Project Title: Control and containment of invasive carp in the Missouri River Basin

Geographic Location:

- Lower Missouri River, from river mile 550 to river mile 200. Mid-sized Missouri River tributaries including Lamine River, Platte River, Nodaway River, and Grand River. Waterbodies including Big Lake.
- Kansas River from WaterOne Dam (Edwardsville, KS, RKM 24) to immediately below the Bowersock Dam (Lawrence, KS, RKM 60).

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Statement of Need:

Invasive carps (Bighead Carp, Black Carp, Grass Carp, and Silver Carp) have become established in many portions of the Mississippi River basin since the 1970s. Establishment of invasive carp populations have the potential to cause ecological, recreational, and economic harm. Effective and efficient methods of containing (i.e., preventing range expansion) and controlling (e.g., mass harvest) invasive carps are needed to prevent/minimize further impacts.

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MDC, in cooperation with USFWS – Columbia, has evaluated multiple bighead carp and silver carp removal methods and identified areas with a high probability of capture. Pilot evaluations focused on removal methods, site identification, and gear procurement. Targeted sampling for the pilot evaluations were conducted in the Missouri River between RKM 0 and 885, including select tributaries and cutoff lakes, using a suite of gears. Efforts conducted during fiscal year 2021 were needed to continue refinement of methods used to remove invasive carp and focused on identifying discrete habitat types with high densities of bighead and silver carp in the Missouri River between, primary tributaries, and cutoff lakes. Age and size structure data was collected to estimate pre-removal mortality. Multiple gears were deployed at variable levels of effort targeting removal of bighead and silver carp.

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The Kansas River drains approximately the north half of the state of Kansas and a portion of south-central Nebraska and flows east to its confluence with the Missouri River at Kansas City. The Bowersock Dam at Lawrence, Kansas serves as a barrier to the upstream movement of invasive carp except during periods of exceptionally high flow (approximately >120,000 cfs). Only six (6) Bighead Carp have been documented upstream of this barrier. These fish likely passed over the Bowersock Dam during extreme flooding in 1993. At that time, invasive carp

populations in the Kansas River were very low and the number of fish that migrated upstream over the dam were insufficient to establish breeding populations in the upper portion of the river basin. The Kansas River basin contains multiple flood control reservoirs upstream from the Bowersock Dam that largely mitigate high flow conditions on the mainstem river except for short-lived flooding that occurs immediately after extraordinary rainfall in the unimpounded portion of the basin.

Removing invasive carp downstream from the Bowersock Dam would reduce the number of fish that may attempt to pass over the dam during a high flow event, decreasing the potential for a breeding population to establish upstream of the dam. Long-term, KDWP is exploring ways to install a barrier at the Bowersock Dam that would prevent passage over the dam during high flow events. The fish removal described in this proposal will be a temporary stopgap to provide time to work toward a more permanent solution.

In addition to the upstream barrier (Bowersock Dam), there is a downstream semi-passable barrier (WaterOne Dam at Edwardsville, KS) that limits further upstream movement in the Kansas River from the Missouri River during normal flows. Data from a 2017-2018 study found that the demographic data for Silver Carp in the section of Kansas River proposed to be fished are different than those of fish in the lowest portion of the Kansas River. Therefore, we do not expect harvested fish to be quickly replaced by migrants. In addition, very few juvenile invasive carp were encountered in the section of river proposed to be fished; most fish will be vulnerable to commercial harvest.

Project Objectives:

1) Determine the feasibility and exploitation of various removal techniques on adult and juvenile bighead and silver carp and the effects on other fish species in the Lower Missouri River basin to inform control actions.
2) Remove invasive carp downstream of Bowersock Dam to provide a buffer against upstream range expansion should the dam be inundated during a high flow event.

Project Highlights:

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- Gill net efforts removed 2,208 lbs (1,001 kg) of invasive carp spp. in 2021 and silver carp comprised 87% of the total.
- Evidence of mesh size in experimental nets to maximize gill net effectiveness for local invasive carp size structures in Missouri River and associated tributaries is becoming more apparent.

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- A contract between KDWP and a commercial fisher is in place. The contractor has completed exploratory/experimental site visits and documented challenges associated with removing invasive carp. A disposal site has been located and prepared, and contractor is prepared to remove invasive carp when target river conditions return.

Methods:

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Locations to test gill net efficiency and removal efforts were selected based on areas of high carp abundance from the Carp Population Demographics study. This resulted in select pool and bar habitats behind dike structures in the mainstem Missouri River near river kilometers 325, 338, and 629. In the lower 10rkm of tributaries pool habitats in outside bends or below bridges were selected.

Several different gill net configurations and techniques were conducted between October and December of 2021 for carp removal efforts. Nets varied in length between 45.75m-121.92m depending on width of area to be sampled and depths between 2.4m-4.9m. Gill net mesh was either 8-ply twisted monofilament or multifilament nylon in 1.5-inch (38.1mm), 2-inch (50.8mm), 3-inch (76.2mm), 4-inch (101.6mm), and 5-inch (127mm) sizes. Herding with electrofishing and stationary sets (no herding) were both used. Nets were either set overnight or for timed sets. For timed sets, soak time did not exceed 6 hours. All sets were in temperatures below 20 degrees C to reduce impact to other species. Nets were used in combination with each other. Some nets were used in conjunction with natural or manmade features to block off potential escape routes while others were placed inside of other gill nets to help facilitate capture.

