Project Title: Invasive carp communication and outreach in the Missouri River Basin
Geographic Location (Figure 1):

- Many of the meetings and conferences happened virtually or a combination of virtual and in-person (i.e., hybrid meetings).
- Kansas River from the confluence with the Missouri River (RKM 0) upstream to the WaterOne Weir at Edwardsville, KS (RKM 24)
- Mainstem Missouri River between Gavins Point Dam and the Big Sioux River.
- Bait shops across North Dakota, South Dakota, Nebraska, Kansas, and Iowa.

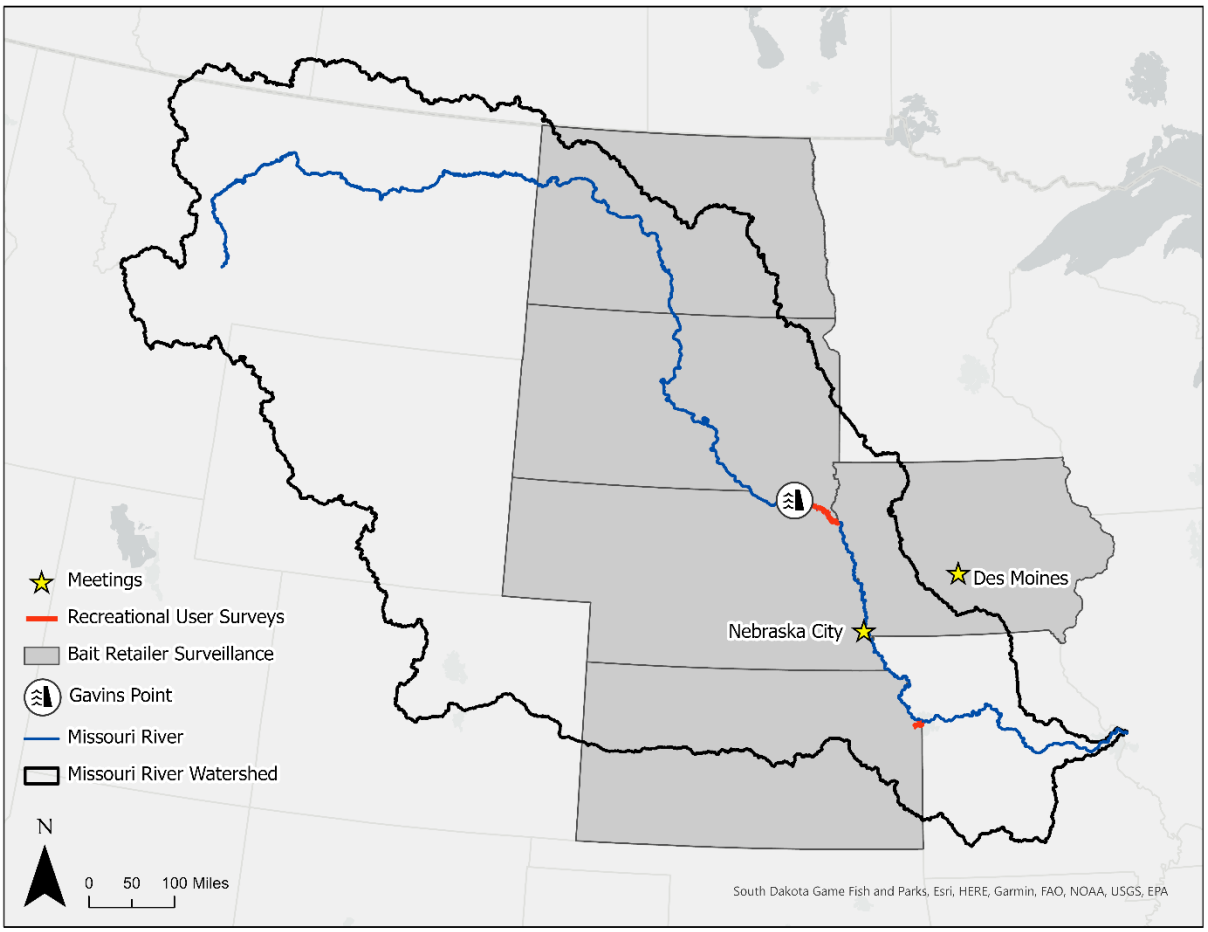

Figure 1. Activities in support of communication and outreach in the Missouri River Basin in 2022 included hybrid and in-person meetings, recreational user surveys, bait retailer surveillance, and dissemination of open-source images of Bighead, Grass, and Silver carp.

Lead Agency: Emily Pherigo (Emily_pherigo@fws.gov), USFWS-Columbia Fish and Wildlife Conservation Office.

Participating Agencies:

- Iowa Department of Natural Resources (IDNR), Kim Bogenschutz, kim.bogenschutz@dnr.iowa.gov

- Kansas Department of Wildlife and Parks (KDWP), Chris Steffen (chris.steffen@ks.gov), Liam Odell (liam.odell@ks.gov)
- Nebraska Game and Parks Commission (NGPC), Kirk Steffensen, kirk.steffensen@nebraska.gov and Kris Stahr, kristopher.stahr@nebraska.gov; Nebraska Cooperative Fish and Wildlife Research Unit (NE CRU), Caroline LaPlante (claplante2@huskers.unl.edu); U.S. Geological Survey—Nebraska Cooperative Fish and Wildlife Research Unit (USGS), Kevin L. Pope kpope2@unl.edu & Jonathan J. Spurgeon jspurgeon2@unl.edu
- North Dakota Game and Fish (NDGF), Ben Holen, bholen@nd.gov
- South Dakota Department of Game, Fish, and Parks (SDGFP), Tanner Davis, tanner.davis@state.sd.us, BJ Schall, benjamin.schall@state.sd.us; South Dakota State University (SDSU), Department of Natural Resource Management, Alison Coulter, alison.coulter@sdstate.edu, 765-414-0278, and Hannah Mulligan; University of South Dakota (USD; Jeff Wesner Hugh Britten).
- USFWS – Columbia Fish and Wildlife Conservation Office (USFWS – Columbia FWCO), Emily Pherigo, Emily_pherigo@fws.gov; USFWS – Denver Regional Office, Joanne Grady, joanne_grady@fws.gov; USFWS-Gavins Point National Fish Hatchery (USFWS-GPNFH) Sam Stukel, Sampson_stukel@fws.gov

Statement of Need:

Invasive carp are found in the lower Missouri River basin up to Gavins Point Dam and extending into states via connected waterways. Preventing range expansion of invasive carp in the Missouri River basin requires a basin-wide approach with communication among partners and agencies as a centerpiece. This annual technical report provides updates and results from partners in the Missouri River Basin on their efforts to communicate with each other, identify impacts to recreational activities, and understand risk of human-mediated activities to better outreach and education in the basin.

It is most important for managers on the ground to effectively communicate with each other to ensure that the most up-to-date science and techniques are being shared. As more research is conducted in the Missouri River Basin on invasive carp, the results and recommendations must be shared across partners in an effective, useable manner to prevent the spread of invasive carp and to manage these species in their current localities.

Education and outreach are critical to preventing invasive carp range expansion. For partners who may not have invasive carp in their jurisdiction but want to create outreach materials, access to high-quality, public-domain images of invasive carp is an asset. This is particularly true regarding juvenile and young-of-year carp, which can easily be mistaken for “bait fish” by anglers. To remedy this, the USFWS Gavins Point National Fish Hatchery (USFWS-GPNFH) produced a set of images available to everyone.

Though invasive carp are believed to impact our aquatic resources, little is understood about how these species affect recreationalists and anglers who use these resources. As invasive carp impact waterways, users can be affected through several ways. Invasive carp may prevent boating or

impact the quality of a fishery. Therefore, it is critical to obtain information from these users to not only better understand how invasive carp affects them, but to gain insight into potential management techniques. Information obtained can also be used to direct specific outreach efforts for all AIS and allow for increased dialogue with aquatic users and managers.

The Nebraska Game and Parks Commission (NGPC) in conjunction with the South Dakota Fish, Game, and Parks oversee two Paddlefish-fishing seasons annually in the mainstem Missouri River between Gavins Point Dam and the Big Sioux River. Invasive carp have steadily increased in abundance in this reach during the past several decades, anecdotally negatively affecting anglers' satisfaction. Currently, state managers rely on a postcard survey to monitor this fishery and judge anglers' satisfaction from the comment section of the returned postcards. NGPC and NE CRU are implementing an in-person creel survey during the June-archery and October-snagging seasons of 2022 and 2023 to quantify catches (target and non-target) and efforts during paddlefish seasons mainly around Gavins Point Dam as anglers are highly concentrated in this area.

The Kansas River basin drains approximately the north half of the state of Kansas and flows East to its confluence with the Missouri River at Kansas City, Kansas. Invasive carp are abundant from the Missouri River confluence upstream to the Bowersock Dam at Lawrence, Kansas (RKM 84). The Kansas River is one of only three rivers in the state of Kansas that is legally a publicly navigable river. The designation allows for public recreation such as kayaking/canoeing, fishing, hunting, wildlife viewing, etc. Additionally, the Kansas River was designated as a National Water Trail in 2012 by the National Park Service. This designation, as well as the recent nationwide surge of participation in kayaking, appears to have led to increasing use of the Kansas River by paddlers. A burgeoning trophy blue catfish population also appears to be increasing angler use of the Kansas River. The Kansas River is a unique and increasingly valuable destination for outdoor recreation in the State of Kansas. The impacts of invasive carp to recreationalists are not well understood. KDWP occasionally receives reports of unfavorable interactions between recreationalists and invasive carp, but it is likely that most of these interactions are unreported. Additionally, there is concern that some blue catfish anglers may be tempted to transport invasive carp to other waterbodies based on their belief that the presence of invasive carp lead to the development of the trophy blue catfish fishery. The prevalence of this perception is unknown, and education and outreach may be needed to address this issue.

One pathway for invasive carp expansion is human-mediated movement. Spread of aquatic invasive species (AIS) via dumping of live bait is a known vector for AIS spread. Invasive carp (primarily as young-of-year) closely resemble common baitfishes, such as Gizzard Shad *Dorosoma cepedianum* and Alewife *Alosa pseudoharengus*, used by anglers and sold commercially. Several Missouri River Basin states allow anglers and bait dealers to collect their own bait, resulting in a high risk of human-mediated movement of invasive carp especially if improperly released. In addition, even in localities with regulations restricting live bait collection, illegal collection and subsequent selling of live bait cannot be ruled out. Thus, it is imperative to not only investigate all methods of human-mediated movement of invasive carp, but to develop pragmatic management solutions to prevent or reduce the risk from this pathway.

Targeted educational campaigns, in specific regions or at particular bait shops, could help reduce the risk of AIS spread by anglers using live bait. Additionally, understanding the relative risks posed by bait shops regionally and how the characteristics of each bait shop (e.g., proximity to AIS established population, regulations of particular states, sources of baitfish) influence risk will help increase the effectiveness of educational programs by targeting interventions. In the Missouri River Basin, Silver Carp (*Hypophthalmichthys molitrix*) and Bighead Carp (*H. nobilis*) are particular AIS of concern. They are established in the Missouri River mainstem upstream into South Dakota where Gavins Point Dam has limited their expansion further upstream. Additional dams on tributaries to the Missouri River (e.g., Big Sioux River Falls and East Vermillion Lake spillway in South Dakota, the Jamestown Reservoir spillway in North Dakota, Bowersock, and Clinton dams in Kansas) have likely also inhibited upstream expansion of these AIS. However, introduction of these species above dams that currently inhibit their spread via bait dumping is a serious concern. In the Great Lakes region, Silver Carp eDNA was previously documented in bait shops that were located outside of the current range of Silver Carp (Nathan et al. 2014) indicating that Silver Carp were currently present or may have passed through bait shop tanks.

