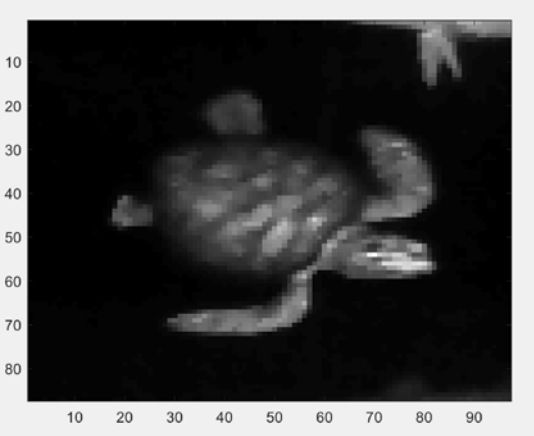
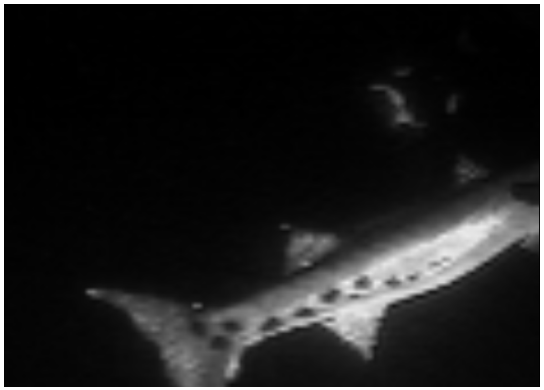




Unobtrusive Multi-static Serial LiDAR Imager (UMSLI) for Wide-area Surveillance and Identification of Marine Life at MHK Installations

DE-EE0007828

Marine and Hydrokinetics Program

October 9, 2019

Principal Investigator

Anni Vuorenkoski Dalgleish, PhD
Florida Atlantic University

Project Overview

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Project Summary

This project will increase the technical performance and cost-effectiveness of an optical monitoring system designed and validated for marine and hydrokinetic (MHK) project lifecycle observation and automated real-time classification of marine animals. This system, called the Unobtrusive Multi-static Serial LiDAR Imager (UMSLI) can be deployed to collect pre-installation baseline species observations at a proposed deployment site with minimal manual post-processing overhead, such as feature detection and classification. To satisfy deployed MHK project endangered/threatened species monitoring requirements, UMSLI provides automated tracking and notification of the presence of managed animals around MHK equipment and provides high resolution imagery of behavior through a wide range of conditions.

Project Objective & Impact

The goal of the project is to leverage past innovation, expertise and capabilities to prototype and validate an active optics based imaging system to monitor the marine biota in the vicinity of a MHK installation in order to detect possible presence and activity of endangered/threatened species. While suitable components, packaging, and low-level software approaches have been developed and tested in specialized research labs, a further effort is needed to demonstrate a utility of an imaging system, which has been customized for surveillance of MHK surroundings and will be commercially available to MHK developers. Critical device performance success factors include the demonstration and optimization of proposed transmitter/receiver configurations to achieve long range omni-directional volumetric coverage of MHK equipment, as well as the demonstration verification of the proposed classification and identification software. The Technology will provide an effective tool to enable the monitoring the surroundings of an MHK device for the presence of endangered species.

Project Information

Project Principal Investigator(s)

Anni Vuorenkoski Dalgleish, PhD

WPTO Lead

Carrie Noonan

Project Partners/Subs

University of Florida

Project Duration

- 10/01/204
- 12/31/2019

Alignment with the Program

Marine and Hydrokinetics (MHK) Program Strategic Approaches

Data Sharing and Analysis

Foundational and Crosscutting R&D

Technology-Specific Design and Validation

Reducing Barriers to Testing

Alignment with the MHK Program

Reducing Barriers to Testing

- Enable access to world-class testing facilities that help accelerate the pace of technology development
- **Work with agencies and other groups to ensure that existing data is well-utilized and identify potential improvements to regulatory processes and requirements**
- **Support additional scientific research as needed, focused on retiring or mitigating environmental risks and reducing costs and complexity of environmental monitoring**
- Engage in relevant coastal planning processes to ensure that MHK development interests are equitably considered

This project contributes to reducing barriers to testing and is focused on reducing costs and complexity of environmental monitoring.

This project is developing a low cost, easily deployable environmental monitoring technology system to meet the regulatory needs of siting and deployment of MHK devices. The goal is to ultimately deliver this as a commercially available system.

Project Budget

DOE	Cost-share	Total
$850,000	$94,444	$944,444

FY17	FY18	FY19 (Q1 & Q2 Only)	Total Actual Costs FY17–FY19 Q1 & Q2 (October 2016 – March 2019)
Costed	Costed	Costed	Total
$132,352.49	$188,587.98	$171,263.74	$492,204.21

Management and Technical Approach

- **Progress monitoring and reporting is carried out by the Principal Investigator (A Vuorenkoski-Dalgleish, Florida Atlantic University).**
- **The management approach includes:**
  - The mentoring and supervision of graduate and post-doctoral students
    - By Harbor Branch Oceanographic Institute and the University of Florida team leaders:
      - Dr. Anni Vuorenkoski Dalgleish, PI (Harbor Branch Oceanographic Institute), Associate Research Professor
      - Dr. Bing Ouyang (Harbor Branch Oceanographic Institute), Associate Research Professor
      - Dr. Fraser Dalgleish (Harbor Branch Oceanographic Institute),
      - Associate Research Professor
      - Dr. Jose Principe (University of Florida), Professor
  - Weekly meetings to report and monitor the progress and discuss current and potential risks in the technical approach
  - The team has organized and facilitated Preliminary Design Review and Critical Design Review meetings with DOE.
  - Field testing and other technical support is provided by the PNNL's Triton Initiative

