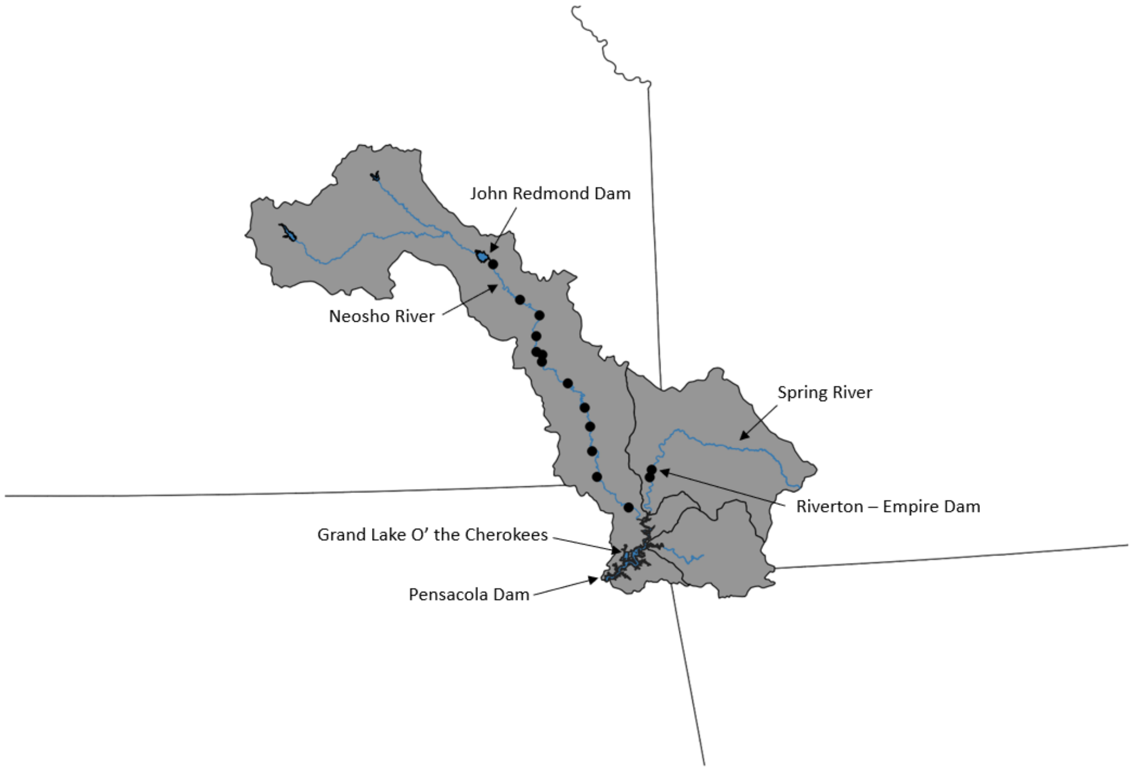
Project Title: Distribution and Population Demographics of Bighead Carp in the Neosho River-Grand Lake System to Inform Removal

Geographic Location: Map of Project Area (unlabeled dots indicate lowhead dam location):



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Statement of Need:
Introduced invasive carps (bighead carp, black carp, grass carp, and silver carp) have become established in many portions of the Mississippi River Basin (Jennings 1998; Kolar et al. 2005). The feeding habits and population densities of the invasive carps cause significant ecological harm where populations become established (Schrank et al. 2003; Irons et al. 2007; Sampson et al. 2009; Solomon et al. 2015; Phelps et al. 2017). The resulting diminished opportunity for fishing (recreational and commercial), boating, and other wildlife-associated recreation causes significant negative economic impact.

Bighead carp are occasionally captured within the Neosho River/Grand Lake system, but very little targeted sampling has occurred in either Kansas or Oklahoma. Existing bighead carp records are from a combination of public captures (primarily from paddlefish anglers) and incidental capture of bighead carp by ODWC while sampling for other fishes. Due to the limitations of the existing data, the precise distribution and abundance of bighead carp in the system is unknown.

This population of bighead carp also represents the only known population of either species of bigheaded carps in the United States to be potentially reproducing in a reservoir completely isolated from the source populations. This provides a unique opportunity to learn about invasive carp and test ideas for removal or suppression in this type of system. Reservoir systems are incredibly important recreationally and economically in the United States. As invasive carp spread up Mississippi River tributaries and congregate below reservoir dams, the risk of introduction of invasive carp to these reservoirs increases; as does the need to learn more about how to manage invasive carp populations in reservoirs.

