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), West Virginia University (WVU)

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.

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 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 conducted over approximately 22 weeks from May through September in 2019. 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, underwater speakers, or electricity. Nets were occasionally set overnight throughout the season in areas where they did not create hazards to navigation. However, prolonged sets were avoided during warmer water temperatures to decrease Paddlefish mortality.

Efforts were focused primarily in 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 were 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. Thirteen fishers were placed on contract with KDFWR and paid to target Asian carp in the Cannelton Pool. Indiana and Kentucky supplied on-board observers to record data on harvest and bycatch. 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. The current contingency and response measures outlined in the draft plan were developed using invasion statuses for Silver Carp since they are the most frequently encountered species along the invasion range. In 2019, this documents was edited according to feedback from basin partners and invasion statuses were added for Grass and Black carps.

Results:
Physical Removal of Asian Carps
Approximately 75 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). One thousand three-hundred carp were removed using boat electrofishing over these four pools in 2019. The highest level of effort was expended in the McAlpine pool where a total number of 417 carps, weighing approximately 2,516 kg

(5,546 lbs), were removed. Electrofishing provided the most success between sampling gears, but was most successful when paired with gill nets.

A total of 6,293 meters (20,646 ft) of large mesh (4" – 6" square) gill nets were used to capture 305 invasive carps in five pools of the Ohio River (Cannelton – R.C. Byrd) (Table 2). This amounted to 2,008 kg (~ 4,427 lbs) of Bighead, Silver, and Grass Carp combined. The largest amount of effort was expended in the Cannelton and R.C. Byrd pools with 5,135 meters (16,847 ft) of net fished to remove 89% of total net catches. However, with approximately equal amounts of effort in each pool, Cannelton made up 97% of the total catch, weighing approximately 1,653 kg (~ 3,644 lbs). 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.

By-catch 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 2019 gill net effort were Paddlefish (~ 65% overall catch), Smallmouth Buffalo (23%), Flathead and Blue Catfish (6%). The additional 6% of remaining bycatch consisted of Common Carp, Bigmouth Buffalo, Longnose Gar, Channel Catfish, and Striped Bass (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.

Contract Fishing Program

Contract harvest between July 2019 and March 2020 increased removal success by over 200% when compared to efforts in 2018. In addition, contract removal was solely restricted to Cannelton Pool, but contributed to 88.5% of the total number of fish removed in the middle and upper Ohio River in 2019. Disposal of harvest was not rigorously tracked, but many fishers indicated that harvest was typically sold when possible. Currently, records of sale account for approximately 43.5% of the total 80,117 kg (176,628 lbs) removed over the nine-month period.

Individual daily catch rates for fishers was highest in the month of January (Figure 2) and daily harvest appears to be well correlated with river gauge height. Gill nets were the only capture gear used over the nine-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 1600 meters (~2,200 ft) of webbing per day. Silver Carp catch ranged in total length from 550 mm to 1050 mm with the greatest frequency of catch falling between 800 – 850 mm (Figure 3). This was consistent with agency observations for Silver Carp length distributions during 2019 projects using multiple gears; however, contract fishers were able to catch greater numbers of Bighead Carp, over a wider range of total lengths than agency crews (Figure 3). Gill net mesh sizes ranged from 3-inch square to 6.5-inch square mesh with the greatest harvest success between 3.75-inches and 4.25-inches bar mesh (Figure 4).

Bycatch from contract effort was highest in September and October with most other months showing that non-target species made up less than 45% of total catch (Figure 5). 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 85% of non-target catch with Common Carp (Cyprinus) being the second most commonly encountered bycatch in contract net sets (Figure 6). Paddlefish were the fifth most frequent bycatch encountered and made up less than 1% of all the bycatch recorded by contract observers. However, 14% of all Paddlefish captured were either DOA or close to death after being pulled from nets. This was relatively high when compared to post-capture condition for other bycatch species and indicates that mortality from gill netting is far higher for Paddlefish than any other bycatch species.

Contingency Planning Effort and Document

The ORB contingency plan draft was updated after basin feedback and information on range statuses for Grass and Black Carp were added. Response matrices currently contain recommendations for actions that can be taken by basin partners as changes in status are detected. General estimation for logistics and resource limitations were added to management actions, but need further review by basin partners. 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 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 2019, 13 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. However, during the months of August, September, and October, the river experienced drought conditions and river levels lowered, drawing water out of the tributaries and decreasing flow within the Cannelton Pool. Invasive carps were difficult for contract crews to target during this time and the majority of fish appeared to be absent from tributaries and other shallow waters. This substantially lowered harvests during these months, but catch began to increase with falling water temperatures and a rise in river height in November. This is a major point for future investigation and variables such as changes in water temperature and flow should be a focus for further investigations. 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 reductions in harvest during months with lower water levels.

