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MEMORANDUM

Date: March 8, 2022

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From: Mark Gaikowski, Center Director MARK GAIKOWSKI Digitally signed by MARK GAIKOWSKI Date: 2022.03.08 11:32:24 -06'00'

Subject: FY21 annual technical report: Evaluation of fish passage for assessment of invasive carp deterrents at locks in the upper Mississippi River

This memorandum summarizes field activities in proximity to Mississippi River Lock 19 at Keokuk, IA. The USGS portion of the research was funded by the U.S. Geological Survey Ecosystems Mission Area Invasive Species Program. This annual progress report is distributed solely for purposes of reporting project progress. Because the annual progress report does not represent an official publication by the U.S. Geological Survey (USGS), it does not represent any official USGS finding or policy. Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Project Title: Evaluation of fish passage for assessment of invasive carp deterrents at locks in the upper Mississippi River

Geographic Location: Upper Mississippi River, Pool 14-20, special emphasis on Locks and Dams 19, 15, and 14

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Participating Agencies: Illinois Natural History Survey (INHS), Missouri Dept of Conservation (MDC), USFWS, U.S. Army Corps of Engineers (USACE)

Statement of Need: Invasive carp are established in the upper, middle, and lower Mississippi River and their expansion upstream threatens a variety of aquatic ecosystem services including fishing and recreational boating. The physical and operational characteristics of Lock and Dam

(LD) 19 restrict upstream movement of fishes because the only upstream fish passage route is through the lock chamber. This restriction might be hindering consistent reproduction and recruitment of invasive carps enough to reduce their abundance upstream of LD 19. Locks and Dams 14 and 15 (upriver of LD 19) are infrequently at open-condition and may also be limiting the continued upstream expansion of invasive carps. Upstream passage of fishes at these locations would be limited to the lock chamber for the majority of the year (Wilcox et al. 2004; Bouska 2021).

Acoustic deterrents have been developed to deter fish movement through restricted passage points, and those systems show promise in deterring invasive carps. To date, small-scale acoustic deterrents have been tested on many native fishes and invasive carps in labs, outdoor ponds, and small rivers (Vetter et al. 2015, 2017; Murchy et al. 2017). Federal, state, and local partners approved the opportunity to test an experimental underwater Acoustic Deterrent System (uADS) at LD 19 and this system, composed of 16 underwater speakers, was installed during Jan-March 2021. Testing of a uADS at a pinch-point dam, such as LD 19, will help managers understand the impact of a management deployment of a uADS at this site and other large river locations.

Lock and Dam 19 is an advantageous location to test an experimental uADS because fish can only move upstream through the lock chamber and because this location has five years of fish passage data that have been collected by the UMR Invasive Carp Team. The partnership has successfully evaluated the seasonal timing of passages of invasive carps and native fish species and evaluated the relation of fish upstream passages with the operation of the lock for river vessels (Fritts et al. 2021). A pivotal discovery from the ongoing work has been the identification of a differential motivation of invasive carps to complete upstream passage at LD 19. Invasive carps that were originally tagged upstream of LD 19 and moved downstream on their own volition were much more likely to complete upstream passage than invasive carps tagged downstream of LD 19 in Pool 20 (Fritts et al. 2021). This observation prompted an experimental translocation effort in 2019. In addition, the partnership has gained insights into behavior of invasive carps tagged with depth-sensitive transmitters. Data from these tags provided information about the position of a fish within the water column at LD 19 and how fishes interact and respond to river vessel presence in the downstream lock approach and the lock chamber.

Passage data for invasive carps and native species (i.e., paddlefish, bigmouth buffalo) have also been studied at LD 15 over the past four years. Locks and Dams 14 and 15 have both been considered as potential locations for deterrents and it is critical to have baseline information on behavior of native and invasive species to inform management decisions including the potential deployment of deterrents at these sites (Upper Mississippi River Asian Carp Partnership 2018).

State and federal partners have identified evaluating the effects of a uADS on native species as a high priority. VEMCO telemetry data are currently being collected by MDC, INHS, USFWS and USGS from previously tagged fish (invasive carps and native species) moving through longitudinal and fine-scale arrays of VEMCO acoustic receivers at LD 19, LD 15, and LD 14. Many of the previously tagged fish will continue to be tracked in addition to the newly tagged fishes. Our project proposes continued collection of movement data using VEMCO receiver arrays and acoustically tagged fish in the UMR to evaluate the effects of the uADS at LD 19 on invasive carps and native species.

This project directly addresses multiple aspects of the UMR sub-basin framework, including providing information on evaluating and implementing deterrent measures at strategic pinch points to prevent dispersal of invasive carp and supporting research to develop new containment technologies. This project also closely aligns with the goal of containing expansions of invasive carps in the UMR while minimizing impacts to native species movement.