Lamine River: Nets were set in combination with one another. The set included: 1) off the dike and stretched across the bottom of a scour pool to sandbar on the inside of the dike completely blocking off the pool, 2) at the dike and curved into the pool on inside of dike, 3) off the dike near where it meets the bank and stretched out parallel with current, and 4) between the bank and sandbar downstream of other nets (Figure 1).

Grand River: Multiple configurations and combinations of gill nets in addition to overnight and timed sets were experimented with in the Grand River and Missouri River bend associated with the confluence of the Grand River. For sets in the Missouri River, gill nets were used to block fish behind the dike structures by setting from the dike to inside sandbars. Next gill nets were used to close off any potential escape routes through dike notches or behind sandbars. Other gill nets were set at steep angles from sandbars or rock structures to form a funnel into block nets but also trap fish between the bank and net. (Figures 2 - 4). Sets consisted of using 5-6 gill nets in combination. In the Grand River, sets used a combination of 6 nets. A gill net was set bank to bank on the downstream end of a deep pool. Two more gill nets were set at steep angles from shore to make a funnel into the downstream gill net acting as a block net. Three additional gill

nets were set on the upstream end of the pool in parallel and running bank to bank. Wind allowed the nets to sag into a U-shape. No herding was used (Figure 5).

Platte River: The Missouri River set at the mouth of the Platte River consisted of using a combination of 8 nets. Two nets were used to block off the dike pool by stretching from the dike to a sandbar. The area within the dike pool was sectioned off into zones using 4 gill nets. Electrofishing settings of 40 pps 20% duty cycle 21 Amps and 130 Volts were used to herd fish out of each zone towards the back of the dike. Once herding was done, a gill net was used to block off the remaining area and a different gill net was used to seine towards the back corner to trap fish (Figure 6).

Nodaway River: At each pool sampled, a single net was set bank to bank below the pool. Starting at the top of the pool, 15 minutes of electrofishing was used to herd fish into net. Electrofishing settings used were 60pps 40% duty cycle 24 Amps and 185 Volts. Once herding was done, one end of net was grabbed and then dragged to the other bank like a seine to trap fish (Figure 7-8).

All fish captured were identified to species, weighed (g), and measured (mm). All native species were released. Silver carp were removed, euthanized, and disposed. The mesh size fish were captured in was also recorded. Gill net catch per unit effort was calculated as fish per 100 yards of net. Relative weight of bycatch was calculated using the length specific standard weight equation for each species and results compared using an ANOVA on Ranks in SigmaPlot 14.5 by SYSTAT Software, Inc. Age data from early population demographic pilot work and year 1 of the Population demographic study that had agreement from 2 of 3 readers were used to create an age-length key. This key was used to assign ages to unknown-age fish based on length. Age frequencies were constructed for each combination of tributary and associated Missouri River bend. This data was then used to create weighted catch curves to estimate total annual mortality in FAMS (Slipke and Maceina 2014).

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KDWP consulted with other states conducting contract invasive carp removal to inform implementation of removal efforts in Kansas. A commercial fisher was contracted for removal of invasive carp and challenges related to invasive carp removal from the Kansas River were documented during initial explorations.

Results and Discussion:

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The techniques typically used to sample juvenile and adult fish populations with gill nets do not necessarily apply when sampling for Silver Carp. Multiple techniques and net combinations were applied in the last two years to shed some light on what may or may not work to sample Silver

Carp in the Missouri River and associated tributaries. Silver Carp gill net catch per unit effort (CPUE) ranged from 3.75 Silver carp per 100 yards of net in the Missouri River bend at the Lamine River mouth to 19.658 Silver Carp per 100 yards of net at the Missouri River bend at the Platte River (Table 1). However, the amount of effort at sites varied in 2021 and the Grand River and Missouri River bend at the Grand River accounted for 81% of the total effort in 2021. Silver Carp CPUE at the Grand River was 10.898 Silver carp per 100 yards of net and the Missouri River bend at the Grand River CPUE was 8.0 Silver Carp per 100 yards of net.

Overnight sets seemed rather ineffective compared to shorter duration timed sets. Timed gill nets resulted in a mean CPUE of 12.05 Silver Carp per 100 yards of net with a maximum of 81.43 Silver Carp per 100 yards of net. Whereas overnight sets resulted in a mean CPUE of 1.74 Silver Carp per 100 yards of net and a maximum of 9.43 Silver Carp per 100 yards of net. However timed sets had more flexibility in terms of locations and configurations compared to overnight sets. Overnight sets were almost all set in the Missouri River bends and efforts were made not to impede navigation of recreational boaters or local fishers. Whereas shorter duration sets could block off dike structures on the Missouri River or the entire channel in tributaries.

Sampling using electrofishing for herding into a single net proved mostly ineffective in a small handful of sets. Only 35 Silver carp were sampled from these efforts. Multiple gill nets set in configurations to trap or corral schools of Silver Carp typically yielded better results. Figure 4 is a diagram of the more productive net configurations used in Missouri River habitats yielding 79 Silver Carp and removing 205.5kg of invasive carps. Also, Figure 5 depicts one of the more productive net configurations deployed on the Grand River yielding 135 Silver Carp and removing 341.2kg of invasive carps.

