

## **Control and Containment of Invasive 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 invasive carps (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 invasive 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 invasive 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 basin.
2. Implement a removal program using contracted fishers at intensive management zones to reduce invasive carp numbers across the Ohio River basin.

### **Project Highlights:**

- Approximately 50 hours of electrofishing effort was used to remove approximately 3,515 kg (~7,749 lbs) of invasive carp from the Ohio River in 2021.
- Approximately 4,221 meters of agency gill netting was used to remove approximately 3,722 kg (~8,205 lbs) of invasive carp from the Ohio River in 2021.
- Contract fishing efforts continue to remove increasingly higher numbers of invasive carps, with approximately 99,456 kg (~219,263 lbs) removed from the Ohio River in 2021. These efforts have not appeared to cause substantial impacts to native fish populations.
- It is imperative that fishing pressure continues in the Cannelton Pool and efforts upriver remain in place to reduce the number of fish capable of reproducing.

## **Methods:**

### *Clarification of Terminology Referenced in This Document*

With the current rate of invasive 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 invasive 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 (YOY) fish has not been observed.

Invasive Carp – one of four species (i.e. Silver Carp, Bighead Carp, diploid 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.

### *Agency Removal of Invasive Carps*

Removal efforts using electrofishing and gill netting was reduced in 2021 due to COVID-19 protocols. Additionally, hiring delays and personnel shortages prevented INDNR from completing most of their anticipated agency removal efforts. 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 (3.75" – 5.0" square) and generally fished by driving fish toward the nets using boat noise or electricity.

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 have been created to aid both agency crews and contract fishers when targeting fish for removal in Cannelton Pool (Figure 1).

In an effort to augment monitoring gill netting, WVDNR conducted removal efforts throughout the R.C. Byrd Pool of the Ohio River in 2021. Efforts were focused on Raccoon Creek and the old lock chambers at the R.C. Byrd Lock and Dam complex.

Carp and all bycatch were identified in the field to the lowest possible taxonomic level. All bycatch was immediately released. Invasive 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.

Multiple agencies aided in a joined effort to collect aging structures from Silver Carp across the Cannelton, McAlpine and Markland pools in 2021. Samples consisting of over 280 otoliths collected in both Cannelton and McAlpine Pools, and 36 otoliths from Markland Pool. Otoliths were harvested, processed, and aged for length at age analyses. INDNR also collected Silver Carp otoliths from 107 fish

in J.T. Myers Pool, 136 fish from Newburgh Pool, and 60 fish from the Wabash River for microchemistry analysis.

In 2021 KDFWR visited the Salt River in Shephardsville to investigate the upstream population of invasive carp and their population structure. We assumed that Silver Carp are establishing themselves throughout the Salt River with the large stretch of restricted waters as it flows through Ft Knox. Surveys upstream help us understand the population dynamics within Salt River and recommend management protocols. During upstream investigations on the Salt River KDFWR removed 17 Silver Carp.

#### *Contract Fishing Program*

The contract fishing program began in July of 2019. In 2021, eight fishers participated in the program and fishing was suspended over approximately two months when water temperatures were high and fish were difficult to catch. When fishing resumed in October, harvests were high and fishers continued to maintain relatively high yields through the cooler months. Contracted fishers were given access to mainstem river, tributaries, and embayments within the Cannelton Pool to target invasive carp species. All bycatch was recorded and released immediately and morbidity of non-target species was tracked. On-board observers collected additional data including total length, sex, and weights on 20 randomly subsampled Silver and Bighead Carp each day.

The contract fishing program was optimized in 2021 by limiting the harvest season to months with peak harvest yields. This allows program funds to support higher yields and overall higher success. Contract fishers also implemented group fishing, where up to five fishers team up and fish a single tributary.

Contract fisherman were given permission to run their fishing gears in the McAlpine Pool for a short trial period to determine potential success and expansion of the intensive management zone. After two days in late November with very little success, contract fishermen were moved back to Cannelton Pool where harvest numbers increased.

#### **Results:**

##### *Physical Removal of Invasive Carps*

Approximately 50 hours were spent boat electrofishing in three pools of the Ohio River and its tributaries between Cannelton and Meldahl (Table 1). Seven hundred and fifty-five carp were removed using boat electrofishing over these three pools in 2021. The highest level of effort was expended in the McAlpine Pool and a total number of 425 carps, weighing approximately 1,881 kg (4,147 lbs.), were removed. INDNR conducted one removal event in the West Fork White River. Two hours of electrofishing effort produced 500 Silver Carp and four Grass carp weighing approximately 1,600 kg (3,528 lbs).

