FY2011 Annual Report submitted to NOPP

For work performed in the period 1 July to 30 September 2011 on the grant

"Portable and Persistent Autonomous Real-Time Marine Mammal Acoustic Monitoring"

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LONG-TERM GOALS

Current marine mammal monitoring (MMM) methods that use archival recorders or towed hydrophone arrays have the disadvantages of being analyzed long after the acoustic events of interest, or being subject to the noise of the ship towing the array and require dedicated on-ship computers and human reviewers to acquire and process the data, respectively. To overcome these disadvantages, this joint work involving the Cornell Lab of Ornithology (CLO) Bioacoustics Research Program (BRP) and SAIC, Inc. will integrate archival recorder electronics and a broadband satellite communications system with on-board detection, classification, and localization (DCL) software onto a Wave-Powered Glider Persistent Autonomous Vehicle ("WaveGlider" from Liquid Robotics, Inc.), to develop a mobile marine mammal monitor (hereafter "M4") capable of transmitting DCL data in near real-time to an on-ship or on-shore Data Management and Communications (DMAC) receiver.

OBJECTIVES

The proposed project objectives are

1. Develop a real-time, portable, Marine Mammal Monitoring System.
2. Acquire marine acoustic data using a four-channel hydrophone array towed behind a WaveGlider, with modified acoustic acquisition electronics integrated onto the WaveGlider.
3. Transmit selected acoustic data and associated metadata in real-time to the DMAC receiver via the high-speed satellite data link.
4. Optimize detection, classification, and localization (DCL) operations both on-board the WaveGlider and at the DMAC receiver to achieve real-time performance similar to BRP's current Auto-Buoy system.[1]

APPROACH AND WORK PLAN

In the first year of proposed work (1 July 2011 to 30 June 2012), the overall goal will be to demonstrate the feasibility of a WaveGlider integrated with acoustic data acquisition electronics and a towed four-element hydrophone array to capture and output acoustic data to an on-ship data collection system. This goal will be approached in three phases, with the success of each phase determined by the metrics in italics:

1. Hardware integration of electronics, hydrophone array, and WaveGlider - *successful mechanical and electrical integration shown by a bench test of the system acquiring four channels of data with power consumption within the WaveGlider's capability.*
2. In-water testing of the WaveGlider system to capture four-channel data - *a successful test here shown by a seaworthy acquisition of test stimuli from an underwater transducer.*
3. Post-processing of the in-water data for evaluating existing detector performance - *success in this last phase to be evaluated by comparing receiver operating characteristics (ROCs) of the in-water data as processed by current BRP detection protocols versus a detector based on the auto-buoy previous work, with equal performance as a minimum standard.*

Key individuals participating in this work are listed with their respective project roles in Table 1 below.

Name	**Organization**	**Project Role**
Harold Cheyne	Cornell	PI
Christopher Clark	Cornell	Co-PI
Adam Strickhart	Cornell	Electrical Engineer
Dean Hawthorne	Cornell	Software Engineer
John Walrod	SAIC	Advanced Systems Division Manager
Michael Ornee	SAIC	Program Manager
Michael Satter	SAIC	Advanced Systems Division Deputy Manager
Charles Key	SAIC	Systems Engineer

Table 1. Key personnel on the project.

WORK COMPLETED

In the period 1 July 2011 to 30 September 2011, we completed three tasks to initiate the M4 project: holding a kickoff meeting, developing an alternative hardware approach, and presenting at the MTS/IEEE Oceans ’11 conference. First, kickoff meeting was held at SAIC’s office in Long Beach, MS on 24 August 2011. It involved reviewing the goals and objectives of the project, and planning the Year 1 work in more detail. Second, since the original proposal for this project, the “V3” electronics described in the proposal have become unusable, resulting in the need to develop an alternative approach for the platform’s acoustic acquisition hardware. In this period we decided to pursue two parallel development paths: modifying SAIC’s existing “VLF” product, and BRP developing its own microcontroller-based acoustic data acquisition subsystem. Lastly, Harold Cheyne (PI) attended and presented at the MTS/IEEE Oceans ’11 conference in September 2011. The reference for the

associated conference proceedings paper appears below under "Publications." Several people and companies expressed interest in and a willingness to collaborate with us on this project, including Liquid Robotics, Falmat Cable, and Jupiter Research Foundation.

