Environment and Natural Resources Trust Fund
2009 Phase 2 Request for Proposals (RFP)

LCCMR ID: 076-C1

Project Title: Controlling the Movement of Invasive Fish Species

Total Project Budget: $ $587,195

Proposed Project Time Period for the Funding Requested: 3 years; Jul 2009 to Jun 2012

Other Non-State Funds: $ $0.00

Priority: C1. Aquatic and Terrestrial Invasive Species

First Name: Vaughan **Last Name:** Voller

Sponsoring Organization: U of M

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Region:	County Name:	City / Township:
Statewide	Carver, Hennepin	

Summary: The ecological integrity of Minnesota's waterways is threatened by invasive fish. We will develop and test sonic barriers that will be effective in preventing and controlling the movement of carp.

Main Proposal: 0908-2-029-proposal-LCCMR_Proposal_Sep_30_2008_submitted.doc

Project Budget: 0908-2-029-budget-RFP_2009_Project Budget_Submitted.xls

Qualifications: 0908-2-029-qualifications-ALL_PIs_cv_2008.doc

Map:

Letter of Resolution:

I. PROJECT STATEMENT

The problem: The ecological integrity of Minnesota's inland waterways is increasingly threatened by invasive species of fish. An increasing concern are Asian river carp, (*Hypophthalmichthys molitrix* and *Hypophthalmichthys nobilis*), which are presently moving up the Mississippi River. Of immediate concern, however, is the common carp, *Cyprinus carpio*, which comprises over half the biomass in a third of Minnesota lakes. The feeding habits of this carp significantly disturbs lake sediments leading to an over-enrichment of nutrients (phosphorous and nitrate). This process, referred to as eutrophication dramatically reduces water quality. Research on the common carp is actively supported by the LCCMR and several watershed districts and is demonstrating that the root of the problem are carp nursery lakes which feed into larger lakes through small creeks. However, while presently funded research is suggesting solutions to suppress carp reproduction and abundance in this nurseries, the utility of this work will be the limited by an inability to stop young carp from re-infesting systems through creeks. This project seeks a solution to this immediate problem while providing potential tools for the Asian carp problem.

Background: The movement of invasive carp and other fish can be controlled by barrier technologies. Although current state of the art electric barriers, can be effective at controlling upstream movement of large adult fish they fail to impede smaller fishes moving downstream, are extremely expensive (~$500,000) and dangerous. There is a need to develop alternative barrier technologies that deter fish movement through exploiting known features of fish physiology and behavior. With respect to common carp, it is well known that they are highly sensitivity to sound, including both near- and far-field sensitivity a peak sensitivity of 500 Hz (Kojima et al., 2005) This has prompted the construction of two pilot barriers which employ sound coupled with air bubbles to produce strong sonic fields. One of these was studied for 3 weeks and reported very promising preliminary results (Taylor et al., 2005). Another barrier which uses a curtain of high density air bubbles has reported initial success in Green Lake, WI (R. Randall, personal communication). The latter study is encouraging because air bubble systems can be inexpensive, portable, species-specific (i.e. will not effect native fish), and effective for impeding downstream swimming young carp. To date, however, there has been no public domain research on appropriate design guidelines for sonic barriers.

The approach*:* This proposal advocates developing and testing sonic barriers that will be effective in controlling the movement of carp in Minnesota waterways. Our multi disciplinary proposal will bring together experts in several different fields (fish physiology, bioacoustics, engineering, environmental fluid mechanics, and computer modeling) and will combine theoretical, laboratory, and field studies to systematically investigate the features of sonic barriers that deter carp migration. This will lead to the identification of effective designs for sonic barriers that can be used to prevent and control carp migration in Minnesota waterways. We propose to develop a four-pronged research plan.

II. DESCRIPTION OF PROJECT RESULTS

(1) *Laboratory investigation to test/define biological potential*: Develop laboratory protocols for testing common carp responses to underwater sonic fields generated by various types of bubble-nets in a controlled environment. Bubble size, velocity, density of these nets will be manipulated to target the carp and avoid impacting native fish. Experiments will be conducted in indoor laboratory under controlled conditions.

(2) *Field investigations to define real-world potential:* We will verify and extend the laboratory findings by utilizing the Outdoor Stream Laboratory (OSL) on the Mississippi River at the Saint Anthony Falls Laboratory (SAFL), University of Minnesota. This unique facility provides a natural stream setting which is tightly controlled and monitored. This will allow for the systematic testing and development of proposed sonic barriers with tagged (radio frequency ID) fish under field conditions. In addition, the interaction of water flow and discharge, channel geometry, and turbidity can be carefully investigated.