Agency crews were able to supply recommendations based off of previous years' experience and 2018 monitoring efforts. Suggestions on where to targeting 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 3.75-inch to 4.25-inch bar-mesh were preferred and appeared to provide the best results when considering Silver Carp harvest numbers. Bighead Carp were captured most often in 5-inch to 6-inch webbing, but were present in harvests from nets with smaller webbing (down to 3-inch bar-mesh). Grass Carp were only captured in webbing between 3 to 4.50 inches and were less frequent in harvests than the bigheaded carps. Fishers also experimented with some additional gears including hoop nets and block nets, the latter of which seem to be most promising. 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 fish until the embayment was cleared out.

Most bycatch was reported as released unharmed by on-board observers, however Paddlefish were the most frequently moribund or confirmed dead. This is consistent with agency observations, but Paddlefish bycatch was far less frequent than most other bycatch species. Ictiobids appear to be the most common bycatch followed by Common Carp. In both cases, the vast majority of fish appeared unhurt or with minimal injuries 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 have 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 pushing into entanglement gear. In 2019, effort was shifted farther upriver with the Cannelton Pool contract fishing effort underway and as a result, agency crews were able to spend more time focusing on low density pools than in previous years. Agency crews are more effective than contract fishers when targeting these pools because fishermen cannot target large schools of fish, making harvest incentives less valuable and gill nets far less efficient as a removal gear.

The contingency planning document was edited using recommendations from basin partners in 2018 and information on Grass and Black Carp was added to the document. As in 2018, 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 2020 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 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. Also, fish disposal appeared to be a significant hurdle for fishers on contract in 2019. Only six of the original 13 fishers on contract continued to harvest through March with many refusing to fish because harvest facilitation was not available. 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.

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.
- In 2019, 13 fishers were placed on contract to provide necessary fishing effort in the Cannelton Pool and observers were hired to record harvest success and bycatch impacts.
- Agency removal in 2019 was shifted farther upriver where contract fishing is less useful and agency crews are more efficient at targeting and capturing fish.
- Approximately 75 hours of electrofishing effort was used to remove approximately 6,800 kg (~15,000 lbs) of invasive carp from the Ohio River in 2019.
- Approximately 6,300 meters of gill netting was used to remove approximately 2,000 kg (~4,400 lbs) of invasive carp from the Ohio River in 2019.
- Currently contract fishing efforts have increased removal harvests by more than 200% and have not appeared to cause substantial impacts to native 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.
- 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

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Appendix A: Tables

Table 1. Electrofishing effort (hours) and resulting catch of Asian carp (catch and weight) for four pools of the Ohio River during Asian carp removal efforts in 2019.

		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	25.33	0	5	857	1	863	0	26	4,087	5	4,118
McAlpine	26.17	0	0	417	0	417	0	0	2,516	0	2,516
Markland	10.17	0	1	16	3	20	0	13	145	20	178
R.C. Byrd	13.00	0	0	0	0	0	0	0	0	0	0
Total	74.67	0	6	1290	4	1300	0	39	6,748	25	6,812

Table 2. Gill netting effort (meters) and resulting catch of Asian carp (number and weight) for four pools of the Ohio River during Asian carp removal efforts in 2019.

		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	2697	38	1	230	3	272	367	6	1,256	24	1,653
McAlpine	564	3	0	21	0	24	43	0	135	0	178
Markland	594	0	0	0	0	0	0	0	0	0	0
R.C. Byrd	2438	8	0	0	1	9	177	0	0	11	177
Total	6293	49	1	251	4	305	587	6	1,391	35	2,008

Table 3. Gill netting bycatch (N) by species for four pools of the Ohio River during Asian carp removal efforts in 2019.

	Ohio River Pools in 2019					
Species	Cannelton	McAlpine	Markland	R.C. Byrd	Totals	Percent Total
Bigmouth Buffalo	2	1			3	1.34%
Blue Catfish	2	3	1	1	7	3.13%
Channel Catfish	1				1	0.45%
Common Carp	1			2	3	1.34%
Flathead Catfish			3	4	7	3.13%
Lamprey				1	1	0.45%
Longnose Gar	1			2	3	1.34%
Paddlefish	101	26		19	146	65.1%
Smallmouth Buffalo	31	12	3	6	52	23.3%
Striped Bass	1				1	0.45%
Total	140	42	7	35	224	