Initial indications from field staff are that the size classes of silver carp that are most abundant in these areas can swim through the 5-inch mesh without entanglement and resulted in low yields as the fish typically find the weakest spot to challenge. Mesh size was reported for 60% of the Silver Carp captured with gill nets in 2021 sampling. Experimental nets with 3-, 4- and 5-inch mesh were used most often, however, some nets containing 1.5- and 2-inch mesh were also used. Silver carp lengths ranged from 371mm in 2-inch mesh to 921mm in 4-inch mesh and mean lengths ranged from 398mm in 2-inch mesh to 628mm in 4-inch mesh (Figure 9). There were only two Silver Carp recorded from 5-inch mesh so that should be taken into consideration with Figure 9. However, there was one Bighead Carp captured with 5-inch mesh that measured 1,058 mm. More samples with mesh size recorded need to be collected to validate Figure 9, however, it does provide preliminary data in need of observation for future gill net work. Previous gill net work done on the U.S. Army Corps of Engineers Pallid Sturgeon Population Assessment (unpublished data) showed that larger mean lengths of Silver Carp (>600 mm) were captured in larger mesh sizes (4 inch), but similar length ranges of fish were also captured in smaller mesh

sizes (2 inch to 3 inch). Appropriate mesh sizes for a given set may need to be dictated by the size classes of Silver carp in that location for maximum effectiveness.

Stationary sets had higher catches in nets set parallel or inside two gill nets acting as block nets. There was also evidence that days with increased wind and wave action on the water yielded higher catches. Wind and wave action anecdotally seemed to cause confusion amongst the schools of Silver Carp as they would continuously jump back and forth between nets with no electrofishing or boat motor sounds to illicit such a response. Even several hours after setting the gill nets fish were constantly jumping and entangling in the gear during periods of ten mph or higher winds. Whereas on calm days after an hour or so the area around the gill nets was for the most part calm with very few fish jumping or being disturbed. These observations lead one to hypothesize that Silver Carp may have trouble identifying the net presence and avoiding the net during increased wind and wave action. However, it could also be a factor of plankton being stirred throughout the water column and blown into the nets and Silver Carp pursuing its food source. All sampling efforts seemed to catch similar size Silver Carp with few fish below 400mm or above 900mm. Paddlefish and Buffalo species were common bycatch in most efforts (Table 3). Relative weights of common bycatch were similar for most species and between sites (Figure 10). However, paddlefish relative weights were significantly different ($P<0.05$) in the Grand River compared to the Missouri River bend at the mouth of the Lamine River. Future efforts will need to take into consideration efforts to not impact those populations.

Total annual mortality (AM) estimates were variable between tributary complexes ranging from 0.141 in 2020 to 0.211 in 2021 for the Lamine River (Table 2). Total annual mortality estimates from 2020 were used as estimates of natural mortality (v) since exploitation (u) was assumed to be zero before any of our removal efforts. Total mortality estimates in 2021 included both components of fishing and natural death; however, exploitation was low in 2020. Multiple-year trends in total annual mortality alongside removal efforts will be required to parse out mortality components.

Table 1. Total invasive carp gill netting efforts in 2021.

2021	Nodaway River	MO NR	Platte River	MO PR	Grand River	MO GR	Lamine River	MO LR
Netting Effort								
Total Yards of Net	200	0	0	117	2083	1050	0	400
Catch Effort[1]								
Total Invasive Carp (N)	14	0	0	23	244	86	0	15
Total Invasive Carp Weight (lbs)	51.5	0	0	133.7	1391	465.7	0	77.8
Total BHCP (N)	0	0	0	0	6	1	0	0
Total BHCP Weight (lbs)	0	0	0	0	81.1	12.3	0	0
Total SVCP (N)	12	0	0	23	227	84	0	15
Total SVCP Weight (lbs)	51.5	0	0	133.7	1183.5	443.3	0	77.8
Total GSCP (N)	2	0	0	0	11	1	0	0
Total GSCP Weight (lbs)	NA	0	0	0	126.4	10.2	0	0
Catch Per Unit Effort (CPUE)								
CPUE (BHCP/100 yds of net)	0	0	0	0	0.288	0.095	0	0
CPUE (SVCP/100 yds of net)	6	0	0	19.658	10.898	8	0	3.75
CPUE (GSCP/100 yds of net)	1	0	0	0	0.528	0.095	0	0
CPUE (Total AC/100 yds of net)	7	0	0	19.658	11.714	8.190	0	3.75

[1]BHCP = Bighead Carp, SVCP = Silver Carp, GSCP = Grass Carp.

Table 2. Intercept, slope (total instantaneous mortality; Z), total annual mortality (AM), survival (S), and maximum age estimates from weighted catch curve analyses by year and tributary complex.

Parameter	2020 Grand River	2020 Lamine River	2020 Nodaway River	2020 Platte River	2021 Grand River	2021 Lamine River	2021 Nodaway River	2021 Platte River
Intercept	3.3192	1.7046		3.7967	4.55	4.8721	4.1143	4.1944
Z	-0.2315	-0.1517		-0.1922	-0.2048	-0.2368	-0.2053	-0.1539
AM	0.207	0.141		0.175	0.185	0.211	0.186	0.143
S	0.793	0.859		0.825	0.815	0.789	0.814	0.857
Max Age	14.3	11.2		19.8	22.2	20.6	20	27.2

Table 3. Total bycatch of species captured with gill nets by river in 2021.