The planned sampling in this project will fill in knowledge gaps on invasive carp distribution in the Neosho-Grand Lake system, which supports Lower Mississippi River Strategy 2.4 [Implement contract surveillance or targeted invasive carp sampling to monitor the distribution and abundance of invasive carps. (National Goal 2)]. Due to suspected low bighead carp density in the system, the use of eDNA sampling is planned, which supports strategy Lower Mississippi River Strategy 2.5 [Use eDNA testing to guide early detection efforts. (National Goal 2)] Sampling will also occur in portions of the basin where it is unknown if bighead carp occur in line with Lower Mississippi River Strategy 2.6 [Use new technology and techniques to aid in the detection of invasive carps outside their known distribution. (National Goal 2)]

This project is planned as a stepping-stone to future work. bighead carp density and reproduction is likely low in the system, which potentially provides an opportunity to suppress the population prior to them reaching problematic levels seen in other systems. This initial work will provide guidance on how, where, and when to capture bighead carp in this system as well as provide insight into the current size of the population.

Project Objectives:

1. Identify locations of presence and upstream extent of bighead carp population within the Neosho River – Grand Lake system.
2. Collect baseline population demographic information including relative abundance, age and growth, and size structure.
3. Determine broadscale movements within the Neosho River system using otolith microchemistry.
4. Identify locations within the Neosho River – Grand Lake system for containment, removal, and/or eradication efforts.

Project Highlights:

- KDWP has contracted with MSU to complete project objectives.
- MSU crews have identified accessible sampling locations and have been actively collecting data within the Neosho River – Grand Lake system.
- Sampling so far indicates that bighead carp are likely very rare in the Neosho – Grand Lake system.

Methods:

KDWP will coordinate and serve in a guidance role. KDWP has contracted with Missouri State University (MSU), who is planning and conducting the project activities. ODWC and KDWP are assisting with project objectives as needed.

Objective 1.

Newly emerging protocols (implemented by USFWS) have been developed using eDNA that allow for quickly assessing the distribution and relative abundance of fishes. In cases where an individual species may be rare or difficult to detect using traditional fisheries sampling gear, eDNA provides a cost effective alternative for fisheries monitoring programs.

We are developing a Neosho River-Grand Lake System invasive carp environmental DNA program throughout the system (see map). Sampling is in progress and will occur throughout the performance period May 2021-March 2023 at spatially selected sites throughout the system. This program is using existing eDNA protocols utilized by the USFWS. The program is using already "in place" infrastructure (i.e., existing eDNA collection and processing approaches) to analyze eDNA samples.

Furthermore, sampling for invasive carp is occurring at the same sites as above (at eDNA locations if feasible) using a defined compliment gill nets, trammel nets, and electrofishing throughout the performance period. For each sample, fishes are identified, quantified (catch per unit effort) measured (to the nearest mm), and weighed (to the nearest gram) in the field. As a point of protocol, macrohabitat type (e.g., channel border, island, tailwater, tributary, main channel, backwater/embayment) and mesohabitat (e.g., water depth, velocity, substrate) is also recorded at each sampling site (allowing for quantification of habitat use).

Objective 2

Our goal is to collect as many bigheaded carp as possible throughout Neosho River-Grand Lake System from objective one above (including fish from anglers or other agency sampling). At time of collection, invasive carp will be measured (total length; nearest mm for size structure Phelps and Willis 2013), weighed (nearest g), and otoliths removed for ageing (Seibert and Phelps 2013, Phelps et al. 2017). Invasive carp will also be necropsied or externally viewed to determine sex (Wolf et al. 2018), reproductive potential (reproductive stages; Seibert et al. 2015 for a similar approach), total gonad weight, and egg counts. Stomach analysis will also be conducted to determine forage items and abundance. Using these population-level attribute data, the following will be constructed; length-frequency distributions, age-frequency distributions, condition (via length-weight regressions), sex ratios, fecundity, gonadosomatic index, and size structure index (proportional size distribution).