A total of 4,221 meters (13,848 ft) of large mesh (3.75" – 5" square) gill nets were used to capture 691 invasive carps in three pools of the Ohio River (Cannelton – Markland) (Table 2). This amounted to 3,722 kg (~ 8,205 lbs.) of Bighead, Silver, and Grass Carp combined. The largest amount of effort was expended in the McAlpine Pool with 2,484 meters (8,149 ft) of net fished. Gill netting alone can be less productive than boat electrofishing for agency crews, but it is an effective gear for targeting large aggregations of invasive Silver Carp or for capturing Bighead carp. Entrapment gear paired with electrofishing has proved to be the most successful combination of gears for large scale removal events.

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 2021 gill net effort were Smallmouth Buffalo (~ 44% overall bycatch), Blue Catfish (~ 20% overall bycatch), and Freshwater Drum (~ 19% overall bycatch). The additional 17% of remaining bycatch consisted of Common Carp, Flathead Catfish, Longnose Gar,

Hybrid Striped Bass, Paddlefish, Striped Bass, and one of each Smallmouth Bass, Skipjack Herring, Channel Catfish, and Bigmouth Buffalo (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 at a time.

Upstream investigation of the Salt River in Shephardsville by KDFWR resulted in 17 Silver Carp removed in 2021. Lengths of Silver Carp ranged from 729mm to 579mm, and averaged 648mm. Average weight associated with these captures is 2.54kg. Female carp make up the majority of these captures at ~%60 of the catch. With total lengths less than the main stem Ohio average, this likely hints at the need for inclusion of population control in internal waters. We thought we would find 2 year old fish, but instead found small 4 and 5 year olds.

WVDNR's removal efforts yielded large adults of both carp species. A total of three removal events were conducted with a total of 457 meters (1,500 ft) of gill netting. Three large Bighead Carp were removed in Summer 2021. Additionally, snagging efforts at the R.C. Byrd Lock and Dam complex removed two invasive carp.

#### *Contract Fishing Program*

Contract harvest in 2021 aided removal success despite limitations from COVID-19 precautions and issues with tributary access. Nineteen thousand nine hundred and thirty-three invasive carp were removed through contract fishing efforts within the Cannelton pool of the Ohio River in 2021, approximating a total of 99,456 kg (~219,263 lbs). Disposal of harvests were not rigorously tracked, but most if not all fishers communicated or provided receipts indicating that harvests were typically sold. 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 not possible under the current program structure, but several strategies are being explored to provide this level harvest during highly productive months throughout the year.

Comparing the daily averages by fisher when focusing on the peak harvest months from the past two years shows a general increase in average harvests (Figure 2). Error bars indicate a decrease in fluctuation of daily harvest averages, suggesting that recently implemented strategies for contract fishers is stabilizing and increasing harvest yields.

Individual average daily catch rates for fishers were highest in the month of February 2021 (Figure 3), and daily harvest appears to be correlated with river gauge height and cooler water temperatures. Gill nets were the only capture gear used over the ten-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 130 mm to 1090 mm with the greatest frequency of catch falling between 800 – 850 mm (Figure 4). Bighead and Grass carp catches were infrequent, with Grass Carp commonly around 750 to 950 mm in total length, and Bighead Carp between 850 and 1150 mm.

Bycatch from contract effort was highest in January and December 2021 with 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 captured in the data record. Ictiobid species were the most common bycatch making up 81% of non-target catch. Freshwater Drum (*Aplodinotus*), Common Carp (*Cyprinus*), and Catfish (Ictaluridae) were the next three most encountered bycatch in contract net sets (Figure 6). Paddlefish were the eighth most frequent bycatch encountered and

made up approximately 0.8% of all the bycatch recorded by contract observers. However, only four individuals from of all Paddlefish captured were either DOA or close to death after being pulled from nets.

### **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 in total length were regularly observed, it was considered the farthest upriver pool within the establishment zone. This was confirmed in 2021 after a large year class of invasive carp recruits were captured for the first time on record. Cannelton is currently regarded as the upmost range of invasive carp establishment and is prioritized as a major target for implementing population control actions.

In 2021, eight fishers were on contract to provide 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 contracted removal services were paused during August and September. Upon restarting commercial harvest in October, target fish yield was nearly three times the yield as the previous October. This increase is likely partially due to the optimization of contract fishing practices where fishers were grouped together in single tributaries to fish, as well as the pause in fishing from previous months. While additional years of data are necessary, information herein suggests that a decrease or suspension in fishing effort during the summer months may help reduce impacts to bycatch and focus fishing effort over cooler seasons where larger harvests and greater impacts are attainable. There was a brief window during late 2021 when regulatory issues prevented contract fishers' access to Indiana tributaries. This led to fewer available fishing locations in Cannelton Pool and caused lower than expected harvest levels throughout November and December. Access to Indiana tributaries was re-established in January, 2022.