Project Objectives:

1. Support coordination and communication among partners regarding invasive carp outreach and management in the Missouri River Basin and beyond for the most efficient use of resources.
2. Evaluate recreational satisfaction and invasive carp knowledge in areas of the Missouri River Basin with invasive carp to inform management actions and increase the effectiveness of outreach messaging.
3. Assess human-mediated pathway risks for invasive carp movement to prevent the introduction and further spread of invasive carp into and within the Missouri River Basin.

Project Highlights:

- Objective 1: Coordination and Communication
    - Organized an invasive carp symposium for the 2022 Midwest Fish and Wildlife Conference
    - Had 9 presentations on a variety of invasive carp topics
    - The Missouri River Basin posted their first annual technical reports to the MICRA website, http://micrarivers.org/missouri-river-sub-basin-annual-summary-reports/.
    - High quality images of Silver Carp, Bighead Carp, and Grass Carp can be downloaded from the USFWS Mountain-Prairie Flickr page (https://www.flickr.com/photos/usfwsmtnprairie/albums/) and the USFWS National Digital Library (https://digitalmedia.fws.gov/digital/).
- Objective 2: Evaluate recreational satisfaction and invasive carp knowledge
    - KDWP has completed the Kansas River user survey interview and outreach portions of project and this information can be used to make informed invasive carp management decisions
        - Survey results provide managers insight into how river users perceive and are impacted by the presence of invasive carp.
        - Identified shortcomings in invasive carp education and outreach efforts to be improved upon.

  - During the June archery Paddlefish season below Gavins Point dam:
    - 75 onsite satisfaction surveys were conducted.
    - 83% of parties encountered bigheaded carp but 88% of parties indicated that they were not impacted by invasive species.
    - 93% of parties reported total satisfaction levels of very satisfied or somewhat satisfied.
  - During the October snagging Paddlefish season below Gavins Point dam:
    - 108 onsite satisfaction surveys were conducted.
    - Over 75% of parties indicated that they were not impacted by aquatic invasive species.
    - Overall satisfaction levels had more variation than in the archery season. 68% of parties self-stated their satisfaction as either “Very satisfied” or “Somewhat satisfied”. 14% of parties self-stated their satisfaction levels as “Somewhat dissatisfied” or “Very dissatisfied”.
- Objective 3: Assess human-mediated pathway risk in bait shops
  - 15% of bait shops sold non-target species and some of these species were not legal bait in a particular state.
  - Only 12% of bait shops displayed educational signage.
  - 5.79% of water samples tested positive for Silver Carp/Bighead Carp eDNA.
  - Analysis of risk factors associated with positive eDNA detections on-going.

Objective 1. Support coordination and communication among partners regarding Invasive carp outreach and management in the Missouri River Basin and beyond for the most efficient use of resources.

Midwest Fish & Wildlife Conference 2022

Kim Bogenschutz (IA DNR), Andrea Fritts (USGS-UMESC), and Emily Pherigo (USFWS) submitted a proposal in the fall of 2021 to host a symposium on invasive carp at the 2022 Midwest Fish and Wildlife Conference held in Des Moines, Iowa, in February 2022. The symposium proposal was accepted by the 2022 Midwest Fish and Wildlife Conference Program Committee, and the project organizers sent out a call for abstracts for presentations for the symposium. By the November 2021 deadline, nine abstracts were submitted, and all authors were invited to present at the symposium.

The title of the symposium was "Research and Management of Four Invasive Carps: Bighead, Black, Grass, and Silver Carp." Presenters were a mix of students and professionals and had the option of attending the meeting in person or virtually. Four presentations were virtual and five were in person. Titles of the presentations were the following:

- Diurnal and Seasonal Habitat Use of Bigheaded Carp in the Wabash and White River
- Environmental factors influencing the toxicity of a historic management chemical: prospective for fisheries management
- Evaluating invasive carp water column use to inform deterrents and control
- Commercial Fishing: A Key Tool for Invasive Carp Management in Kentucky
- RNA interference as a potential tool for invasive Asian carps management
- Decision Analysis of Barrier Placement and Targeted Removal to Control Invasive Carp in the Tennessee River Basin
- Comparison of Native and Invasive Fish Larvae Occupancy and Detection Probabilities in the Upper Mississippi River
- Tracking Movement of Invasive Silver and Bighead Carp in Three Missouri River Tributaries in Eastern South Dakota
- Investigating Bigheaded Carp Reproductive Success in Small Rivers

Planning, Coordination, and Communication

The USFWS – Region 3 provides a coordinator to the Missouri River Basin Invasive Carp partnership. In 2022, the coordinator, Emily Pherigo, provided guidance on the annual planning and reporting processes by hosting virtual and hybrid meetings via Microsoft teams. Documents created as part of the annual planning and reporting process were shared with MICRA for posting on their website, http://micrarivers.org/invasive-carp-plans-and-reports/ (Figure 2).

In January 2022 an informational meeting on the partnerships' first annual technical reports was held to answer questions on the guidance documents shared over email. The meeting was recorded and provided to partners as a reference and for those unable to attend the meeting. Once the annual technical reports were completed the coordinator submitted them to MICRA for posting on MICRA website, http://micrarivers.org/missouri-river-sub-basin-annual-summary-reports/. Partners presented their findings to each other at a hybrid meeting in July 2022. This three-day meeting had approximately 12 people attend in person and approximately 20

participate on-line. Researchers and managers presented their results to each other, and then discussion was started for how this informs 2023 projects. Following the hybrid meeting, four virtual meetings were held to create a project list for FY23 funding consideration. This resulted in four project proposals for the sub-basin by the end of calendar year 2022.

The Partnership met in conjunction with the 2022 Missouri River Natural Resources Conference (MRNRC) on March 21 in Nebraska City, NE, via a half-day hybrid meeting with twelve in-person participants at the Lied Lodge and ten partners joining virtually. Agenda topics included updates from Kasey Whiteman on MICRA, Kirk Steffensen on the MRNRC, Adam McDaniel on the National Invasive Carp Monitoring strategy ad-hoc committee, and a review of the annual planning and implementation cycle with reminders about due dates for work plans and grant applications. The meeting culminated with a discussion on invasive carp impacts of concern in the Missouri River Basin and locations to target for invasive carp management and control.

An ad-hoc committee of representatives across the Mississippi River Basin met in 2022 to lay the foundation for a National Invasive Carp Population Assessment Team structure. Missouri River Basin representatives included Adam McDaniel, MDC, and Kirk Steffensen, NGPC. The ad-hoc committee met once per month between January and August 2022.

Open-source images for outreach and education

Sam Stukel, USFWS-GPNFH, took professional quality photos of three species of invasive carp to share via open source for use in outreach and education efforts. The images are well suited for signage, presentations, media use, etc (Figure 3). A selection of young-of-year Grass, Silver, and Bighead carp were acquired from USGS CERC, USGS UMESC, and Great Plains FWCO biologists working on the local Missouri River. The FWCO crew also provided adult Grass Carp and Silver Carp for the project. The fish were stabilized in aquariums of various sizes inside the aquarium building at GPNFH. Once ready, suitable-looking individuals were selected and photographed while swimming in aquariums in front of both black and white backgrounds with studio-grade lighting, lenses, and cameras. Through the end of 2022, the effort produced 42 finished images of Silver Carp, 23 images of Bighead Carp, and 18 images of Grass Carp. The best of these were posted on the USFWS Mountain-Prairie Flickr page (https://www.flickr.com/photos/usfwsmtnprairie/albums/) and submitted to USFWS National Digital Library (https://digitalmedia.fws.gov/digital/).

This photography project also provided images of live zebra mussels photographed with the same gear, both in the studio and the field. This effort produced 41 finished images that were also posted to the same outlets. Additionally, the gear was used to photograph a field project directed at assessing the status of the Bighead and Silver carp populations in the Missouri River basin (a collaboration between Columbia FWCO and Great Plains FWCO). Those images are also available on the Flickr site.

Tables and Figures:

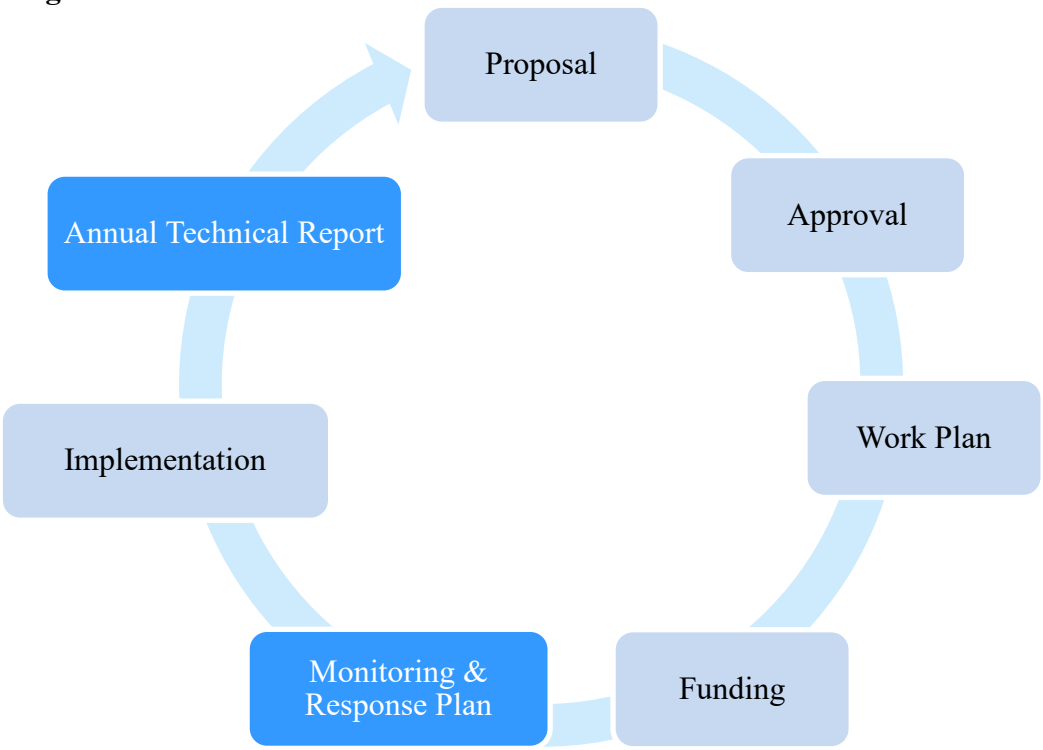

Figure 2. Annual planning, implementation, and reporting cycle for the Missouri River Basin Invasive Carp Partnership. Blue boxes represent documents posted to MICRArivers.org.

