# U.S. Navy Wave Energy Test Site


NAVFAC Naval Facilities Engineering Command

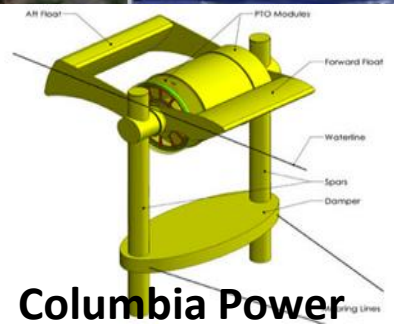
APPLIED RESEARCH LABORATORY
UNIVERSITY OF HAWAI'I

ONR Science & Technology

**Update for International Marine Renewable Energy Conference**
**Washington, DC**
**2 May 2018**

Patrick Cross, Hawaii Natural Energy Institute
University of Hawaii



# WETS Layout


80m

Waverider

Waverider

60m

30m

Bunker

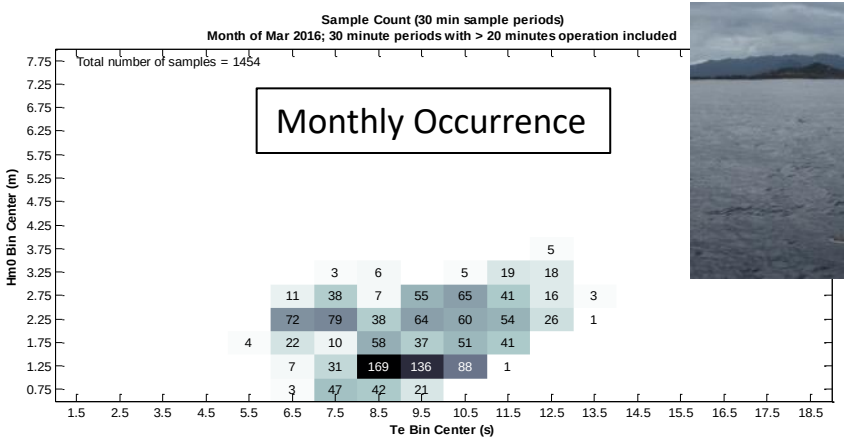
Cable Capacity
30m Berth – 250kW
60/80m Berths – 1MW

Legend
Splice Box
Mooring Anchor
WEC Device Mooring Point
Waverider Buoy
Surface Buoy (with WEC deployed)
Surface Buoy (vacant berth)
Work Boat Mooring
WET Existing Buoy
SubSeaCables
SubSeaCable_80mSite
SubSeaCable_60mSiite
Existing Cable (30m site)
MooringLegs
Terestial Cable Route
Contour 5m

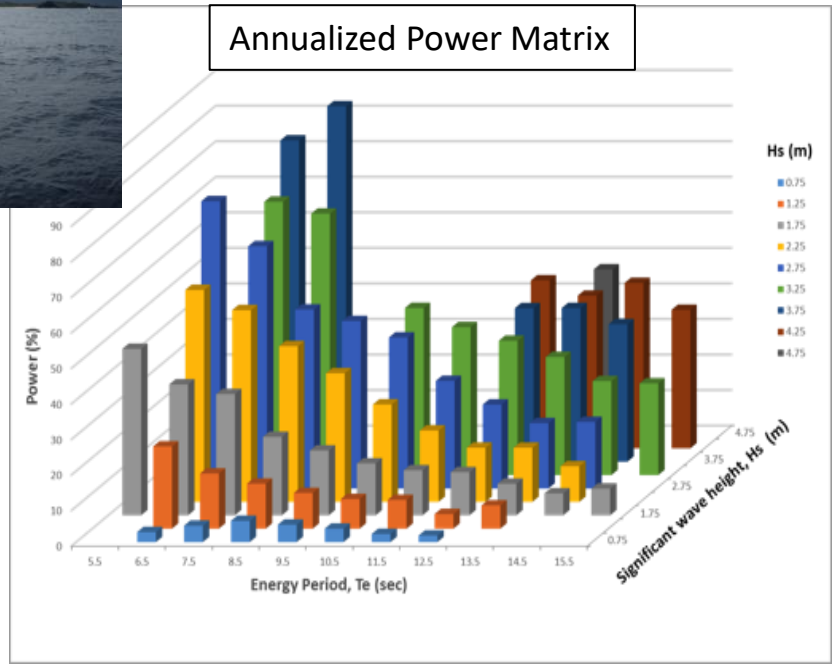
157°46'0"W 157°45'45"W 157°45'30"W 157°45'15"W 157°45'0"W 157°44'45"W 157°44'30"W
21°28'15"N 21°28'0"N 21°27'45"N 21°27'30"N
-175 -150 -130 -115 -100 -90 -80 -75 -70 -65 -50 -45 -35 -25 -20 -15 -10 -5

