Environment and Natural Resources Trust Fund
2017 Request for Proposals (RFP)

Project Title: **ENRTF ID: 113-D**

Bioacoustics to Deter and Eliminate Invasive Bigheaded Carp

Category: D. Aquatic and Terrestrial Invasive Species

Total Project Budget: $ 399,934

Proposed Project Time Period for the Funding Requested: 3 years, July 2017 - June 2020

Summary:

The next generation of sound based deterent barriers and herding/capture technolgy will be developed, tested and deployed to deter, control and/or eliminate invasive silver and bighead carp.

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Sponsoring Organization: U of MN - Duluth

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Location

Region: Statewide

County Name: Statewide

City / Township: Statewide

Alternate Text for Visual:

Figure one shows the proposed acoustic deterrent barrier and the carp capture/herding technology

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%

PROJECT TITLE: Bioacoustics to deter and eliminate invasive bigheaded carp

I. PROJECT STATEMENT

The goals of this proposal are to optimize sound for deterrence and capture of invasive bigheaded carp. We will develop next generation acoustic barriers to block the upstream migration of these invasive fish and develop mobile, boat mounted, underwater speaker arrays for herding, capturing and eliminating new or established populations. The initial experiments will be conducted in large outside ponds (WI) or carp infested waterways (IL) to optimize the technology and determine the effectiveness against wild carp while eliminating the threat of accidental release in MN waters. Once developed, the technology will be made available for deployment in MN locks and dams (acoustic barrier) or for detecting, capturing and eliminating new invasions in MN.

The bigheaded carp continue to pose a significant threat to Minnesota's aquatic habitats. Previous ENRTF support allowed us to make significance progress in understanding the behavior of the carp and their reaction to sound, in an effort to isolate their "Achilles" fin. In conjunction with our USGS partners, we were the first lab to determine that broadband/complex sound repels both silver and bighead carp. We are currently the only MN research group working both on juvenile and adult bigheaded carp in the laboratory and the field, and have achieved success in small laboratory tanks, large outdoor ponds and in the Illinois River. We have demonstrated that higher frequency sound is an effective carp deterrent, but does not affect MN game fish (i.e. walleye) or native species with similar hearing capabilities as the carp (i.e. big mouth buffalo).

Based on feedback from state and federal agencies, our goal is to translate our preliminary studies into effective management techniques such as installing acoustic barriers at natural chokepoints (i.e. lock and dams). Preliminary trials suggest that sound gradients generated by a parallel series of underwater speakers along the waterway would be more effective than a perpendicular line of speakers or bubbles across the waterway. Controlled studies in areas with carp are needed to determine the effectiveness of acoustic deterrence as fortunately, insufficient populations exist in MN waters to properly test the technology. For example, fish will habituate or suffer hearing damage to constant sound which would render acoustic barriers ineffective. However, the locks are only vulnerable when open, and we will determine the procedures to maximize repulsion and minimize habituation. This proposal will allow us to develop, test and deploy the next generation of acoustic barriers.

Few organizations are addressing how to attack recently invaded or established populations. We have developed portable, multi speaker arrays that are mounted on motor boats that effectively drive wild carp both up and downstream. We have demonstrated that the fish can be herded into small areas for capture and now propose to refine these techniques to optimize capture success as part of a rapid response protocol.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: *Optimizing acoustic barriers to prevent carp movement* **Budget: $ 189697**

We have developed a sound barrier that is deployed across a channel/waterway. While its effectiveness exceeds 90%, we observed that the short width of the sound field (5 yd) causes some fish to startle in the opposite direction and break through the barrier. Our goal is to develop a long (100 yd) linear array of speakers aligned parallel to the waterway (i.e. along walls of lock), which would greatly discourage the fish from moving further upstream against ever increasing sound. Additionally, intermittent sound is more effective than continuous sound as there is less risk of fish habituating and ignoring the sound. We have obtained lock opening/closing timetables from the Army Core of Engineers to test carp to intermittent sound based on normal operating schedules. We have developed "mock lock" chamber for use in a ½ acre pond in LaCrosse, WI and in a large, submerged gravel pit in Morris, IL. We will tag fish to monitor their position throughout the experiments. For outcome 1, we will use speaker pairs placed at intervals to generate a sound gradients in the "lock" and

observe the behavior of silver and bighead carp when broadband sound is generated in the channel. For outcome 2, the mock lock will be opened and closed according to a normal operating schedules (i.e. 10 to 12 openings day/night). If the carp are deterred, we will experiment with shorter sound generation times to determine the optimal balance between sound playback and potential habituation.