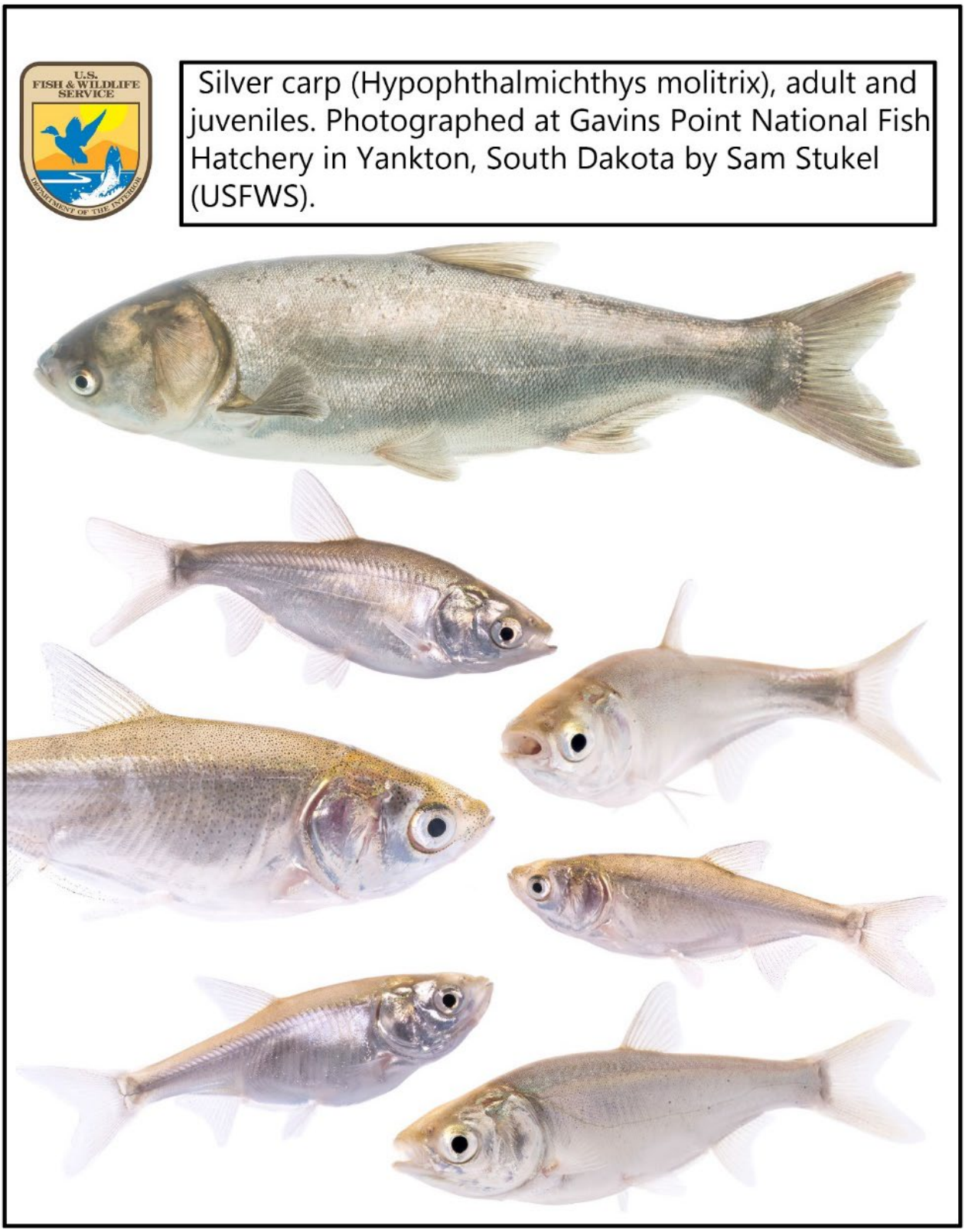

Figure 3. Silver Carp collage created by Sam Stukel, USFWS, can be found on the USFWS Mountain Prairie Region Flickr site: https://www.flickr.com/photos/usfwsmtnprairie/albums/

Objective 2. Evaluate recreational satisfaction and Invasive carp knowledge in areas of the Missouri River Basin with Invasive carp to inform management actions and increase the effectiveness of outreach messaging.

KANSAS

Methods:

Interviews and outreach were conducted March 1 through October 31, 2022 (Table 1). Due to logistical constraints, survey activities were limited to the stretch of the Kansas River from the confluence with the Missouri River (RKM 0) upstream to the WaterOne Weir at Edwardsville, KS (RKM 24; Figure 4). When river flows were from 127 m^3/s to 566 m^3/s, surveys were conducted by boat; above and below these thresholds, surveys were conducted by truck at access points. In this stretch of the Kansas River, there are three public access points – Kaw Point (RKM 0), Turner Bridge (RKM 15), and the WaterOne Weir (RKM 24; Figure 5). A randomized progressive count methodology was used to interview river recreationalists using predetermined routes. KDWP staff conducted a total of 729 interviews, all of which also included staff providing educational materials about invasive carp and other aquatic invasive species.

The KDWP fisheries division includes a human dimensions specialist who designed the survey, the sampling methodology, and is leading data analysis for this project. This expertise improved the overall project and will be invaluable in interpretation of results.

Results and Discussion: KDWP staff conducted a total of 729 interviews, all of which also included staff providing educational materials about invasive carp and other aquatic invasive species. Data analysis is underway, and a final report is anticipated to be completed by June 2023. Preliminary data summaries and analyses are presented below and in figures 6-17.

Survey participants were largely anglers (92%; Figure 6) that were shore-based (84%; Figure 7). Of survey participants using a boat, 73% were using a motorized boat, and the remaining 27% used a non-motorized boat (Figure 8). Approximately half of survey participants were black, indigenous, or people of color (BIPOC; Figure 9). The most common language spoken by survey participants was English at 80%, with Spanish being the second most common at 18%; other languages spoken by river users were Burmese, Chinese, Farsi, Korean, and Karenic (Figure 10).

From the list of 10 aquatic species provided in the survey, participants were most familiar with Channel Catfish (97%), followed by Largemouth Bass, (88%), Silver Carp (82%), Bighead Carp (72%), Grass Carp (68%), White Perch (64%), zebra mussels (62%), Black Carp (38%), hydrilla (24%), and Eurasian watermilfoil (11%; Figure 11). Of survey participants overall, 66% were aware that invasive carp were present in the Kansas River at the location in which they were surveyed (Figure 12). A further analysis of this awareness data found that 53% of BIPOC and 75% of non-BIPOC survey participants were aware that invasive carp are present in the section of the Kansas River in which they were surveyed (Figure 13). Additionally, when analyzed by primary language spoken, 43% of Spanish-speaking survey participants, and 90% of English-speaking survey participants were aware that invasive carp are present in the section of the Kansas River in which they were surveyed (Figure 14).

Survey participants were also surveyed about their perceptions and use of invasive carp and how invasive carp have impacted their Kansas River recreational activities. Among perceived favorable impacts and uses, 57% of survey participants reported using invasive carp as bait, 31% indicated they targeted invasive carp, 13% thought invasive carp had a positive impact on other species, 8% increased their time on the river because of invasive carp, and 8% used invasive carp as food (Figures 15 and 17). Among perceived unfavorable impacts and uses, 32% of survey participants thought invasive carp negatively impacted other species, 29% reported being hit or injured by invasive carp, 23% feared for their safety because of invasive carp, 14% reported invasive carp damaging their equipment or boat, and 8% reduced their time on the river because of invasive carp (Figures 16 and 17). 47% of survey participants also reported invasive carp jumping in their boat; however, this was categorized as neutral due to survey participants having both favorable (free, easily obtained bait) and unfavorable (injury, safety, damage) perceptions of this situation (Figures 15, 16, and 17).

Tables and Figures:

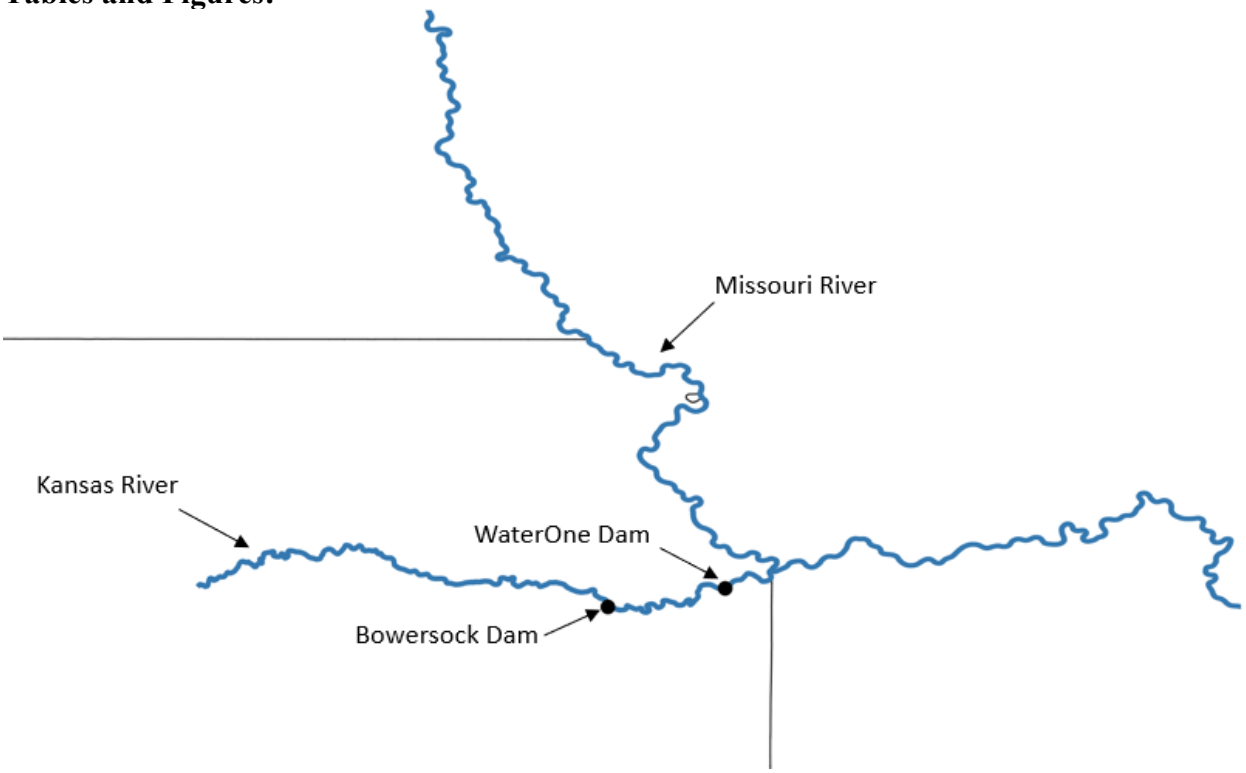

Figure 4. Map of Kansas River project area.

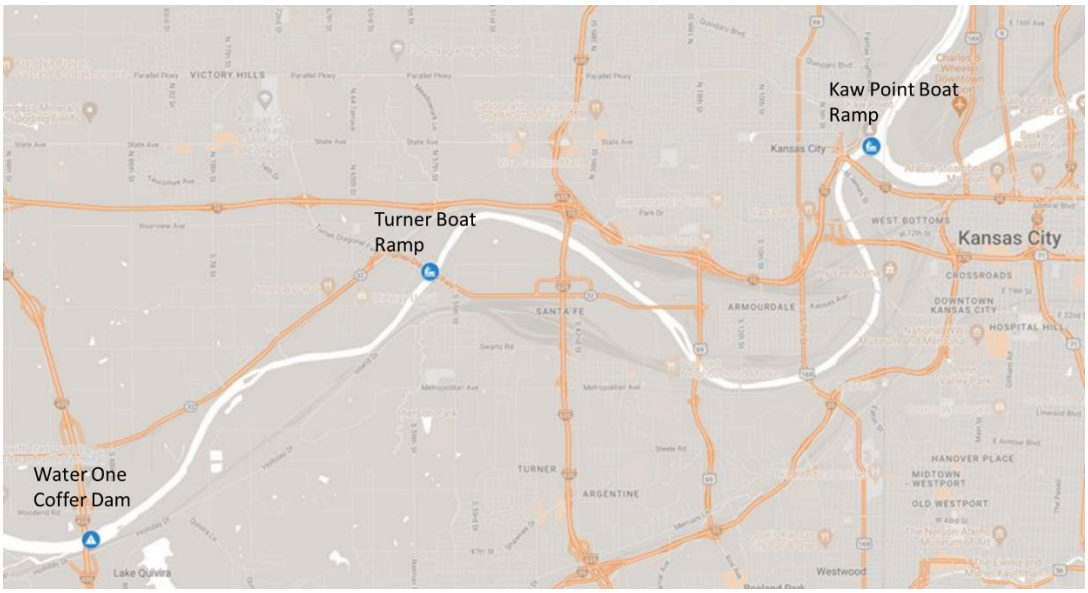

Figure 5. Map of Kansas River access points where surveys were conducted.

