Environment and Natural Resources Trust Fund
2018 Request for Proposals (RFP)

Project Title: **ENRTF ID: 136-D**

Sound Gradient for Acoustic Deterrence of Bigheaded Carp

Category: D. Aquatic and Terrestrial Invasive Species

Total Project Budget: $ 396,310

Proposed Project Time Period for the Funding Requested: 3 years, July 2018 to June 2021

Summary:

Develop a sound gradient acoustic barrier for deployment in locks. As invasive carp swim upstream, they will encounter ever increasing, louder sound and be forced to turn back downstream

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

The figures shows a acoustic sound gradient deployed in a lock and the increasing sound forcing the invasive carp downstream.

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

PROJECT TITLE: Sound Gradient for Acoustic Deterrence of Bigheaded Carp

I. PROJECT STATEMENT

1) Develop an acoustic deterrence system using underwater sound gradients. These will be deployed at strategic "choke" points such as lock chambers to deter invasive big head and silver carp. As the fish move upstream, they will encounter every increasing noise levels and be motivated to turn back. These invasive species continue to threaten Minnesota waters and acoustic deterrents offer cost -effective, environmental friendly solutions to deter carp movement while not impeding navigation and minimizing detrimental effects to native species.

2) The proposed experiments build on the strong foundation of bioacoustics sound studies previously funded by The Environmental and Natural Resources Trust Fund. We determined broad band sound (underwater motor boat recording) is an effective deterrent to both species of invasive carp and can be used to repel the fish in outdoor ponds and tributaries. We have recently determined the exact sound frequencies that the carp can hear (Vetter and Mensinger, 2017) and will be able optimize the sound that produces the greatest deterrent to invasive species and smallest risk to native fishes. The proposed experiments dramatically expand the effectiveness, scope and size of the acoustic deterrent already developed and provide a system that can installed on any lock or narrow tributary in partnership with stakeholders such as the Army Corps of Engineers or the Minnesota DNR.

3) The Mensinger lab at the University of Minnesota Duluth is currently the only laboratory in Minnesota to be conducting acoustic deterrent experiments on invasive carp in large outdoor ponds and carp infested waterways (Vetter et al., 2015; Vetter et al., 2017). It is important to conduct experiments in large, outdoor venues to minimize echoes prevalent in small indoor tanks and to ensure normal carp behavior. We have shown the acoustic deterrent to be effective in medium size outdoors ponds and plan to expand the size and scope of the deterrent system for field deployment. We will conduct experiments in larger ponds (1/2 acre) and carp infested tributaries to determine the optimal sound playback parameters (sound duration, noise level, frequency) and how often the sound can be played to optimize carp repulsion while minimizing potential habituation to the stimulus. The goal is to a develop a sound gradient barrier than can be deployed in locks or across waterways to deter the upstream migration of carp.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: *Optimize the underwater sound to maximize carp deterrence* **Budget**: **$198,155**

We have determined that invasive carp are consistently repelled by broad band sound stimulus (sound from outboard motor) ,however they may eventually either fatigue (stop swimming) or ignore continuous stimuli. We now plan to investigate the effect of changing different aspects of this sound such as volume, frequency and duration to further optimize carp repulsion while minimizing habituation and harm to native species. These experiments will be conducted in very large outdoor ponds that contain concrete passageways to mimic scale downed lock chambers. Multiple speaker sound arrays will be placed in these ponds or small carp infested rivers to determine the optimal speaker configuration and sound stimulus to repel invasive carp.

Outcome	Completion Date
1. Determine optimal duration, noise level, sound frequency, and sound composition to deter carp in large pond with scaled lock chambers by varying sound stimulus and monitoring how many times carp will cross an acoustic barrier under varying sound stimuli	*Summer 2019*
2. Determine how often sound stimulus developed in outcome 1 can be used to maximize repulsion and minimize habituation in both a small river and large outdoor pond	*Summer 2019*

Activity 2: *Sound gradient acoustic deterrent for lock chamber* **Budget: $198,155**

Our work has shown that a sound gradient (every increasing sound intensity) is much more effective than just using sound at a single location (for example lock gate opening). As carp swim upstream into the sound gradient, they will encounter louder and louder sound and will turn back. We will design and test a multi speaker sound array for use in a lock chamber. However, it is imperative that this sound gradient is tested in carp infested water to assess its efficacy before being installed in MN.