RESULTS

During the first three months of work on the project we gained technical knowledge regarding feasible low-power subsystems for the M4 platform, and we learned of other application areas. First, we learned that implementing a microcontroller-based data acquisition system for the M4 platform was feasible as we successfully bench-tested a Texas Instruments MSP430 microcontroller writing data onto a microSD card at a rate equivalent to a sampling frequency of 96kHz. Second, by attending the Oceans '11 conference and discussing the M4 project with other researchers and companies, we learned of other potential application areas not previously considered such as open-ocean fish hatchery monitoring or port security monitoring.

IMPACT AND APPLICATIONS

National Security

Successful development of the M4 platform will have the direct National Security impact of providing a more cost-effective way for the US Navy to monitor the effects its activities have on marine mammals. Indirectly, such a platform may have other National Security uses such as port monitoring or unmanned monitoring of activity in US or international waters.

Economic Development

The M4 platform would potentially transform the current standard methods for monitoring marine mammals. Instead of requiring expensive ship time, which also uses significant amounts of fossil fuels, a renewable-energy-powered Waveglider could monitor the area instead. People who previously served as Marine Mammal Observers (MMOs) on-board operating vessels may instead be able to perform their duties on-shore by confirming detections by the M4 system.

Quality of Life

The potential future impact of a Waveglider-based MMM platform would be an improvement in general ocean ecosystem health due to greater monitoring and thus enhanced regulation of industrial activities. This would also contribute to more comprehensive coastal resource management, such as persistent acoustic monitoring of offshore wind energy sites before construction, during construction, and during operation.

Science Education and Communication

One of the key software components of this project is BRP's "Raven" software for acoustic signal visualization and measurement (see http://www.birds.cornell.edu/brp/raven/RavenOverview.html). This software package has a related application named "Raven Exhibit," which is dedicated to using the Raven audio-visual software for science education and outreach, particularly in museum installations. A potential future impact on Science Education and Communication may be transferring

some of the acoustic data from such a Waveglider MMM platform to Raven Exhibit to provide the public with a real-time auditory experience of the marine mammal environment.

TRANSITIONS

National Security None as yet.

Economic Development None as yet.

Quality of Life None as yet.

Science Education and Communication None as yet.

RELATED PROJECTS

There are three closely related projects to this effort: the ongoing BRP improvement of its Marine Autonomous Recording Unit (MARU), the CLO Acoustic Monitoring Project (AMP), and a grant award under ONR BAA 10-024 (PI: Peter Dugan). Both the ongoing MARU improvement and AMP are looking towards a microcontroller-based, low-power acoustic data acquisition system for their next generation of acoustic monitoring devices. These two efforts will differ from the M4 project in the number of channels to be recorded and in the peripheral communications, but the core acoustic acquisition and storage methodologies can be achieved in a synergistic development. Peter Dugan's grant focuses on developing novel detection and classification algorithms for marine mammal monitoring, and may provide a collaborative opportunity in reduction to practice by implementing an embedded version of such an algorithm on the M4 platform itself.

REFERENCES

1. Eric Spaulding, et al. "An autonomous, near-real-time buoy system for automatic detection of North Atlantic right whale calls," Proceedings of the 157th Meeting of the Acoustical Society of America, Portland, Oregon, 18-22 May 2009.

PUBLICATIONS

Cheyne, H., Walrod, J., Gholson, N., Ornee, M., Clark, C., Developing a Portable and Persistent Autonomous Real-Time Marine Mammal Acoustic Monitor. Proceedings of the Oceans '11 MTS/IEEE Conference, 2011.

OUTREACH MATERIALS None as yet.