Agency crews were able to supply recommendations based off 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. Programmatic changes included combining fishermen effort in tributaries and embayments where to increase focus and harvest capacity. This method was effectively adopted by contract fishermen in 2021 and recent success supports continuing efforts to increase fishing efficacy by scheduling fishers in groups.

Fish removed from Salt River in Shephardsville had total lengths averaging less than the main stem Ohio River averages. KDFWR assumed the fish we caught were two years old when removed from this location, based on their lengths. When aged in the lab, the resulting otoliths were dominated by 4 and 5 year old fish. This likely hints at the need for more inclusion of population control in internal waters.

Most bycatch was reported as released and unharmed by on-board observers. The frequency of Paddlefish morbidity slightly increased compared to numbers seen in 2020. Ictiobids appear to be the most common bycatch followed by Freshwater Drum, Common Carp, and Ictalurids. In all three cases, the vast majority of fish appeared unharmed 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 invasive carp because of their evasive habits and tendency to accumulate in large groups.

Currently, pairing electrofishing with gill nets has produced the most success for agency crews when targeting invasive carp for removal efforts. Schools of carp can be located with side-scan technology, while groups can be herded using electricity to move fish into entrapment gears. However, capture success is highly dependent on the experience of the driver and dipper and nets often must 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 netting gear.

**Recommendations:**

It is imperative that fishing pressure is sustained or increased throughout the course of our control efforts in the Cannelton Pool to help protect and reduce migration 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 and coordinate additional effort into multi-agency removal events in hotspot areas such as the Nugent Sand Pit in McAlpine Pool or 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.

## Literature Cited

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Appendix A: Tables

Table 1. Electrofishing effort (hours) and resulting catch of invasive carp (catch and weight) for three pools of the Ohio River during agency invasive carp control efforts in 2021.

<b>Pool</b>	Electro Effort (hr)	<b>Capture Number (N)</b>					<b>Total Weight (kg)</b>				
		Bighead Carp	Hybrid Bigheaded Carp	Silver Carp	Grass Carp	Total	Bighead Carp	Hybrid Bigheaded Carp	Silver Carp	Grass Carp	Total
Cannelton	10.7	0	0	290	3	293	0	0	1,314	18	1,332
McAlpine	21.7	0	1	424	0	425	0	13	1,868	0	1,881
Markland	17.7	1	0	35	1	37	0.1	0	295	7	302.1
Total	50.1	1	1	749	4	755	0.1	13	3,477	25	3,515.1



Table 2. Netting effort (meters) and resulting catch of invasive carp (number and weight) for four pools of the Ohio River during agency invasive carp control efforts in 2021.

Pool	Net Effort (m)	Capture Number (N)					Total Weight (kg)				
		Bighead Carp	Hybrid Bigheaded Carp	Silver Carp	Grass Carp	Total	Bighead Carp	Hybrid Bigheaded Carp	Silver Carp	Grass Carp	Total
Cannelton	884	5	0	316	4	325	48	0	1,564	30	1,642
McAlpine	2484	1	0	362	3	366	23	0	2,029	28	2,080
Markland	0	0	0	0	0	0	0	0	0	0	0
Meldahl	853	0	0	0	0	0	0	0	0	0	0
Total	4221	6	0	678	7	691	71	0	3,593	58	3,722

Table 3. Gill netting bycatch (N) by species for four pools of the Ohio River during agency invasive carp control efforts in 2021.

Species	Ohio River Pools in 2021				Totals	Percent Total Bycatch
	Cannelton	McAlpine	Markland	Meldahl		
Bigmouth Buffalo				1	1	< 1
Blue Catfish		58		1	59	20
Channel Catfish		1			1	<1
Common Carp		9		6	15	5
Flathead Catfish	1			6	7	2
Freshwater Drum		54		1	55	19
Longnose Gar	1	9			10	3
Paddlefish	2	1		3	6	2
Skipjack Herring		1			1	< 1
Smallmouth Bass		1			1	< 1
Smallmouth Buffalo	2	104		22	128	44
Striped Bass		1		1	2	< 1
W/S Hybrid Bass		7			7	2
Total	6	246		41	293	