Outcome	Completion Date
1. Sound deterrence: development and testing of a long, linear sound gradient	*October 31, 2018*
2. Sound deterrence: determine the optimal sound on/off schedule to maximize deterrence and minimize habituation	*October 31, 2019*

Activity 2: *Bigheaded carp herding, capture and elimination* **Budget: $ 209697**

We have developed a portable, multiple speaker array for mounting on motorboats. We were successful in driving carp ahead of the boat using sound for several hundred yards in the Spoon River, IL and propose to combine herding with capture. The requested sonar unit will extend our ability to monitor both jumping (silver) and non jumping (bighead) wild carp. The Spoon River is 25 to 75 yds wide and can be blocked by nets. We will refine the technique by investigating speaker configuration and the number of arrays and boats necessary to drive the carp into nets. The second phase of the study will examine different types and configuration of nets to maximize capture and removal.

Outcome	Completion Date
1. Carp herding: Develop multiple speaker arrays to drive/herd wild carp	*October 31, 2019*
2. Carp capture: Develop the best combination of herding and net configuration to maximize capture	*June 30, 2020*

III. PROJECT STRATEGY

A. Project Team/Partners

Project partners receiving funds

- Allen Mensinger – UMD-Duluth – Principal investigator will be responsible for the entire project. He will recruit and train the Post doctoral scientist, graduate student, and undergraduate students with Minnesota residents specifically recruited and given the highest priority for participation.

Project partners not receiving funds

- Mark Gaikowski, Jon Amberg and Mary Beth Brey USGS, LaCrosse, WI. In-kind support. Will provide fish, tags, acoustic tracking equipment and access to outdoors ponds in LaCrosse,WI and Morris, IL.
- Robin Chafee USGS, Columbia, MO. In-kind support. Will provide boats, nets, personnel and sonar equipment to assist with Spoon River, IL Experiments
- Andy Caspar- Illinois Natural History Survey. In-kind support. Will provide boats, nets, personnel and base of operations for Spoon River, IL Experiments.

B. Project Impact and Long-Term Strategy: The long term strategy is to prevent the expansion of bigheaded carp by developing the next generation of acoustic barriers and new techniques to capture and eliminate carp. We will broadly disseminate our data at meetings and in the scientific literature to keep all partners and interested agencies appraised of our activities. Any technology developed will be readily shared with interested agencies.

C. Timeline Requirements: We anticipate two summer seasons (May through September) to optimize the sound gradient and determine the most effective sound deterrent schedule to minimize habituation using both outdoor ponds and field trials. We anticipate three summer field seasons to optimize carp herding and capture to ensure that goals are obtained in case of weather/flooding delays.

2017 Detailed Project Budget

Project Title: Bioacoustics to deter and eliminate invasive bigheaded carp

IV. TOTAL ENRTF REQUEST BUDGET 3 years

BUDGET ITEM	AMOUNT
Personnel:	
Allen Mensinger, PhD, Project Manager (74.7% salary, 25.3 benefits). In charge of all aspects of project. One month summer salary is requested per year. 8.3% FTE per summer and 25% FTE for project duration.	$ 43,018
Post-Doctoral Scientist. Responsible for conducting experiments and data analysis (81.7% salary and 18.3 % benefits). 100% FTE each year for three years	$ 151,334
Graduate Research Assistant. Assist post-doc with field experiments, data monitoring and analysis. One semester of support and summer salary is requested each year. (57.6% salary, 42.4% benefits). 31.3% FTE each year.	$ 66,500
Undergraduate student. Assist with summer field experiments. Summer salary support is requested for three years. (100% salary). 12.5 % FTE per year	$ 14,082
Equipment/Tools/Supplies	
Side scan underwater sonar unit for monitoring carp underwater	$ 30,000
Underwater speakers and amplifiers for sound deterent. 6 units @ $2500 requested	$ 15,000
Fish tags- Acoustical, reusable tags that allow carp tracking in small areas. 100 tags @ $100	$ 10,000
Fish nets - For herding carp into for capturing. 2 nets @ $5,000	$ 10,000
Hardware, wood, pipes, etc for building speaker arrays and mounts for boats	$ 15,000
Travel:	
To properly test the technology, travel is requested to the USGS facility in LaCrosse, WI, the submerged gravel pit in Morris, IL and to the Illinois River Biological Station in Havanna, IL which will provide access to invasive carp outdoor ponds or waterways. Costs include car rental (~$200 week) to transport equipment and personnel, lodging ($75 per night hotel, $25 per night at Field Station in Havanna, IL) and per diem costs ($35/day) that are calculated based on the University of MN travel rates. When possible (i.e. car rental, LaCrosse lodging) will be contracted with MN vendors. It is anticipated that personnel will be at these sites three to four months per year. $15,000 is requested for personnel travel support per year.	$ 45,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 399,934