End-User Engagement and Dissemination Strategy

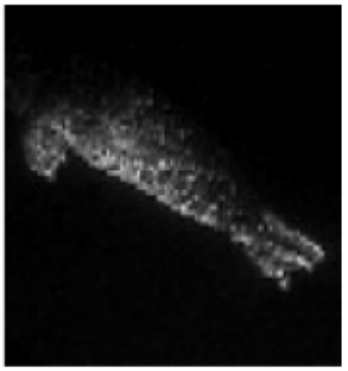
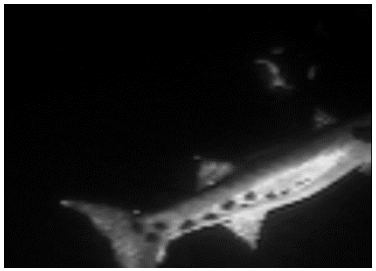
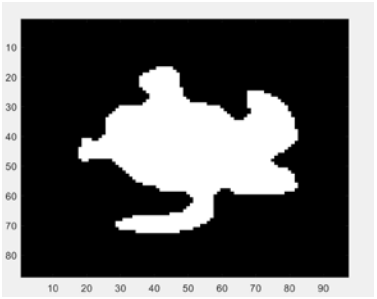
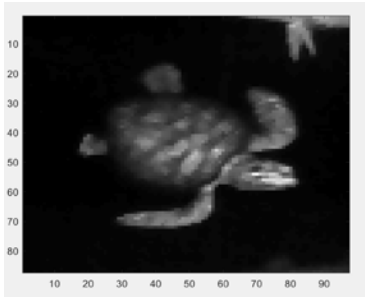
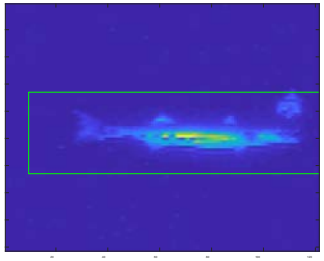
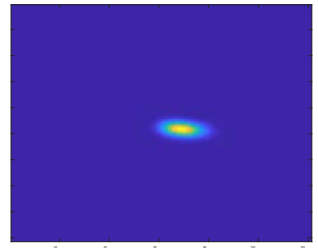
- To aid in eventual commercialization of the system, the team is currently in progress of identifying and engaging with diverse end-user groups outside of the marine renewable energy application, which include applications involving:
  - Fisheries management
  - Ocean exploration
  - Oil and gas industry
  - National security
- Methods for engaging with potential end users include:
  - Develop a commercialization strategy with a future commercialization partner
  - One-on-one meetings, conferences, publications, webinars, presentations

Technical Accomplishments

- The first generation UMSLI instrument design, fabrication, and test tank and field testing was completed under a separate funding opportunity from the WPTO (2014-2017).
- Accomplishments under this award included:
  - Hardware for the sensing front end
    - Six receivers (Rx), six red laser transmitters (Tx), and a digital signal processor
    - Transmitters artificially "illuminate" a volume of water around an MHK device by scanning a grid of pulses in a bi-directional raster pattern using an analog micro-mirror device (AMD) and a scan angle expansion lens.
  - A scan field that can be instantly configured to be either sparse or dense:
    - Concentrating a lower density pulse grid through a wider range of angles (sparse; level one, i.e. feature detection)
    - Once an object is detected, concentrating a higher pulse density through a narrower range of angles (dense; level two , i.e. feature classification).
  - A demonstrated detection and classification algorithm
    - From three test tank marine animal targets (sea turtle, barracuda, and amberjack)
    - Improvements included: distortion correction; multiview learning methods to improve classifier; a gamma detector and bounding box approach for object detection

Technical Accomplishments (Cont.)

- **The current, second generation UMSLI instrument design, fabrication, and test tank and field testing, and validation at the PNNL's Marine Science Laboratory in Sequim, WA is in progress:**
  - First generation UMSLI baseline testing at PNNL
  - Development and implementation of technical approaches to improve the UMSLI sensor performance
  - Deployment, retrieval, operations and maintenance methods
  - Improvements to the UMSLI engineering concept design to reduce capital expenditures (CAPEX) and operating expenditures (OPEX) costs
  - Improvements to the red channel performance laser transmitter performance
  - An extended range capability for detecting undersea marine life out to 20 meters using a higher pulse energy green pulsed laser channel
  - Based on the findings from the baseline testing, algorithmic and classifier enhancements have been investigated and implemented

Future Work

- **Future work on the second generation UMSLI includes:**
  - System integration, testing, and validation
  - Fall 2019 instrument testing and validation in a wave environment at PNNL
  - Spring 2020 deployment at Wave Energy Test Site (WETS) facility in Hawaii
    - The UMSLI operation will be demonstrated using autonomous system control/acquisition and processing architecture
- **Currently the team is testing and evaluating the system and sub-systems in the extended range underwater imaging facility at HBO.**
- **Final assembly and the field testing at PNNL was delayed due to issues with a sub-system failures as well as specification and fabrication inconsistencies.**
  - The team is working with the suppliers to resolve the issues with the expectation that the components will be available for integration in September 2019