil the sub-basin framework goal 2.1; that is to "develop a response plan for the Ohio River basin that identifies risk and return of actions when new information [on Asian carp] emerges." To fulfil this need, this plan must contain three things: 1. Identify pre-planned responses to changes in status, 2. Identify most appropriate actions, 3. Define a communication chain between partner groups and the public.

Background:
The Ohio River is a large riverine system running 981 miles from the confluence of the Allegheny and Monongahela rivers in Pittsburgh, PA to its confluence with the Mississippi river near Cairo, IL. It flows directly through or along six basin states (PA, OH, WV, KY, IN, IL) and receives water from several large river systems which expand the watershed into nine additional states. The main stem itself has 20 dams that are managed by the U.S. Army Corps of Engineers, which alter the flow of the river for the purpose of navigation and flood protection. With individual pools along the river acting much like flowing reservoirs, pools can look very different in terms of their biological communities and geomorphology. In addition, dams can provide significant barriers to dispersal for invasive carp populations. In recent years, telemetry efforts have shown limited movement of tagged fish across pool boundaries. Considering this information, this document was written with invasion statuses, population life stages, and response actions broken down by pools as regular units of measure.

Currently, there are several projects being conducted in the Ohio River basin as part of a larger framework that concerns the invasion of Asian carp species across US waterways. In the Ohio River, projects involve population control, evaluation of control efforts, tracking abundance and distribution of early life stages, and quantifying movement or lock and dam passage. These projects together have

shaped the ORB's current knowledge on the status of Asian carp populations and their progression up the Ohio River.

The invasion statuses for Asian carp can be broken into four different categories: Established, Invading, Present, and Non-present. Each of these different categories is assigned to a pool using a body of evidence based on the different life history stages seen from monitoring populations in each pool. Each front is not necessarily the same for each of the four species of invasive carp as unique introduction events, invasion rates, and establishment of carp species likely depends on many factors. Thus, status changes and response actions must be considered separately for each individual carp species in each pool. Establishment status is assigned to those pools in which recruitment is verified or strongly suspected. Invasion status is defined by high frequencies of adult fish and indications of successful spawning, but negligible recruitment. Presence fronts are defined as areas where migrant groups of fish appear with less frequency and large amounts of fishing effort are needed to successfully capture individuals. Finally, non-present areas are where carp species are not yet documented.

Status:
Below is a bulleted list of population statuses for invasive carps in the Ohio River. However, we provide an abbreviated synopsis for each species ahead of each pool breakdown:

Silver carp (Hypophthalmichthys molitrix) are the most frequently encountered species among the four invasive carp and are commonly reported through both agency and public captures and sightings. Currently, Cannelton is considered the farthest upriver pool with establishment status. No young-of-year (YOY) fish have been reported in Cannelton, but YOY Silver Carp have been found below the pool in Newburgh and J.T. Myers. Some juvenile fish < 400 mm in total length (TL) having been captured within Cannelton Pool, but are infrequent. Above Cannelton, McAlpine Pool marks the beginning of the invasion front and is characterized by a large decrease in catch rates of Silver Carp in addition to far fewer sightings and records. Fish in this section of river appear to be primarily adult and may be in numbers high enough to spawn, but there is no evidence of successful recruitment. Three pools ahead of McAlpine Dam is Greenup Lock and Dam. Fish between Greenup and Racine pools are considered present, but in numbers below detection capabilities with current standardized sampling protocols. Only one record of an adult Silver Carp has ever been reported from the R.C. Byrd Pool in Raccoon Creek by ODNR in 2016. Above Racine Lock and Dam no Silver Carp have been reported.

- Newburgh Pool and Below
    - Established
        - Adult and juvenile fish reported regularly
        - Large schools present and frequently seen
        - Evidence of successful spawning
        - Evidence of successful recruitment
- Cannelton Pool
    - Established
        - Adults present in numbers and some juvenile fish captured
        - Large aggregations (> 1000 fish) present often
        - Evidence of successful spawning
        - No confirmed evidence of YOY fish, but small juvenile fish (< 400 mm) have been captured
- McAlpine Pool
    - Invading
        - Adults present in number, occasional juvenile fish (400mm > **fish** < 650 mm)
        - Large aggregations (~ 100 – 1000 fish) of fish found in specific locations
        - Evidence of successful spawning