Appendix B: Figures

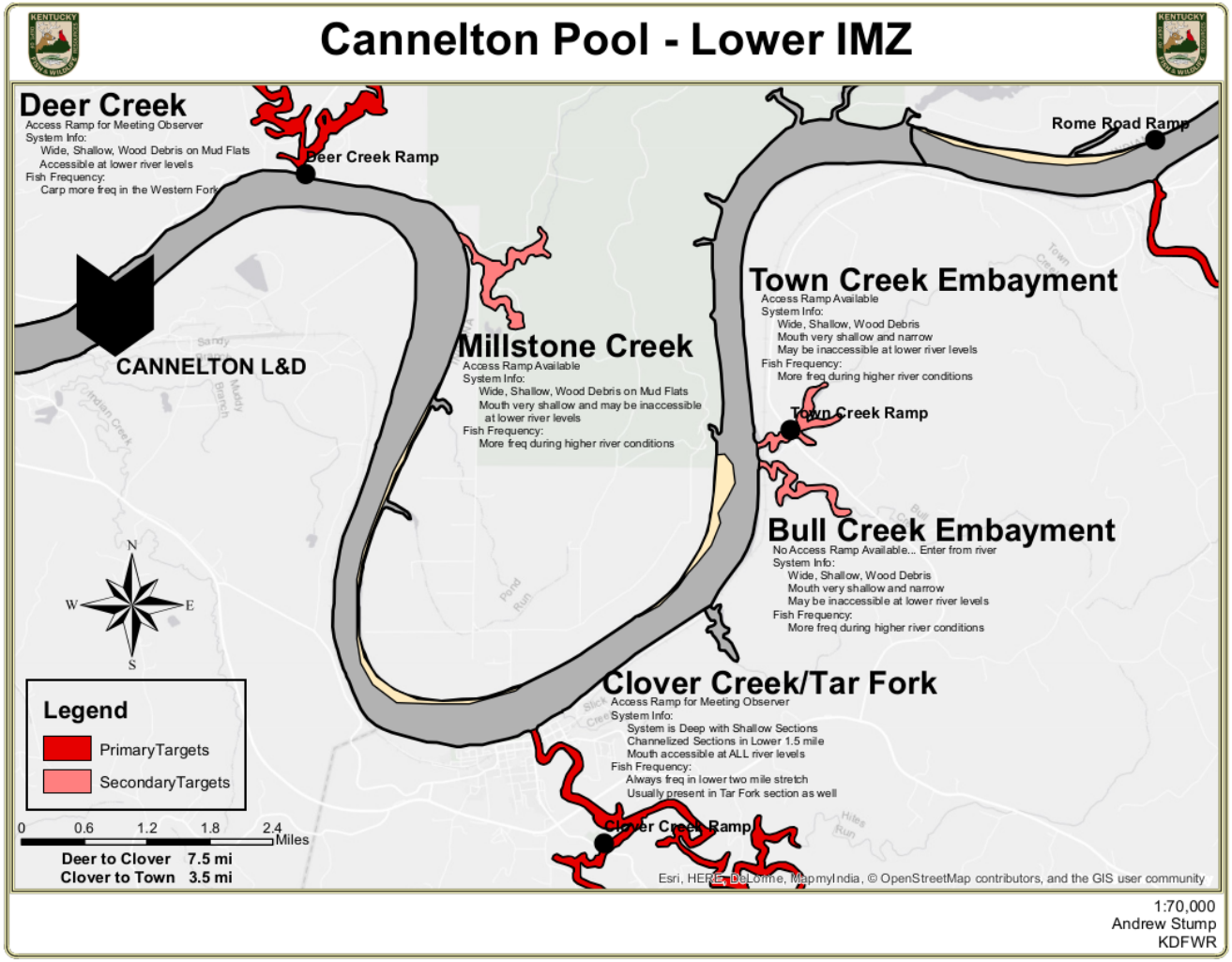

Figure 1. An example of the maps generated to help agency and contract fishing crews prioritize locations under different water conditions when conducting removal in the lower Cannelton Pool. This is one of five maps which were generated using monitoring and removal data collected over the past four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