Project Objectives:

1) Assess fish behavior and passage rates of invasive carps and native fishes at LD 19 to evaluate the performance of an experimental underwater Acoustic Deterrent Systems (uADS) to deter invasive carps while minimizing effects to native species
2) Analyze depth-sensor data from invasive carps and native species to determine vertical positioning within the water column near LD 19
3) Evaluate fish passage dynamics (e.g., route, timing, relation with environmental variables) for baseline information at LD 15 and LD 14 (see INHS FY21 report)
4) Use USACE Lock Queue Reports to inform the relationship between fish movements and behavior in relation to lock structures and operation at LDs 14, 15, and 19

Project Highlights:

- Experimental uADS deployed at LD 19 in spring 2021
- 351 invasive carp and 208 native fish internally implanted with acoustic transmitters to monitor passage through and behavior around the uADS during on and off conditions
    - A subset of these fish were tagged with VEMCO depth transmitters

Methods: USGS maintained a VEMCO telemetry receiver array at LD19 (Figure 1). Six receivers were deployed in the downstream lock approach, three additional receivers were deployed in the lock chamber, and one additional receiver was deployed above the upper lock gates at LD 19 to enhance vertical position monitoring in the lock chamber and to supplement the existing receivers maintained by MDC. An additional fine-scale telemetry system (HTI) was installed concurrent with the installation of the uADS.

A large fish-tagging event occurred during spring 2021. Silver carp, bighead carp, grass carp, and bigmouth buffalo were collected in locations upstream of LD 19 and translocated, tagged, and released downstream into Pool 20. This was done to increase the sample size of invasive carps that would approach and challenge the uADS, thereby increasing the amount of data available to assess the efficacy of this experimental deterrent. Native fish species (i.e., bigmouth buffalo, paddlefish, lake sturgeon, flathead catfish, freshwater drum, blue sucker, walleye, white bass) were collected and tagged in Pool 20 (i.e. downstream of LD 19).

Lock Queue Reports were obtained from the U.S. Army Corps of Engineers Lock Performance Management System to evaluate the relation between fish passage, operation of the uADS, and operation of the lock for river vessels.

Results: The uADS system construction and installation was completed in early 2021. Construction set-up began January 3, 2021 and deployment of the uADS soundbar occurred in February 2021 (Figure 2). The entire uADS, including scientific sound and fish monitoring

equipment, was installed by the opening of the navigation season (March 15, 2021). All equipment testing was completed by April 2021. The uADS was operated on an 80-hr *on-off* cycle from March-December 2021.

From April through June 2021, 351 invasive carp and 208 native fish were internally implanted with acoustic transmitters to monitor passage through and behavior around the uADS during on and off conditions. Two telemetry systems are being used for the uADS evaluation (i.e., VEMCO and HTI).

VEMCO depth transmitters were deployed in bighead carp and silver carp in 2019 and a subset of these tagged carps are still being detected near LD 19. Bigmouth buffalo, paddlefish, lake sturgeon, and flathead catfish were tagged with depth transmitters in spring 2021. The depth sensor transmitters are providing information on the position of bigheaded carps and native fish species in the water column at LD 19 and how fish are responding to the uADS.

Presentations on invasive carp behavior at LD 19 were provided at the Midwest Fish and Wildlife Conference and the Mississippi River Research Consortium Conference during FY21.

Data from 2017-2018 were analyzed to determine how environmental conditions and lock operations affect native species and invasive carp movement and behavior at LD 19. These analyses were published in the journal Biological Invasions.

> Fritts, A.K., B.C. Knights, J.C. Stanton, A.S. Milde, J.M. Vallazza, M.K. Brey, S.J. Tripp, T.E. Devine, W. Sleeper, J.T. Lamer, K.J. Mosel. 2021. Lock operations influence upstream passages of invasive and native fishes at a Mississippi River high-head dam. *Biological Invasions* 23: 771-794. https://doi.org/10.1007/s10530-020-02401-7

A review paper was published in 2021 that provides an overview of emerging invasive carp control efforts, including information on the uADS.

> Cupp A, Brey M, Calfee R, Chapman D, Erickson R, Fischer J, Fritts A, George A, Jackson R, Knights B, Saari G, and Kocovsky P (2021). Emerging control strategies for Integrated Pest Management of invasive carps. *Journal of Vertebrate Biology*. 70(4):21057. DOI:10.25225/jvb.21057

Analysis of depth sensor tags and an evaluation of differences in behavior of invasive carps that originated from the UMR IMZ relative to invasive carps collected from Pool 20 is currently being conducted and an associated manuscript will be submitted to a peer reviewed journal in 2022.