Furthermore, the dynamic rate functions will be estimated using the following methods:
To determine the relative number of invasive carp that are entering (i.e., recruiting) the systems each year, the number of fish in each year class will be quantified. Ages derived from otoliths will be used to determine recruitment patterns. For each age class present throughout the Neosho River-Grand Lake System, we will quantify the relative strength or weakness of each cohort within each reach using the residual method. Specifically, positive residual values from the

regression would indicate a relatively strong year class while negative residuals would indicate weak year classes. Recruitment variability will be quantitatively analyzed using recruitment coefficient of determination. Mortality rates of the invasive carp in the Neosho River-Grand Lake System will be determined using a catch-curve approach. Catch curves will be generated by summing the number of fish caught per age class. These data will allow for the development of individual regression models to estimate instantaneous mortality. Instantaneous mortality rate (Z), which will be used to determine the total annual mortality ($A = 1- e^{-Z}$) for selected fishes from each river reach. Growth will be estimated for invasive carp by determining the mean length at age. Mean-length at age data will be incorporated into Fisheries Analysis and Modeling Simulator and will be used to model growth using a von Bertalanffy approach. The equation generated using the von Bertalanffy growth model is $Lt = L\infty(1\text{-}e(-K(t\text{-}t0))$; where, Length infinity ($L\infty$) is the theoretical maximum length that a fish can achieve, K is the growth constant or growth rate of the population, and t0 is the theoretical length at time zero (i.e., age 0).

Given the dynamic rate information (i.e., growth, mortality, maximum age, length-weight regression, natural mortality, and male to female ratios) obtained above, we will use the yield-per-recruit modeling option in FAMS (Slipke and Maceina 2014) to determine the relative exploitation rate to overfish the invasive carp population. FAMS uses the Jones (1957) modification of the Beverton– Holt equilibrium yield equation developed by Ricker (Ricker 1975). Within the modelling interface of FAMS, we will use both the yield-per-recruit (YPR) and the static spawning potential ratio (SPR) option. This modeling approach assumes fixed recruitment and all simulations will be started with an initial population size of 1,000 recruits. This will ultimately allow the evaluation of the relative influence of many exploitation rates simultaneously on the population (Slipke and Maceina 2014). Using FAMS, Yield-per- recruit (YPR) and spawning potential ratio (SPR) will be assessed for various exploitation rates in 5% intervals, (i.e., 5% – 95%) with invasive carp of varying target harvest lengths

Objective 3

Recent research has demonstrated that fishes that reside in the Upper Mississippi, Middle Mississippi, Ohio, Missouri, or Illinois rivers can be distinguished from one another using naturally occurring, river-specific chemical "signatures" present in fish otoliths, fin spines, and fin rays. Fish hard parts contain a permanent chronological record of the "signatures" representing environments an individual fish has occupied during its lifetime, enabling reconstruction of that fish's environmental history through sub-sampling for isotopic and elemental analysis across the hard part (Carlson et al. 2017). This approach is currently being applied to identify natal environments and immigration patterns of adult invasive carps in the Illinois River, Missouri River, and Mississippi River.

We are in the process of using a similar approach as above to identify natal/nursery environment throughout the Neosho River, Spring River, and Grand River system and characterize movement patterns for all invasive carps collected throughout the system through analyses of trace elements or isotopes within fish hard parts. Fishes are being collected using a variety of gears, principally electrofishing, gill nets, angling, and trammel nets (see objective one). Fish hard parts (e.g., otoliths) are extracted from each fish (from objective one); one structure from each fish will be embedded in epoxy, sectioned, cleaned, and analyzed for trace elements or isotopic composition using mass spectrometry. Trace element or isotopic signature at the core will be used to identify natal environment for each fish via comparison with established signatures indicative of residency in each of the river segments listed above. Changes in elemental composition along the fish hard part will be used to infer frequency and timing of immigration into various river reaches from other river segments. Additional water samples will need to be collected overtime to bolster the water chemical library and ensure temporal consistency in water chemistry.

Objective 4
Using insight from information from the 3 objectives above, project participants will enter all data into a standardized database and share with all project partners. Discussions among partnering agencies will occur and an executive summary and final project report will be constructed to determine locations within the Neosho River – Grand Lake system for containment, removal, and/or eradication efforts. MSU will send regular updates to project partners as samples are processed, to inform the group of any new findings. These data will help inform managers of the current status of invasive carp populations in the Neosho River – Grand Lake system. Project partners will disseminate these findings to the basin planning committee, which will be used to guide the allocation of future management efforts to meet the needs of the LMR basin. An executive summary will be provided to the ODWC April 2023.

