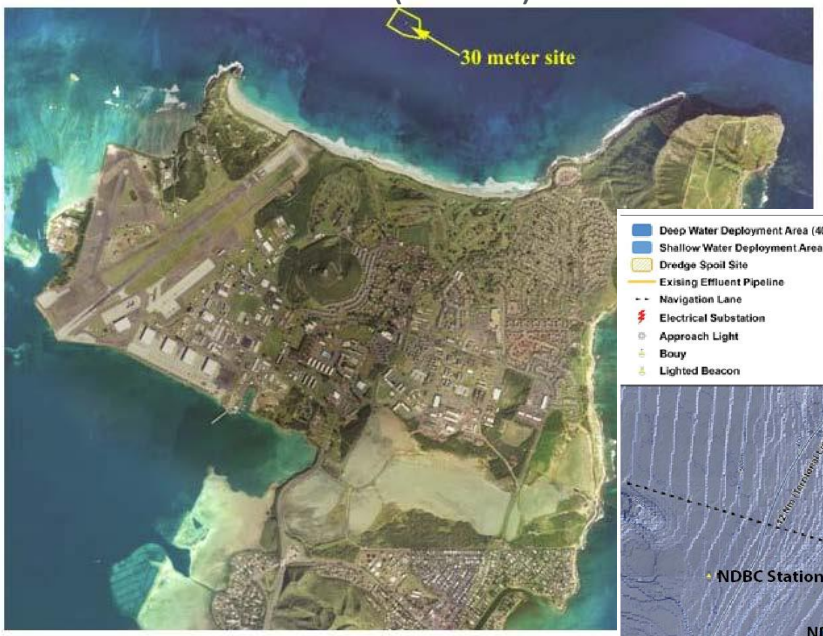
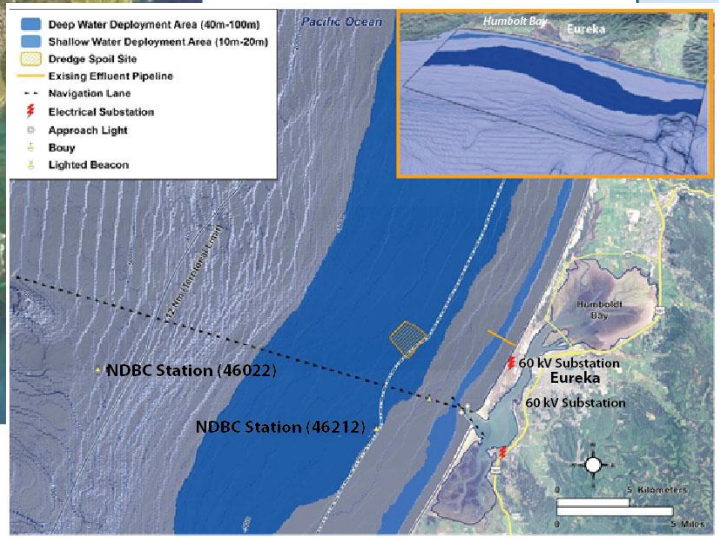
WETS (Hawaii)

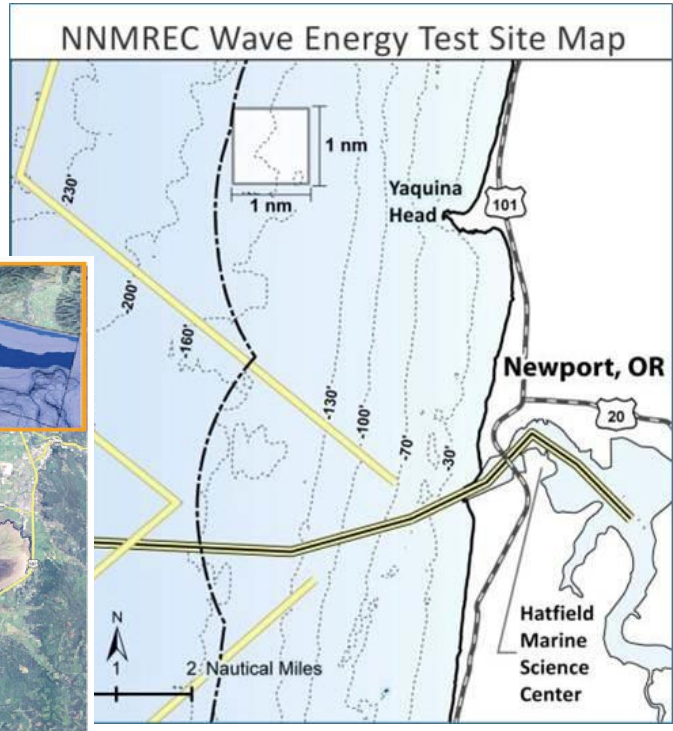


Source: http://azurawave.com/projects/hawaii/

Humboldt Bay (CA)