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period:	n/a	
Other State $ To Be Applied To Project During Project Period:	n/a	
In-kind Services To Be Applied To Project During Project Period: University of MN Duluth Foregone indirect costs (26%)	$ 86,966	Secured
USGS Upper Midwest Environmental Research Center- Will provide outdoor ponds, fish, and support personnel for the project on its LaCrosse, WI campus and Morris IL. $30,000 year 1 and $10,000 year 2 and 3	$ 50,000	Secured
USGS Columbia Environmental Research Center. Columbia, MO. Will provide logistics and support for carp herding on Spoon River, IL. This includes, boats, personnel, additional sonar stations and fish nets. $10,000 per year	$ 30,000	Secured
Illinois Natural History Survey- Havanna, IL. Provide support base for Spoon River studies. Will provide up to 4 weeks of boat and personnel time per year @$5,000 per year	$ 15,000	Secured
Funding History: $175,500 - ENRTF for ML 2010-113d "Bioacoustic Traps for Management of the Round Goby" $262,000 - ENRTF for ML 2014-04b "Bioacoustics to Detect, Deter, and Eliminate Silver Carp"		
Remaining $ From Current ENRTF Appropriation: $100,000 remaining for ML 2014-04b "Bioacoustics to Detect, Deter, and Eliminate Silver Carp" (Ending in 6/30/2017)	$ 100,000	Legally Obligated

Bioacoustics to deter and eliminate invasive carp

Allen F. Mensinger UM-Duluth

Activity 1: Optimizing acoustic barriers to prevent carp movement

- Sound deterrent: development and testing of a long, linear sound gradient
- Develop sound broadcast schedule consistent with normal lock opening/closing schedule to maximize deterrence and minimize habituation

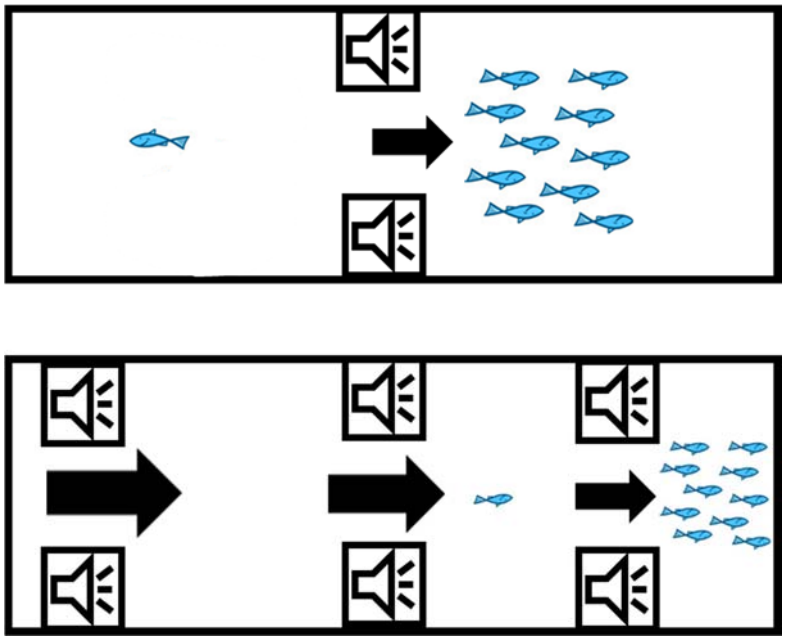

Figure 1. Top panel: Current single speaker pair acoustic barrier that spans channel in "mock lock". Barrier was 90% effective during preliminary trials but because the sound field is narrow, some fish push through it. Bottom panel: Proposed barrier of serially arranged speakers of increasing sound intensity (Arrow size). Fish that pass the first barrier will encounter ever increasing sound and be deterred.