2021	Nodaway River	MO NR	Platte River	MO PR	Grand River	MO GR	Lamine River	MO LR
Family/Species								
Acipenseridae								
Shovelnose Sturgeon					1	4		7
Catostomidae								
Bigmouth Buffalo					15	9		2
Black Buffalo					7	3		1
Blue Sucker					4	1		
River Carpsucker				4	6	12		17
Smallmouth Buffalo	2				155	15		17
Clupeidae								
Gizzard Shad					1	1		
Cyprinidae								
Common Carp				1	8	5		1
Ictaluridae								
Channel Catfish					3	2		3
Blue Catfish					3	4		2
Flathead Catfish					1	2		
Lepisosteidae								
Longnose Gar					2	2		
Shortnose Gar					9	13		2
Sciaenidae								
Freshwater Drum					4	3		
Polyodontidae								
Paddlefish	4			7	42			11
Total	6	0	0	12	261	76	0	63

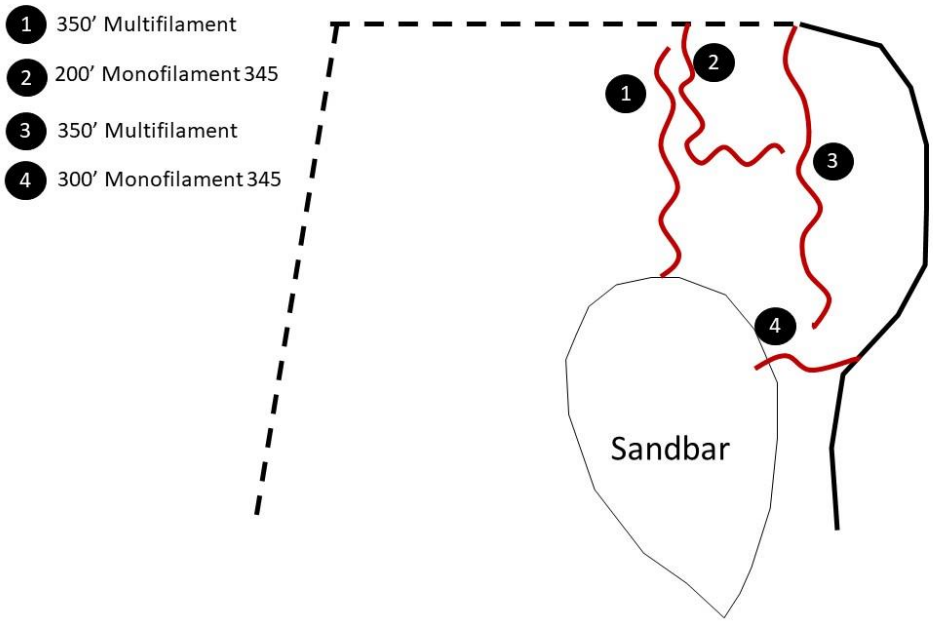

Figure 1. Gill net set up for Missouri River at Mouth of the Lamine River.

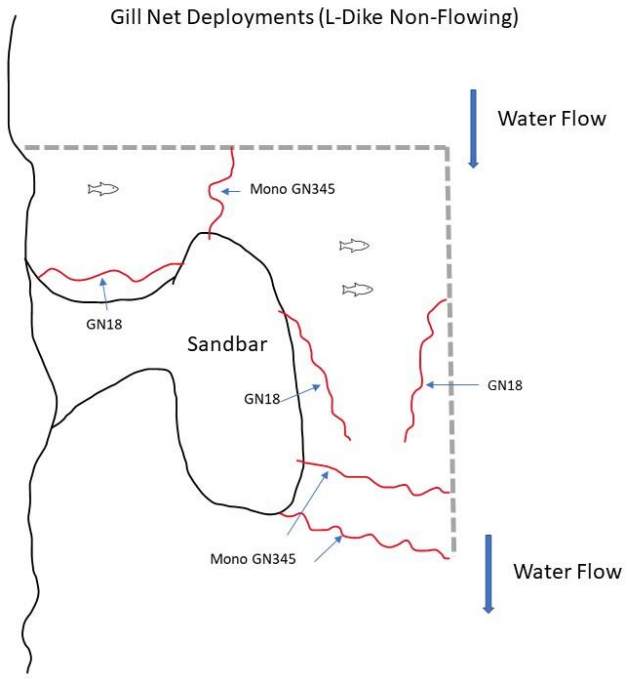

Figure 2. Gill net set up for Missouri River at Mouth of the Grand River in a non-flowing L-dike. GN18 = multifilament gill net with a repeating sequence of 1.5”, 2”, 3”, and 4” mesh panels. GN345 = typical commercially produce carp monofilament gill net with a sequence of 3”, 4”, and 5” mesh panels.

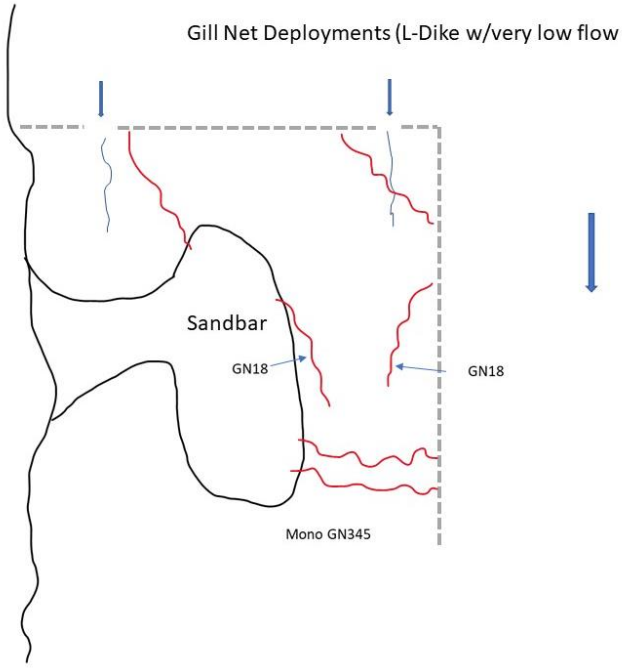

Figure 3. Gill net set up for Missouri River at Mouth of the Grand River in a flowing notched L-dike. GN18 = multifilament gill net with a repeating sequence of 1.5", 2", 3", and 4" mesh panels. GN345 = typical commercially produce carp monofilament gill net with a sequence of 3", 4", and 5" mesh panels.