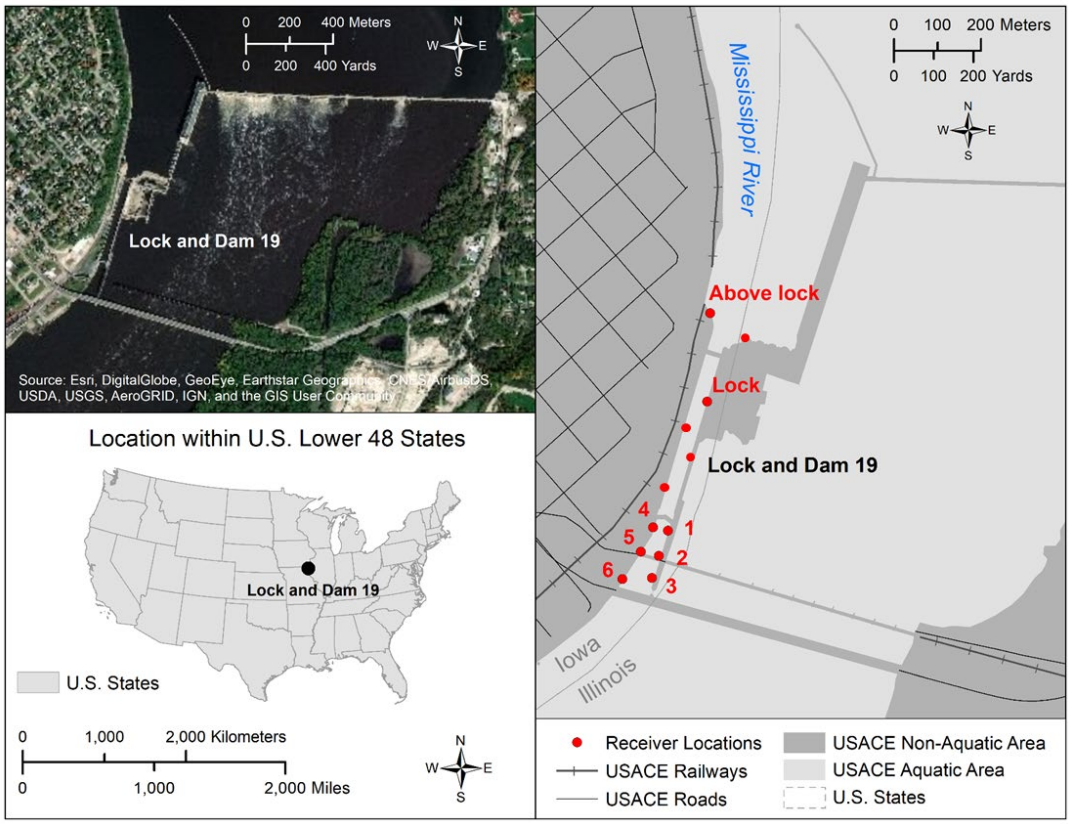

Figure 1. Location of receivers comprising the fine-scale array in the lock approach at Lock 19.

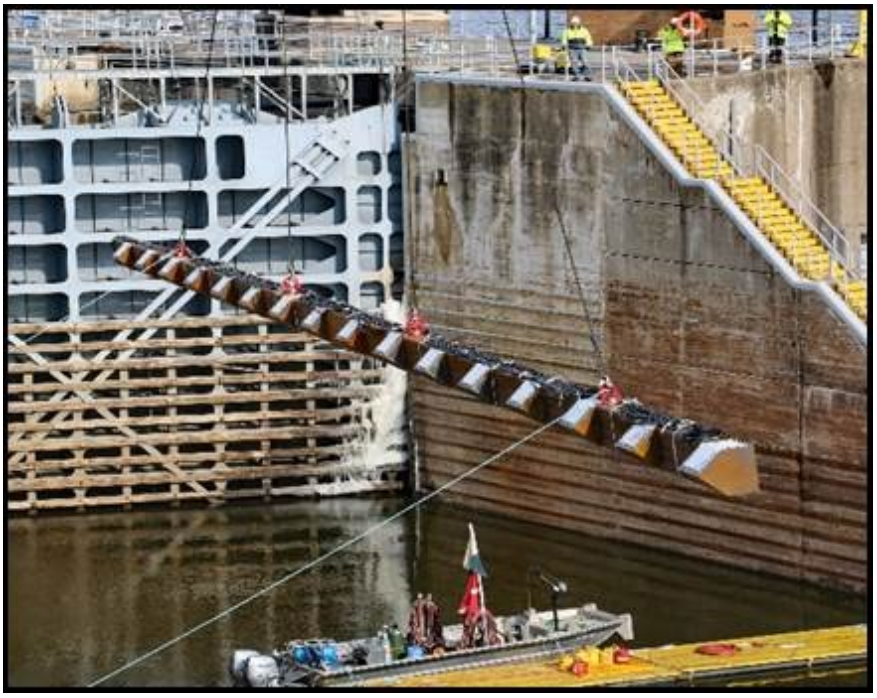

Figure 2. Photo of the uADS speaker soundbar during deployment at Lock 19 (Photo by Mark Cornish, USACE).

Recommendation: Understanding how sound affects invasive carp and resident native fish species at LD 19, where invasive carp are abundant, can help further develop methods that limit invasive carp movement. The deployment and evaluation of a uADS at LD 19 is integral to determining if underwater sound is an effective deterrent for upstream migrating invasive carp at strategic locks and dams. In addition, we will gain valuable information on freshwater soundscapes and native and invasive fish behavior to develop a framework for evaluating deterrents at locks and dams and other locations in large rivers. Information will help managers and other researchers (e.g., USACE Engineer Research and Development Center) make decisions for deterrent usage at other locations (e.g., Brandon Road Lock and Dam; UMR LDs 14 and 15; locks and dams in other basins).

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