Results and Discussion: We are still in the data collection phase of this study. Following are some summaries of netting and electrofishing efforts so far and the fish encountered during those activities.

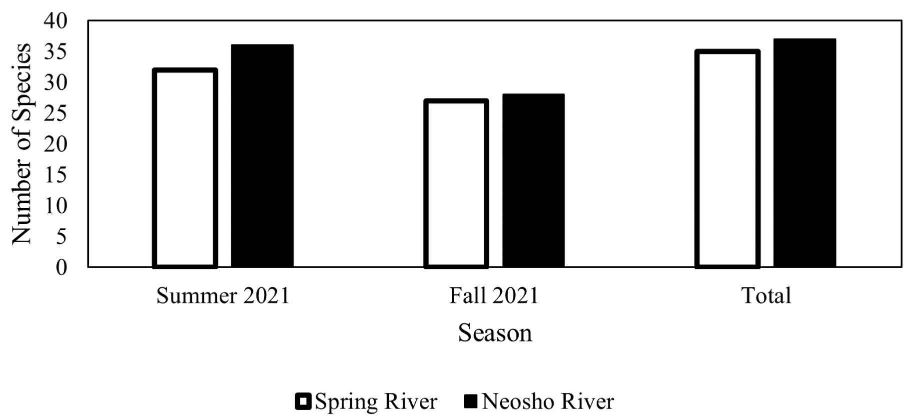
Table 1. Summary of boat electrofishing effort and catches for the Spring and Neosho River(s) during summer and fall of 2021. Catch-per-unit-effort (CPUE) is expressed as averages (SE).

	Spring River			Neosho River		
	Summer 2021	Fall 2021	Total	Summer 2021	Fall 2021	Total
Electrofishing Effort						
Samples (runs)	7	5	12	38	15	53
Electrofishing hours	1.8	1.3	3	9.5	3.8	13.3
Electrofishing Catch						
All fish (N)	432	569	1001	1094	895	1989
Species (N)	32	25	35	31	27	33
Bighead Carp (N)	-	-	-	-	-	-
Grass Carp (N)	-	6	6	1	1	2
Common Carp (N)	8	8	16	93	65	158
CPUE all fish (fish/hr)	246.8 (91.8)	455.2 (46.0)	333.6 (62.9)	115.2 (18.4)	238.8 (52.8)	150.0 (21.1)
CPUE Grass Carp (fish/hr)	-	4.8 (2.3)	2.0 (1.2)	0.1 (0.1)	0.4 (0.3)	0.0 (0.1)
CPUE Common Carp (fish/hr)	4.6 (1.6)	6.4 (1.6)	5.2 (1.2)	9.8 (1.5)	17.2 (3.7)	12.0 (1.6)

Table 2. Summary of passive netting (i.e., gill net, mini gill net, modified fyke net, mini fyke net, hoop nets) effort and catches for the Spring and Neosho River(s) during summer and fall of 2021. Catch-per-unit-effort (CPUE) is expressed as averages (SE).

	Spring River			Neosho River		
	Summer 2021	Fall 2021	Total	Summer 2021	Fall 2021	Total
Netting Effort						
Samples (net sets)	17	13	30	95	36	131
Netting Catch						
All fish (N)	44	37	81	2159	277	2436
Species (N)	12	11	17	31	19	31
Bighead Carp (N)	-	-	-	-	-	-
Grass Carp (N)	-	-	-	1	-	1
Common Carp (N)	-	2	2	19	7	26
CPUE all fish (fish/net)	2.6 (1.3)	2.8 (0.8)	2.7 (0.8)	22.7 (12.6)	7.7 (1.9)	18.6 (17.5)
CPUE Grass Carp (fish/net)	-	-	-	0.0 (0.0)	-	0.0 (0.0)
CPUE Common Carp (fish/net)	-	0.2 (0.1)	0.1 (0.0)	0.2 (0.1)	0.2 (0.1)	0.2 (0.1)

Figure 1. Total species encountered in the Spring and Neosho River(s) from boat electrofishing and passive netting in summer and fall of 2021.



Recommendations:
Contintue on with this project as scheduled. Opportunistically collect additional data from bighead carp collected by others (fishermen, ODWC paddlefish crews, etc.) in the Neosho – Grand Lake system. Sampling efforts should continue to improve understanding of bighead carp and native fish in this system.

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