        - No evidence of successful recruitment
- Markland Pool
    - Invading
        - Adults present
        - Small aggregations (~ 10 – 100 Fish) of fish confined to a few sections of river
        - No evidence of successful spawning, but successful spawning is likely
        - No evidence of successful recruitment
- Meldahl Pool
    - Invading
        - Large adults present
        - No aggregations or schools reported, only solitary fish captures
        - Evidence of successful spawning for *Hypophthalmichthys* genus, but no confirmation for Silver Carp
        - No evidence of successful recruitment
- Greenup pool
    - Present
        - Large adults have only been present in data occasionally
        - No aggregations or schools reported, only solitary fish captures
        - No evidence of successful spawning
        - No evidence of successful recruitment
- RC Byrd pool
    - Present
        - Large adult reported from ODNR in 2016
        - No aggregations or schools reported
        - No evidence of successful spawning
        - No evidence of successful recruitment
- Racine and Above
    - Not Present
        - No reports of adult Silver Carp
        - No aggregations or schools ever reported
        - No evidence of successful spawning
        - No evidence of successful recruitment

Population statuses for Bighead Carp (Hypophthalmichthys nobilis) are difficult to define because less information and fewer fish have been captured through framework projects. To date, there have been records of young-of-year Bighead Carp captured in Hovey Lake in the J.T. Myers Pool using trawls and in Gar Creek above Olmsted Dam using a seine and dip nets. Since 2015, no juvenile fish < 400 mm have been captured in any pool above Cannelton Dam and only 11 records exist for fish smaller than 600 mm; all of which were captured in the Cannelton Pool. There have been additional unverified reports of juvenile Bighead carp below Taylorsville Lake in the Salt River system (a tributary of the Cannelton Pool) but this has remained unconfirmed to date. Thus, the establishment front for Bighead Carp remains a gap in knowledge for ORB partners, but efforts are underway to refine this range through objectives set in the "Abundance and distribution of early life stages of Asian carp" project coordinated by lead agency INDNR. For management purposes, the range for Bighead carp establishment is currently aligned with that of Silver Carp in the Cannelton pool. The invasion range for Bighead Carp extends from McAlpine through the R.C. Byrd Pool, where large adult fish can be caught regularly if targeting the upriver side of the R.C. Byrd Dam, Raccoon Creek, and the Kanawha River. Above Racine, Bighead Carp are reported infrequently and the farthest upriver record is from the New Cumberland Pool at Stratton, OH where an adult fish was observed impinged against a water intake screen. Above New Cumberland, no records or

observations exist in conjunction with the Ohio River and that is currently considered as the Bighead non-present range.

- JT Myers and Below
  - Established
    - Adult and juvenile fish reported regularly
    - Occasional reports of groups of adult fish captured or conveyed together
    - Evidence of successful spawning
    - Evidence of successful recruitment
- Newburgh Pool
  - Established
    - Adult and juvenile fish reported regularly
    - Occasional reports of several adult fish captured or conveyed together
    - No evidence of successful spawning
    - No evidence of successful recruitment
- Cannelton Pool
  - Established
    - Adults reported regularly some juvenile fish (< 600 mm) captured in 2017
    - Occasional records where several adult fish were captured together
    - Evidence of spawning with spawning patches visible in spring
    - No evidence of successful recruitment
- McAlpine - Markland pools
  - Invading
    - Adults reported occasionally in some sections of the river
    - Occasional records where several adult fish were captured together
    - Evidence of spawning with spawning patches visible in spring
    - No evidence of successful recruitment
- Meldahl Pool
  - Invading
    - Adults rarely captured in some specific locations
    - Large adults have only been present, solitary fish captured occasionally
    - Evidence of spawning with spawning patches visible in spring
    - No evidence of successful recruitment
- Greenup Pool
  - Invading
    - Adults rarely reported or captured
    - Large adults have only been present, solitary fish captured infrequently
    - No evidence of successful spawning
    - No evidence of successful recruitment
- RC Byrd Pool
  - Invading
    - Large adults regularly reported or captured
    - Large adults captured annually
    - No evidence of successful spawning
    - No evidence of successful recruitment
- Racine – New Cumberland pools
  - Present
    - Adults reported infrequently, telemetry and manual tracking show movement into and above Racine
    - Adults rarely reported or captured
    - No evidence of successful spawning

        - No evidence of successful recruitment
- Montgomery Island and above
    - Not Present
        - No records exist above Montgomery Locks and Dam

Adult Black Carp records within the lower part of the Ohio River and surrounding systems have increased in the past few years. Starting in 2017, two fish were reported and verified in the Ohio River basin. In 2018, the number of reports increased to 14, and then 51 in 2019. In 2020 there were 10 records reported by June in the lower Ohio River and surrounding tributaries. Only one young-of-year Black Carp has been discovered in the ORB. The 23mm fish was captured during routine sampling by KDFWR ichthyologists and verified through corroboration between other experts at USGS and the Missouri Department of Conservation. This finding marked the first location where juvenile Black Carp have been observed outside of the Dutchtown ditch, near southeast Cape Girardeau, MO.

