

Ocean Energy in Hawaii



**OES IEA Workshop
Ocean Renewable Energy in Island Regions
Cherbourg, France
11 June 2018**

Outline

- U.S. Department of Energy Perspectives
- WETS Overview and University of Hawaii Support
- Recent and Upcoming WETS Deployments
- Thoughts on Commercialization of Wave Energy in Hawaii
- Other Ocean Energy in Hawaii – OTEC, Offshore Wind, SWAC

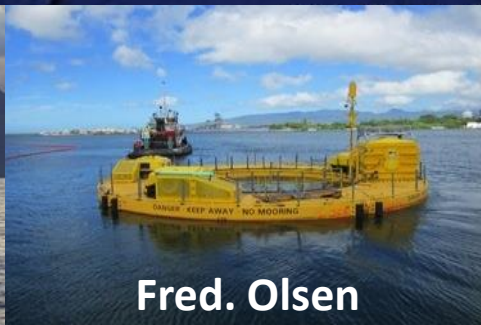
U.S. Navy Wave Energy Test Site



APPLIED RESEARCH LABORATORY
UNIVERSITY OF HAWAII



NWEI



Fred. Olsen

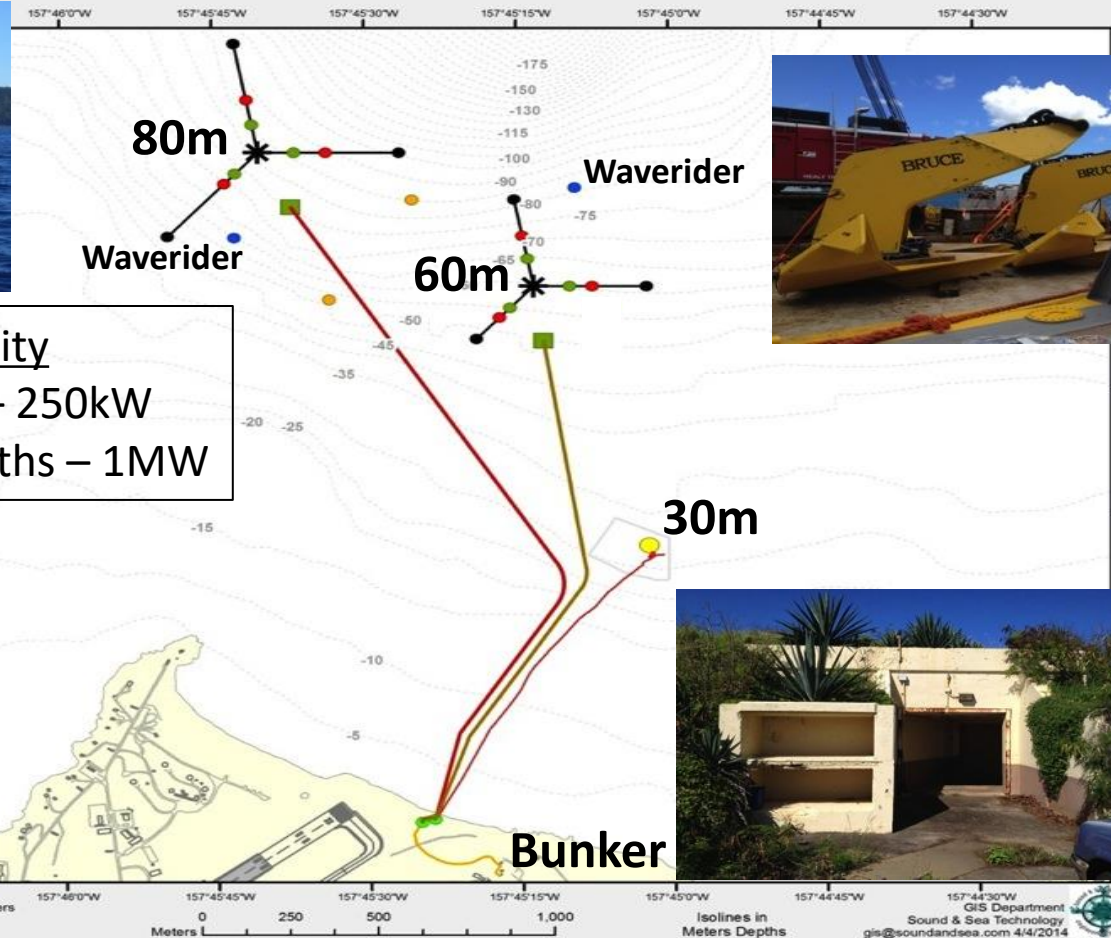


Ocean Energy

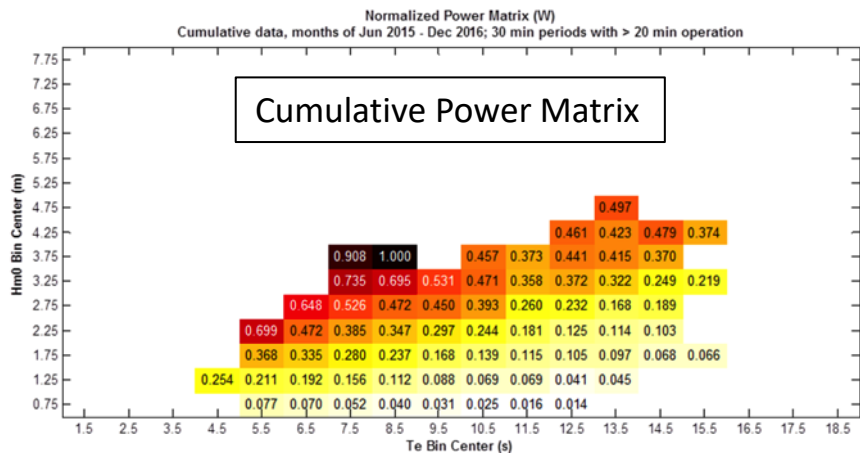
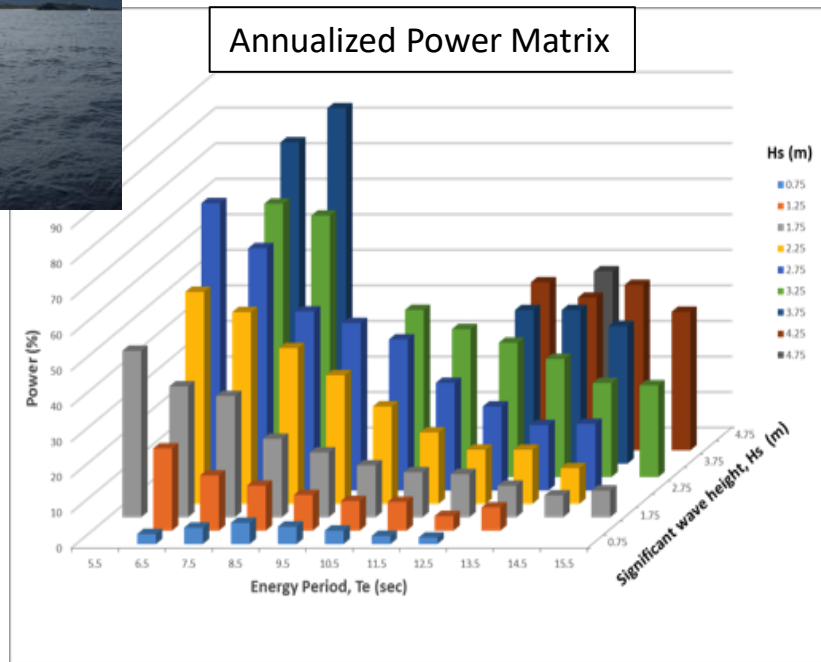
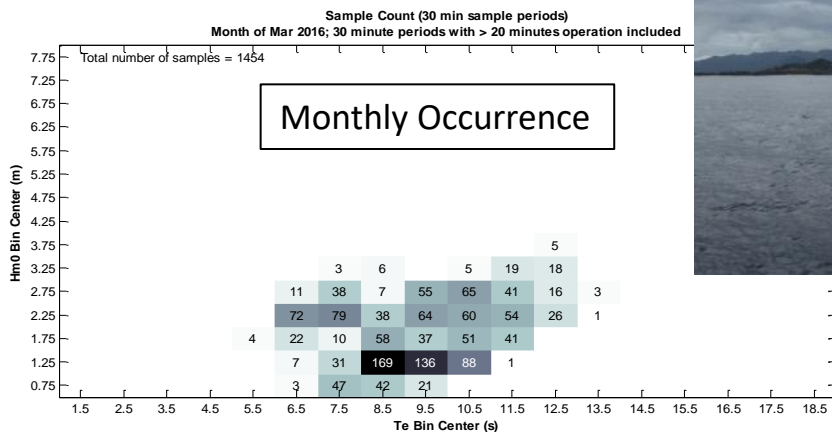


Columbia Power

WETS Layout

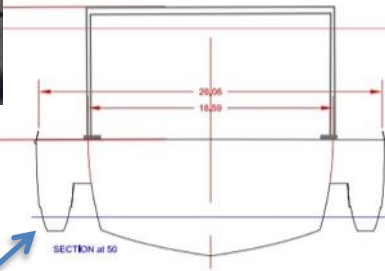


Power Performance Assessment



Performance assessed in accordance with
IEC Technical Specification 62600-100

WETS Site-Dedicated Support Vessel – Sea Engineering, Inc.