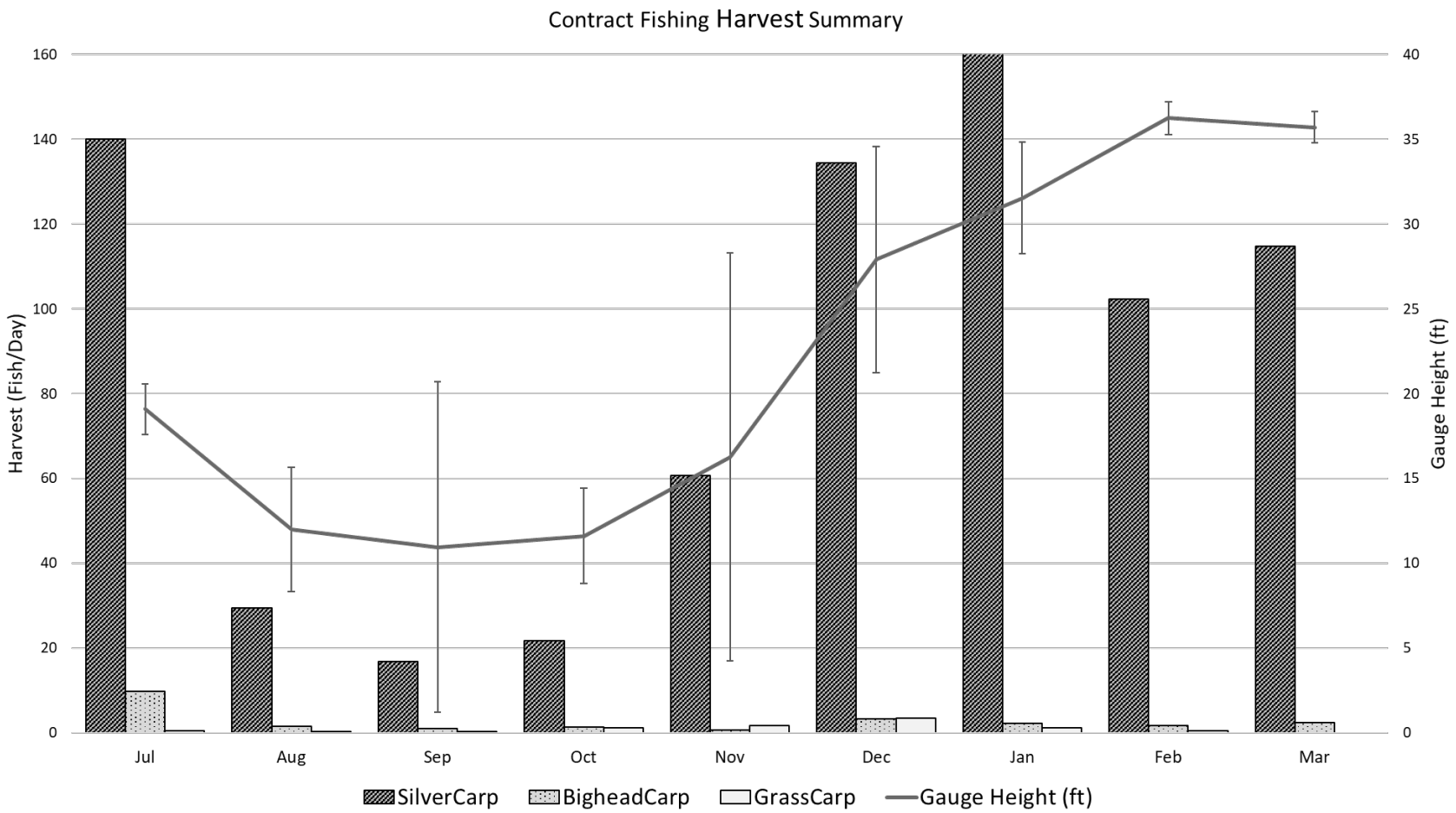

Figure 2. This graph shows the typical daily harvest (Fish/Day) by contract fishers in each month of the contract starting in July 2019 and ending in March 2020. In addition, the average gauge height in feet is also shown with the variation (standard deviation) in river level during each month. Typical daily harvests correlated well with river levels, suggesting that harvest success may depend on gauge height.