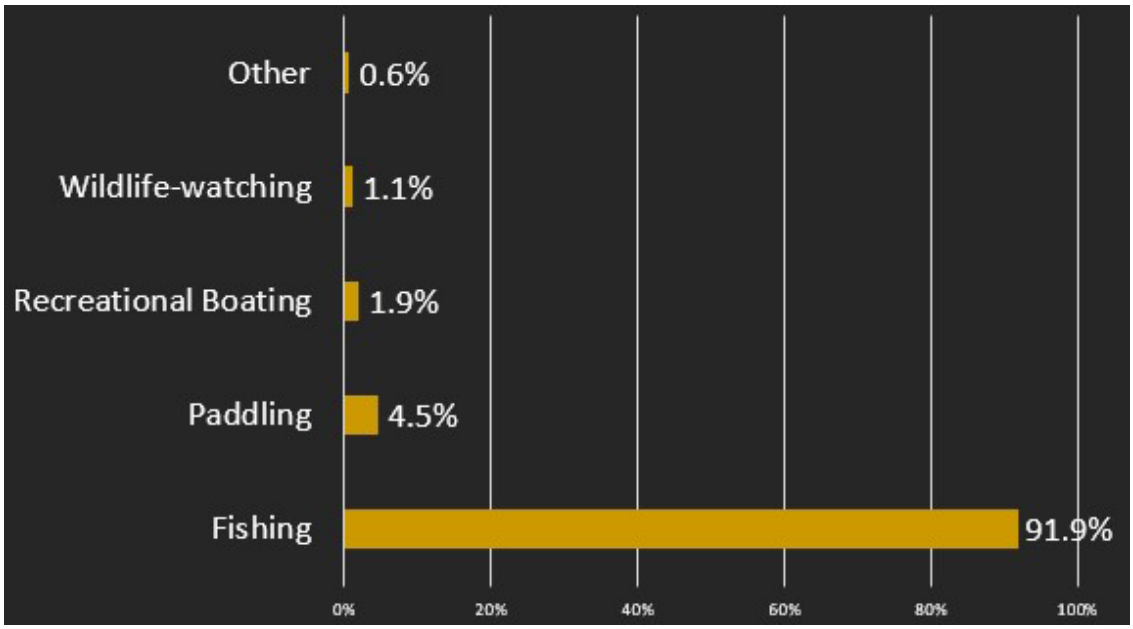

Figure 6. Primary activity of survey participants.

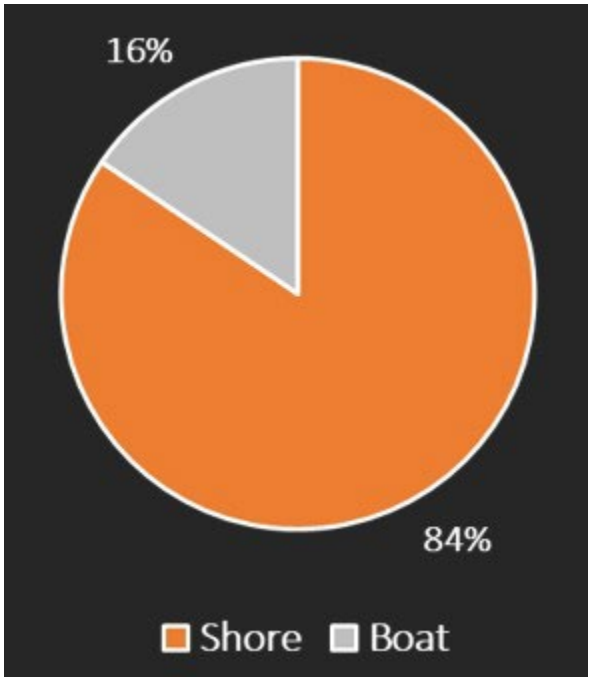

Figure 7. Percent of participants that were boat vs. shore-based users.

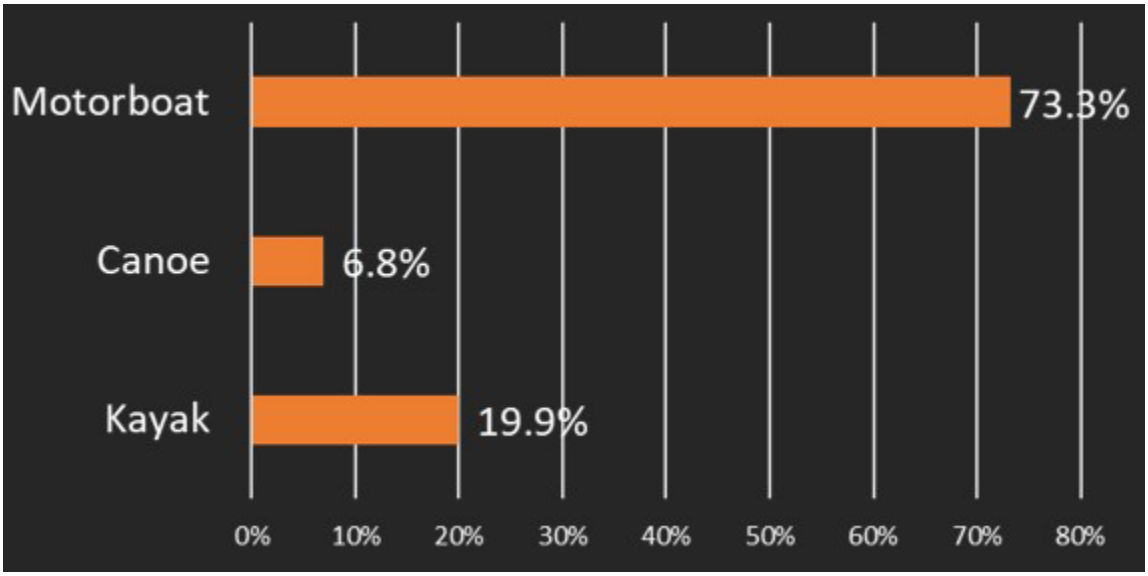

Figure 8. Boat type of survey participants that were using a boat.

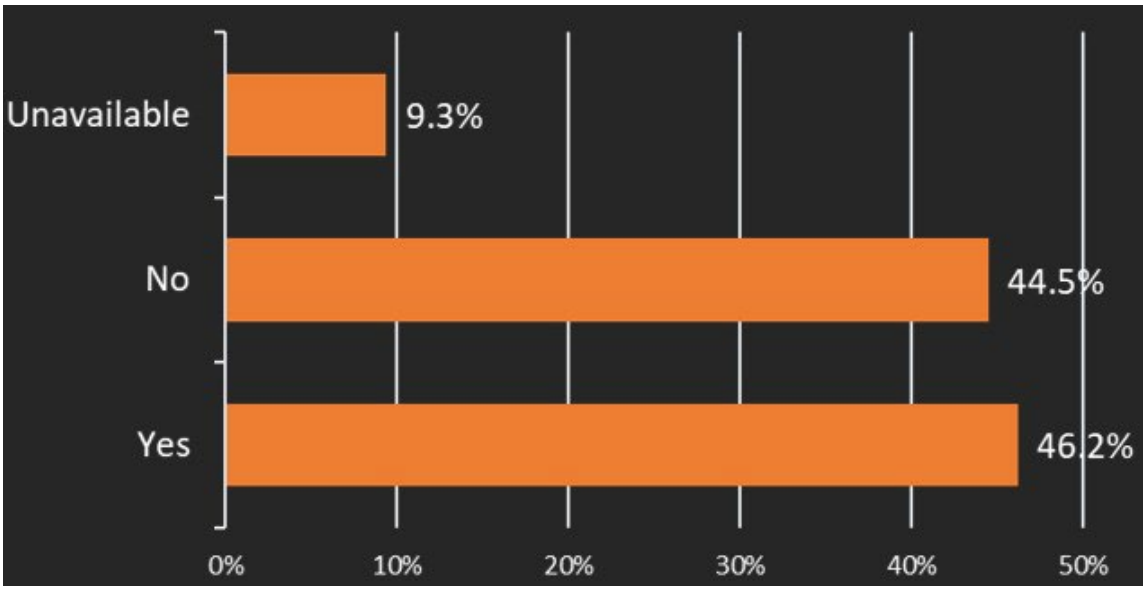

Figure 9. Percent of survey participants that are Black, Indigenous, or Person of Color (BIPOC).

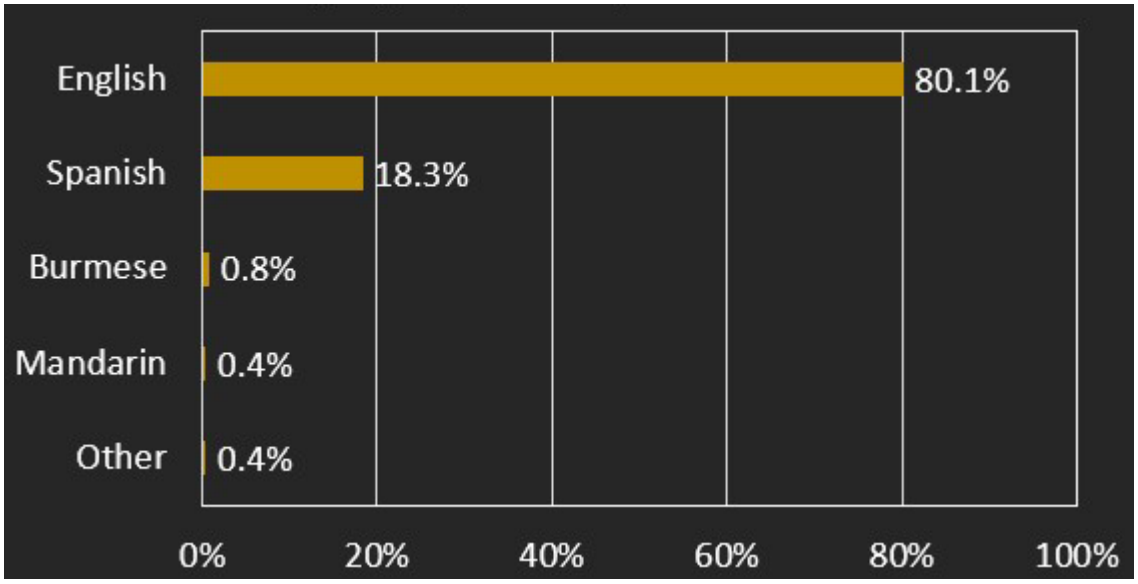

Figure 10. Primary language of survey participants.

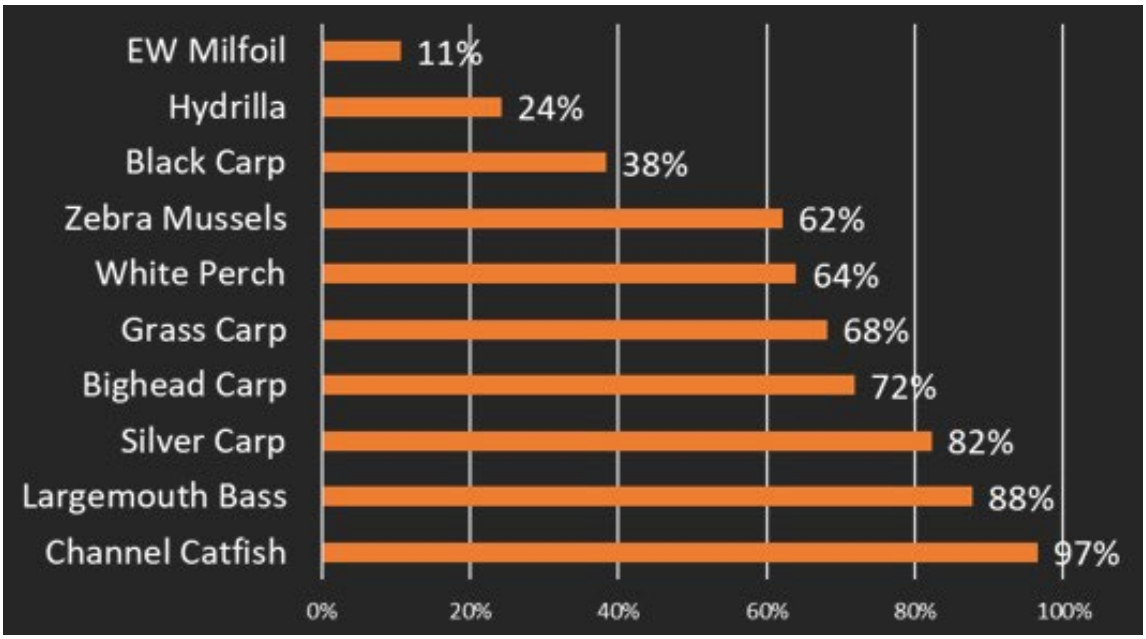

Figure 11. Percent of survey participants that had "heard of" the aquatic species on this list.