- 85 foot LOA
- 4-point mooring capability
- 10-ton A-frame lift capacity
- Knuckle-boom crane
- Deepwater dive spread
- Reconfigured w/added beam
- ROV and ROV command/control van
- To be kept at boat harbor ~ 1hr away

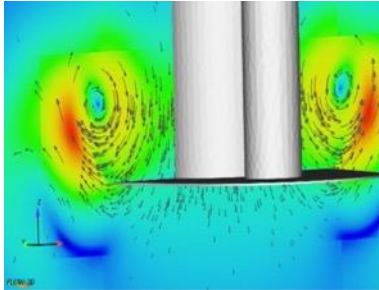


Numerical Modeling Efforts

- Develop numerical models to enhance independent assessment of WEC performance
- Model comparison with ocean test data

Hydrodynamic Motion Analysis

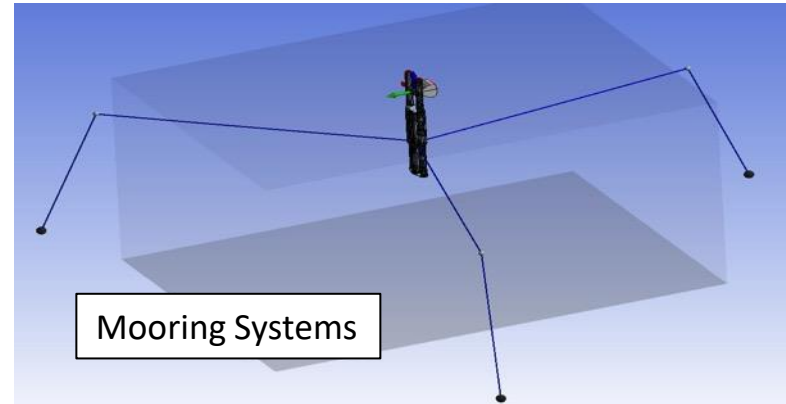
- WEC-Sim (Primary) & In-house code (Selected cases)
- Solution of equations of motion in time domain
- BEM: Estimation of hydrodynamic coefficients (Added mass, Wave damping)
- CFD : Estimation of viscous drag
- Predicted electric power, body motions
- Numerical model tuned with prototype trial data
- (Tuned) Num. model applied for comparative evaluation of versions 1 & 2 of Azura



Dr. Kumar Rajagopalan

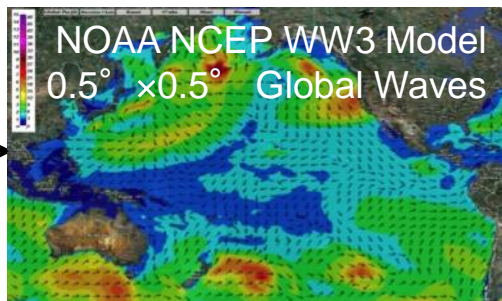
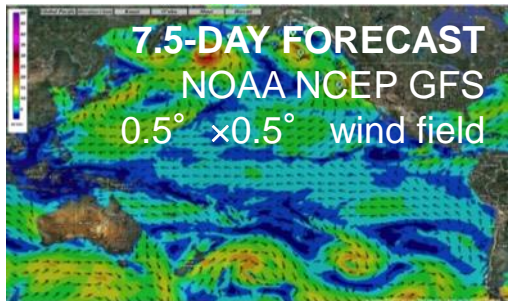
Modeling tools employed

- WEC-Sim
- Flow3D
- OpenFOAM
- ANSYS SUITE
- In-house codes



- Azura moored at 30m berth
- Mooring modeled in ANSYS AQWA

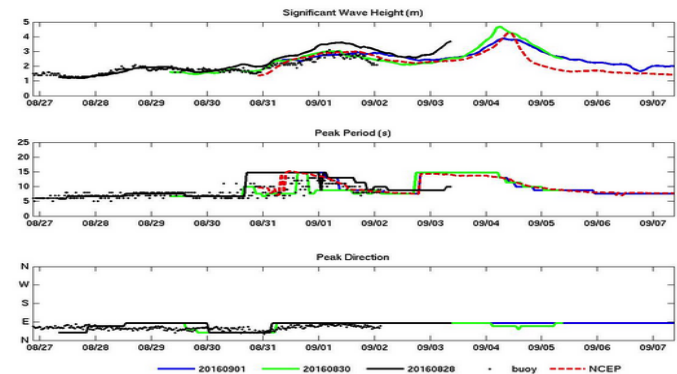
Daily 7.5-day Wave Forecast (oceanforecast.org)