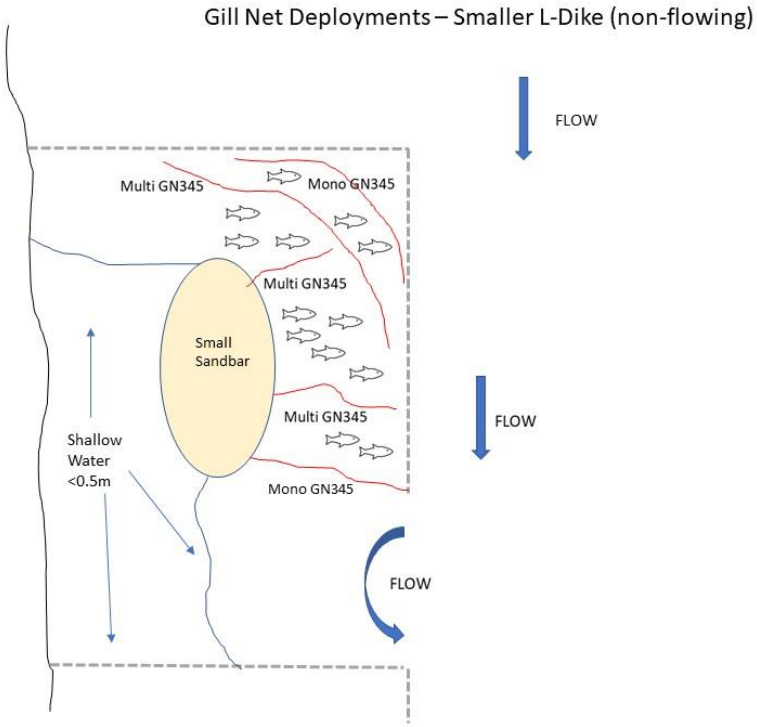

Figure 4. Alternate gill net set up for the Missouri River at the Mouth of the Grand River in a non-flowing L-dike. Mono GN345 = typical commercially produce carp monofilament gill net with a sequence of 3", 4", and 5" mesh. Multi GN345 = multifilament gill net with a sequence of 3", 4", and 5" mesh panels.

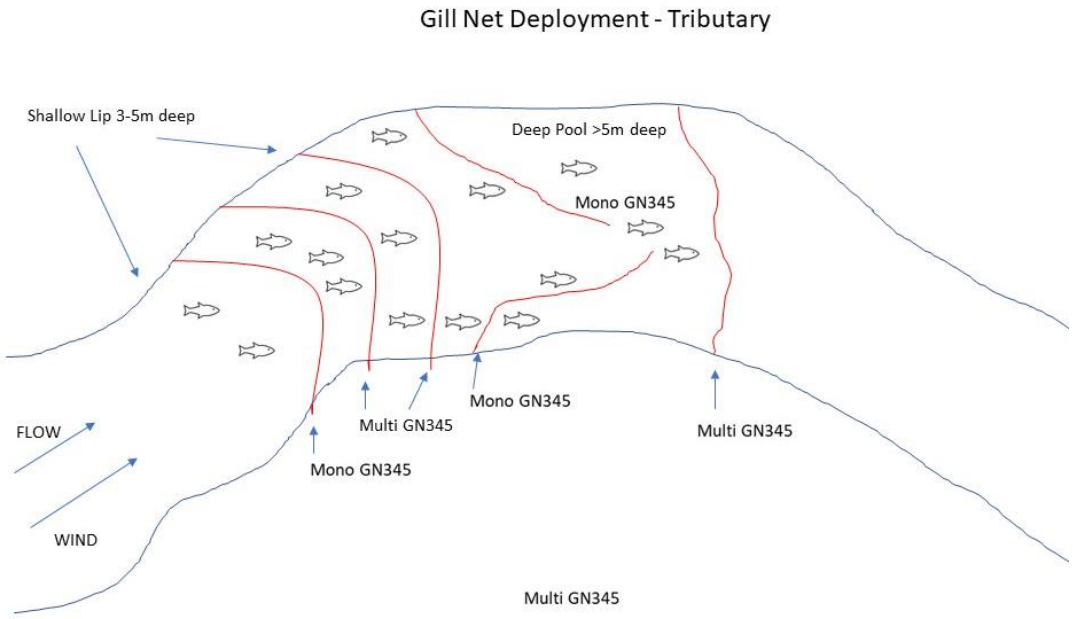

Figure 5. Gillnet set up for the Grand River. Mono GN345 = typical commercially produce carp monofilament gill net with a sequence of 3", 4", and 5" mesh. Multi GN345 = multifilament gill net with a sequence of 3", 4", and 5" mesh panels.