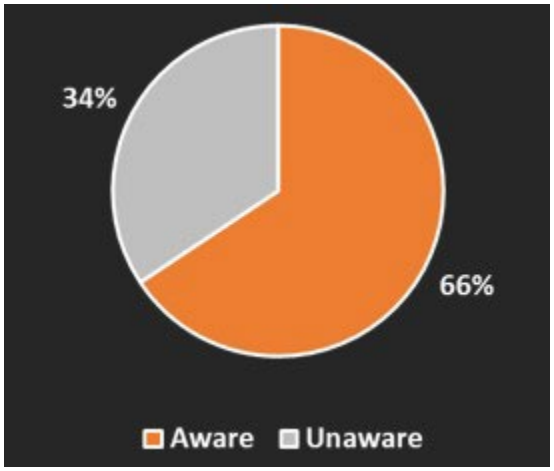

Figure 12. Percent of survey participants that were aware that invasive carp are present in the section of the Kansas River in which they were surveyed.

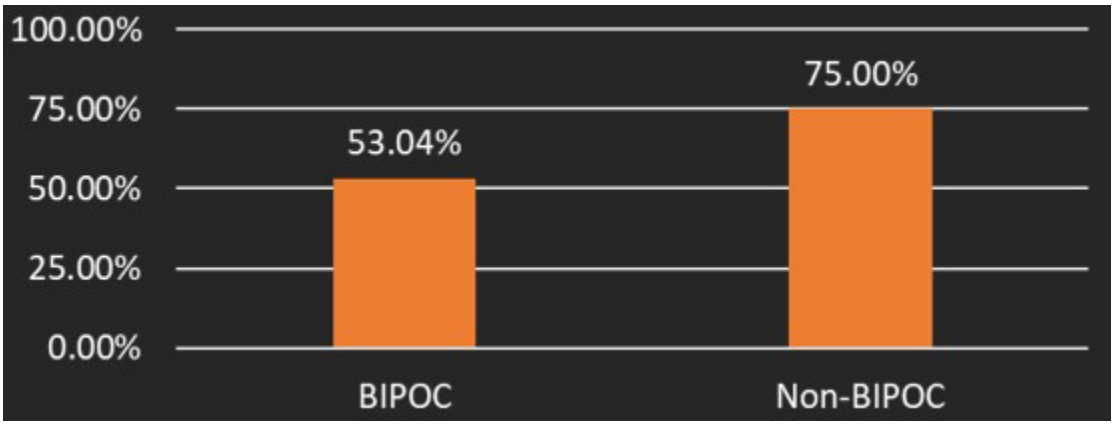

Figure 13. Percent of BIPOC and non-BIPOC survey participants that were aware that invasive carp are present in the section of the Kansas River in which they were surveyed.

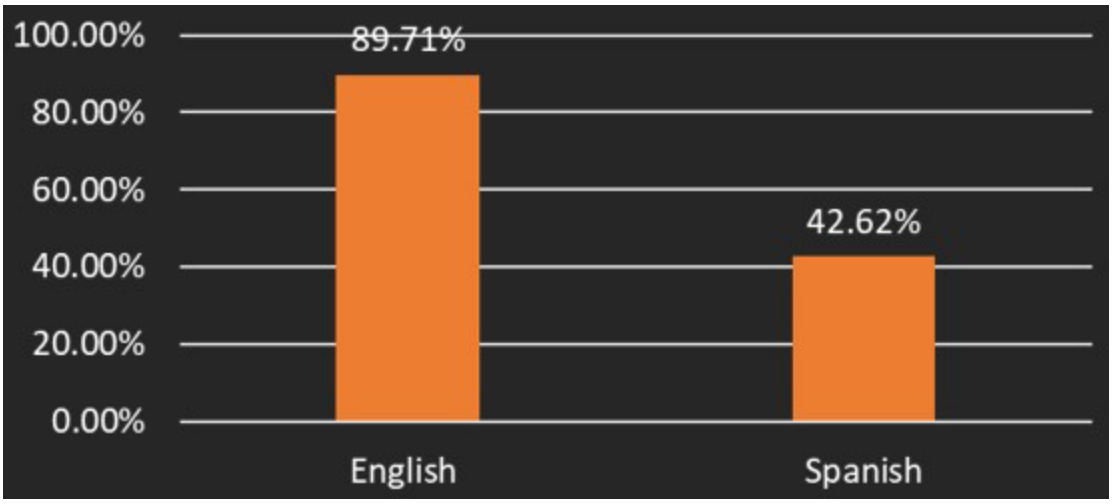

Figure 14. Percent of English and Spanish speaking survey participants that were aware that invasive carp are present in the section of the Kansas River in which they were surveyed.

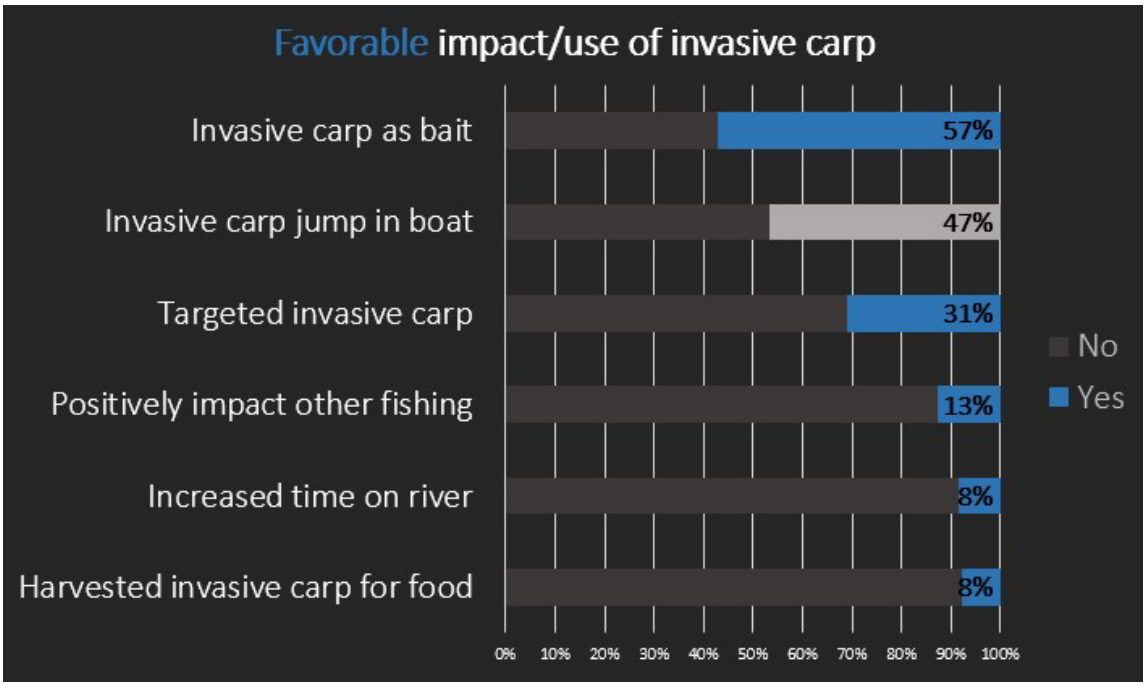

Figure 15. Percent of survey participants that indicated experiencing provided favorable impacts of invasive carp. Invasive carp jumping in boat was perceived as both favorable and unfavorable depending on survey participant, so it is listed here as a "neutral" impact.

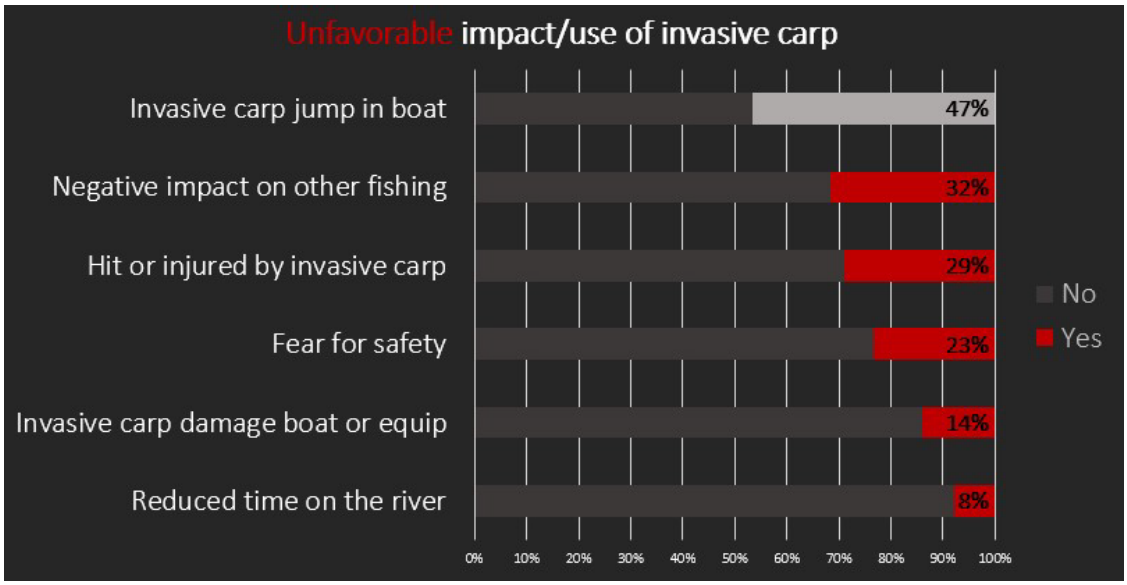

Figure 16. Percent of survey participants that indicated experiencing provided unfavorable impacts of invasive carp. Invasive carp jumping in boat was perceived as both favorable and unfavorable depending on survey participant, so it is listed here as a "neutral" impact.

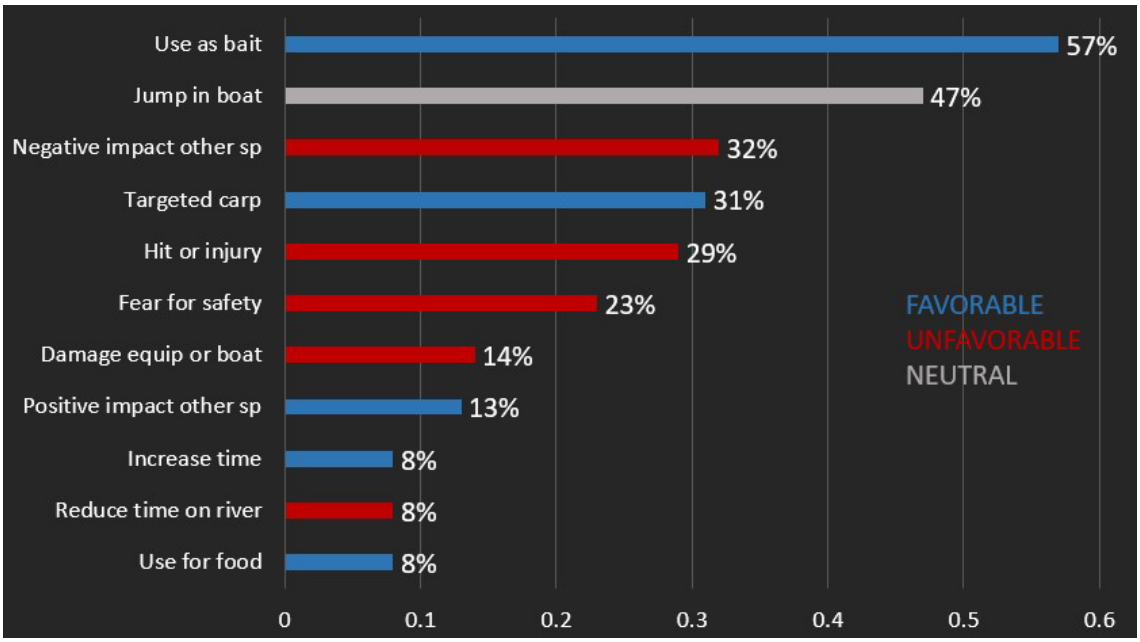

Figure 17. Percent of survey participants that indicated experiencing provided favorable and unfavorable impacts of invasive carp. Invasive carp jumping in boat was perceived as both favorable and unfavorable depending on survey participant, so it is listed here as a "neutral" impact.