## Appendix B: Figures

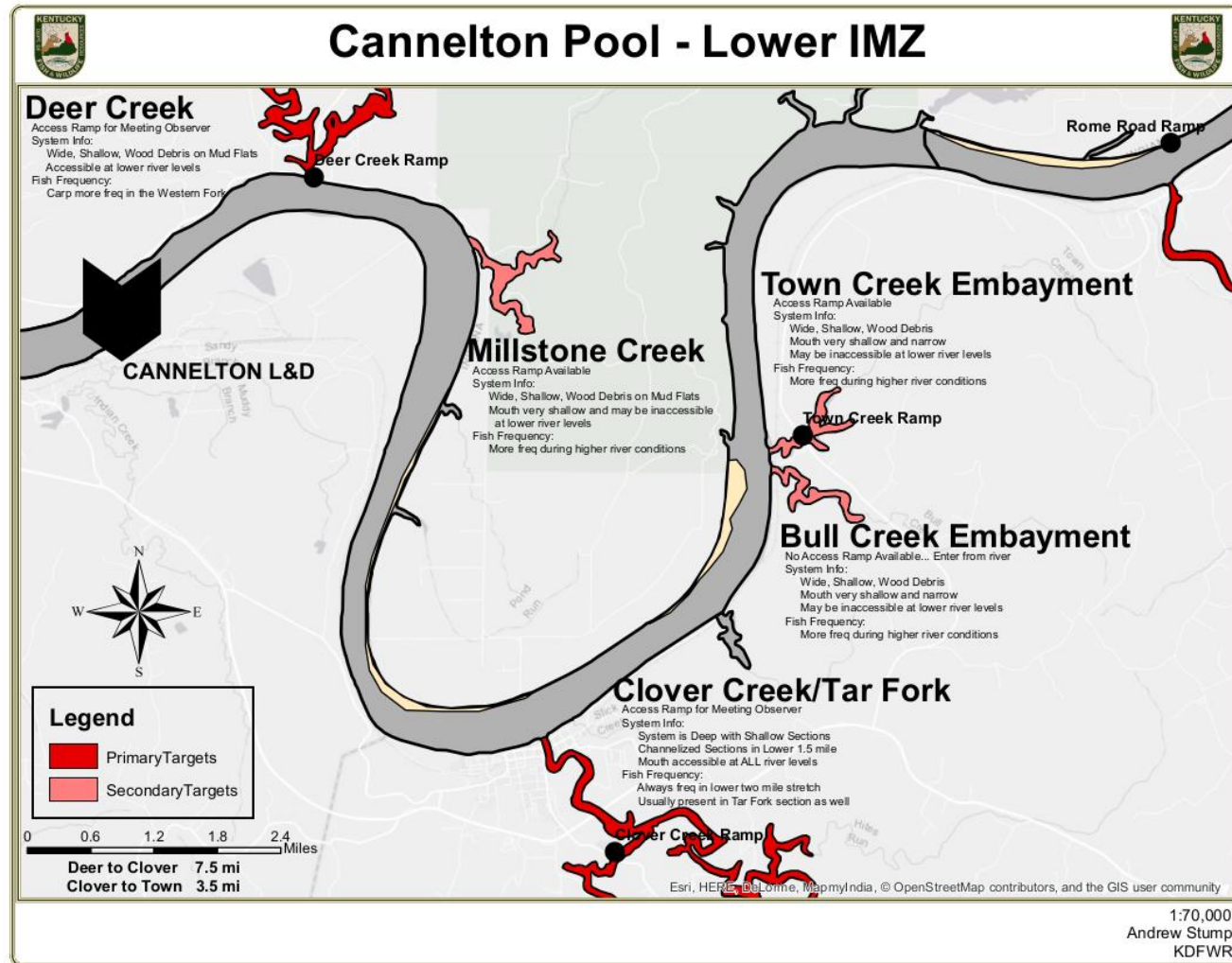


Figure 1. An example of the maps generated to help agency and contract fishing crews prioritize locations under different water conditions when conducting removal in the lower Cannelton Pool. This is one of five maps which were generated using monitoring and removal data collected over the past five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