- Smithland and below
    - Established
        - Increasing records of adult fish captured annually
        - One record of a juvenile YOY fish captured above Olmsted Locks and Dam
- JT Myers
    - Invading to Present
        - Two records of adult fish captured in JT Myers
        -
- Newburgh and Above
    - Unknown
        - No adult captures
        - Records are so uncommon in upper pools so statuses are likely to change rapidly

Grass Carp (Ctenopharyngodon idella) are captured infrequently through framework projects however their basin-wide distribution extends from the Mississippi River through the ORB and into the Monongahela and Allegheny River systems. Reports through the upper end of the basin consist of both diploid and triploid captures and the species does not follow a clear invasion pattern along its distribution like Silver Carp. Most introductions are likely from escapement after stocking fish for biological control of aquatic vegetation. Grass Carp captures are tracked through ORB sampling, but they are considered broadly established throughout the basin. Fish are euthanized when captured in the Ohio River or adjacent tributaries but are not currently tested for ploidy.

- Entire Basin Range
    - Established
        1. Diploid adult captures throughout basin
        2. Accounts of larvae up to Meldahl pool

Waters Connected to Priority Resources:
Outside of preparations to address changes in Asian carp population status for the Ohio River, it is also important to acknowledge the interconnectedness of our adjacent tributaries and inland water resources that are under direct threat from the spread of carp. Below is a list of agency-identified, inland priorities within each pool, along the invasion front. Systems where the greatest potential impacts to lake resources, boating and fishing access, and sensitive aquatic groups would be prioritized in a response effort counteracting changes in Asian carp populations.

- KDFWR
    - Cannelton Pool

1. **Salt River** – Is interconnected to several inland water resources (Taylorsville Lake, Floyds Fork, Guist Creek Lake); provides public fishing and boating access in several locations; and contains current and historical records for sensitive aquatic species (Fanshell Mussel, Slippershell Mussel, Salamander Mussel, Paddlefish).
2. **Otter Creek** – Provides access to public fishing resources and a state-stocked trout fishery; and resides within a KDFWR owned and operated Outdoor Recreation Area.
3. **Yellowbank Creek** – Provides access to public fishing resources; and resides within a Kentucky Wildlife Management Area.

- McAlpine
  1. **Kentucky River** – Is interconnected to a large number of inland water resources (Herrington Lake, Buckhorn Lake, Carr Fork Lake); provides public fishing and boating access in several locations, contains current and historical records for sensitive aquatic species.
  2. **Harrod's Creek** – Provides popular recreational boating access.
  3. **Little Kentucky River** – Is interconnected to Lake Jericho.
- Markland
  1. **Licking River** – Is interconnected to a large number of inland water resources (Cave Run Lake, Kincaid Lake, Williamstown Lake, Campbell County Lake); provides public fishing and boating access in several locations; and contains records for sensitive aquatic species (Eastern Hellbender, Catspaw Mussel, Elktoe Mussel, Fanshell Mussel, Slippershell Mussel, Paddlefish, American Brook Lamprey, Redside Dace, Spotted Darter, Burbot).
  2. **Craig's Creek** – Provides public fishing and boating access; supports sportfish populations.
  3. **Big Bone Creek** – Provides public fishing and boating access.
- Meldahl
  1. **Tygart's Creek** – Is interconnected to Smokey Valley Lake; provides public fishing access; supports natural populations of Muskellunge; and contains records for sensitive aquatic species (Northern Brook Lamprey, Green Floater Mussel, Snuffbox Mussel).
  2. **Kinniconick Creek** – Provides public fishing and boating access.
- Greenup
  1. **Big Sandy River** – Is interconnected to a large number of inland water resources (Yatesville Lake, Dewey Lake, Fishtrap Lake, John W. Flannagan Reservoir, Paintsville Lake); and contains records for sensitive aquatic species (Northern Brook Lamprey, American Book Lamprey, Big Sandy Crayfish).
  2. **Little Sandy River** – Is interconnected to Greenbo Lake and Grayson Lake; provides public boating access; and contains records for sensitive aquatic species (Northern Brook Lamprey, American Book Lamprey).

