Environment and Natural Resources Trust Fund
2014 Request for Proposals (RFP)

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Project Title:

Bioacoustics to Detect, Deter and Eliminate Flying Carp

Category: D. Aquatic and Terrestrial Invasive Species

Total Project Budget: $ 262,907

Proposed Project Time Period for the Funding Requested: 3 Years, July 2014 - June 2017

Other Non-State Funds: $ 0

Summary:

Develop bioacoustic (sound) technology for silver carp 1) detection and early warning systems; 2) capture and elimination methods; 3) deterrent systems

Name: Allen Mensinger

Sponsoring Organization: U of MN Duluth

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Duluth MN 55812

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Web Address

Location

Region: Statewide, Northeast

County Name: Statewide, St. Louis

City / Township: Duluth

MP: 0613-2-144-proposa
Budget: 0613-2-144-bud
Qual: 0613-2-144-qualifi
Map: 0613-2-144-map-M
Resolution:
List:

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

PROJECT TITLE: Bioacoustics to detect, deter and eliminate flying carp

I. PROJECT STATEMENT

The Asian silver carp, one of four invasive carp species, is migrating north via the Mississippi River and threatening native fish in Minnesota rivers and lakes by outcompeting them for food supplies. Additionally, its unique jumping ability places recreational boaters in danger of being injured during collisions with airborne fish. However, this jumping ability is a weakness that can be exploited to detect, manage and control fish populations. The goals of this proposal are:

1) use the sound that stimulates jumping to develop early warning and detection systems

2) develop management techniques using sound to exhaust the fish on the surface or to herd the fish into shallow waters for capture and removal

3) use sound to deter or repel fish from moving through strategic waterways

In the previous year, we have made two significant findings: 1) determined the sound that initiates jumping in wild silver carp in the Illinois River; 2) successfully used this sound to repel carp in experimental outdoor ponds at the USGS Upper Midwest Environmental Science Center (UMESC) in LaCrosse, Wisconsin. This proposal would allow us to develop bioacoustic (sound) technology to combat the invasive silver carp. The most effective sound that influences carp behavior is of relatively high frequency and will not harm most native and game fishes. Our first goal is to develop remotely operated buoys with underwater speakers and above water video cameras to stimulate carp jumping to ascertain if an early detection or identification system can be developed. Our second goal is to develop a mobile sound system to stimulate continuous jumping for exhausting the fish on the surface and/or use sound to herd the fish into shallow water or nets for easy capture. Finally, we will test the efficacy of using sound to repel carp from specific areas. All the proposed studies will take place in large, secured (caged) outdoor experimental ponds at the USGS UMESC in LaCrosse, Wisconsin or on populations of wild carp in the Illinois River near Havanna, IL. Both sites provide access to fish in outdoor locations where they behave naturally, allow large scale trials that cannot be replicated in indoor facilities and pose no danger of silver carp being released in MN waters . While we are eager to share our results and eventually team with the Aquatic Invasive Species Center in St. Paul, the facility is not yet equipped for these large outdoor tank or pond studies that are necessary to test the efficacy of sound in combating the silver carp.

II. DESCRIPTION OF PROJECT ACTIVITIES

Activity 1: Develop early warning and detection systems **Budget: $90,000**

Silver carp of different size and age classes will be maintained in large, secured outdoor tanks at the UMESC facility in Lacrosse, WI which has a captive silver carp populations. We will develop a remotely operated, early warning buoy with video cameras, underwater speakers and hydrophones that will be used to observe carp behavior during sound generation. Fish behavior (ie jumping) will be correlated with specific sound levels and frequencies. As fish behavior is related to age (size), density and temperature, the sound will be tested on both juvenile and adult fish at different temperatures and densities. Preliminary studies on the Illinois River have shown sound to effective in stimulating jumping even at low carp densities. Once the sound is characterized for temperatures, densities and size classes, we will travel to Havanna, IL to test the system on wild populations in the Illinois River.

Outcome	Completion Date
1. Test early warning/detection buoy in captive population in outdoor pond	*Fall 2015*
2. Test early warning/detection buoy in wild population	*Fall 2015*

Activity 2: Using sound to exhaust and/or herd carp for easy capture Budget: $90,000

Aerial jumps are energetically expensive for fish, and even salmon that migrate hundreds of miles upstream, need to rest before jumping successive water falls. If carp are stimulated to jump repeatedly, it may be possible to exhaust them to the point where they will float on the surface and easily be netted. Even if we cannot exhaust the fish, it is anticipated that multiple arrays of speakers could concentrate the fish into shallows for capture. Anecdotal evidence indicates that commercial fishermen already use crude sound to concentrate fish and these arrays will expand on these practices by focusing the sound to drive fish into specific areas.