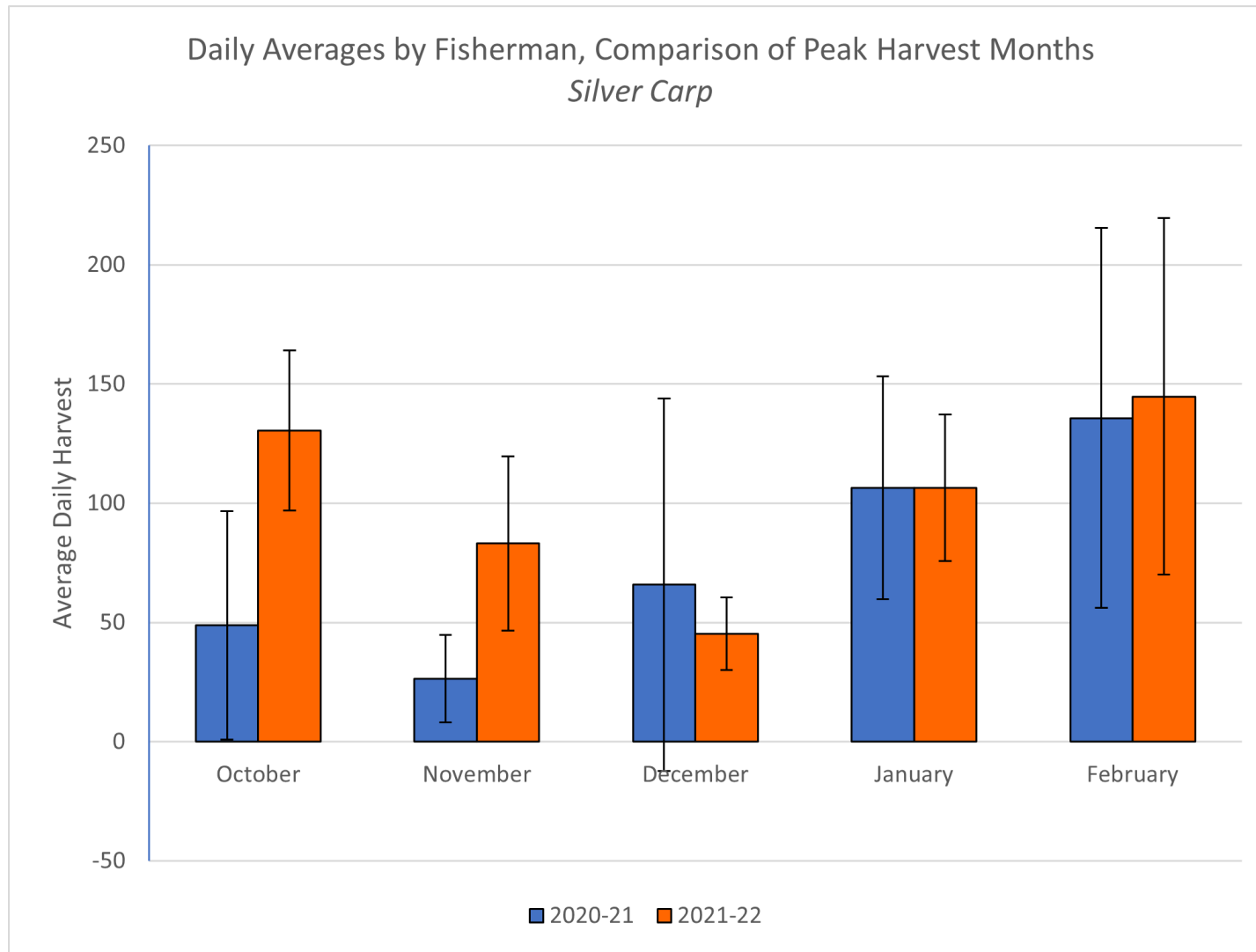


Figure 2. Graph shows the difference in average daily silver carp harvests for peak months from the past two contract fishing seasons. Error bars indicate SD.