Table 1. Summary of survey schedule and effort.

Month	Number of Weekday Sampling Shifts	Number of Weekend Day Sampling Shifts	Total Sampling Shifts	Total hours sampled
March	8	8	16	96 + (10 hours data entry) = 106
April	8	8	16	106
May	8	8	16	106
June	8	8	16	106
July	8	8	16	106
August	8	8	16	106
September	8	8	16	106
October	8	8	16	106

NEBRASKA

Project Title:
Assessment of Angler Satisfaction in the Mainstem Missouri River, Nebraska: Emphasis on Paddlefish Fishery below Gavin's Point Dam

Project Objectives:

Objective 1: Conduct angler satisfaction surveys in the Missouri River Basin to access recreational anglers' reactions to Asian carp and use this information to inform management actions.

Objective 2: Conduct surveys of anglers and the general public to assess general knowledge about Asian carp and understanding of potential consequences of human-mediated spread and use this information to inform management actions

Methods:

Onsite Surveys:

Onsite angler satisfaction surveys were conducted below Gavins Point Dam during the June archery season and the October snagging season. Onsite surveys consisted of a pre-trip and post-trip section. Pre-trip surveys asked anglers to rank the importance levels of various factors that could contribute to their daily satisfaction. Post-trip surveys asked about the same factors, but instead of importance, they were asked how the day related to the fishers' expectations. Having ranked importance done pre-departure and expectations done post-trip allowed for comparisons to be made between self-stated importance and the actual daily outcome. Post-trip surveys also asked the important questions of total satisfaction of fishers. This allows us to assess what factors best predict fishers' satisfaction.

For the June archery season, there were 20 different factors divided into catch-based and non-catch based. The catch-based factors were seeing Paddlefish, shooting Paddlefish, harvesting Paddlefish, harvesting trophy Paddlefish, seeing bigheaded carp, shooting bigheaded carp, harvesting bigheaded carp, seeing other species, shooting other species, and harvesting other species. The non-catch-based factors were seeing other fishers harvest Paddlefish, fishing favorable weather, fishing waterbodies free of aquatic invasive species, fishing uncrowded conditions, not being interfered with by other fishers, access to fishing spot, access to waterbody, amount of time spent fishing, effort required for harvest, and social aspect of recreational fishing.

For the October snagging season, there were 17 different factors divided into catch-based and non-catch-based that will be assessed. The catch-based factors were snagging any length Paddlefish, snagging a Paddlefish outside of the slot length, harvesting a Paddlefish, harvesting a trophy Paddlefish, seeing bigheaded carp, snagging bigheaded carp, and harvesting bigheaded carp. The non-catch-based factors were seeing other fishers harvest Paddlefish, fishing favorable weather, fishing waterbodies free of aquatic invasive species, fishing uncrowded conditions, not being interfered with by other fishers, access to desired fishing spot, amount of time spent fishing, access to waterbody, and the social aspect of fishing.

In both the June season and the October season, identical questions regarding awareness of invasive species including zebra mussels and carp were asked in the post trip portion. Similarly, the onsite surveys will collect data regarding any Paddlefish harvested such as length

of harvest, condition of harvest, and effort required for harvest (number of shots or number of casts). Snagging season surveys included questions about the number of bigheaded carp snagged and the number and sizes of Paddlefish snagged before harvest.

Mail surveys:

Mail surveys were sent out in the weeks following the completion of the onsite surveys. Mail surveys include ranked importance and ask how the season performed relative to the fishers' expectations of the same 20 and 17 factors. Unlike the onsite surveys which are daily assessments, the mail surveys asked about the fishers' impressions of the entire season of fishing. They also included questions on fishers' awareness of invasive species such as the spread of zebra mussels and the impacts of invasive bigheaded carp.

Analysis:

Basic data analytical techniques were run to get averages and basic assessments. Importance performance analysis (IPA) were run in order to assess how the fishery is performing relative to what anglers have stated as important to them. An importance grid analysis (IGA) were run to assess what factors explicitly and implicitly contribute to fishers' satisfaction. Finally, a penalty reward contrast analysis (PRCA) were run in order to assess what factors contribute positively or negatively to angler satisfaction. In addition to those analyses, a multi-variate analysis of variance (MANOVA) was run to determine what factors best predict angler satisfaction.

Results and Discussion:

June 2022:

During the June 2022 archery Paddlefish season, there were 75 completed onsite satisfaction surveys. Surveys were done at the party level, so within the 75 interviews, 113 tags were accounted for. There was a daily harvest rate of 87% with very few parties not harvesting. 83% of parties encountered bigheaded carp. Despite this high percentage, 88% of parties indicated that they were not impacted by invasive species (Figure 18), suggesting a disconnect between bigheaded carp being perceived as invasive relative to other potential species. Self-ranked importance of seeing, shooting, and harvesting bigheaded carp was ranked very low relative to expectations. The opposite was true to seeing, shooting, and harvesting Paddlefish, which were all ranked of high importance and high performance. An exception to this was the factor of catching a trophy Paddlefish, which was ranked of low importance and low performance to fishers.

It is very important to note that the majority of fishers during the June season were very satisfied or somewhat satisfied. 93% of parties reported total satisfaction levels of very satisfied or somewhat satisfied. Only one party was explicitly somewhat dissatisfied, and no parties were explicitly very dissatisfied. Four parties stated that they were neither satisfied nor dissatisfied. (Figure 19).

October 2022:

In the October snagging season, there were 108 completed interviews. These interviews accounted for 190 tags. A total of 17 tags were harvested, giving a daily harvest rate of 9%. Of the 17 interviewed tag holders that harvested fish, 15 harvested fish were below 35", and 2 were

above 45” when measuring from the eye to the fork in the tail. Overall satisfaction levels had more variation than in archery season. 68% of parties self-stated their satisfaction as either “Very satisfied” or “Somewhat satisfied”. 14% of parties self-stated their satisfaction levels as “Somewhat dissatisfied” or “Very dissatisfied”. 18% of parties listed their satisfaction level as “Neither satisfied or dissatisfied”. (Figure 19)

Project Deviations:

In addition to in-person creel surveys, we intended to send mail (or internet) surveys to previous year’s license holders to quantify anglers’ expectations as a basis for understanding stated satisfactions. Timing of personnel hires did not allow for such. In an effort to meet the spirit of that action, we decided to evaluate anglers’ expectations on two scales: daily evaluated by on-site interviews and seasonally evaluated by follow-up mail surveys. Given the timeframe of the project, follow-up mail surveys will only occur for the 2022 fishing seasons. Onsite surveys will occur during both 2023 Paddlefish seasons.

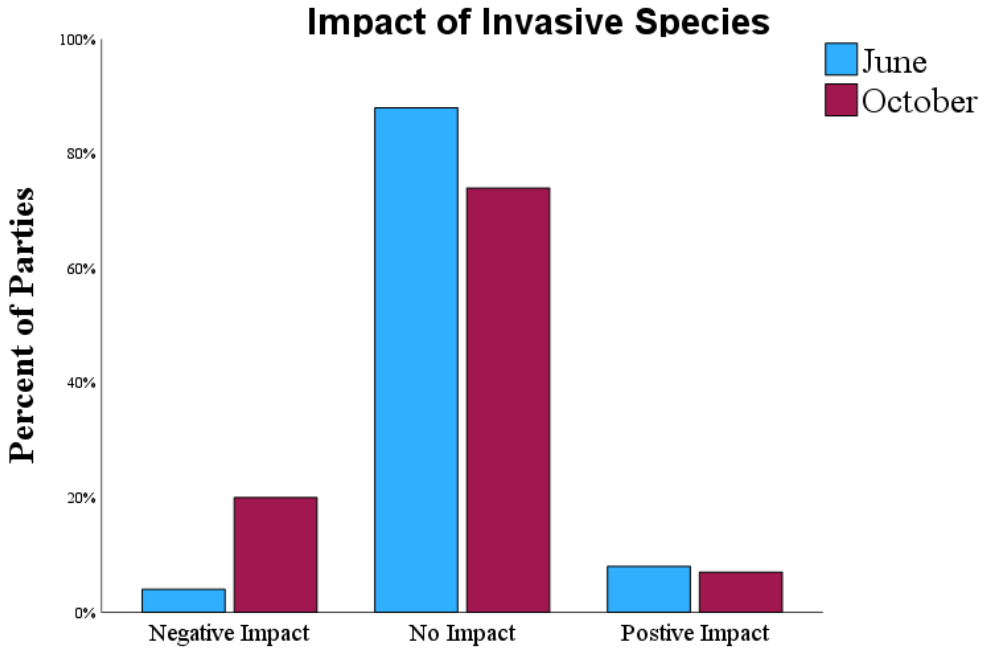

Figure 18. Self stated impact of aquatic invasive species (AIS) in June and October.

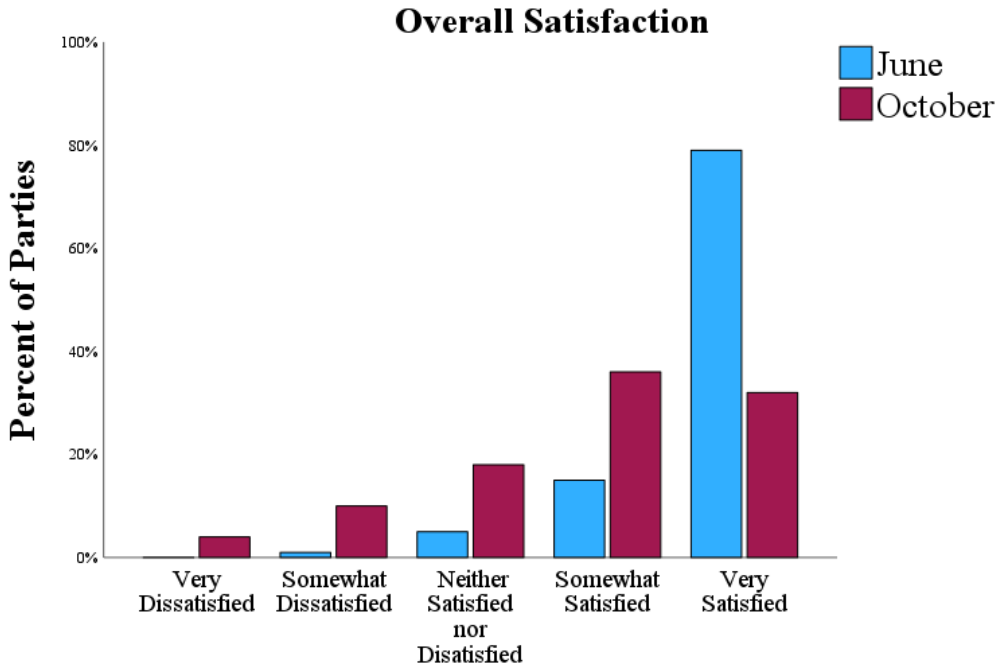

Figure 19. Overall fishers' satisfaction at the daily level in June and October.