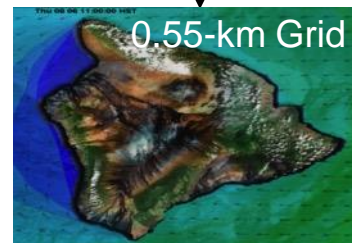
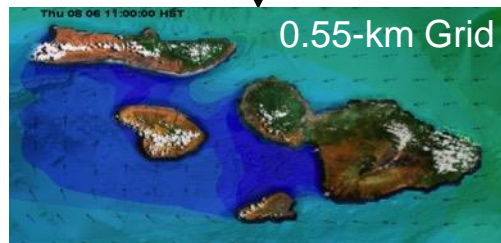
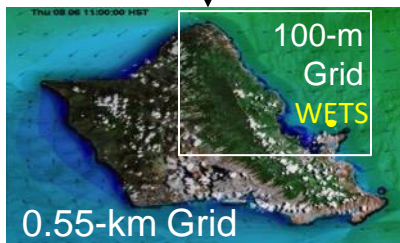
Real-time validation with measurements

- 30 buoys in the Pacific Basin
- Example on-line display for WETS

Hawaii Region, 51207_Kaneohe_Bay UH Forecast Bouy lat = 21.477 N, lon = 157.752 W
Waves are 2.8 meters/ 9.2 feet 8.7 sec. 82° dir. on Thu Sep 01 2016 6 PM HST
[7.5 Day forecast plot](#) [3D spectral animation](#) [7.5 Day forecast table](#) [Performance history](#)
[51207_Kaneohe_Bay Webpage](#)