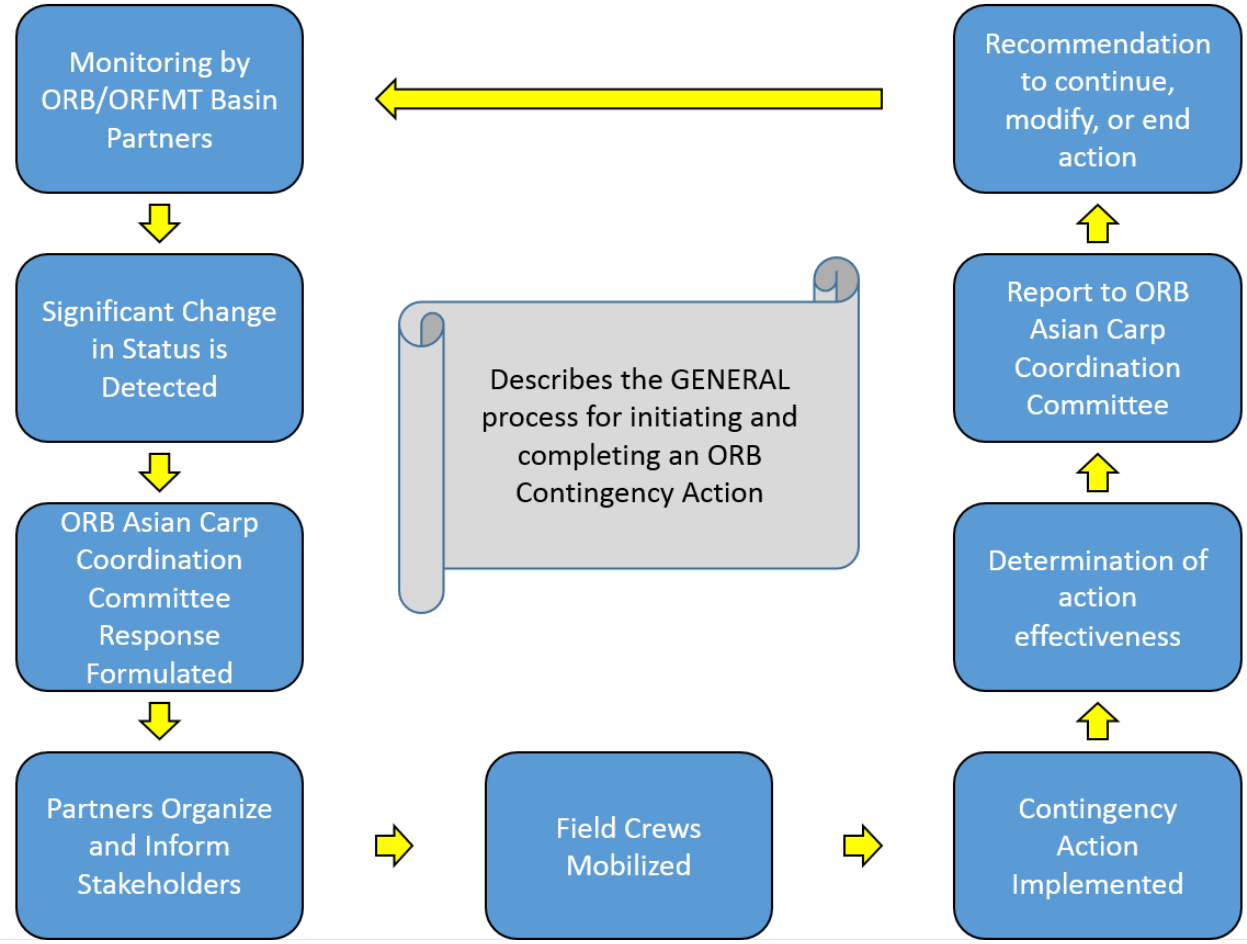
Planning Assumptions and Constraints:
These planning assumptions are to anticipate realistic situation, conditions, and possible constraints for partner groups:

Coordination Assumptions

- Response to changes in status are important from a basin wide perspective and actions will need participation from all partner groups in order to have the best chance of success.

- Response actions will be discussed as a basin and decisions will be made based on conditions, timing, geographic location, and take into consideration comments from all participating stakeholders.
- Response actions will take place in the Ohio River and contiguous waters.