Objective 3: Assess human-mediated pathway risks for Asian carp movement to prevent the introduction and further spread of Asian carp into and within the Missouri River Basin.

SOUTH DAKOTA

Project Title: Assessing the risk of Asian carp spread posed by live bait trade

Project Objectives:

1) Collect and process samples to assess the risk of Asian carp (Silver Carp and Bighead Carp) spread in the Missouri River Basin via the live bait trade and identify risk factors associated with particular bait shop operations (e.g., state regulations, proximity to established Asian carp populations).

Methods:

A total of 112 retail locations in North Dakota, South Dakota, Nebraska, Kansas, and Iowa that sold live baitfish were randomly selected based on a gradient of Silver and Bighead Carp abundances, as well as to target locations where barriers have inhibited Silver Carp and Bighead Carp spread in the Missouri River Basin (Figure 20). Aquatic invasive species coordinators from each study state also provided a list of high-priority locations for sampling which was accounted for when selecting baitfish retailers. Google Map searches (i.e., “bait shop”, “live bait near me”, “live minnows”) and inquiries from state agencies provided a list of bait shops, convenience stores, and department stores that sold live baitfish for each state. Bait retailers were then randomly selected through a random number generator. However, there were cases when random selection was not possible due to the small number of bait retailers present in the area. We selected 20 bait shops per state for widespread regional surveillance and visited an additional 12 bait shops during fall South Dakota sampling.

Sampling methods were adapted based on previously described methodology (Nathan et al. 2015; Snyder et al. 2020; Mahon et al. 2010) where water is collected from bait retailers in sterile bottles and placed in a cooler of ice during transportation to limit eDNA degradation. For each sampling day, we filled a half-gallon milk jug (1.87 L) with tap water and filtered it with the rest of the samples to serve as the negative field control to ensure contamination was not occurring. Additionally, all sampling equipment was decontaminated and soaked in a 10% bleach solution for 10 minutes between samples. Nitrile gloves were also worn and changed between and during water and baitfish collection and filtering.

At each baitfish retailer, one unit of baitfish (either one dozen or one scoop depending on the retailer) was purchased and held in a decontaminated bucket. Advertised baitfish purchased were usually Fathead Minnows (n = 91 retailers) but Golden Shiners (n = 19 retailers), Red Shiners, (n = 1 retailer), or a combination of both Fathead Minnows and Golden Shiners (n = 1) were purchased if Fathead Minnows were not available. During the purchase, the presence of any educational signage about bait dumping and/or invasive species was also recorded. Baitfish were strained from water with a colander and the water was divided into two replicate 1L water samples which were funneled into sterile half-gallon milk jugs. The half-gallon milk jugs were

immediately placed in a cooler with ice. The baitfish were euthanized (IACUC protocol 2109-056A), and placed in a labeled plastic bag (date, state, bait retailer) with 70% ethanol. Purchased bait was identified to species in the lab.

All water samples were filtered within 12 hours using a multiple vacuum pump filtration system (Cytiva Whatman, Little Chalfont, Buckinghamshire, UK) onto a 1.5-µm pore size glass fiber filter (Nathan et al. 2015; Snyder et al. 2016). To minimize bleach residue, 500 mL of tap water was run through the apparatus before filtering each sample. Filters were then placed into 15 ml Falcon tubes with 99% ethanol for shipment to the Bozeman Fish Health Center. In cases where the water sample would not filter through completely, the amount of water filtered was recorded and a new filter was placed on the filter funnel. In cases where the sample required more than 2 filters, a new vial was labeled, and the process was repeated for up to 4 filters. Vials were wiped with DNA AWAY™ (T Thermo Fisher Scientific, Waltham, MA, USA) and shipped to the USFWS Bozeman Fish Health Center in Bozeman, Montana.

In 2022, water samples were collected from 100 bait retailers (two water samples per bait shop with exception of one bait shop in Kansas that only supplied enough water for one sample; 20 retailers per state) in North Dakota, South Dakota, Nebraska, Kansas, and Iowa from June to September. Sampling moved from south to north to match when Bighead Carp and Silver Carp juveniles may be abundant and of similar size to native baitfish species. In September and October 2022, 60 additional water samples were collected in South Dakota from 30 bait retailers, including 18 bait retailers that were previously sampled and 12 new bait retailers.

Staff at the USFWS Bozeman Fish Health Center performed DNA extraction and quantitative real-time polymerase chain reaction (qPCR) analysis on each sample and field control filter to identify the presence or absence of target species DNA. The USFWS eDNA sampling processing protocol, detailed in the 2022 Quality Assurance Project Plan, uses an assay with two general invasive carp markers (ACTM 1/3), two markers specific to Silver Carp (SCTM 4/5), and two markers specific to Bighead Carp during qPCR amplification (BHTM 1/2) (QAPP; USFWS 2020). A sample is considered positive if fluorescence is above a threshold for any of the primers, in at least one of the eight amplification replicates. Thresholds are determined by running standards during each amplification.

Results and Discussion: Out of the 259 water samples collected from bait retailers in June to October 2022, 15 (5.79%) tested positive for at least 1 of the Silver and/or Bighead Carp qPCR replicates in North Dakota (n = 1), South Dakota (n = 9), Kansas (n = 1), and Iowa (n = 4) (Figure 21; Table 2). Nebraska did not have any positive detections for Silver and/or Bighead Carp in the selected bait retailers. The only detection for Bighead Carp was documented in 1 Kansas bait retailer. Out of the 15 positive detections, 2 bait retailers had educational signage and 5 bait retailers had non-advertised species present within purchased bait. All field controls were negative (n = 27 filters). We are currently completing analysis to evaluate links among risk factors and positive eDNA detections.

Out of the 112 bait shops sampled, 13 (12%) had educational signage about bait dumping and/or invasive species in Kansas (n = 2), Nebraska (n = 2), and North Dakota (n = 9) (Figure 22). We did not observe educational signage in South Dakota or Iowa in the bait shops surveyed. All educational signage present was in the form of posters; we did not observe educational signage or outreach in the form of pamphlets, bait bags, or verbal communication. Stop Aquatic Hitchhikers!™ (Clean, Drain, Dry) was the only signage recorded in Kansas and Nebraska. North Dakota educational signage was predominantly provided to bait retailers by North Dakota Game and Fish and included posters regarding proper disposal of live bait, baitfish identification, and signage regarding the importation of bait. Bait retailers in North Dakota typically had more than 1 poster displayed.

Out of 112 bait shops, 17 bait shops (15%) had non-target species present within the purchased bait in Kansas (n = 1), Nebraska (n = 4), Iowa (n = 6), South Dakota (n = 5), and North Dakota (n = 1) (Figure 23). In South Dakota, 3 bait shops that did not originally have a non-target species had a non-target species present during the additional fall survey. One bait shop in South Dakota that originally had a non-target species did not have non-target species present during the second visit. Non-advertised species included the Rosy Red variation of the Fathead Minnow, Brook Stickleback, Black Bullhead, White Sucker, Topminnow, and River Carpsucker. We also observed a common mudpuppy in one South Dakota bait shop tank. There was also a bait shop in Iowa with multiple non-target species within one purchase (4 Brook Stickleback).

Although positive eDNA detections do not necessarily mean a live Silver Carp or Bighead Carp was present, positive eDNA detections coupled with the sale of non-target species indicates that the live bait trade is a potential vector for invasive carps in the Missouri River Basin. Analysis is on-going to further clarify risk factors associated with positive eDNA hits and will be included in the next report. Lack of educational signage indicates an opportunity to work with bait shops to educate the public regarding invasive carps.

Tables and Figures:

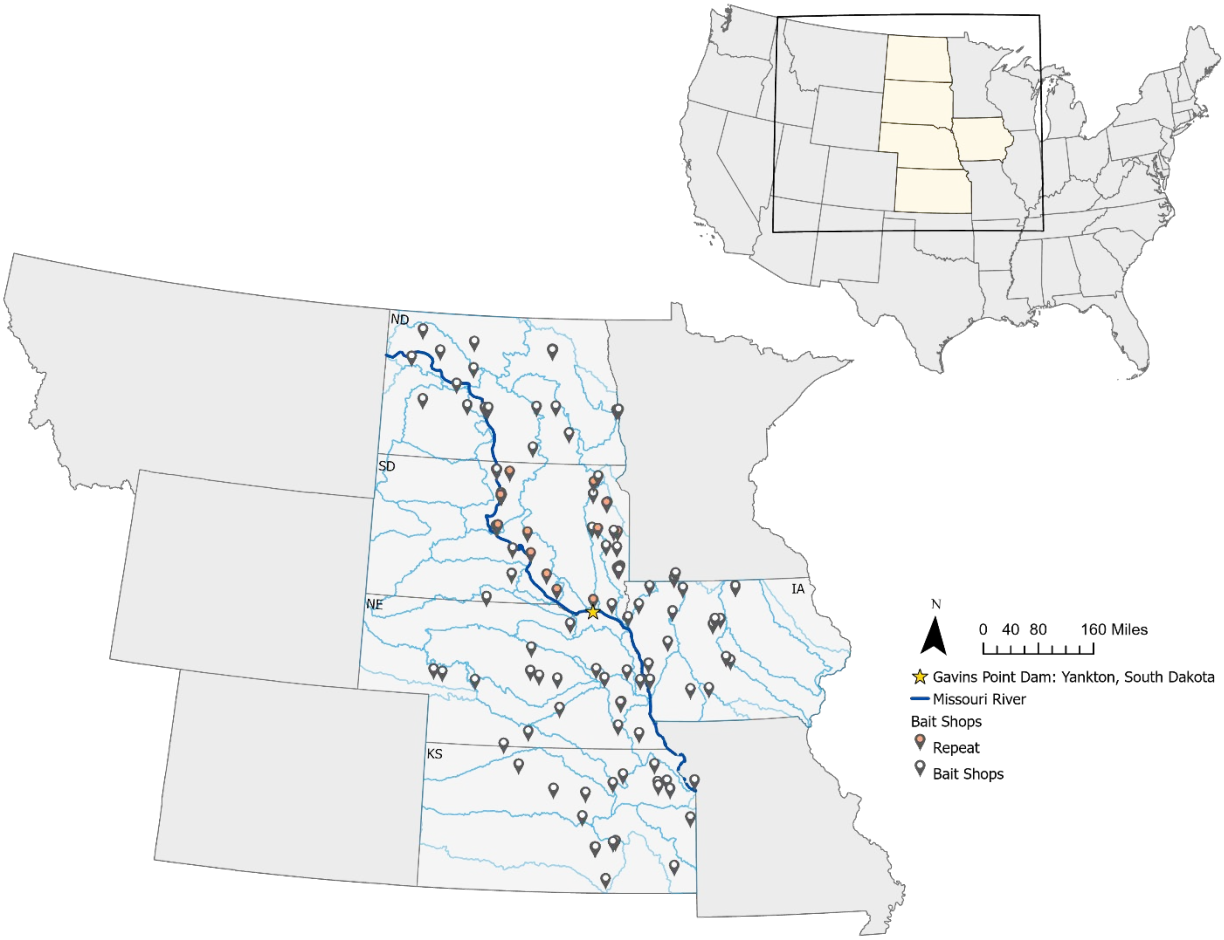

Figure 20. Locations of the 112 bait retailers selected for eDNA surveillance in the Missouri River basin during June to October 2022. Bait retailers included bait shops, convenience stores, and department stores.