Source: Reference Model Report



Source: http://nnmrec.oregonstate.edu/pmec-facilities

Wave Environmental Characterization at Wave Test Sites

Vincent Neary, Ann Dallman

Sandia National Laboratories
vsneary@sandia.gov 505.288.2638
ardallm@sandia.gov

February 2017

Sandia National Laboratories is a multi-mission laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Project Overview

Wave Test Site Characterization: Technology developers need open water test sites for scale-independent tests, and to demonstrate and certify their wave energy converter (WEC) technologies. Met-ocean statistics at these sites are essential for planning open water tests, and reducing risks associated with testing in the open ocean environment.

The Challenge: Numerous statistics and time-consuming analysis are required to fully characterize opportunities and risks at WEC test sites; existing characterization reports for individual sites are not analyzed consistently.

Partners: Oregon State University, Humboldt State University, University Hawaii, The Coastal Studies Institute (North Carolina), University of Washington, U.S. Army Corps of Engineers

Program Strategic Priorities

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

Technology Maturity

- Test and demonstrate prototypes
- Develop cost effective approaches for installation, grid integration, operations and maintenance
- Conduct R&D for Innovative MHK systems & components
- Develop tools to optimize device and array performance and reliability
- Develop and apply quantitative metrics to advance MHK technologies

Deployment Barriers

- Identify potential improvements to regulatory processes and requirements
- Support research focused on retiring or mitigating environmental risks and reducing costs
- Build awareness of MHK technologies
- Ensure MHK interests are considered in coastal and marine planning processes
- Evaluate deployment infrastructure needs and possible approaches to bridge gaps

Market Development

- Support project demonstrations to reduce risk and build investor confidence
- Assess and communicate potential MHK market opportunities, including off-grid and non-electric
- Inform incentives and policy measures
- Develop, maintain and communicate our national strategy
- Support development of standards
- Expand MHK technical and research community

Crosscutting Approaches

- **Enable access to testing facilities that help accelerate the pace of technology development**
- **Improve resource characterization to optimize technologies, reduce deployment risks and identify promising markets**
- Exchange of data, information and expertise

Program Strategic Priorities

Crosscutting Approaches

- **Enable access to testing facilities that help accelerate the pace of technology development**
- **Improve resource characterization to optimize technologies, reduce deployment risks and identify promising markets**
- Exchange of data information and expertise

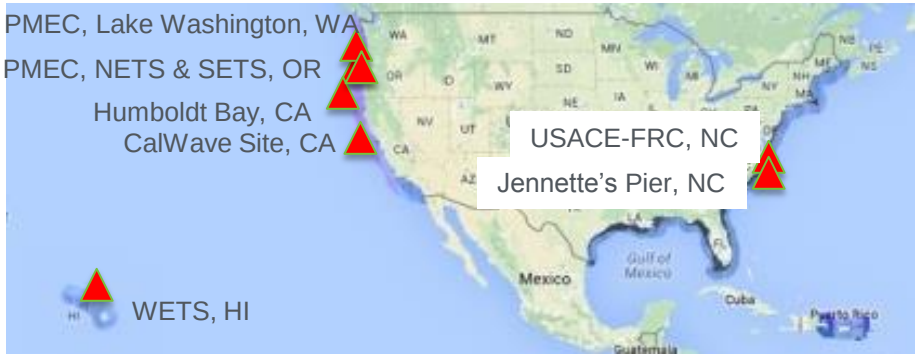
Target: Improved characterization of wave climate statistics at WEC test sites, and their public dissemination, facilitates technology testing, while reducing deployment risks.

Impact: Reduces burden on technology developers who do not have the time or resources to do comprehensive characterization of wave test sites.

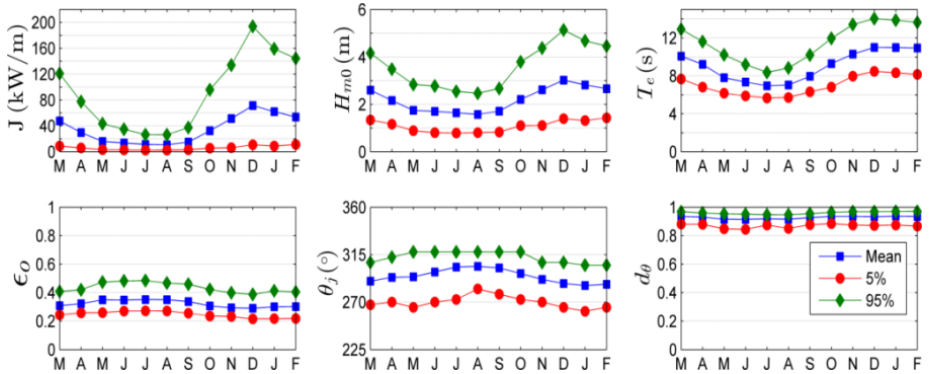
Endpoint and Final Products: Published catalogue with comprehensive and consistent wave climate characterization at eight (8) U.S. WEC test sites.