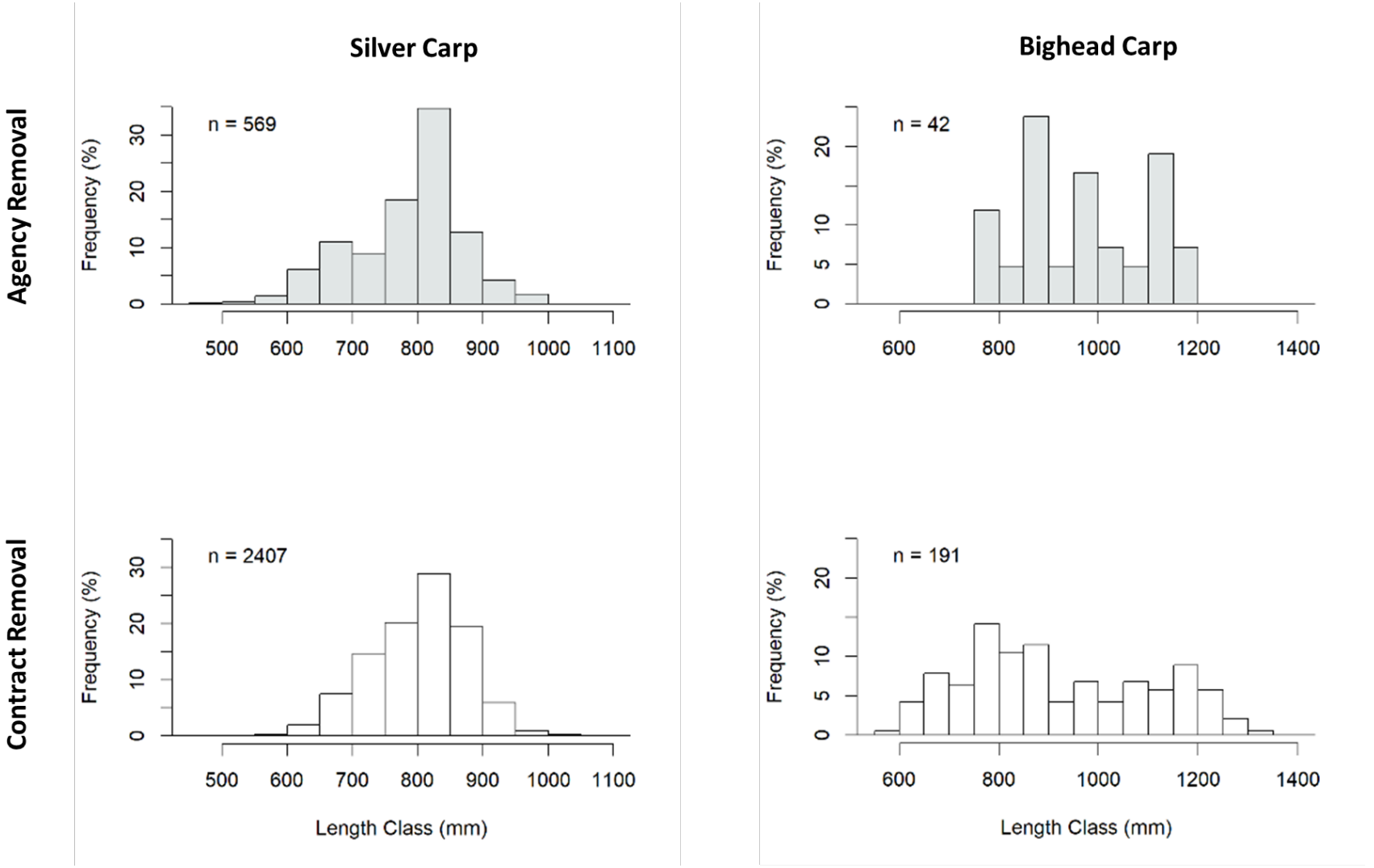

Figure 3. Histograms of the distribution in total lengths for fish captured in the Cannelton Pool by contract fishers and agency crews.