(3) *Field tests of optimized designs:* Findings will be tested at an ongoing carp barrier installation at the outflow of Lake Susan (Chanhassen) whose water district is supporting Sorensen's research. This barrier is being designed to accommodate experimental systems such as air-bubble barriers but does not include funding for active study.

(4) *Desktop design tool*: To fully understand how sonic fish barriers function, and to then apply this information other (perhaps larger) systems it is vital to understand the transport process and generation of sound in channel systems. This requires application of state-of-the-art Computational Fluid Dynamics (CFD) models and fish behavior. The final prong in our effort is to develop a desktop tool and public domain software that can be used to design a non-site sonic fish barrier. This will enable a rapid prototyping of workable and practical sonic barriers at the field scale.

Deliverables:

Result 1: *Laboratory investigation:* **Budget: $** 201,457 (7/2010)

Sonic fish barriers will be tested individually and in multiple settings. Specific deliverables will be: (1) determination of the relationship between fish barrier features (e.g. sound intensity, frequency, variability) and carp behavior; and (2) the validity of these relationships under different water velocity and depth conditions using different sizes of carp (3) insure that they are species specific and allow native fish 9which are largely insensitive to sound) to pass.

Result 2: *Field channel investigation*: **Budget: $** 175,869 (10/2011)

Sonic barriers will be tested in multiple settings. Deliverables include: (1) identification of field operating conditions under which sonic barriers are effective; (2) specification of the optimal sonic barrier design for given field conditions; (3) an assessment of the robustness of sonic barrier design under varying conditions of discharge, channel geometry, and water quality; and (4) suitability of these parameters for different sizes of carp.

Result 3: *Desktop design tool and field verification in a lake :* **Budget: $** 210,048 (6/2012)

The design will be tested in the spring of 2012 in an infested carp lake. A Computational Fluid Dynamics model will be developed and verified based on the laboratory and field measurements. This tool will enable a rapid implementation of sonic barrier at a given site with known channel geometry and discharge conditions. Deliverable includes a PC-based design tool for sonic fish barriers including (1) specification of sonic components; (2) placement in the channel, and (3) optimal operating conditions.

III. PROJECT STRATEGY AND TIMELINE

A. Project Partners: Profs. V. Voller (project management and desktop design tool), A. Mensinger and P. Sorensen (carp behavior, fish sensory biology and bioacoustics), M. Hondzo (sensors and sensing devices), A. Lightbody (OSL experiments), all the University of Minnesota, Twin Cities and Duluth.

B. Project Impact: Most of the lake systems in the lower 1/3 of the state are severely impacted by the presence of common carp. The control and management of these fish in a given lake system requires three essential steps; 1) removal of adults; 2) suppression of reproductive success; and 3) prevention of re-infestation through connecting channels. The stream barrier technologies developed in this project will be the critical tool for preventing carp re-infestation of lakes where adults have been removed and reproduction suppressed. The success of this project will have a significant contribution toward the ability to manage and control the impact of carp on lake water quality in the southern portions Minnesota. Further, the sonic bubble net technology can be adapted to prevent Asian carp from invading Minnesota's waterways.

C. Time: The total requested budget is **$587,195**. **Staff: $367,761.** PI (Voller) and CoPIs (Hondzo, Mensinger, Lightbody, Sorensen) for overall project coordination, supervision of graduate students, and report preparation; graduate student and staff (1 Ph.D. student, 1 post-Doctoral researcher) to deploy and investigate barriers, process samples, and analyze data; 1 technician (part time) at SAFL for the construction of sonic fish barrier. **Equipment: $30,000.** Sound sensors, temperature measurements, radio frequency identifiers (RFID), digital cameras, and particle image velocimetry. **Other: $90,000.** Laboratory supplies and services, fish purchase and maintenance, equipment repair, funds for travel to test sites and to local workshops/conferences for dissemination of results. The goals of the project will be completed in three years (July, 2009 to June, 2012).

Project Budget

INSTRUCTIONS AND TEMPLATE (1 PAGE LIMIT)

(One page limit, single-sided, 10 pt. font minimum Retain the bold text and remove all instructions typed in italics. Add or delete rows as is necessary. If a category is not applicable you may write "N/A" , leave it blank, or delete the row.)