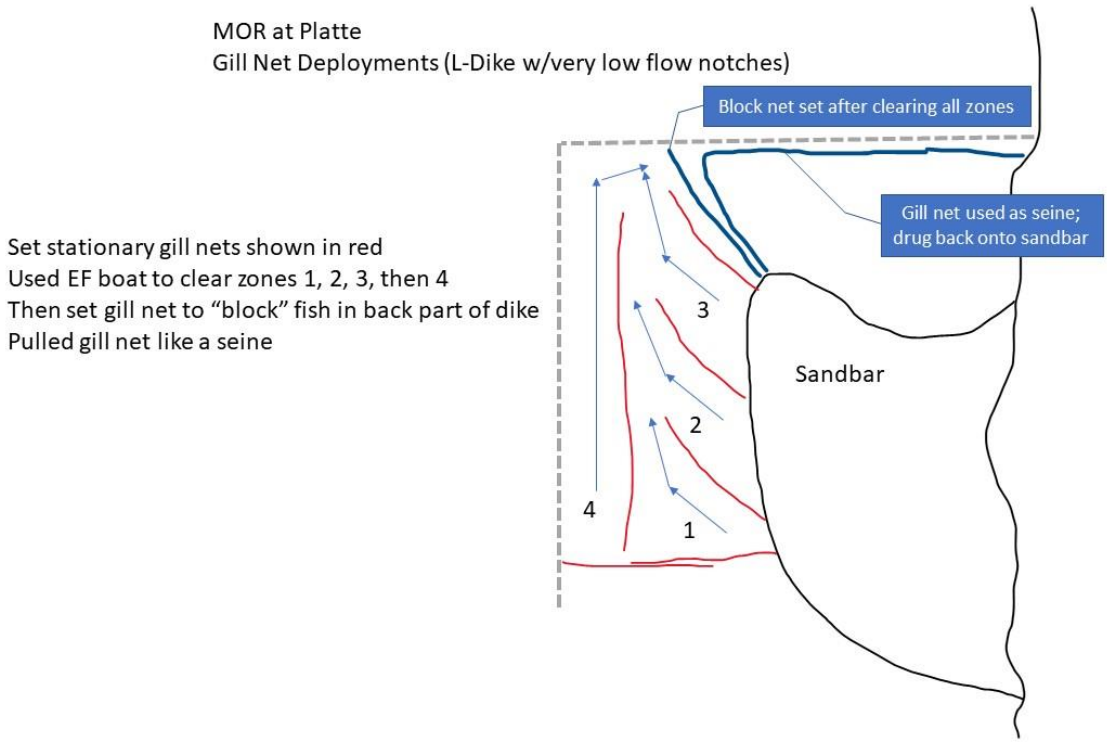

Figure 6. Gill net set up for the Missouri River at Mouth of the Platte River. Electrofishing used to herd fish.

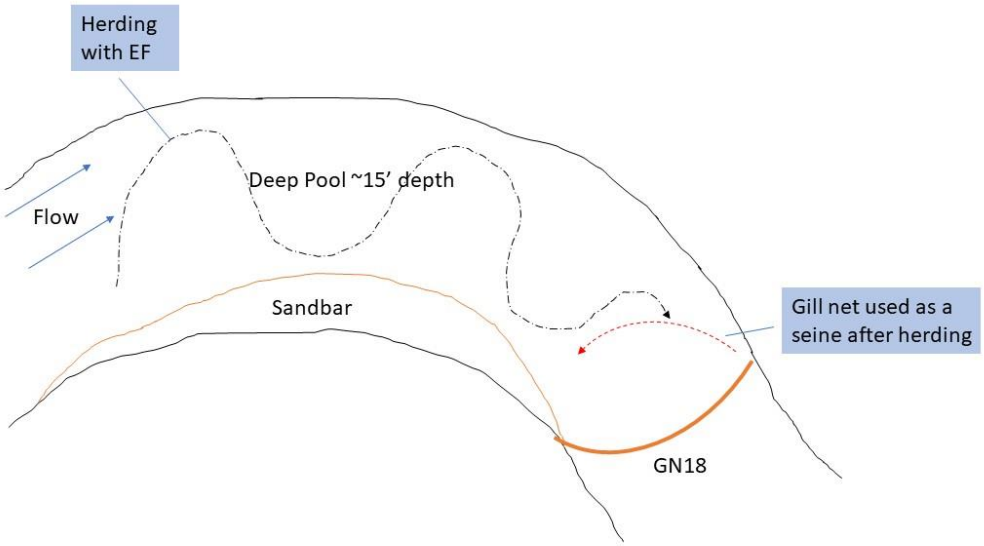

Figure 7. Gill net set up for the Nodaway River below an outside bend pool. Electrofishing used to herd fish. GN18 = multifilament gill net with a repeating sequence of 1.5”, 2”, 3”, and 4” mesh panels.