Technical Approach

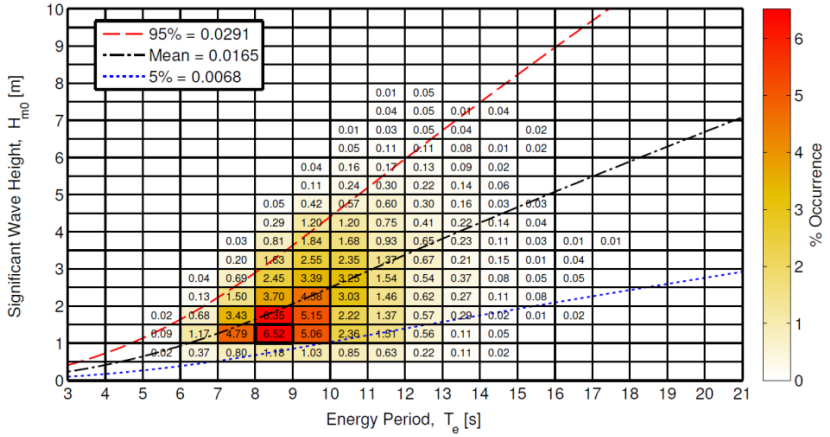
- Wave statistics generated from hindcast simulations and local NDBC buoy data
- Emphasized consistency in characterization and uniform presentation for "*apple-to-apple"* comparison of all eight (8) sites
- Applied international standards for wave climate characterization (IEC TS 62600-101 Technical Specification
- Leveraged local knowledge and most hindcast simulations from test site partners



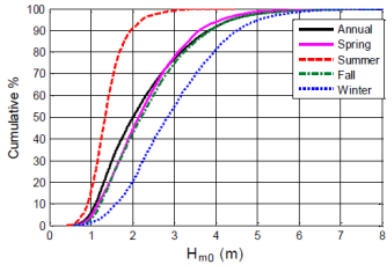
Map showing location of eight US WEC test sites



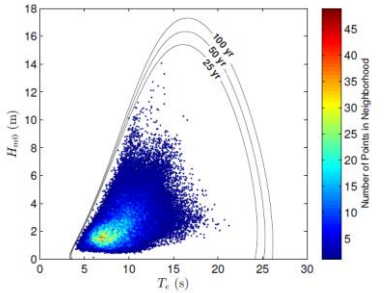
Monthly mean values of six (6) IEC wave energy characterization parameters