IV. TOTAL PROJECT REQUEST BUDGET

BUDGET ITEM *(See list of Eligible & Non-Eligible Costs, p. 17)*	**AMOUNT**	**% FTE**
Personnel: Senior Personnel (Voller - 1 month, Hondzo - 1 month, Mesinger - 0.5 month, Lightbody - 1 month, Sorensen - 1 month)	$ 175,053	%
Support Staff (Recknor [accounting] - 0.5 months, Plante [technician] - 0.5 months)	$ 18,755	%
Students & Postdoctoral Research Associates (Grad Student - 12 months @ 50% FTE, Postdoctoral Researcher - 12 months @ 100% FTE)	$ 273,387	%
Contracts: None	$ -	
	$ -	
	$ -	
Equipment/Tools: Sound sensors, temperature measurements, radio frequency idenfitiers, digitial cameras, and particle image velocimetry.	$ 30,000	
Acquisition (Including Easements): None.	$ -	
Restoration: None.	$ -	
Other: General lab supplies and services, fish purchase and maintenance, equipment repair, funds for travel to test sites and to local workshops/conferences for dissemination of results.	$ 90,000	
	$ -	
TOTAL PROJECT BUDGET REQUEST TO LCCMR	$ 587,195	

V. OTHER FUNDS

SOURCE OF FUNDS	**AMOUNT**	**Status**
Remaining $ From Previous Trust Fund Appropriation (if applicable): None.	$ -	*Unspent or Not Legally Obligated*
Other Non-State $ Being Leveraged During Project Period: None.	$ -	*Secured or Pending*
Other State $ Being Spent During Project Period: None.	$ -	*Secured or Pending*
In-kind Services During Project Period: (1) The NSF sponsored National Center for Earth-surface Dynamics will provide 50% salary matching for A. Lightbody; (2) approximately $80k will be provided by the Riley Purgatory Bluff Creek Watershed to design an experimental barrier that could be used for our lake experiments.	$ 217,542	
Past Spending: None.	$ -	

VAUGHAN R. VOLLER
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EDUCATION

Ph.D., 1980, Sunderland University, Applied Mathematics (UK)
M.Sc., 1976, University of East Anglia, Applied Mathematics (UK)
B.Sc., 1975, University of East Anglia, Applied Mathematics (UK)

POSITIONS HELD

Professor, Civil Engineering, University of Minnesota, 1997-present
Associate Professor, Civil Engineering, University of Minnesota, 1987-1997
Assistant Professor, Civil Engineering, University of Minnesota, 1985-1987
Senior Lecturer, Mathematics, Greenwich University (UK), 1982-1985
Post Doctoral Fellow, MRRC, University of Minnesota, 1980-1983
Research Assistant, Sunderland University, 1977-1980

RESEARCH

Main research areas are (i) modeling of heat and mass transfer phenomena and (ii) analysis of free and moving boundary problems. Current areas of interest are focused on solidification phenomena, unsaturated flow in porous media, landscape dynamics, and residual stress development.

This work has resulted in over 100 papers in leading referred journals.
Voller has graduated 12 PhD students.

RECENT PUBLICATIONS

Qin Qian, V.R. Voller, H G. Stefan, “Modeling of solute transport into sub-aqueous sediments,” *Applied Mathematical Modeling*, **31**, 1461-1478 2007.

Wonsuck Kim , John B. Swenson , Chris Paola, and Vaughan R. Voller, Shoreline response to autogenic processes of sediment storage and release in the fluvial system, *JGR Earth Surface*, **111**, FO4013, 2006.

A. Jain, B.B. Guzina, and V.R. Voller, Effects of overburden on Joint Spacing in Layered Rocks, *Journal of Structural Geology*, **29**, 288-297, 2006.

H. Toniolo, G. Parker, V.Voller, R.T. Beauboueff, “Depositional turbidity currents in diapiric minibasins on the continental slope: Experiments: numerical simulation and upscaling,” *Journal of Sedimentary Research*, **76**, 798-818, 2006.

V.R. Voller, J. B. Swenson, W. Kim and C. Paola, “An enthalpy method for moving boundary problems on the earths surface,” *Int. J. Heat and Fluid Flow***, 16,** 641-654, 2006.

Chris Paola and Vaughan Voller. “A generalized Exner equation for sediment mass balance" *JGR-Earth Surface*, **110**, 2005.