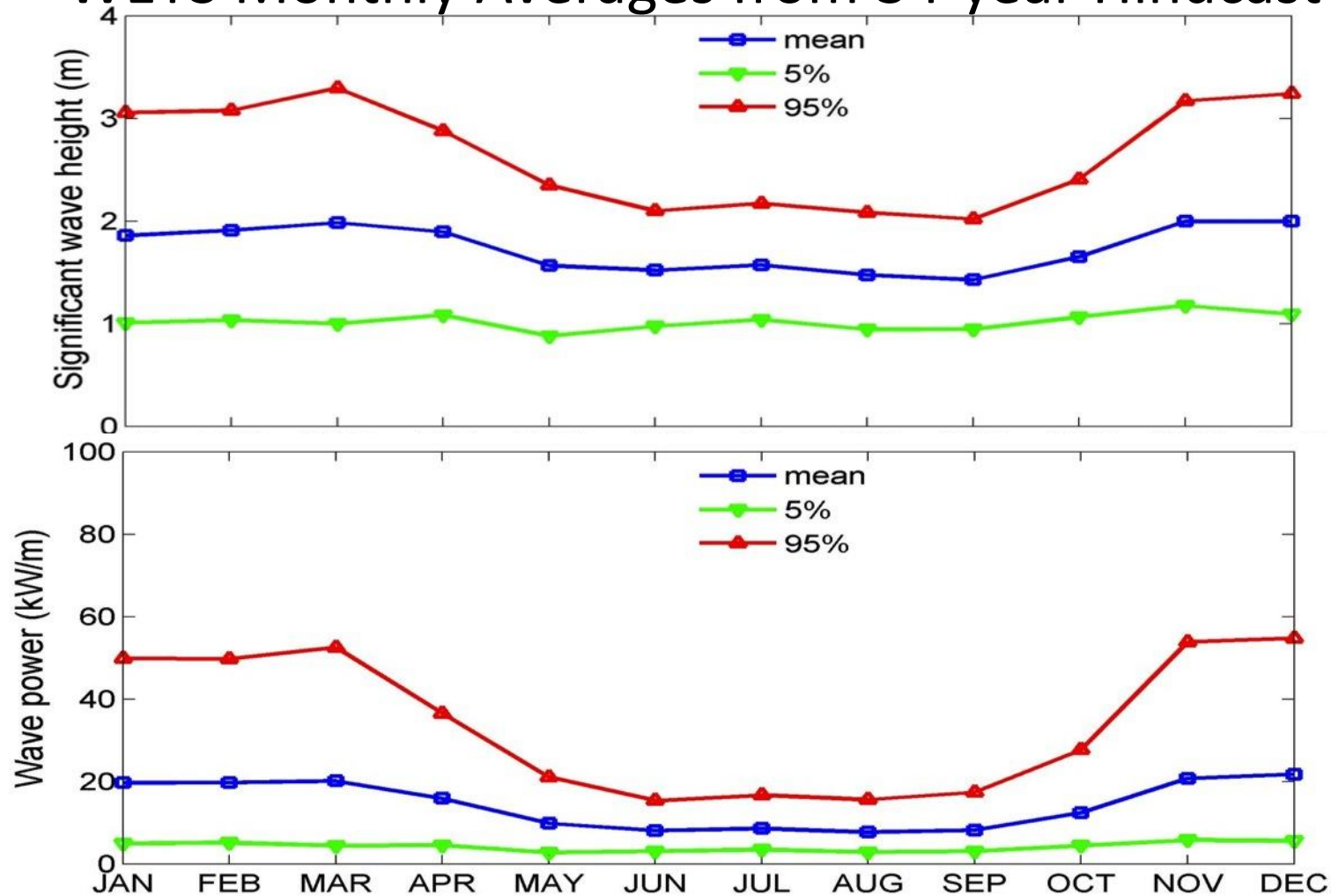


Dr. Ning Li



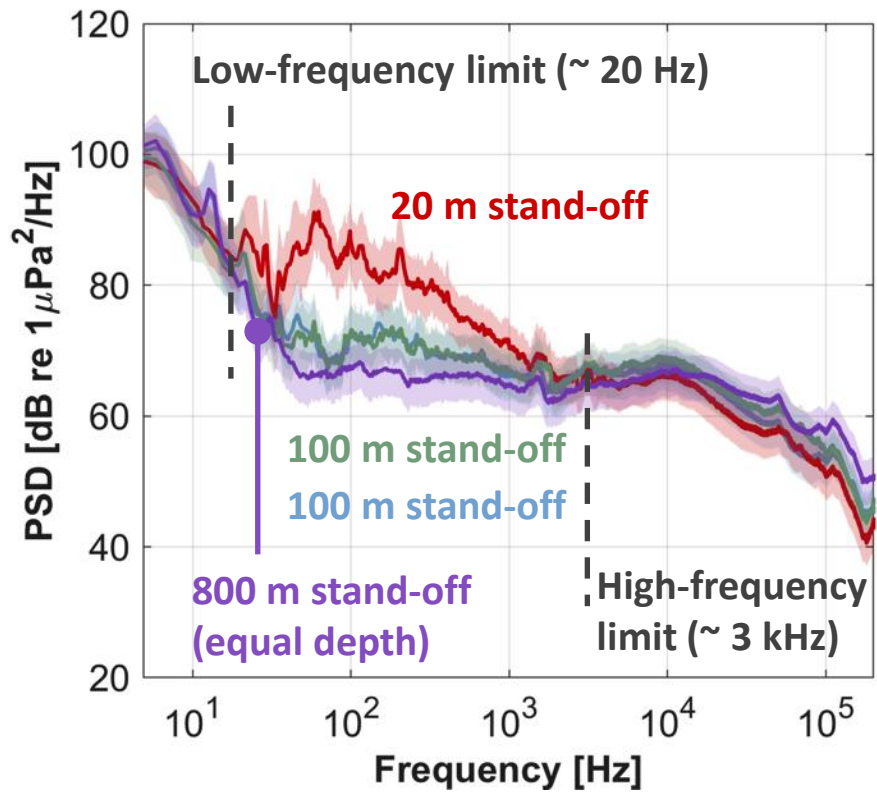
34-year Hindcast paper – N. Li, et al, *Ocean Modelling*, vol. 100, pp. 78-95, Feb. 2016.

WETS Monthly Averages from 34-year Hindcast



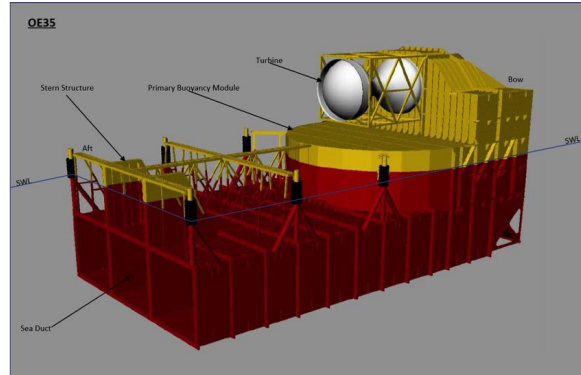
Environmental Data Collection

- Device acoustic signatures
 - Bottom-mounted and drifting hydrophone systems
- Sediment transport
- Ecological surveys
- Protected marine species monitoring