Outcome	Completion Date
1. Use sound to stimulate jumping in silver carp to drive the fish to exhaustion	*Fall 2016*
2. Use sound to drive or herd silver carp onto the shore, into shallow water or into nets for removal	*Fall 2016*

Activity 3: Use sound to deter fish from moving through strategic waterways Budget: 82,907

We have determined that pure tones (same frequency) that normally are used for fish behavior and/or barriers is ineffective in deterring movement, however silver carp will readily swim away from complex sounds (playbacks of outboard motor noise). These preliminary experiments indicate that sound either alone or as part of a combined light and bubble barrier, may provide a cost effective and environmentally friendly barrier to silver carp migration or repel them from breeding areas. We will test the effects of sound in deterring carp from moving through narrow channels in large tanks. We will continue to increase the channel width to determine the coverage areas of the speaker array. The initial tests will be conducted in large tanks and if successful, field trials will be conducted in Illinois River, in small areas or tributaries that have been cleared of carp using the methodology developed in Activity 2.

Outcome	Completion Date
1. Use sound to deter carp movement in large outdoor tanks	*Summer 2017*
2. Use sound to deter carp movement in the field (Illinois River)	*Summer 2017*

III. PROJECT STRATEGY

A. Project Partners: Professor Allen Mensinger of the University of Minnesota Duluth is an expert on fish sound and hearing and will direct the project. Mark Gaikowski of the UMESC is an expert on invasive species and will provide critical guidance and access to facilities. Graduate students will come from the Integrated Biosciences Program and undergraduate students will be recruited from the Department of Biology at UMD. Mensinger and Gaikowski will train the graduate students, develop the technology, conduct the experiments, and complete the field trials. Mensinger will work with MN Sea Grant, MN DNR, the AIS center and the Great Lakes Aquarium to disseminate results to MN state residents.

B. Timeline Requirements: Year 1: Develop early warning buoy; **Year 2**: Develop mobile underwater speaker arrays to exhaust or herd carp **Year 3:** Test sound as carp deterrent

C. Long-Term Strategy: The overall goal of the project is to exploit carp jumping and turn this strategy against the fish. Outdoor tank and infested river trials will be conducted to determine the efficacy of the above stated deliverables. These techniques/devices will be made available for interested parties (ie DNR) as part of a multipronged strategy to battle the invasive carp. When possible, the technology will be patented to provide future resources for the MN Environmental Trust Fund.

2014 Detailed Project Budget

Project Title: Bioacoustics to detect, deter and eliminate flying carp

IV. TOTAL ENRTF REQUEST BUDGET 3 years

BUDGET ITEM	AMOUNT
Personnel: PI Allen F. Mensinger PhD. The PI has a 9 month position at the University of Minnesota Duluth. A total of 3 months of summer salary (1 month /yr) is requested. Total reflects 74.8% salary and 25.2% fringe (.11 FTE)	$ 40,331
Graduate student - Brooke Vetter - support is requested for 36 months of support for one PhD graduate student. Total reflects 57.3% salary and 42.7% fringe (1 FTE)	$ 124,526
Graduate student summer salary. 50% summer salary is requested for one Masters student for 3 summers (total 4.5 months) 80.6% salary and 19.4% fringe (.25 FTE)	$ 19,065
Undergraduate student summer salary: 2 months summer salary is requested for two undergraduate students each summer (total 12 months) 93.1% salary and 6.9% fringe (.083 FTE)	$ 12,226
Contracts: Boat Rental Illinois River. *Illinois River Biological Station Field - $25 per hour for motorboat rental. 8 hrs per for 5 days each week. $1000 per week for nine weeks tota*	$ 9,000
Equipment/Tools/Supplies:	$ -
Bouy or floating platform for early warning system plus floats, mooring lines, cables and materials	7,500
Two amplifiers for underwater speakers arrays @$1000	2,000
Four wireless video cameras, digital video recorders and DC power supplies for filming carp jumping from bouy or boats	5,000
Electronics supplies including cables, wireless routers, camera and underwater speaker control units for remote operation of early warning system, sound exhaustion and deterent systems	10,000
Fish food and water testing kits for silver carp in captivity	1,000
Travel: Travel to the Illinois Biological Research Station in Havanna, IL. This out of state travel is essential to the project as it allows us to test the equipment and strategies in carp infested water. We will travel in spring, summer and fall for one week each. Car ($620 per trip based on 1100 miles RT @ $0.565 per mile), lodging ($77 per night) and per diem ($46 per night) based on current government rates for area = $861 per person per week. 9 weeks total for grant with two people each week	$ 21,078
Travel: Travel is requested to the USGS facility in Lacrosse, WI to monitor carp behavior in outdoor ponds and test equipment. This out of state travel is essential for the project as these are the only large and outdoor secure ponds that house silver carp that are available for this research. The PhD student will spend approximately one month in residence at the facility each year to compelete the experiments. Car ($283 per trip based on 500 miles RT). Hotel and per diem is $861 per week and 4 weeks are anticipated each year.	$ 11,181
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 262,907

