

A Combined Electric/Magnetic Field Instrument for MHK Environmental Monitoring

DE- EE0007825

Marine and Hydrokinetics Program

8 October 2019

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Project Summary

The scientific/technical goal is measurement of the direct and indirect effects of MHK systems on the seafloor vector magnetic and electric fields with a resolution of 0.1 nT and 0.1 $\mu\text{V}/\text{m}$, respectively, over the range of 10^{-4} -100 Hz. An instrument design that is a modification of a Technology Readiness Level 9 one designed and built at WHOI was proposed. Four units of the instrument were constructed and tested at PNNL during Budget Periods 1 and 2. In addition, a Geometrics G-882 scalar cesium vapor magnetometer with altimeter was used to measure the magnetic field in the water column.

Project Information

Project Principal Investigator(s)

A D Chave
R L Evans
J W Bailey

WPTO Lead

S Eaves
Y Shininger

Project Partners/Subs

None

Project Duration

- 1/1/2017
- 3/31/2020

Project Objective & Impact

Commercial off-the-shelf instrumentation to measure the seafloor electric and/or magnetic fields at frequencies near those of power systems (i.e., 60 Hz in North America) does not exist. The expertise to design, build, deploy and recover such instrumentation is vested in a small number of universities or research institutions. The major objectives of this project are 1) design, construct and test custom electric/magnetic field instrumentation for characterizing the electromagnetic environment around MHK systems, 2) test the instrumentation and demonstrate its performance at simulated MHK sites, 3) measure the electromagnetic fields produced by an operational MHK system, 4) characterize the total magnetic field within the water column at simulated and actual MHK sites and 5) compare all measurements to theory. The outcome of the project will be an operational instrument design that did not exist at the time of project inception, and a preliminary characterization of the electromagnetic fields produced by MHK systems for use in possible future regulatory actions and for comparison with fish behavior studies.

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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

- Support additional scientific research as needed, focused on retiring or mitigating environmental risks and reducing costs and complexity of environmental monitoring.

There is presently neither an understanding of the electromagnetic effects of MHK systems, nor proven instrumentation to measure the electromagnetic environment around them. This project will provide those capabilities. The result may be useful in understanding the biological effects of MHK systems and in future regulatory environments.

Project Budget

Total Project Budget		
DoE	Cost-share	Total
\$749,949	\$83,385	\$833,340

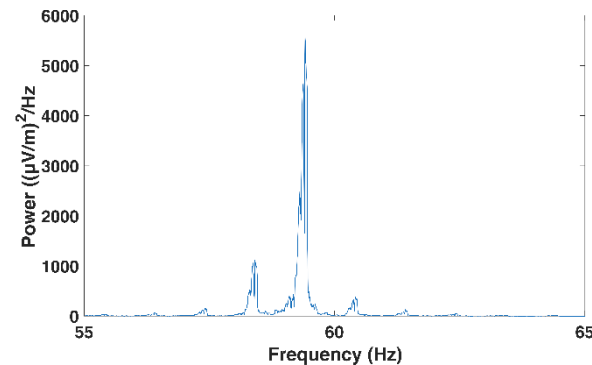
FY17	FY18	FY19 (Q1/Q2)	Total Actual Costs
Costed	Costed	Costed	Total
\$178,848	\$352,911	\$136,001	\$667,760

- This project is located at a single institution, and is of a size that is easily managed by a single PI interacting with engineers and administrators
- Milestones were included in the SOPO that provides the overarching management plan
- Success is defined by the ability to operate in the environment and with the support infrastructure around M-HK systems, and the ability to meet Technical Performance Metrics for sensitivity and resolution
- Other than the sponsor, the only external entity that was involved is Pacific Northwest National Laboratory, and interactions with them were smooth and professional
- The two major challenges were delivery delays from parts vendors and unforeseen increases in Institutional overhead rates after project inception that had to be accommodated by de-scoping in consultation with the sponsor

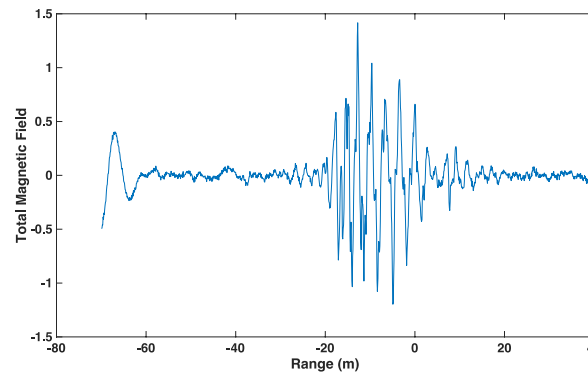
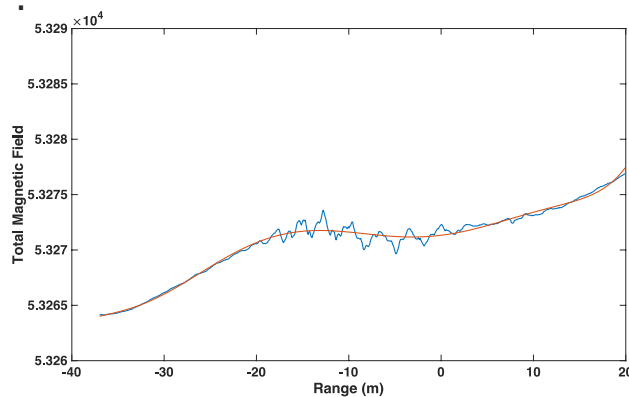
- The benefits to stakeholders are indirect and long term
- There is presently little information about the electromagnetic environment around MHK locations
- No regulation of the electromagnetic environment around MHK systems currently exists worldwide
- The Project Final Report will be made publicly available upon completion for use by interested stakeholders

- **BP 1 and 2 testing was carried out at PNNL-permitted sites in Sequim Bay, WA**
 - BP1 site had pervasive EM noise that precluded comparisons with a test cable, but did demonstrate instrument technical performance
 - BP2 fixed sensor testing was in a low noise environment with some instrumental issues encountered
 - Both electric and magnetic fields were detectable out to 100 m range over 5-20 A, single phase
 - Neither electric nor magnetic fields could be detected in three phase mode

Vertical electric field at 25 m range
for 20 A, single phase source



- Testing with the towed total field magnetometer using a vertical magnetic dipole (VMD) source
 - Magnetometer was towed across the VMD center twice at each current step over 0, 5, 10, 15 and 20 A, single and three phase
 - Analysis issues with local magnetic anomalies and aliasing (magnetometer sampled at 10 Hz, while frequency of interest is 60 Hz) were easily overcome



5 A, single phase run

All single phase runs agree with theory to within a factor of 2

Three phase fields were reduced by 18 dB compared to single phase

Progress Since Project Summary Submittal

- No changes

- During BP3, both seafloor and towed instruments will be deployed around a Wave Energy Converter at WETS, Kaneohe Bay, Oahu
- Exact schedule depends on delivery of MHK device
- Minor instrument improvements are planned in advance of test
- Once data are analyzed, a final report will be submitted to the sponsor