WEC Device Testing at WETS

- Northwest Energy Innovations (NWEI) Azura
- Fred. Olsen BOLT Lifesaver
- NWEI Modified Azura
- BOLT Lifesaver Redeployment
- Ocean Energy USA, LLC OE35
- Columbia Power Technologies StingRay
- NWEI (grid-scale device)
- Oscilla Power
- California Wave Power Technologies
- Aquaharmonics



Jun 2015 – Dec 2016

Mar 2016 – Apr 2017

Feb – Jun 2018

Jul 2018 – Jan 2019

Nov 2018 – Nov 2019

Jun 2019 – Jun 2020

Late 2019 – late 2020

Jul 2019 – Jul 2020

2020/2021

Late 2019 – late 2020

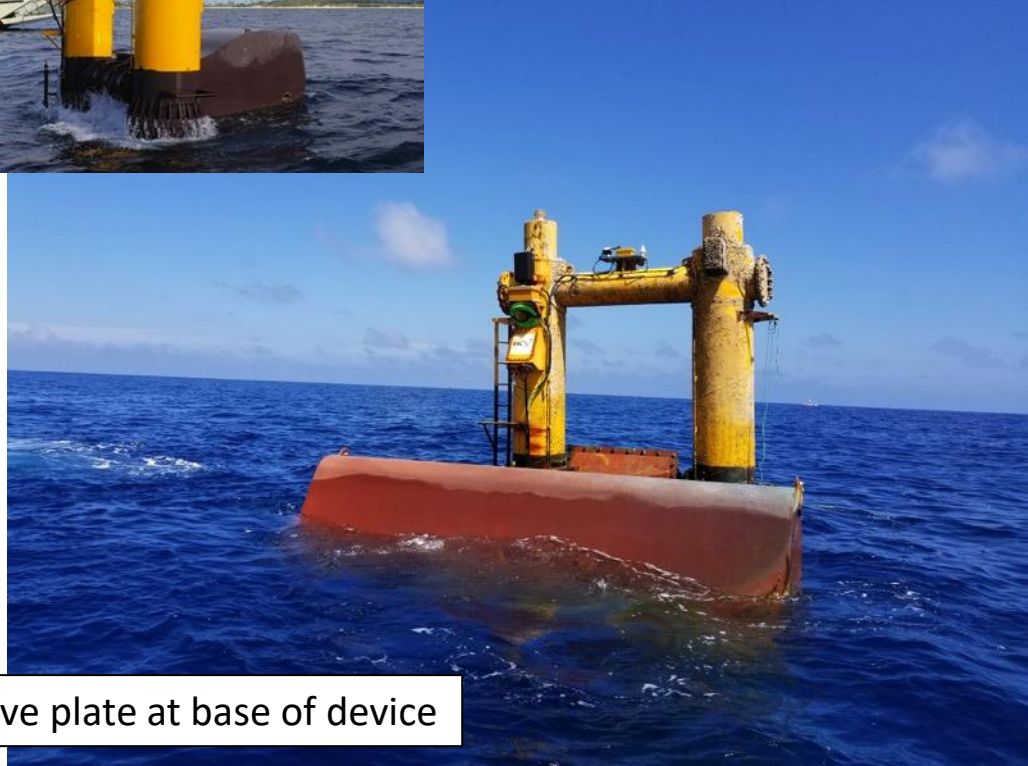
Projects receive support funding from Navy and/or DOE

NWEI Azura Modification

Objective: Push “sweet spot” of wave response to longer wavelengths to more closely match WETS