Omni-directionall power density scatter plot

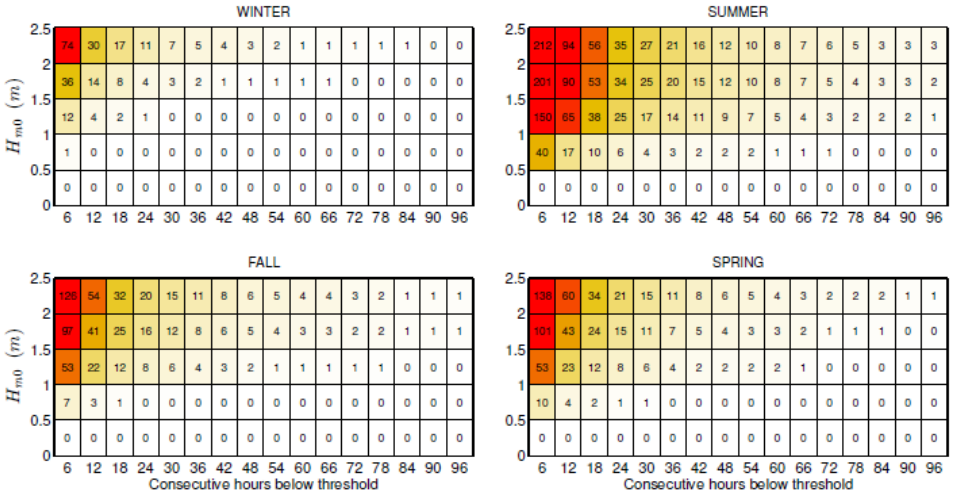


Cumulative frequency distribution plot

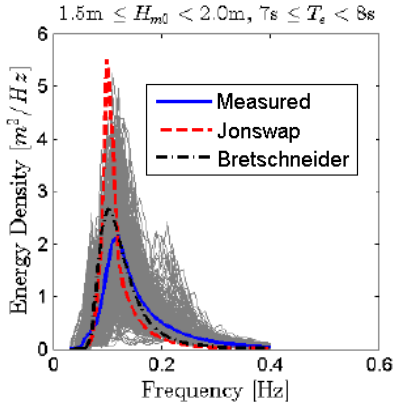


Extreme sea state contours

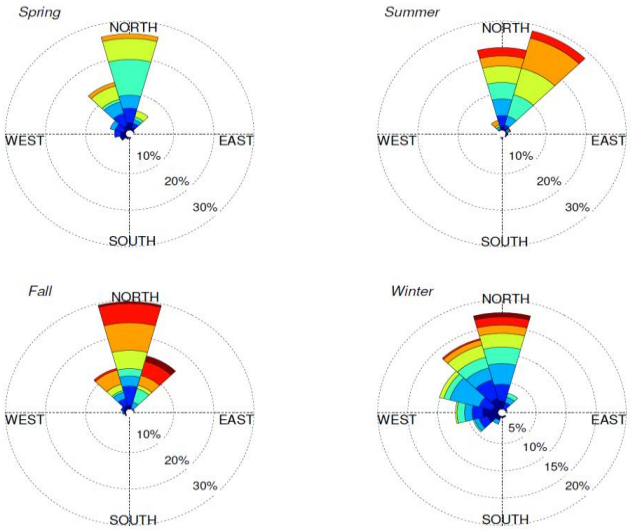
Technical Approach



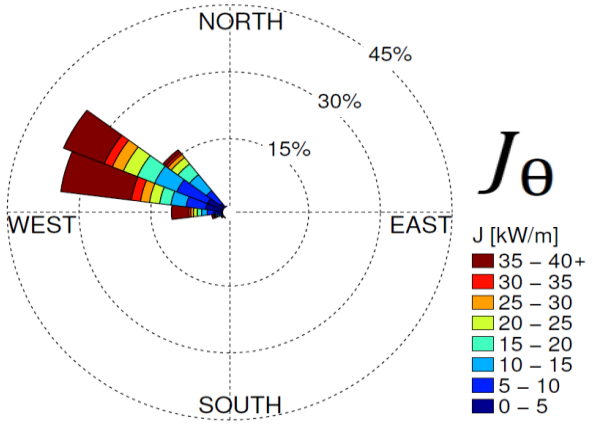
Weather windows



Representative wave spectra



Seasonal ocean current roses



Annual wave rose

Available at: http://en.openei.org/wiki/Characterization_of_U.S._Wave_Energy_Converter_(WEC)_Test_Sites

Accomplishments and Progress

- Published catalogue with comprehensive set of met-ocean and wave climate statistics at eight (8) test sites
  - Test infrastructure and support services
  - Sea state scatter plots with frequency and distribution of wave power density
  - Seasonal variation of six IEC wave energy resource parameters (IEC 62600-101 TS)
  - Extreme sea state statistics
  - Wind and ocean current statistics
  - Weather windows
- With this comprehensive information and data technology developers can:
  - Quickly select the most suitable test site(s) that best meets their needs
  - Design their WEC test article
  - Schedule optimal deployment and testing periods
  - Assess operation and maintenance opportunities and risks

Project Plan & Schedule

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

- Project original initiation date: October 1, 2013 (FY14 start)
- Completed characterization of three (3) test sites and published 1st edition of catalogue: September 30, 2014
- Added five (5) test sites and published 2nd edition of catalogue: September 30, 2015

Project Budget

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

Budget History					
FY2014		FY2015		FY2016	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$300k	N/A	$300k	N/A	$0	N/A

Research Integration & Collaboration

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

Partners, Subcontractors, and Collaborators:

- Oregon State University: Drs. Batten, Ozkan-Haller
- University of Hawaii: Drs. Vega, Cheung, Li
- Humboldt State University, Dr. Colin Shepard
- University of Washington, Dr. Thomson
- Coastal Studies Institute, North Carolina, Drs. Billy Edge, Lindsay Dubbs
- Corps Engineers, Field Research Facility, Drs. Forte, Waters and Hathaway
- Columbia Power Technologies, Ken Rhinefrank and Puhka Lenee-Bluhm
- Oscilla Power, Dr. Tim Mundon

Communications and Technology Transfer:

- Five conference presentations: American Geophysical Union (AGU) Fall Meeting 2014, Marine Energy Technology Symposium (METS) 2014, AGU Ocean Sciences 2014 & 2016
- One conference publication: METS 2014
- One peer-reviewed journal publication, *Ocean Engineering*
- Two Sandia National Laboratories SAND reports (catalogues)

Next Steps and Future Research

FY17/Current research: N/A

Proposed future research: N/A