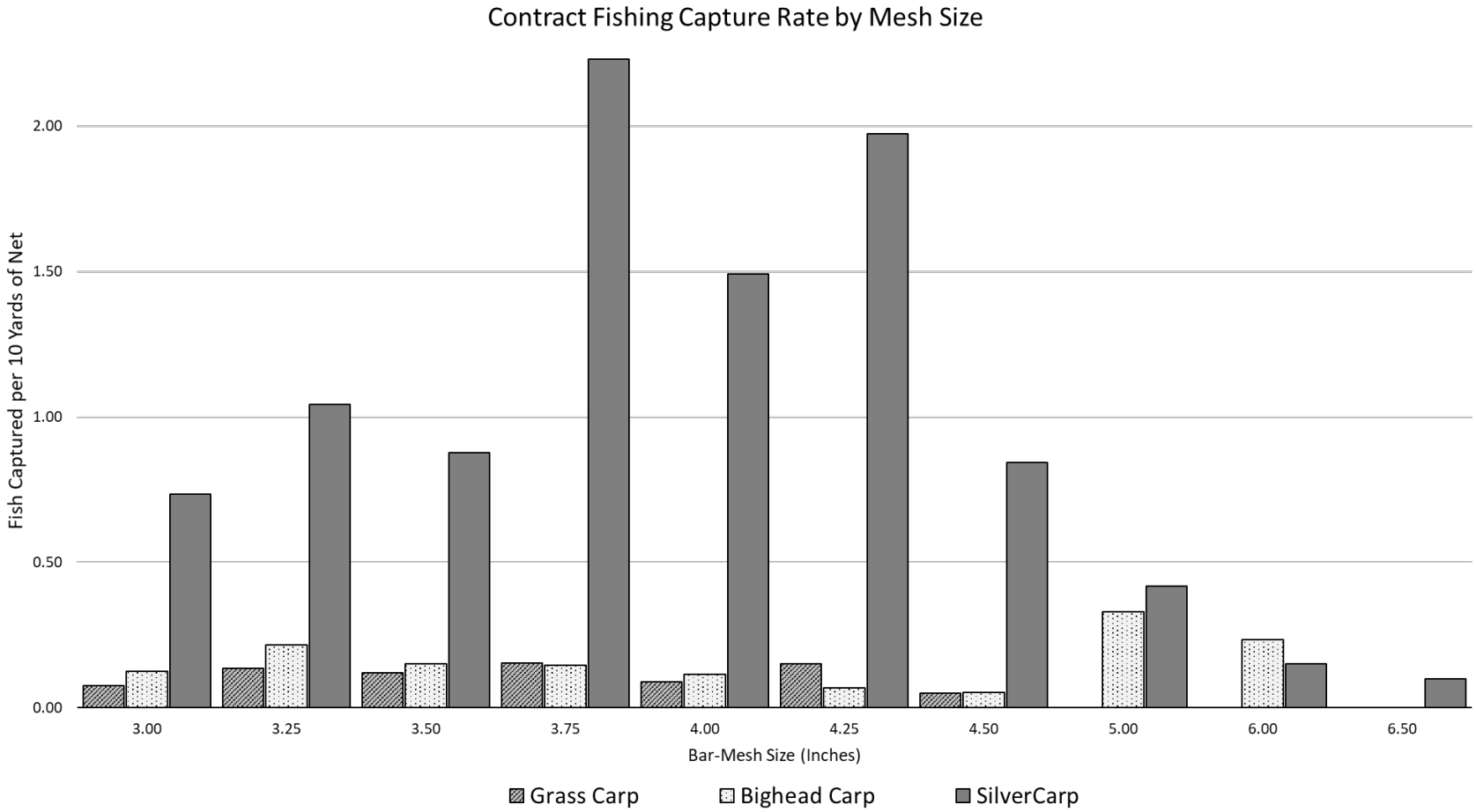

Figure 4. A bar graph showing the number of fish captured per 10 yards of net at different mesh sizes. The majority of fish in Cannelton Pool were caught in 3.75-inch to 4.25-inch bar mesh.

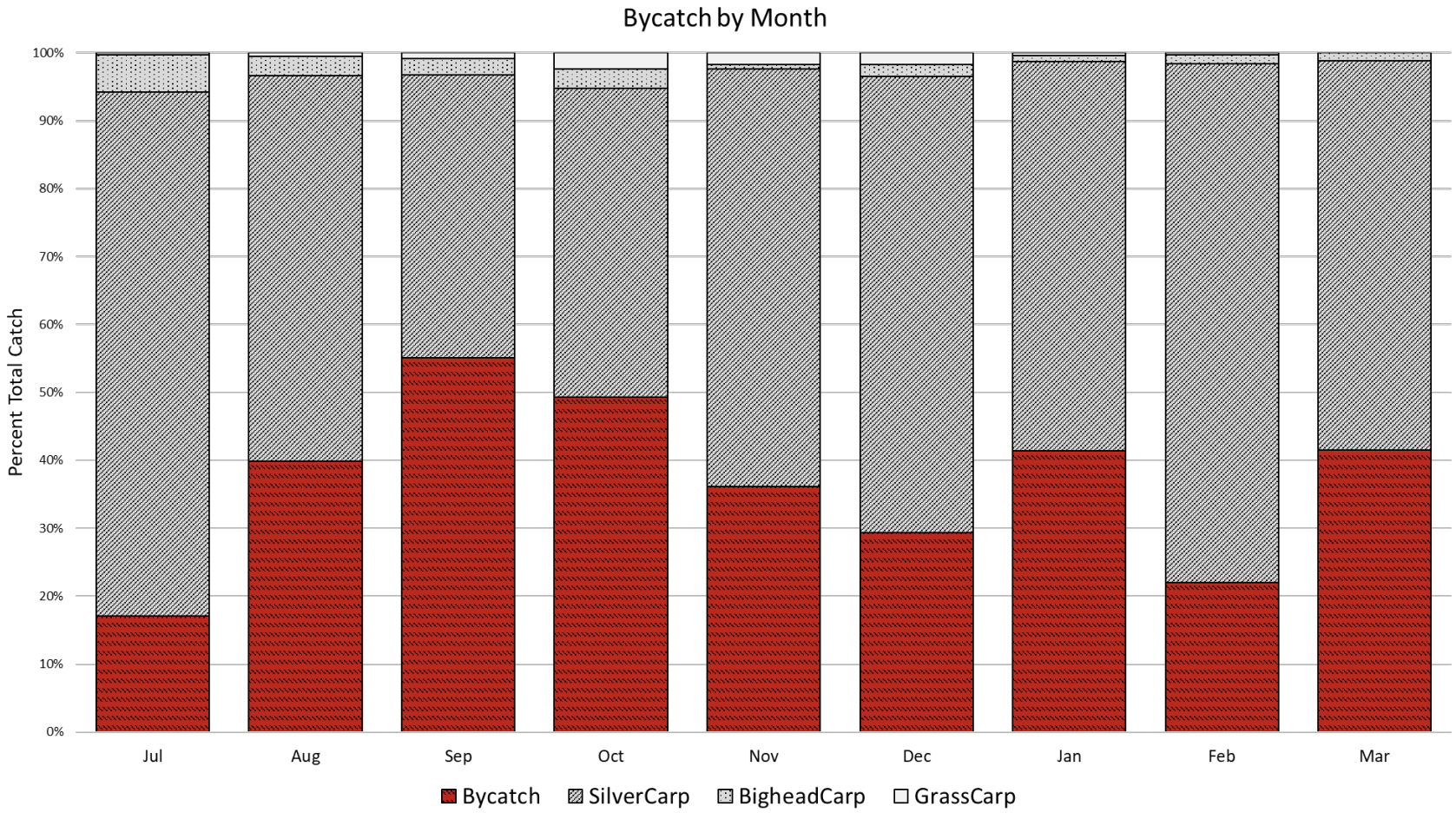

Figure 5. A bar graph showing the percent of total catch for three species of invasive Asian carp in relation to all bycatch species for the first nine months of the contract fishing program.