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non State $ Being Applied to Project During Project Period: The Integrated Bioscience program will provide summer salary match for the masters student requested in the project (4.5 months summer salary)	$ 9,516	*pending*
Undergraduate research opportunity grants are available from UMD to further support the undergraduate students selected for the this grant. Typically each student in the Mensinger lab is awarded $1400 in support from this program each year	$ 8,400	*pending*
UMD pilot grant funds to support project	$ 5,500	*secured*
In-kind Services During Project Period: The PI (Mensinger) is on a 9 month academic appointment. He will provide two months of his academic year salary as in kind support for this proposal	$ 79,324	*secured*
USGS will provide in kind support including access to their captive silver carp population and outdoor ponds at no cost to the proposal.	$ 10,000	*secured*
Funding History: The PI received support for using bioacoustics to control the round goby. The speakers and electronics purchased for this project will be used for the current project	$ 5,000	secured

Bioacoustics to detect, deter and eliminate flying carp

1) Sound makes carp jump

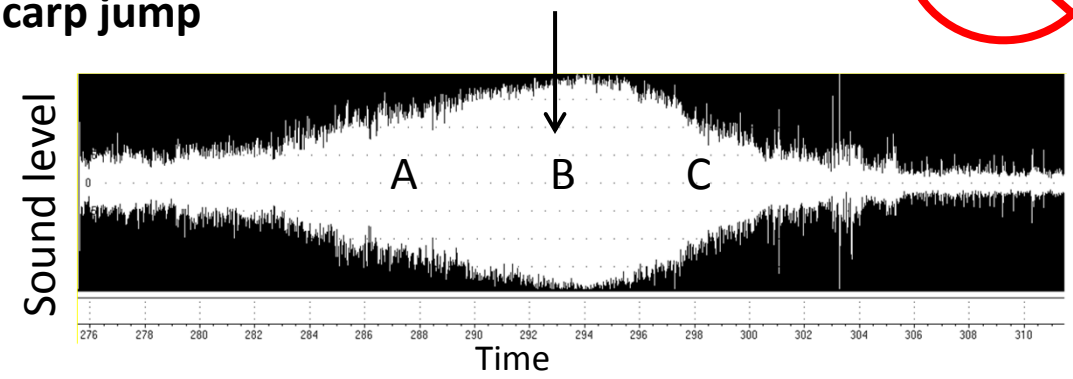

Figure 1. Field recording of underwater outboard motor noise motor boat noise that stimulated carp to jump in the Illinois River as boat passed by designated recording area. Arrow indicates when boat was in center of area. A) initiation of jumping; B) peak jumping; C) cessation of jumping.

2) Different sounds and boat speeds will effect carp jumping

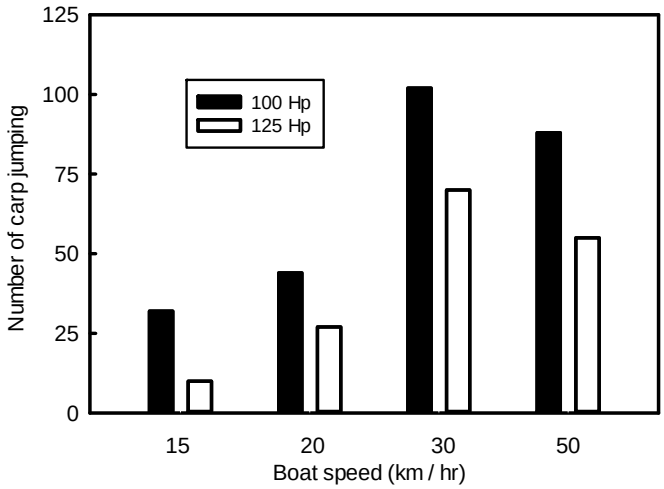

Figure 2. Number of carp jumping vs boat speed (km / hr) and engine size (hp).