Activity 2: Bigheaded carp herding, capture and elimination

- Carp herding: Develop multiple speaker arrays to drive/herd wild carp
- Carp capture: Develop the best combination of herding and net configuration to maximize capture

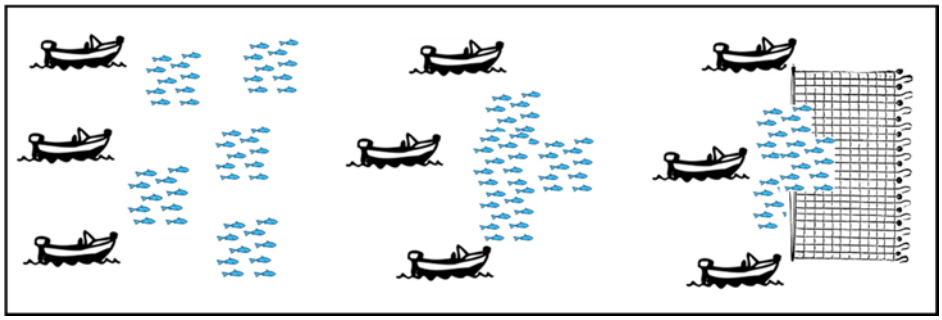

Figure 2. Herding/driving of wild carp. Left: carp are loosely schooled. Middle: boats with underwater speaker arrays concentrate carp. Right: carp are driven into nets for capture.

Dr. Allen Mensinger is a professor at the University of Minnesota Duluth in the Department of Biology. He is a sensory physiology that has been working on fish behavior for over 25 years. He has published numerous papers on fish hearing and bioacoustics and became intrigued by the unique jumping ability of the silver carp. He was the first person to establish that invasive bigheaded carp react to complex, broad band sound, and for the past three years, thanks to ENRTF funding, has been conducting experiments to further understand the interactions of invasive carp with sound. He has been advising the MN DNR, US Fish and Wildlife and the Army Core of Engineers on possible deployments of the acoustic barriers. He has developed an acoustic barrier for small ponds that has greater than 90% success rate against silver and bigheaded carp. He has also been studying carp behavior in the Illinois River and its tributaries to understand why silver carp jump and how sound effects wild carp.

He has partnered with the USGS and Illinois Natural History Survey (INHS) to perform experiments in large outdoor ponds and carp infested waters to avoid complications of sound in small, indoor tanks. He will supervise all aspects of the project and hire and train the post-doctoral researcher, the graduate and undergraduate student(s). He will coordinate the construction of the mock lock chambers with the USGS and work with both the USGS and INHS to schedule experiments and boat time for the field experiments.

The University of Minnesota Duluth (UMD) is a comprehensive regional university. UMD participates in two all-university PhD programs and consistently ranks among the top Midwestern, regional universities in U.S. News and World Report's "America's Best Colleges" issue. Providing an alternative to both large research universities and small liberal arts colleges, UMD attracts students looking for a personalized learning experience on a medium-sized campus of a major university. Mensinger maintains a laboratory on campus s suitable for developing and constructing the speaker arrays necessary for the project. However, because of the problem (echoes) with acoustics in small tanks, the experiments need large outdoor ponds or field trials.

He has partnered with the USGS Upper Midwest Environmental Science Center in LaCrosse, WI for deploying the technology in large (1/2 acre) outdoor ponds and a submerged gravel pit in Morris, IL to optimize the acoustic deterrents in controlled experiments. The USGS will provide the ponds, fish, acoustical telemetry (to track the fish) and logistics support for the sound gradient in behavior trials both in LaCrosse WI and Morris, IL. It is imperative to test the technology on this scale prior to deployment in locks and dams to understand how the sound is effecting fish behavior.

The carp herding and capture experiments need to be conducted in areas that have already been invaded with bigheaded carp to properly develop the technology. The Spoon River in Illinois is an excellent test site as it close to the (INHS) field station in Havana, IL. The river has high densities of both silver and bighead carp, provides long stretches to herd the carp and can be spanned by nets. INHS and USGS Columbia Environmental Science Center will support this portion of the project and provide boats, personnel, additional sonar units and fish nets. This is a large scale project that will involve several miles of the river and is one the best sites we have found to conduct this study.