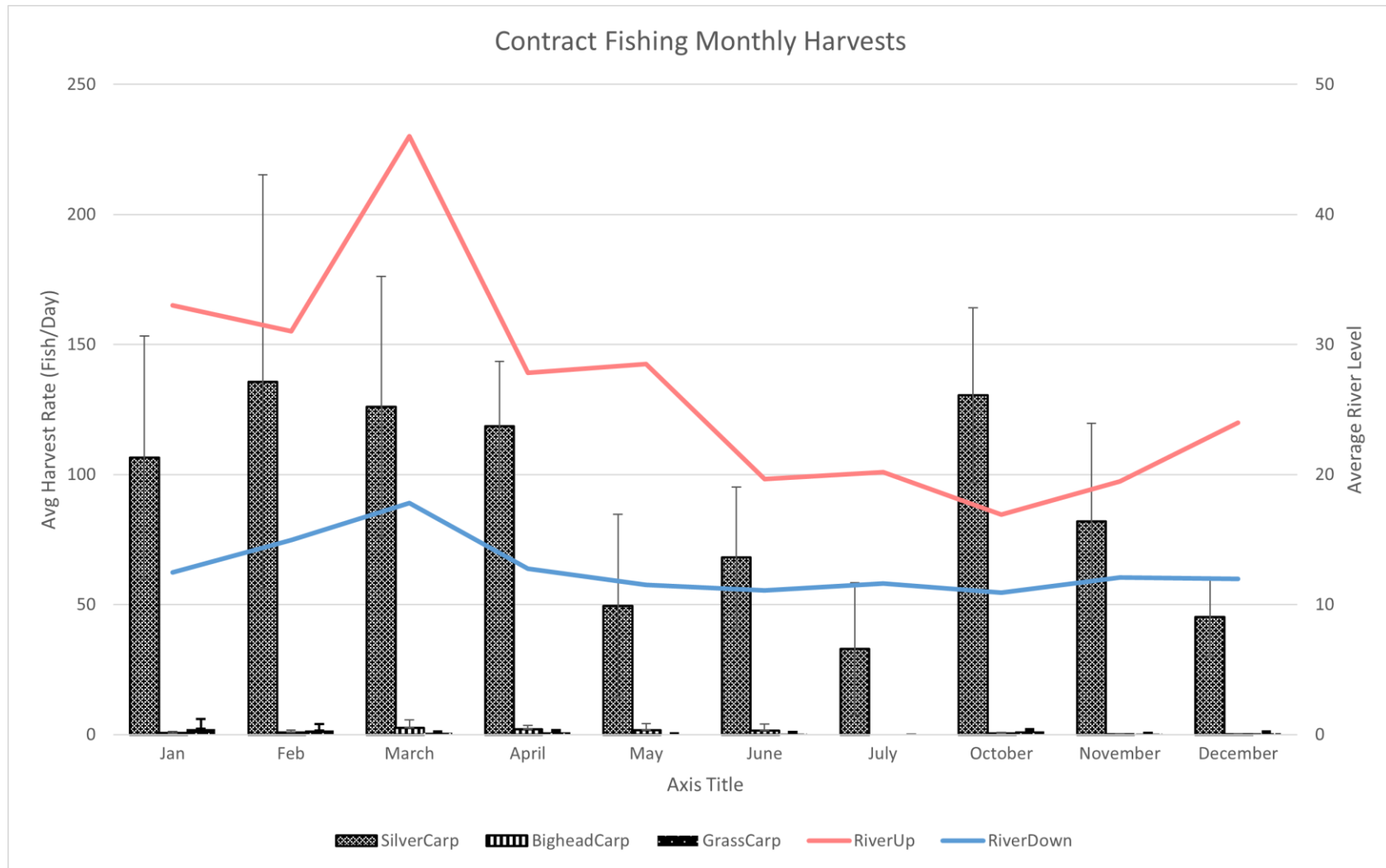


Figure 3. The average daily harvest rates (Fish/Day) by contract fishers for each month employed from January 2021 through December 2021 with error bars representing the standard deviation in daily catches. In addition, upper and lower bounds for the river level is shown using data collected from gauge height measurements reported on the USGS WaterWatch site (<https://waterwatch.usgs.gov>, 2021). Increases in average daily landings generally correlate with higher river levels and cooler months.

