Poster Abstract:

# Cybermussels: A Biological Sensor Network using Freshwater Mussels

Henry Baidoo-Williams[1], Jeremy Bril[2], Mehmed Diken[1], Jonathan Durst[2], Josiah McClurg[1]
Soura Dasgupta[1], Craig Just[2], Anton Kruger[1], Raghuraman Mudumbai[1], Teresa Newton[3]

[1]Electrical & Computer Engineering, University of Iowa, Iowa City, IA
[2]Civil & Environmental Engineering, University of Iowa, Iowa City, IA
[3]Upper Midwest Environmental Sciences Center, US Geological Survey, La Crosse, WI

[henry-baidoo-williams, jeremy-bril, mehmed-diken, jonathan-durst, Josiah-mcclurg]@uiowa.edu
[soura-dasgupta, craig-just, anton-kruger, raghuraman-mudumbai]@uiowa.edu, [Tnewton]@usgs.gov

## ABSTRACT
In this paper, we describe our ongoing work on designing an underwater sensor network for monitoring the ecosystem of the Mississippi river using freshwater mussels as biological sensors.

One of the most extensive manifestations of anthropogenic mismanagement of nitrogen is eutrophication of the Gulf of Mexico. Our vision is to create a biosensor network of native freshwater mussels in the Mississippi river to monitor and model key components of the nitrogen cycle.

## Categories and Subject Descriptors
C.2.1 [**Network architecture and design**]: Wireless Communication

## General Terms
Design, Experimentation, Verification

## Keywords
Bio-sensor, wireless sensor network, freshwater mussel

## 1. INTRODUCTION
Native freshwater mussels are a guild of long-lived, suspension feeding bivalves that can influence nutrient cycling by transferring nutrients from the water column to the riverbed. There is a long history of monitoring the response of individual mussels to changes in their environment. These range from biological investigations of mussels to complete commercial systems that use mussels as biological sensors, such as *Mosselmonitor* [1]. Our work goes beyond this previous literature in networking individual mussel sensors to create a wireless biosensor network. The gape, a rhythmic opening and closing of a mussel's valve, is by far the most commonly studied/used behavior, however we are exploring sensors for three additional variables: heart rate, valve pumping, and burrowing.


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## 2. IMPLEMENTATION OF FRESHWATER MUSSEL SENSOR NETWORK
As a preliminary step towards this vision, our interdisciplinary team has built a mussel microhabitat with a constant river water feed stock, solar simulator, and a variety of water chemistry sensors. We have also designed simple, compact "backpacks" to be glued to a number of mussels; these backpacks each include a Hall-effect sensor to monitor the gape response of the mussel, memory, and a low-power wireless transceiver to connect the mussels into a wireless sensor network. It is well-known that RF wireless signals suffer very high attenuation underwater and therefore it has been assumed that underwater wireless networks are not feasible. However, we take advantage of the fact that freshwater mussels tend to congregate together in closely-packed clusters, and our preliminary experimental work has shown that off-the-shelf wireless transceivers work quite well underwater over distances of up to 1.2 meters (~4 feet).

Our poster will report on our initial results with the design of the backpack, experimental work with underwater wireless networking, design of the mussel microhabitat and our ongoing work on modeling the role of mussels in the freshwater ecosystem.

Figure 1 shows the sensors to be instrumented onto the mussels in our experimental setup; these include a mounted Hall-effect sensor which performs gape sensing, a digital thermometer chip providing both temperature and a unique "silicon id" for each mussel, and a pressure sensor to weigh the water column above the mussel which can provide information about vertical movement (burrowing) of the mussels.

Figure 2 also shows a tracking system used to track the mussels in our experimental microhabitat. It consists of a high resolution camera that is controlled via a custom application residing on computer. Continuously acquired pictures of the tanks are processed using image processing techniques that can identify and calculate the location of each mussel. In addition, the system utilizes a RFID tracking setup that traverses a reader under the tanks along the x/y-plane to detect and log unique mussel locations. Both processed images and RFID data are stored in a central database and we plan to make these available on the web along with time-lapse videos.

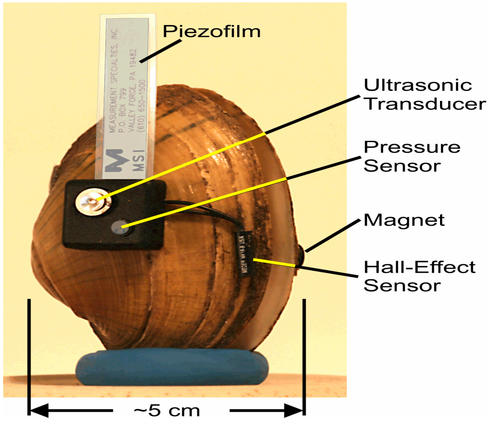


**Figure 1. A mock-up of an instrumented freshwater mussel.**

Our objective with the setup in Figure 2 is to validate and profile Mussel behavior both with and without backpacks in a controlled environment through autonomous tracking of identification of RFID tags on the mussels.

We also plan to use the mussel location data obtained from the setup in Figure 2 to develop simple analytical models to describe the observed spatial aggregation behavior of mussels [2][3].

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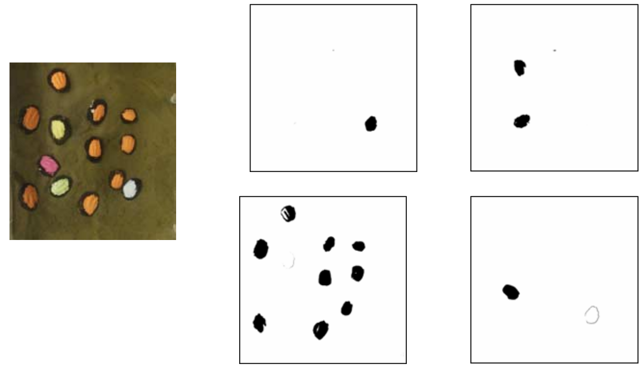

**Figure 2. A sample image of mussel identification scheme using different colors and the masks generated to detect each color. These masks are further processed to find centroid information that is stored in a central database for further analysis.**

# 3. REFERENCES

[1] de Zwart, D., Kramer, K. J. M. and Jenner, H. A. (1995), Practical experiences with the biological early warning system "mosselmonitor". Environmental Toxicology and Water Quality, 10: 237–247. doi: 10.1002/tox.2530100403

[2] van de Koppel J, Gascoigne J. C, Theraulaz G, Rietkerk M, Mooij W. M, et al. (2008) Experimental evidence for spatial self-organization and its emergent effects in mussel bed ecosystems. Science 322: 739–742

[3] M. de Jager et al, Levy walks evolve through interaction between movement and environmental complexity, Science 322, 1551 (2011)