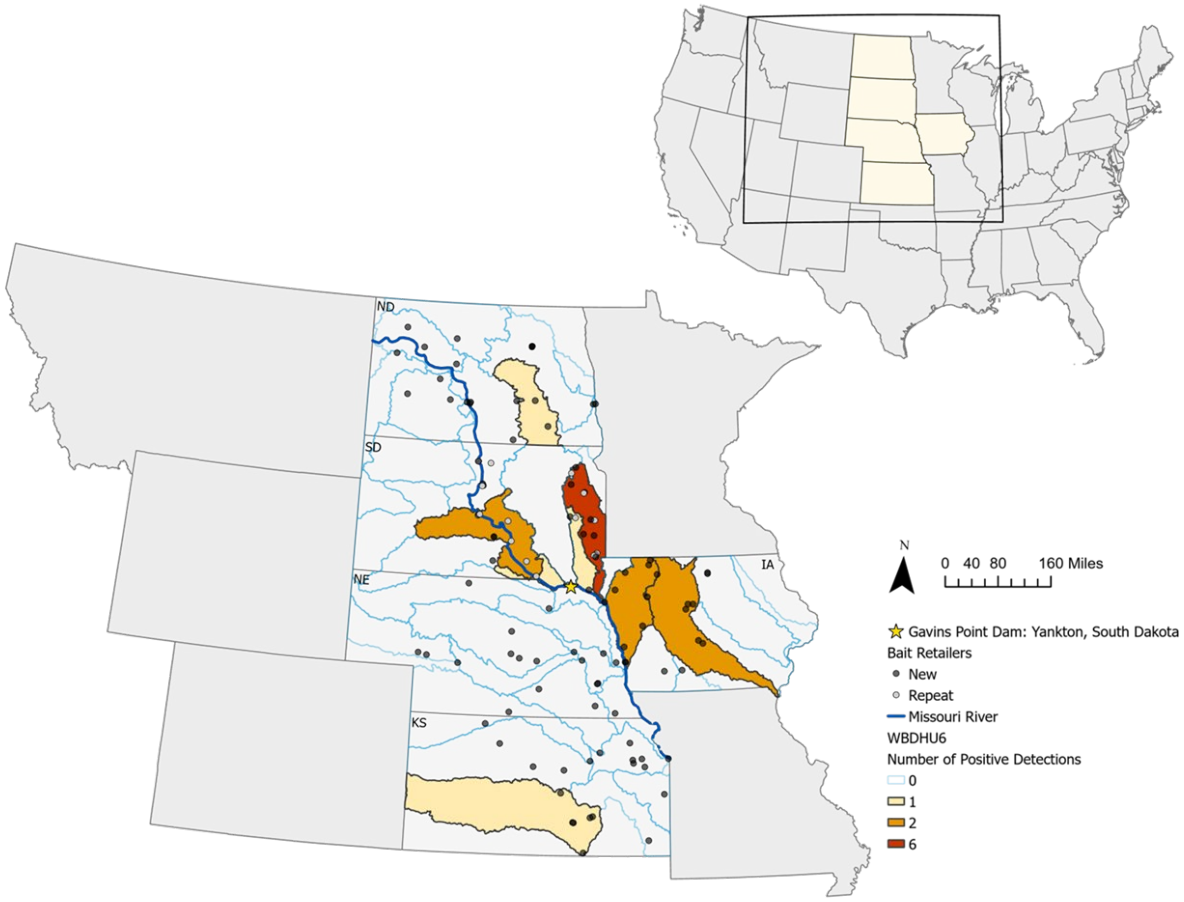

Figure 21. Locations of positive detections for Silver Carp and/or Bighead Carp eDNA during 2022 environmental DNA (eDNA) surveillance by hydrologic unit code 6 (HUC – 6), commonly referred to as basin.

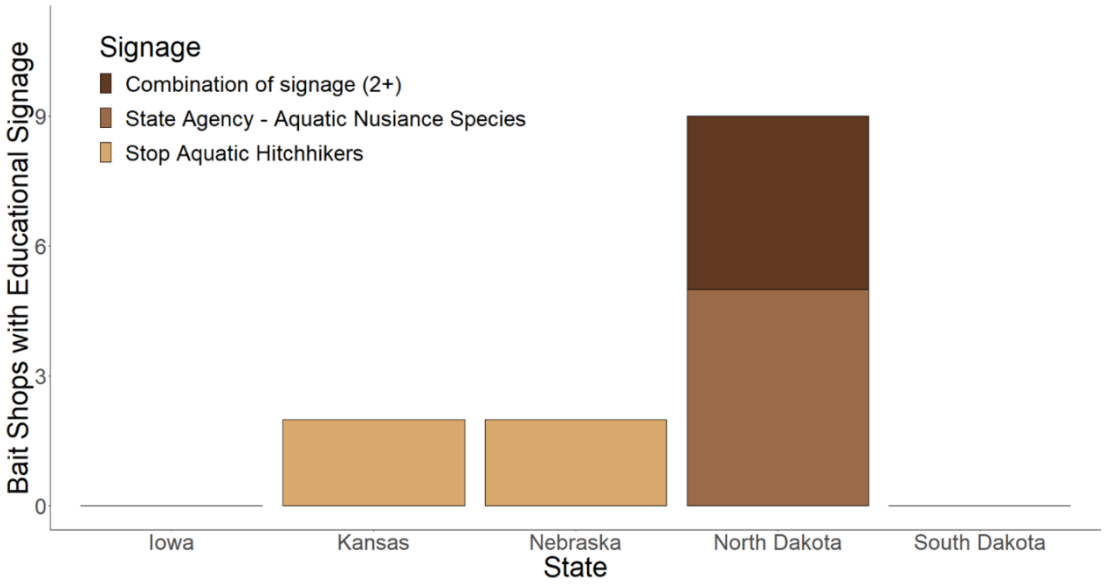

Figure 22. Quantity of Aquatic Invasive Species (AIS) signage by state in sampled bait shops (N= 20/state). Recorded educational signage included state agency- aquatic nuisance species, state agency- do not dump bait bucket (included in combination of signage) and stop aquatic hitchhikers.

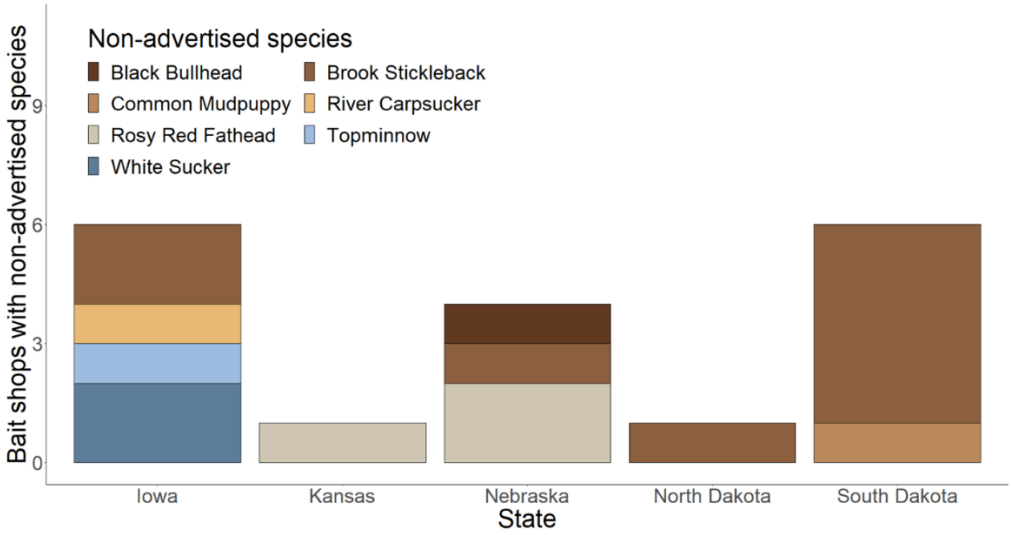

Figure 23. Quantity of non-advertised species present in purchased bait by state (N = 20 bait retailers/state, SD = 32 bait retailers and 18 repeated visits) in Iowa, Kansas, North Dakota, Nebraska, and South Dakota. Non-advertised species included the Rosy Red variation of the Fathead Minnow, Brook Stickleback, Black Bullhead, White Sucker, Topminnow, and River Carpsucker.

Table 2. Number of bait shops within different watersheds that tested positive for at least one of the three primers evaluated. Primers are fully described in the USFWS 2022 Quality Assurance Plan.

Hydrologic Unit Code 6	Detection of AC only	BH or BH and AC only	SC or SC and AC only
Middle Arkansas	0	1	0
Missouri-Little Sioux: IA	1	0	1
Des Moines	1	0	1
Big Sioux	4	0	2
James: ND	0	0	1
Lewis and Clark Lake	1	0	0
Fort Randall Reservoir	1	0	1

Recommendations:

- Continue to explore options to communicate results of invasive carp research to partners at all levels.
    - A bibliography with contact information was added to this document as Appendix A and will be updated on an annual basis.
    - Research or management that takes place in the Missouri River Basin that may not have been funded by FWS or developed within the partnership but are of interest to the partnership should be communicated. This information may be included in the bibliography Appendix or produced as a stand-alone appendix for the Communication and Outreach annual report or other annual technical reports of the Missouri River Basin partnership that may be more applicable (see Appendix B).
- Although analyses are on-going for Objective 2 (Evaluating recreational satisfaction) and Objective 3 (Assessing human-mediated pathway risk), initial results indicate that increased signage or educational materials regarding the risk of Silver Carp are needed.
    - Communicating with other ethnicities or user groups is essential. Signage at boat ramps or river access points to communicate with those who do not speak English is recommended. Options are signs in other languages (e.g., Spanish along the Kansas River) or creating signs without words that use images to convey the message, similar to pesticide or hazardous material labeling.
    - Bait shops had limited education materials, and what was there was often related to Stop Aquatic Hitchhikers!TM (Clean, Drain, Dry). Increased materials in bait shops, educational signage, and outreach in the form of pamphlets, bait bags, or verbal communication regarding proper disposal of live bait, baitfish identification, and the importation of bait is recommended.
    - Current organization in some state hunting and fishing regulations have bait regulations and AIS information in separate locations. It is recommended to house this information in similar locations of hunting and fishing regulations for anglers to easily access.
- This research has brought awareness to the confusion surrounding the term invasive carp. Some of the confusion is about what species of carp are invasive. Some of it may also be due to the success of the campaigns of the Western states to educate citizens on the impacts of the invasive zebra and quagga mussels and the pertinent management actions (Clean, Drain, Dry). Because of those campaigns, people often think of mussels (not carp) when they hear the term invasive. Therefore, it is recommended to continue conversations about how to explain what species are included when referring to invasive carp or convert to using species names, i.e., Silver Carp.

References:
Start references on new page. Please use AFS formatting for citations; see https://fisheries.org/docs/pub_style9.pdf or https://fisheries.org/books-journals/writing-tools/style-guide/ for details.

Mahon, A. R., L. R. Nathan, and C. L. Jerde. 2014. Meta-genomic surveillance of invasive species in the bait trade. Conservation Genetics Resources 6(3):563-567.

Nathan, L. R., C. L. Jerde, M. L. Budny, and A. R. Mahon. 2015. The use of environmental DNA in invasive species surveillance of the Great Lakes commercial bait trade. Conservation Biology 29(2):430-439.

Snyder, M. R., C. A. Stepien, N. T. Marshall, H. B. Scheppler, C. L. Black, and K. P. Czajkowski. 2020. Detecting aquatic invasive species in bait and pond stores with targeted environmental (e)DNA high-throughput sequencing metabarcode assays: Angler, retailer, and manager implications. Biological Conservation 245:108430.

Appendix A. Bibliography

Goode K, Weber MJ, Dixon PM. 2023. WhoseEgg: classification software for invasive carp eggs. PeerJ 11:e14787 https://doi.org/10.7717/peerj.14787. Contact: Dr. Michael Weber, Associate Professor, Iowa State University, Department of Natural Resource Ecology & Management, email: mjw@iastate.edu

Appendix B. Additional information