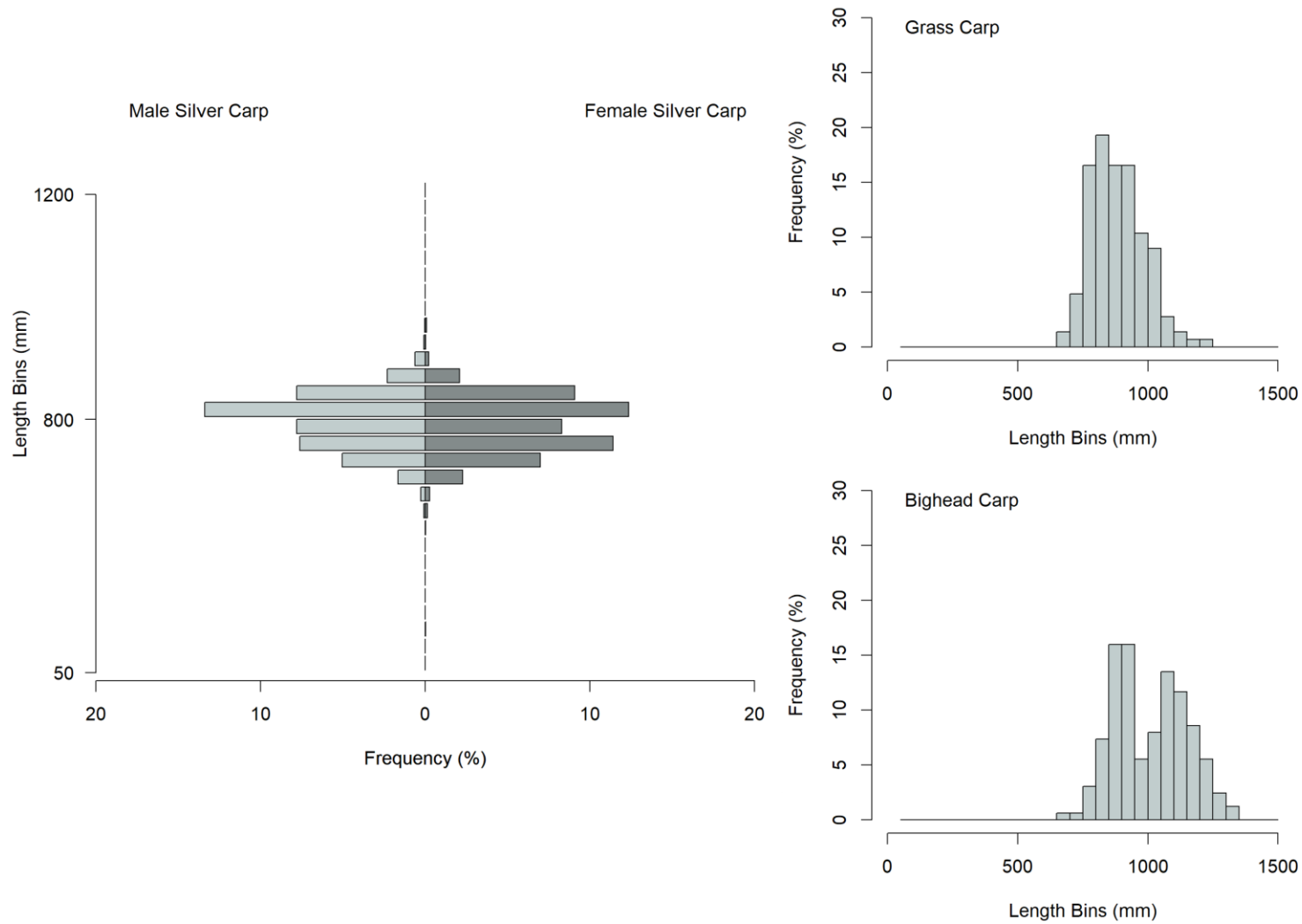


Figure 4. Histograms of the distribution in total lengths for fish captured in the Cannelton Pool by contract fishermen.



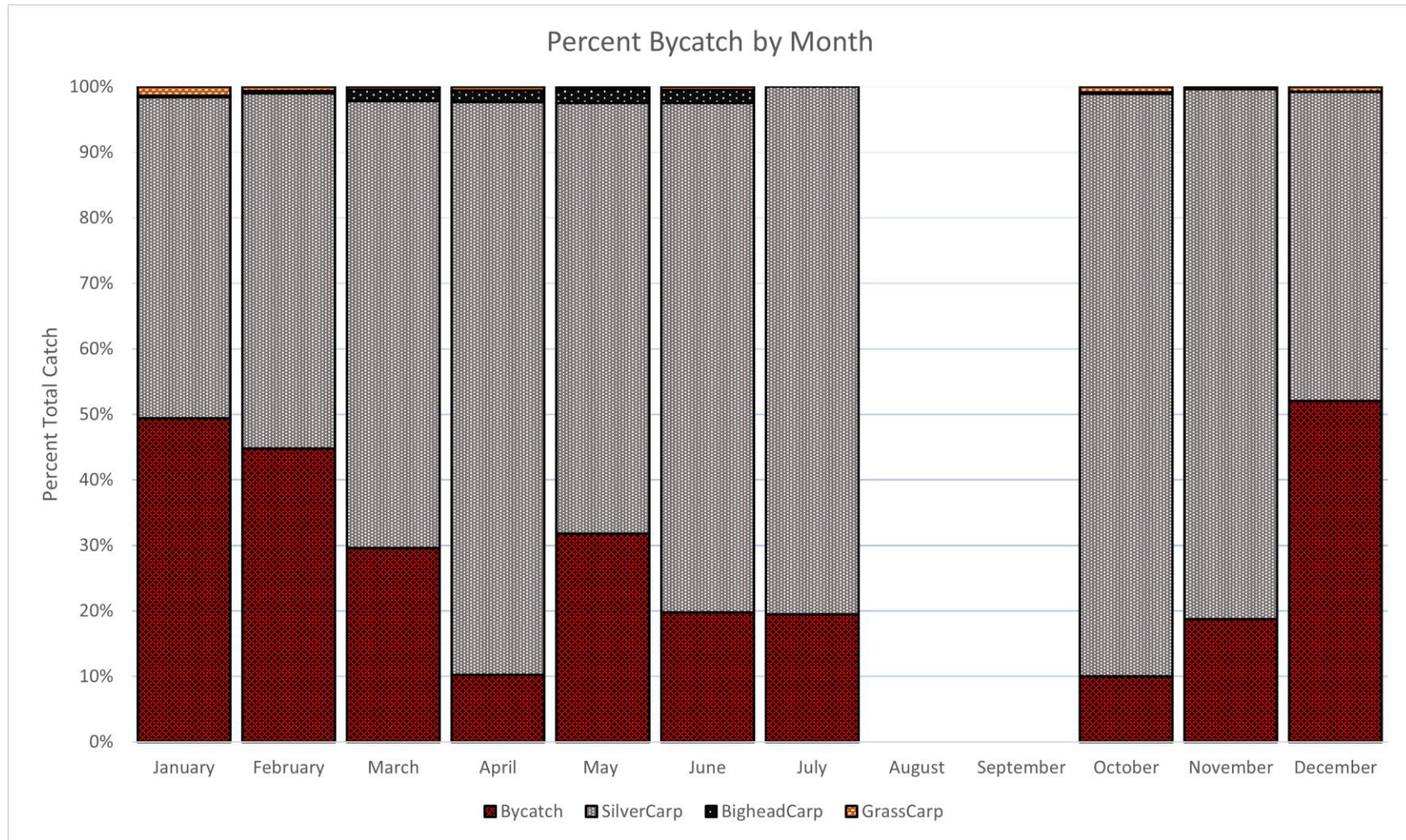


Figure 5. The percent of total catch for contract fishing efforts when considering all bycatch species in relation to the three of the target species of Invasive carps from January through December 2021.