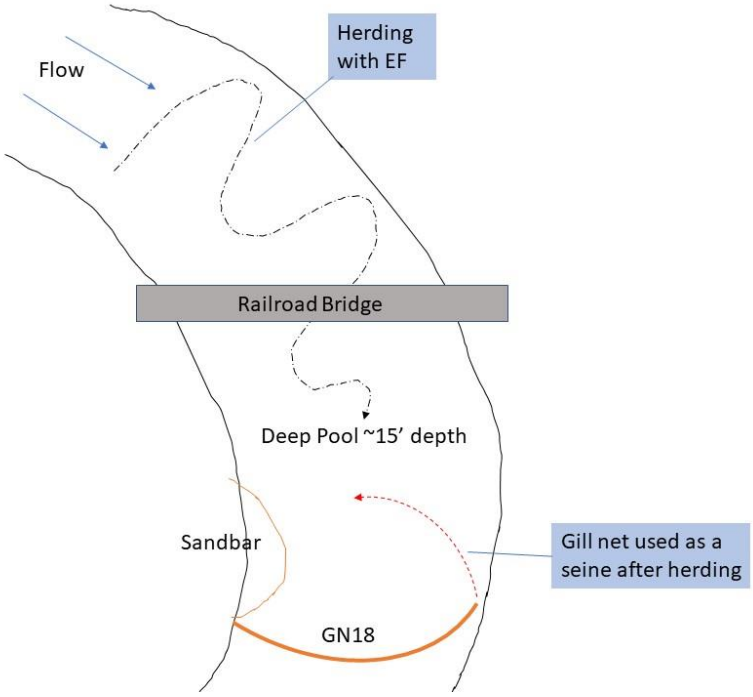

Figure 8. Gill net set up for the Nodaway River below a railroad bridge. Electrofishing used to herd fish. GN18 = multifilament gill net with a repeating sequence of 1.5”, 2”, 3”, and 4” mesh panels.

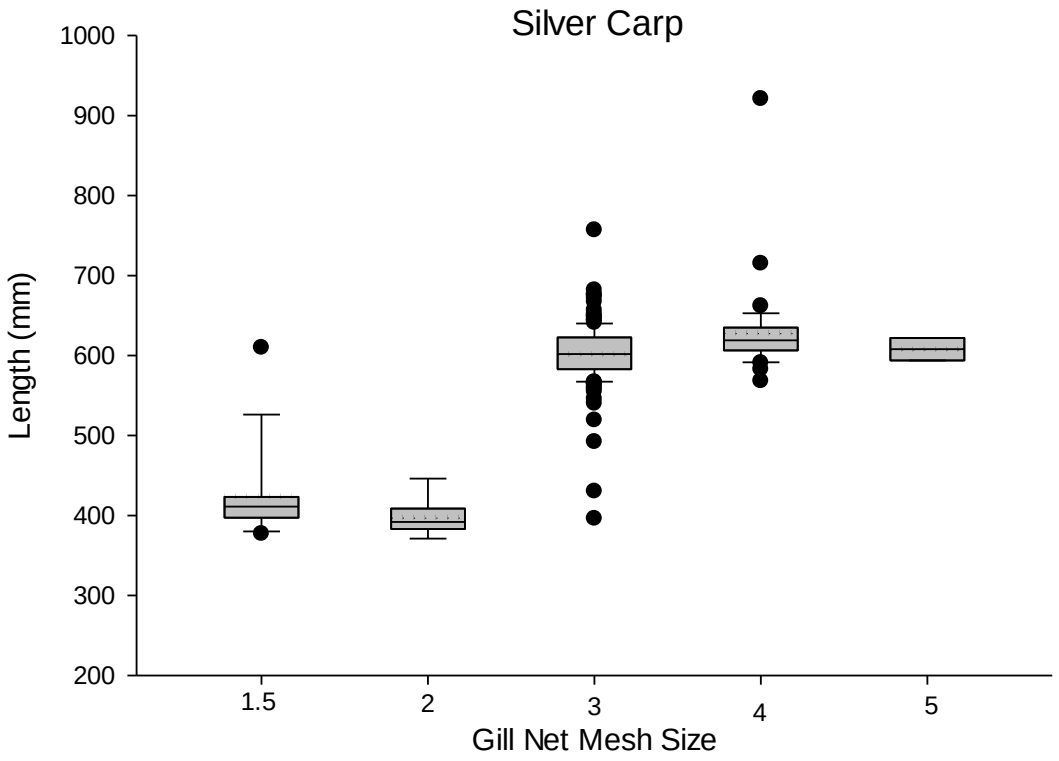

Figure 9. Length of Silver Carp captured by mesh size with gill nets in 2021. Box and whiskers represent 10th and 90th percentiles with solid line in box representing median and dotted line representing the mean and dark circles as outliers.