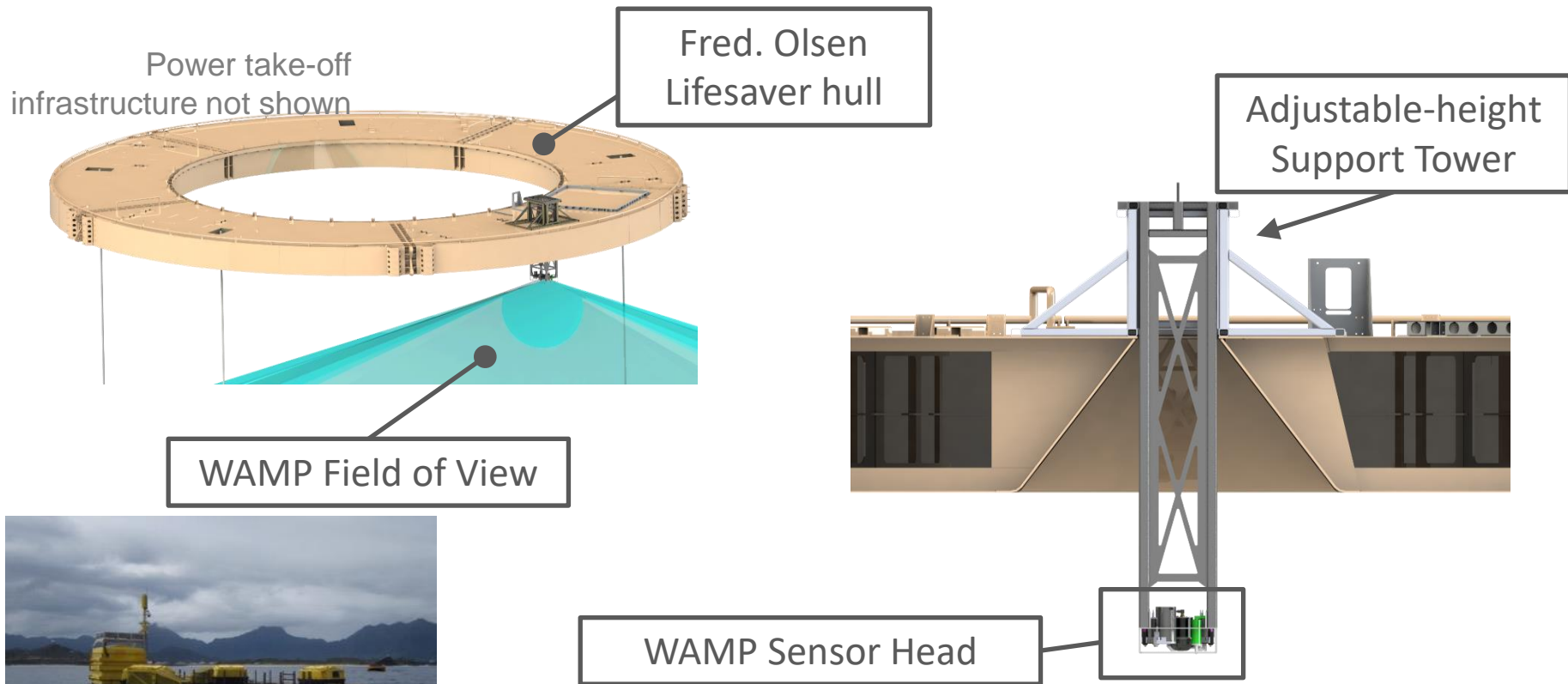


Baseline Azura



Also added heave plate at base of device

UW AMP Integrated w/Fred. Olsen Lifesaver

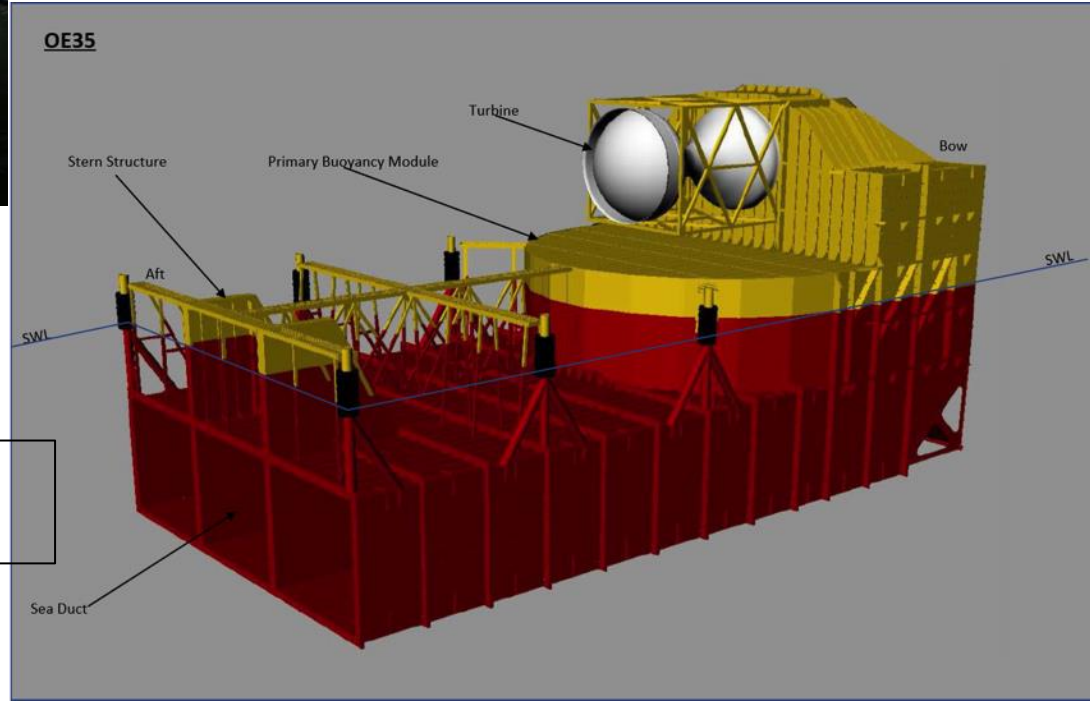


Ocean Energy OE35



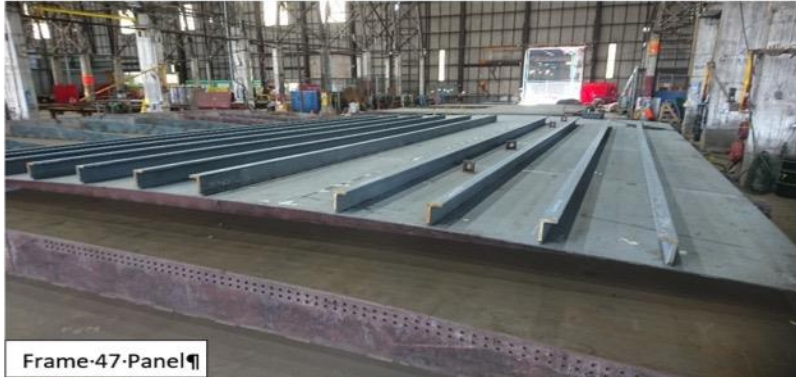
Quarter-scale device in Galway Bay

Will deploy at WETS 60m berth late 2018 for 1 year



Ocean Energy OE35

Now Under Construction in
Portland, Oregon



Frame-47-Panel



Forward-Towing-Padeye-Insert-Plates



Forward-Ballast-Tank-Assembly



Longitudinal-Bulkheads-Internal-Stiffening-Sub-Assembly

Thoughts on Commercialization of Wave Energy in Hawaii

The Good News

- Good wave resource year round
- Excellent State (govt.) appetite for renewables
 - RPS – 100% electrical generation by 2045
 - Highest electricity rates in the U.S. (mostly from shipped oil)
- Growing experience base in local industry and academia – due to WETS relationships

The Challenges

- Tourism emphasis may limit deployment opportunities (view-shed)