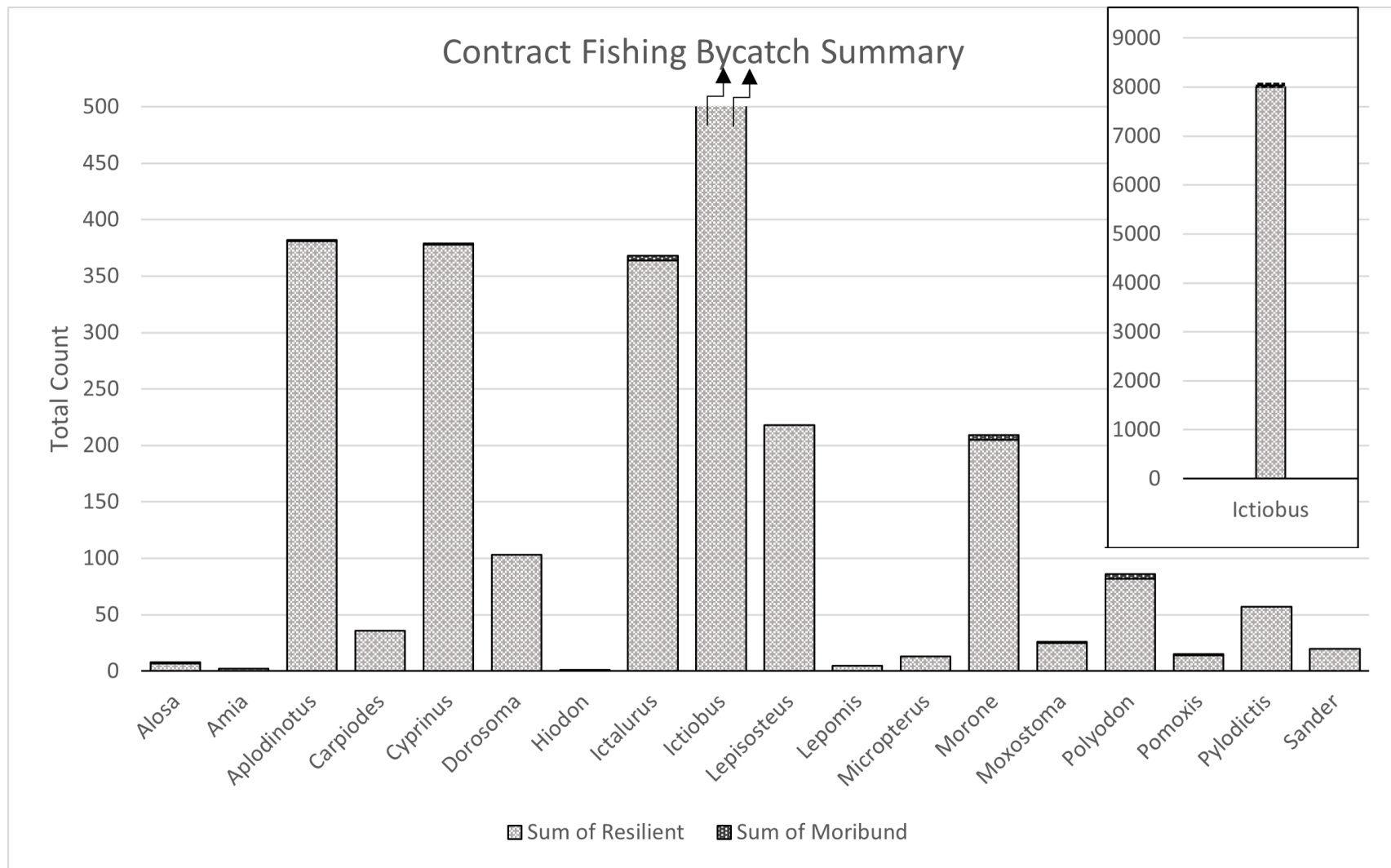


Figure 6. The total counts for all contract fishing bycatch recorded from January 2021 through December 2021. Each bar is broken down by the recorded status of fish removed from contract fishing nets. Fish were marked moribund if it appeared to have suffered significant damage or could not swim off after release. Fish were marked resilient if they recovered quickly and swam off under their own power.