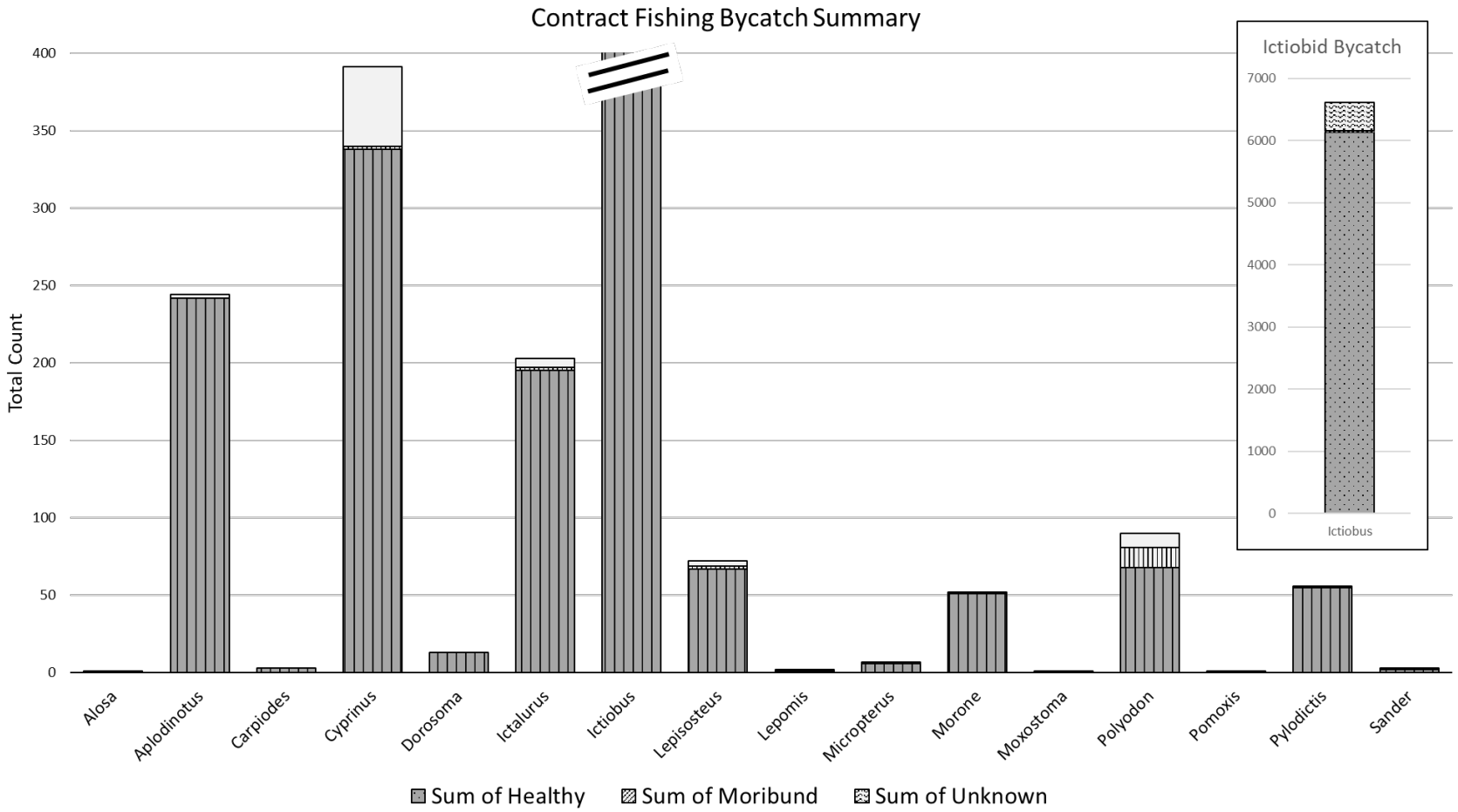

Figure 6. The total counts for all bycatch recorded during the first nine months of the contract fishing program. Each bar is broken down by the recorded health status of fish removed from contract fishing nets. Fish were marked unknown if the observer failed to record the status on the field datasheets.

Appendix C: Ohio River Contingency Response Plan

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Ohio River Contingency Response Plan

Participating Agencies: KDFWR, WVDNR, INDNR (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 to 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.

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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 few sightings and records. Fish in this section of river appear to be primarily adult and may be in numbers high enough successfully spawn, but there is no evidence of successful recruitment. Three pools ahead of McAlpine Dam is Greenup Locks 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 Locks 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 down in the Abundance and distribution of early life stages of Asian carp 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 is consider to extend 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 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 diploidy.