- Other ocean users may object – DoD, fishing
- Limited industrial capacity for construction, O&M
- Distance from more capable port cities on west coast



Other Ocean Energy Efforts in Hawaii

OTEC – Support to Makai Ocean Engineering OTEC Test Facility at NELHA (Hawaii Island)

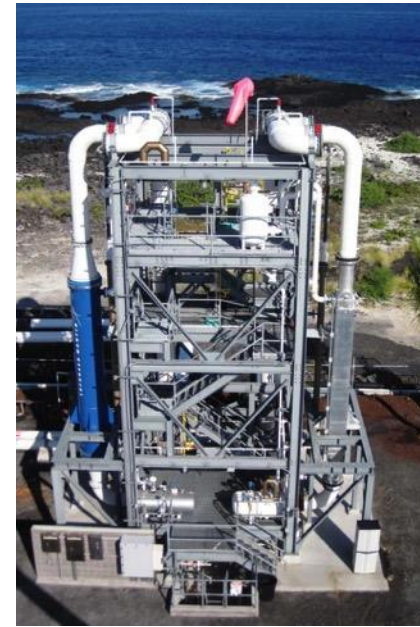
- Design & testing of heat exchangers, corrosion testing
- Integrated NH₃ and seawater systems (deep (600m) and surface)
- 100kW turbine connected to grid Aug 2015
- Testing 3 Condensers and 3 Evaporators
 - Establishing performance of *cost-effective*, corrosion-resistant and compact heat exchangers
 - Developing autonomous plant controls, improved cost projections, power studies

Offshore Wind – Progression, Statoil, AW Hawaii exploring large (~400MW) floating arrays off Oahu

- Working with BOEM to explore offshore leases

Seawater Air Conditioning

- Honolulu SWAC (company) has secured all permits, still seeking sufficient customers to proceed



Questions?