Overview of Response Action Workflow



Logistics and Resource Assumptions

- Step 1 – Monitoring by ORB Partners
  - Monitoring effort is sufficient for detecting a population status change (current efforts indicate that we may only be able to detect changes in the Cannelton Pool)
- Step 2 – A change is detected
  - A single event may signify a change in population status, but repeated effort should be used to confirm. This may require additional or redirection of project resources.
- Step 3 – Response is formulated
  - Appropriate response efforts that consider both resources and
- Step 4 – Partners Organize and Coordinate
  - Communications concerning a basin decision will be coordinated through the ORB sub-basin coordinator
- Step 5 – Field Crews Mobilized
  - Response action requires field personnel
  - Field crews have the capacity to respond with the designated action

- Step 6-9 – Action Implemented, Determination of Effectiveness, Recommendations
    - A response is implemented with some benchmark or measurement capable of determining its effectiveness and informing future decision

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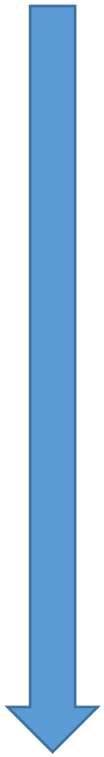
Decision Matrices:

Silver Carp	Pool	Eggs/Larvae			Small Fish (< 450mm)			Adult Fish		
		Rare	Common	Abundant	Rare	Common	Abundant	Rare	Common	Abundant
Direction of River Flow 	Emsworth									
	Dashields									
	Montgomery Isl									
	New Cumberland									
	Pike Island									
	Hannibal									
	Willow Island									
	Belleville									
	Racine									
	RC Byrd									
	Greenup									
	Meldahl									
	Markland									
	McAlpine									
	Cannelton									
	Newburgh									
	JT Myers									
	Smithland									
	Lock 52									
	Lock 53									
	Olmsted									

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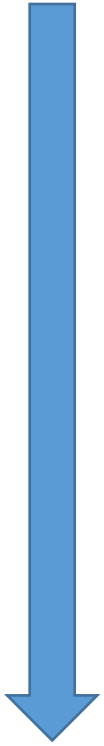
Bighead Carp	Pool	Eggs/Larvae			Small Fish (< 450mm)			Large Fish		
		Rare	Common	Abundant	Rare	Common	Abundant	Rare	Common	Abundant
Direction of River Flow 	Emsworth									
	Dashields									
	Montgomery Isl									
	New Cumberland									
	Pike Island									
	Hannibal									
	Willow Island									
	Belleville									
	Racine									
	RC Byrd									
	Greenup									
	Meldahl	?	?							
	Markland	?	?	?						
	McAlpine	?	?	?						
	Cannelton			?						
	Newburgh									
	JT Myers									
	Smithland									
	Lock 52									
	Lock 53									
	Olmsted									

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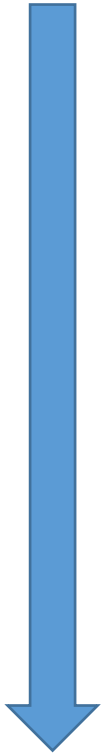
Black Carp	Pool	Eggs/Larvae			Small Fish (< 450mm)			Adult Fish		
		Rare	Common	Abundant	Rare	Common	Abundant	Rare	Common	Abundant
Direction of River Flow 	Emsworth									
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	Montgomery Isl									
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	McAlpine									
	Cannelton									
	Newburgh									
	JT Myers									
	Smithland									
	Lock 52									
	Lock 53									
	Olmsted									

Response Action Matrix

Urgency Level	Potential Actions	Applicable Locations	Responsible Partners	Estimated Implementation Time	Regulatory or Other Requirements	Relative Cost
Significant Change	Coordinated Rapid Response	All	KDFWR, USFWS	1 day	Unknown	$
	Agency Control Efforts Shifted	All	INDNR, KDFWR, WVDNR	7 days	Sampling Permits; ORB Coordination	$
	Increased Monitoring Effort	All	INDNR, KDFWR, WVDNR, PFBC	14 days	Sampling Permits	$
	Strategic Public Outreach	All	All Agencies	30 days	Unknown	$
	Implementation of Contract Fishing	IN, KY Waters	INDNR, KDFWR	Months	ORB Coordination	$$
	Use of toxicants/chemicals	Non-sensitive Areas	All Agencies	Unknown	Federal and State Regulations	$$$
	Implementation of Barrier	Unknown	All State Agencies, USGS	Years	Unknown	$$$$
Moderate Change	Coordinated Rapid Response	All	KDFWR	1 day	Unknown	$
	Agency Control Efforts Shifted	All	INDNR, KDFWR, WVDNR	7 days	Sampling Permits; ORB Coordination	$
	Increased Monitoring Effort	All	INDNR, KDFWR, WVDNR, PFBC	14 days	Sampling Permits	$
	Strategic Public Outreach	All	All Agencies	30 days	Unknown	$
No Change	Maintain Current Level of Effort	N/A	All	Ongoing through 2021	N/A	$