Outcome	Completion Date
1. Accurately measure the acoustic environment of the lock chamber	*Summer 2019*
2. Deploy speaker array in carp infested water in lock chamber out of state to test efficacy	*Summer 2020*
3. Fine tune, construct and make speaker array available for use in MN	*Spring 2021*

III. PROJECT STRATEGY

A. Project Team/Partners

The Mensinger laboratory at the University of Minnesota Duluth will team with long time USGS partners at LaCrosse, WI and Columbia, MO as well as the Illinois Natural History Survey in Havana, IL. These partners are vital as they provide access to the large ponds, carp infested waterway and out of state lock testing areas to test the deterrent system "where the carp are" and not further endanger MN waters by bringing carp into the state for testing. The partners will provide fish, ponds, materials, access and boats at no charge to the ENRFT and will not be receiving money. We will also work closely with the MN DNR and the Army Corps of Engineers to ensure that we are meeting their needs and goals and that the sound array will not affect navigation. The ultimate goal is to develop a field tested deterrent system that can be installed in MN waters with a high confidence of success.

B. Project Impact and Long-Term Strategy

The strategy is to use sound to repel carp at strategic chokepoints and reduce or eliminate upstream migration. Lock chambers present an easily accessible upstream route for carp expansion. By establishing long and loud sound gradients in the lock, carp swimming upstream will continue to encounter louder and louder sound and be turned back. The sound only needs to operate when the lock is open, lessening the chance of carp becoming habituated to the sound and ignoring it. Additionally, sound may only need to be broadcast during critical migration times. The sound will be designed to be of higher frequency than is detected by most native game fishes and will be environmental friendly. The ultimate goal is to develop a field tested deterrent system that can be installed in MN waters with a high confidence of success.

C. Timeline Requirements

We have completed the all the preliminary tests in small outdoors ponds and need access to larger ponds to fine tune the stimulus prior to field work. All sound tests are scheduled to be conducted by summer of 2019 with field trials planned for late 2019 and/or 2020. The final sound array will be made available for use in MN locks by 2021 if not sooner.

Vetter, B. J., Cupp, A. R., Fredricks, K. T., Gaikowski, M. P. and Mensinger, A. F. (2015). Acoustical deterrence of Silver Carp (Hypophthalmichthys molitrix). *Biological Invasions* **17**, 3383-3392.

Vetter, B. J., Murchy, K. A., Cupp, A. R., Amberg, J. J., Gaikowski, M. P. and Mensinger, A. F. (2017). Acoustic deterrence of bighead carp (Hypophthalmichthys nobilis) to a broadband sound stimulus. *Journal of Great Lakes Research* **43**, 163-171.