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

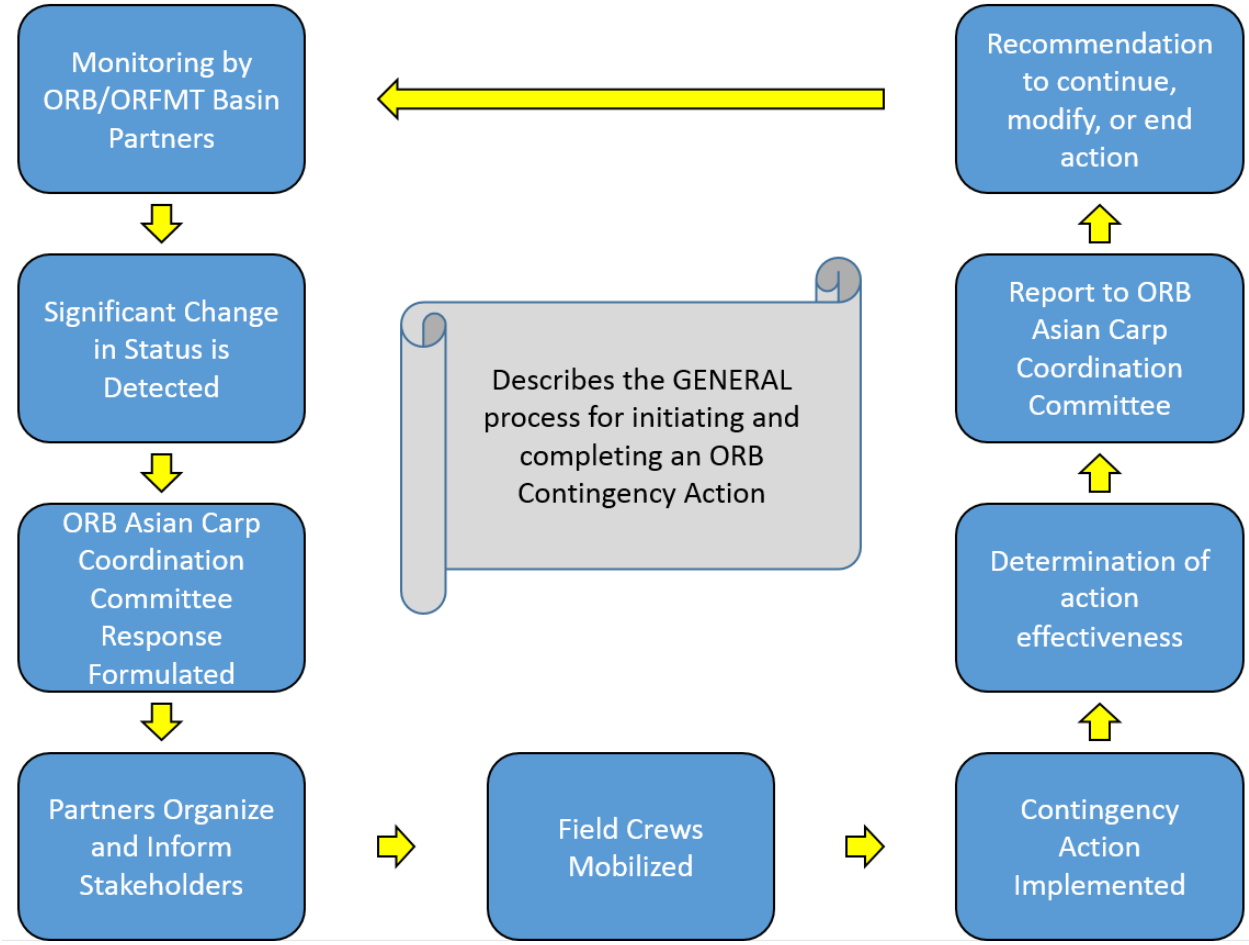
Planning Assumptions and Constraints:
These planning assumptions are to anticipate realistic situation, conditions, and possible constraints for partner groups:

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.

---Draft---

Overview of Response Action Workflow



Logistics and Resource Assumptions

- Section needs work…

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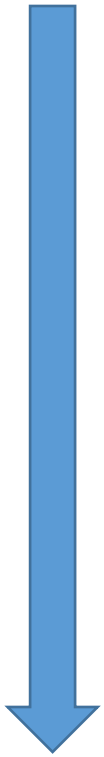
Decision Matrices:

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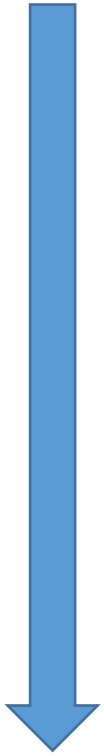
Black Carp	Pool	Eggs/Larvae			Small Fish (< 450mm)			Adult Fish		
		Rare	Common	Abundant	Rare	Common	Abundant	Rare	Common	Abundant
Direction of River Flow 	Emsworth									
	Dashields									
	Montgomery Isl									
	New Cumberland									
	Pike Island									
	Hannibal									
	Willow Island	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

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	$