3rd Generation Adaptable Monitoring Package

DE-EE0007827

Marine and Hydrokinetics Program

October 9, 2019
### Project Overview

#### Project Summary

The 3G-AMP combines real-time, machine learning algorithms with modular hardware to characterize marine animal activity at marine energy sites accurately, at low cost, and without biasing animal behavior. Real-time information about animal activity can close the loop for adaptive management and accelerate risk retirement.

#### Project Objective & Impact

- **Problem**: Low-probability, high-consequence environmental interactions (e.g., collision) cannot be retired by continuously archiving sensor data.
- **Objective**: Continuously observe marine environment and process data in real-time using machine learning to rapidly characterize animal activity.
- **Impact**: Prove the effectiveness and flexibility of the AMP architecture to reduce barriers to commercial adoption.

### Project Information

#### Project Principal Investigator(s)

- Brian Polagye
- Andy Stewart (*departing*)
- Chris Bassett (*incoming*)

#### WPTO Lead

- Samantha Eaves

#### Project Partners/Subs

- MarineSitu, Inc.
- NOAA NMFS AK Fisheries Science Center

#### Project Duration

- December 2016
- November 2019 (*pending extension*)
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
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

The 3G-AMP’s modular, endurance-tested design expands monitoring capabilities while reducing monitoring complexity.
## Total Project Budget – Award Information

<table>
<thead>
<tr>
<th>DOE</th>
<th>Cost-share</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1397k</td>
<td>$158k</td>
<td>$1555k</td>
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</table>

## Total Actual Costs

<table>
<thead>
<tr>
<th>FY17</th>
<th>FY18</th>
<th>FY19 (Q1 &amp; Q2 Only)</th>
<th>Total Actual Costs FY17–FY19 Q1 &amp; Q2 (October 2016 – March 2019)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costed</td>
<td>Costed</td>
<td>Costed</td>
<td>Total</td>
</tr>
<tr>
<td>$148k</td>
<td>$649k</td>
<td>$231k</td>
<td>$1028k</td>
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</tbody>
</table>

- Project benefited from concurrent activities associated with:
  - Development of illumination system for fish reaction study (NOAA)
  - Fabrication of an AMP for WETS (DOD NAVFAC) powered by a WEC
  - Data streams from AMP deployment at WETS (DOE iAMP)
  - Graduate student support (NSF Graduate Research Fellowship)
Management and Technical Approach

2G-AMP 2015-2016

2.5G-AMP 2017

3G-AMP 2019

AutoAMP 2017

WAMP 2018

Autonomous Battery-powered

Autonomous Wave-powered
Management and Technical Approach

Planned

2017
- Deploy baseline AMP

2018
- Hardware and Software Upgrades
- Deploy 3G-AMP at MSL

2019
- Deploy 3G-AMP at WETS

Actual

2017
- Deploy baseline AMP

2018
- Long-lead items and serial design decisions

2019
- Deploy 3G-AMP at MSL
- Deploy 3G-AMP at WETS
Management and Technical Approach

• **Success Factors**
  
  – *Technical*: Demonstrated reliability and flexibility
  
  – *Market*: Demonstrated ability to retire risk
  
  – *Business*: Commercially-viable entity offering AMP services

• **Challenges**
  
  – *Marine energy market size*: Limited number of deployments large enough to warrant AMP-scale environmental monitoring
  
  – *Cost perception*: AMP backbone costs equivalent to a single sensor (e.g., multibeam sonar), but end-users perceive high system cost
  
  – *Replacement perception*: Potential end-users underestimate the cost and complexity of hardware and software integration (perception that DIY is cheap and easy)
End-User Engagement and Dissemination Strategy

**Industry Interviews – BP1**

<table>
<thead>
<tr>
<th>Wave Energy Device Developers</th>
<th>Current Energy Developers</th>
<th>Test Facilities</th>
<th>Supporting Organizations</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Oscilla Power</td>
<td>• ORPC</td>
<td>• PMEC</td>
<td>• UMaine</td>
</tr>
<tr>
<td>• Columbia Power Power</td>
<td>• Verdant Power</td>
<td>• WETS</td>
<td>• SMRU consulting</td>
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<tr>
<td>• NWEI</td>
<td>• OpenHydro</td>
<td>• EMEC</td>
<td>• PNNL</td>
</tr>
<tr>
<td>• Ocean Energy Ltd.</td>
<td>• MeyGen</td>
<td></td>
<td>• Aquatera</td>
</tr>
<tr>
<td>• Instream Energy</td>
<td>• Instream Energy</td>
<td></td>
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</tr>
</tbody>
</table>

- Need for demonstrations at fully energetic sites
- Specific monitoring requirements for each project
- Data visualization and acceptance

- **ORPC contract for camera system software development**
- **FORCE Pathway Project contract for imaging sonar review**
End-User Engagement and Dissemination Strategy

• Presentations
  – OES Collision Workshop
  – EIMR conference
  – METS conference

• Publications
  – Cotter et al. (2019) - Acoustic characterization of sensors used for marine environmental monitoring
  – Cotter and Polagye (in review) - Automatic classification of biological targets in a tidal channel using a multibeam sonar
Technical Accomplishments

AMP Architecture Overview

Integration Hub
- Power Distribution
- Condition Health
- Sensor Communication

Sensor Synchronization and Control
- Sensor A
- Sensor B
- Sensor C
- Sensor N

Real-Time Processing Modules
- Target Detection and Tracking
- Target Classification

Fiber Optic Link

II) Power Source
I) Integrated Sensor Package
III) Control Computer

Standard
Backbone
Specific to Deployment
External Power
Technical Accomplishments

Jan. 16 - Deployment
Jan. 22
Umbilical damage

Jan. 29
Recovery
Umbilical replacement
Redeployment

174 days
97% uptime

May 28 - Recovery
Technical Accomplishments

Initial Result

Post-processed Classifier (2017)

Biological vs. Non-biological Target

Biological Targets

TPR_{bio}

Diving Birds

TPR_B

Seals

TPR_S

Air bubbles and sonar artifacts

Real-time Classifier (2019)

Individual Fish and Debris

Fish Schools

TPR_{Sm}

TPR_{N}

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Technical Accomplishments

- 10 m deep
- 1.5 m/s currents

- 6 m deep
- 2 m/s currents
Technical Accomplishments

Average of 1 fish school/day

Average of 3 fish schools/day

Puget Sound

Sequim Bay

Pacific Northwest National Laboratory

15 | Water Power Technologies Office
Technical Accomplishments
Technical Accomplishments

Re-trained Model

Biological Targets

Diving Birds

Seals

Air bubbles and sonar artifacts

Individual Fish and Debris

Fish Schools

Biological vs. Non-biological Target
• **Comparison of imaging sonars:** Teledyne BlueView (2250 kHz) and Tritech Gemini (720 kHz)
  
  – Easier for human reviewer to identify targets in BlueView
  – More targets detectable in Gemini
  – Similar automatic classification capabilities for detected targets

• **Go/No-Go decision for Budget Period 3**
  – Meeting on August 20
Future Work

- **Budget Period 3**: WETS Deployment on OE 35 WEC

3G-AMP Integration on OE35