2018 Detailed Project Budget

Project Title: Acoustic Deterrence of Bigheaded Carp

IV. TOTAL ENRTF REQUEST BUDGET 3 years

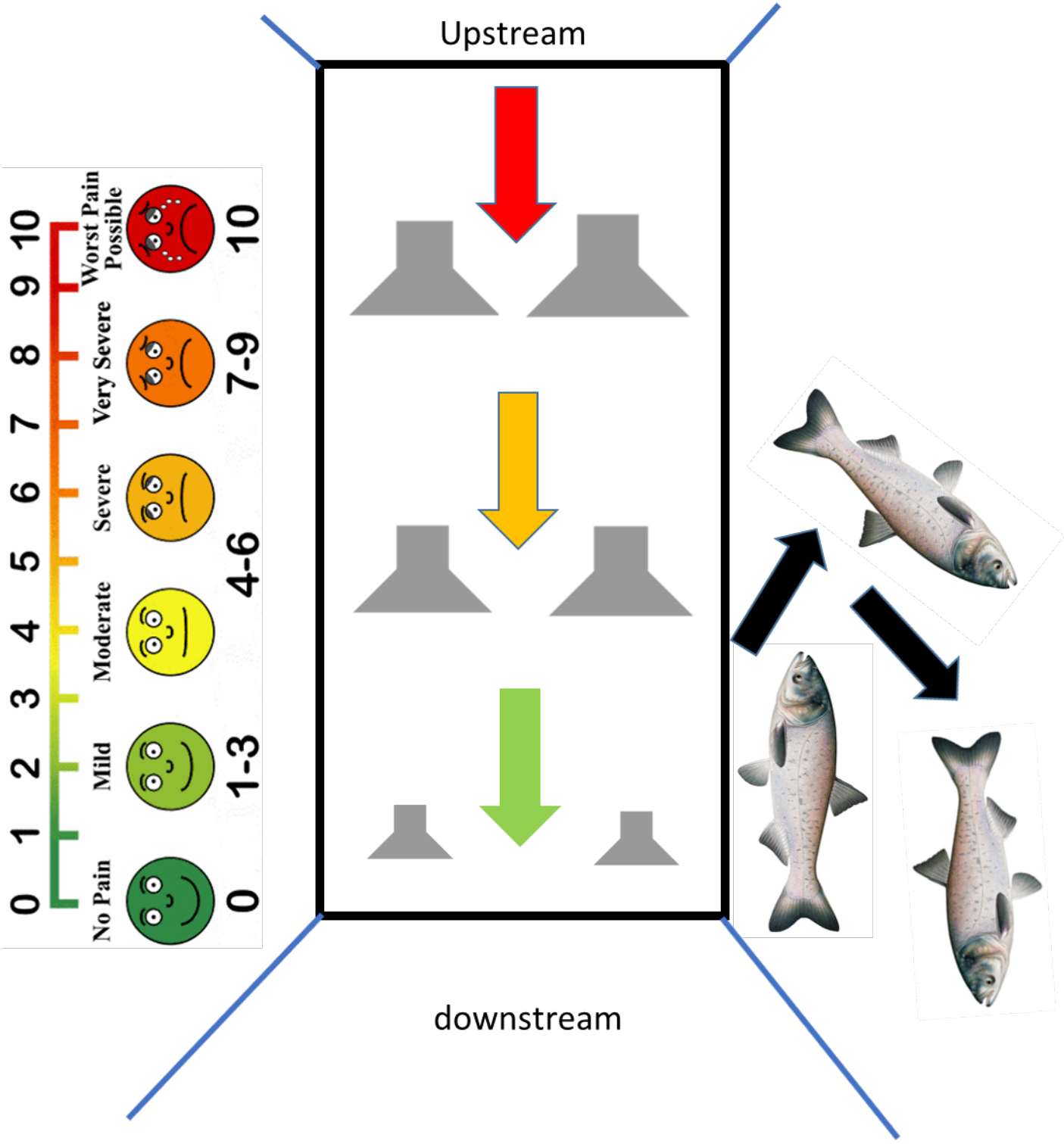
BUDGET ITEM	AMOUNT
Personnel:	$ -
Allen Mensinger, Principal Investigator: Will be in charge of all aspects of the project. He has a nine month appointment at UMD. One month summer salary is requested each year of the project for a total of 3 months of summer support (75.0% salary, 25.0% fringe). .083 FTE	46,560
One post-doctoral fellow that will conduct all the experiments at the various sites. 3 years of support requested (82.0% salary and 18.0% fringe). 1.00 FTE	188,993
One graduate student that will assist post-doc with experiments and data analysis. Summer salary (3 months) is requested for the student (87.0 salary, 13.0 % fringe) for each year of proposal .25 FTE	25,450
Undergraduate student. Assist with summer field experiments. Summer salary support is requested for three years. (100% salary). .125 FTE per year	16,198
Equipment/Tools/Supplies:	$ -
Sound projection: Underwater speakers and amplifiers for sound deterent array. 12 units from Lubell labs @ $4750 requested	$ 57,000
Sound recording: Sound trap hydrophones with 4 channel data collection for measuring under water sound. 2 hydrophones @ $2400. 2 4 channel data collection units @ $4800. 8 HTI hydrophones for the data units @$350	$ 17,200
Construction. Wood,PVC pipe, fasteners needed for mounting speakers and hydrophones	$ 5,000
Electronics: Computer for data collection ($1K), oscilliscope for equipment testing ($3K), wire and cable for hydrophones and speakers ($5K)	9,000
Travel:	$ -
To properly test the technology, travel is requested to the USGS facility in LaCrosse, WI, the submerged gravel pit in Morris, IL the Illinois River Biological Station in Havanna, IL and Brandon Roads lock and dam in Illinoise 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 two to three months per year. $10,000 is requested for personnel travel support per year	$ 30,909
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 396,310

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
In-kind Services To Be Applied To Project During Project Period: University of MN Duluth Foregone indirect costs (26%)	$ 115,025	Secured
One month of Mensinger academic salary per year	$ 46,094	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	pending
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)	$ 75,000	Legally Obligated

Sound Gradient for Acoustic Deterrence of Bigheaded Carp

- Overhead view of lock chamber
- Carp swimming upstream encounter increasing sound
- High sound levels cause carp to turn back downstream



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 Corps 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 potentially asubmerged gravel pit in Morris, IL or the lack chamber at Brandon Roads, 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 Illinois. It is imperative to test the technology on this scale in the presence of invasive fish to understand how the sound is effecting fish behavior.

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. 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 observer how carp react to sound in the wild.