3) Sound will repel carp

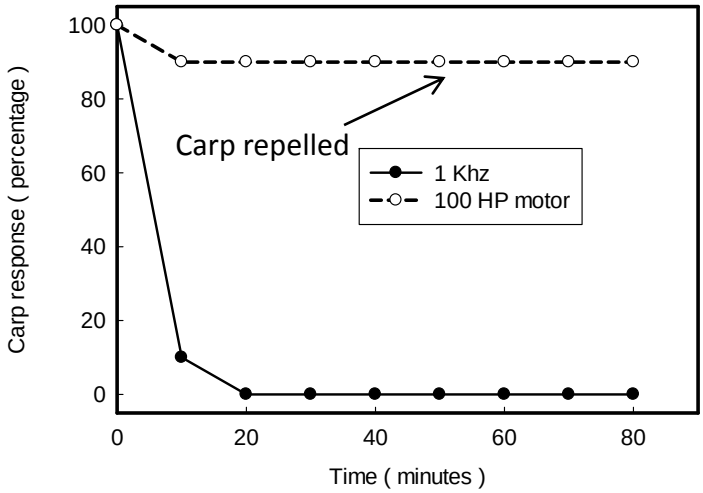

Figure 3. Percentage of carp (N=10) repelled by a 1 KHz pure tone sound and 100 hp outboard motor sounds versus time (min).

Bioacoustics to detect, deter and eliminate flying carp

Dr. Allen Mensinger is a professor at the University of MN Duluth and is an expert on fish hearing. He has been working on sound producing fish and how fish behave during sound presentation for over 20 yrs. He is currently developing with ENRTF funding, a fish trap that uses sound to capture the invasive round goby, and has been the first to demonstrate the ability to lure round gobies into unbaited traps by using sound. He has collaborated with Dr. Peter Sorensen and Dr. Vaughn Voller on developing a bubble barrier to prevent the migration of common carp.

In the summer of 2012, he teamed with Mark Gaikowski of the USGS Upper Midwest Environmental Science (UMESC) Center to perform preliminary experiments on the use of sound to manage the silver carp and conducted field studies on the Illinois River in Havanna, IL. These preliminary studies demonstrated that silver carp will respond to sound and offer promise that sound may be an effective strategy to manage wild populations.

The University of Minnesota (Twin Cities or Duluth) does not currently have the capacity to house carp in large outdoor ponds which encourage the fish's natural behavior and while providing better environments for underwater sound tests. The UMESC offers a captive silver carp population with the necessary permits and secure facilities that will allow experimental testing without the threat of escape into the environment. The Illinois River Biological Station in Havanna, IL is in the heart of silver carp infestation of varying sizes and densities. The station provides access to testing the technology on wild populations. While both sites involve out of state travel, they provide unique opportunities to test technology on captive and wild silver carp populations without danger of infesting MN lakes or rivers.

CURRICULUM VITAE (abridged)

Allen F. Mensinger

Present position: Professor
University of Minnesota Duluth, Biology Department, Duluth, MN 55812

Areas of expertise: Fish bioacoustics, invasive fish and sensory physiology

Education:
1983 B.S. – Biology, Duke University, Durham, North Carolina
1991 Ph.D. University of California, Santa Barbara

Professional experience:

1991-94	Post-doctoral fellow, Vanderbilt University Nashville, TN.
1994 -99	Research Associate, Wash. Univ. Sch. Med., St. Louis, MO.
1997-98	NASA Life Sciences Fellow, MBL, Woods Hole, MA
2000-05	Assistant Professor, University of Minnesota-Duluth
2005-09	Associate Professor, University of Minnesota Duluth
2010	Professor, University of MN Duluth

Relevant peer reviewed publications: (36 total publications)

Lynch, M. P. and **A. F. Mensinger**. 2013. Temporal patterns in the growth and survival of the round goby (*Neogobius melanostomus*) over a 13 month period in the Duluth-Superior Harbor. *J. Fish Biol*. 82:111-124

Lynch, M. P. and **A. F. Mensinger**. 2012. Seasonal abundance and movement of the invasive round goby (Neogobius melanostomus) on rocky substrate in the Duluth-Superior Harbor of Lake Superior. *Ecol. Freshwater Fish.* 21:64-74.

Bergstrom, M.A. and **A. F. Mensinger**. 2009. Interspecific resource competition between the invasive round goby and three native species: logperch, slimy sculpin and spoonhead sculpin. *Trans. Amer. Fish. Soc.* 138:1009-1017.

Maruska, K. P. and **A. F. Mensinger**. 2009. Acoustic characteristics and variations in grunt vocalizations in the oyster toadfish *Opsanus tau. Environ. Biol. Fish*. 84:325-337.

Bergstrom, M. A., L. M. Evard and **A. F. Mensinger**. 2008. Distribution, abundance, and range expansion of the round goby, *Apollonia melanostoma*, in the Duluth-Superior Harbor and St. Louis River Estuary, 1998-2004. *J. Great Lakes Res.* 535-543.

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