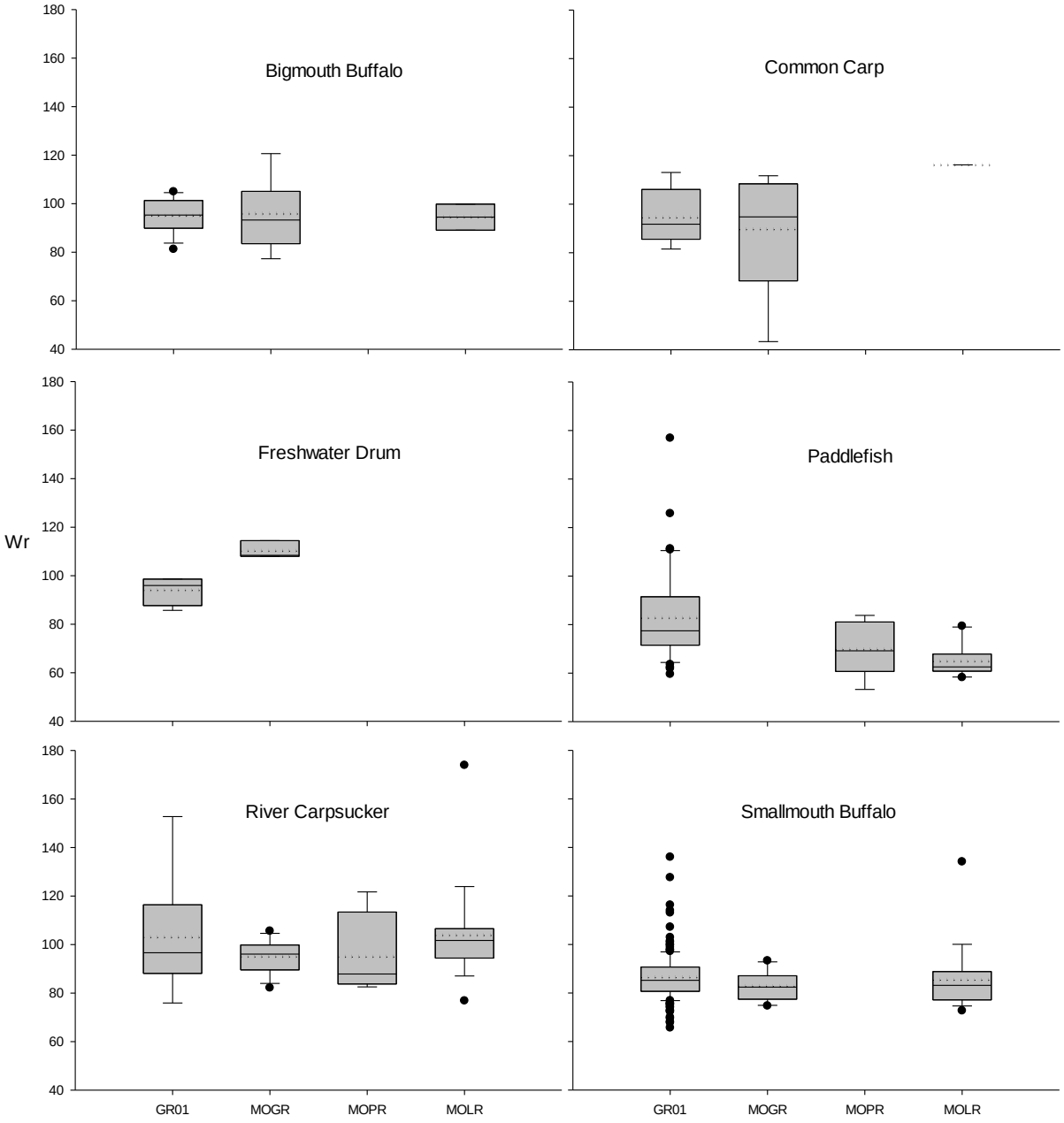

Figure 10. Box plots of relative weight of common bycatch in gill nets by site from 2021. Box and whiskers represent 10th and 90th percentiles with solid line in box representing median and dotted line representing the mean and dark circles as outliers. GR = Grand River Site 1, MOGR = Missouri River Bend at Grand River mouth, MOPR = Missouri River Bend at Platte River mouth and MOLR = Missouri River Bend at Lamine River mouth.

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KDWP contracted with Jackie Bell to meet the objective of this project. The contract states: "*Contractor agrees to harvest or remove invasive carp located in the Kansas River between the Bowersock dam and the WaterOne Coffer dam between September 2021 and June 2022."*. The contractor has made several "exploratory" trips to the Kansas River to familiarize himself and his

crew with different areas of the river under various flow conditions. During these trips he has also experimented with different types/sizes of boats, various nets, and netting methods for invasive carp removal. Flow and physical characteristics of the Kansas River make navigation and invasive carp removal difficult without intimate knowledge of the system. So far, only this background work has been conducted, however the contractor has stated they are now prepared to conduct removal of invasive carp when acceptable flow conditions return. The number of commercial fishers available and willing to conduct contract removal of invasive carp in Kansas is very limited; we now suspect meeting project objectives is more likely to occur by using future funds to hire additional KDWP staff to conduct this work. Disposal of invasive carp is problematic and limited opportunities currently exist, however, a disposal site has been prepared on Clinton Wildlife Area. Further results are forthcoming.

Recommendation:

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Silver Carp at this time prove difficult to catch and will typically find the easiest escape route or exhibit net avoidance. This is one reason one individual gill net set parallel or perpendicular to water flow or the bank common in many fish community sampling regimes will typically yield unsatisfactory results in terms of Silver Carp catch. Flexibility in netting techniques to match the site conditions may be more productive for removal efforts but difficult to standardize.

Gill nets containing 2-inch mesh panels may prove beneficial in areas abundant with 350mm to 450mm size invasive carp. However, increased bycatch especially gar spp. would probably be associated with nets containing 2-inch mesh. Also, the larger 5-inch mesh in gill nets is being replaced with 3.5-inch (88.9mm) mesh to hopefully circumvent invasive carp from evading capture through the 5-inch mesh. Corresponding gill net mesh sizes appropriate to local size structures of invasive carps is essential to the gear's effectiveness. Also, more sampling is needed to produce more robust results with condition appropriate techniques. Once condition appropriate techniques are developed, more standardized removal efforts and estimation of exploitation can occur.

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- Some states (e.g., Arkansas) are having trouble finding commercial fishers to contract with for contract invasive carp removal and should be prepared to use funds to hire additional staff to conduct the work, especially if timing and location of invasive carp removal is particularly important.
- Additional options or destinations for disposal or utilization of invasive carp carcasses should be identified or created to make removal projects more feasible and socially acceptable.

- Agencies conducting invasive carp removal projects should share their experience and successes with others to increase awareness of the many logistical challenges associated with invasive carp removal projects.

References:

Slipke, J.W., and M. J. Maceina. 2014. Fishery Analysis and Modeling Simulator (FAMS). Version 1.64. American Fisheries Society, Bethesda, Maryland.