Coordinate System: UTM Zone 4 North - Depth/Elevation in Meters
Data Source: UofH, RSIMS, NOAA
Geovisualization by Sound & Sea Technology, Inc.
0 250 500 1,000
Meters
Isolines in Meters Depths
GIS Department
Sound & Sea Technology
gis@soundandsea.com 4/4/2014

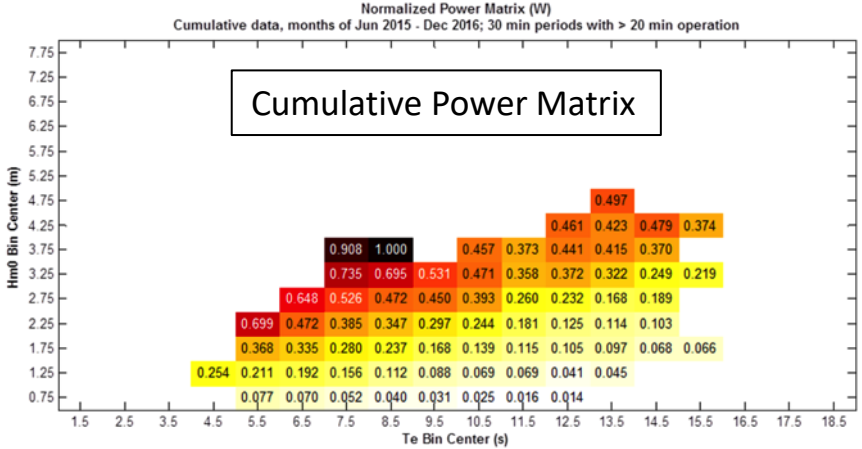
# Power Performance Assessment




Monthly Occurrence




Annualized Power Matrix

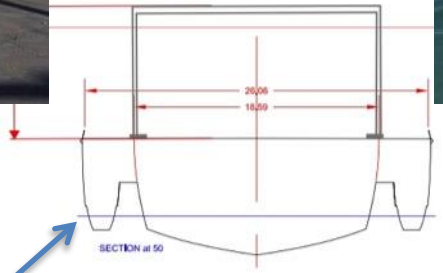



Cumulative Power Matrix

Performance assessed in accordance with IEC Technical Specification 62600-100

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





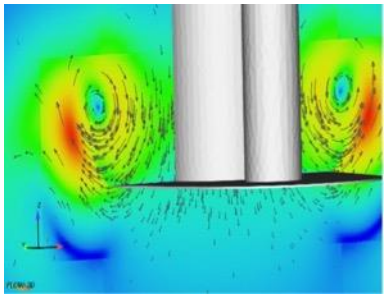

- 85 foot LOA
- 4-point mooring capability
- 10-ton A-frame lift capacity
- Knuckle-boom crane
- Deepwater dive spread
- ROV enclosure
- Reconfiguring w/added beam
- To be kept at boat harbor ~ 1hr away

# Numerical Modeling Efforts

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

## Hydrodynamic Motion Analysis

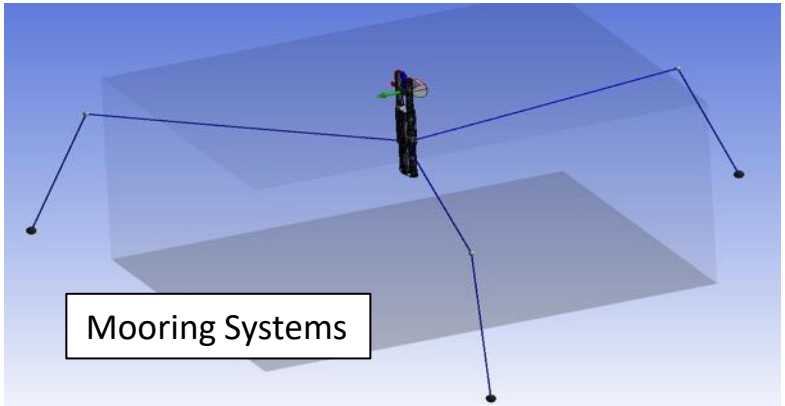
- WEC-Sim (Primary) & In-house code (Selected cases)
- Solution of equations of motion in time domain
- BEM: Estimation of hydrodynamic coefficients (Added mass, Wave damping)
- CFD : Estimation of viscous drag
- Predicted electric power, body motions
- Numerical model tuned with prototype trial data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



Dr. Kumar Rajagopalan

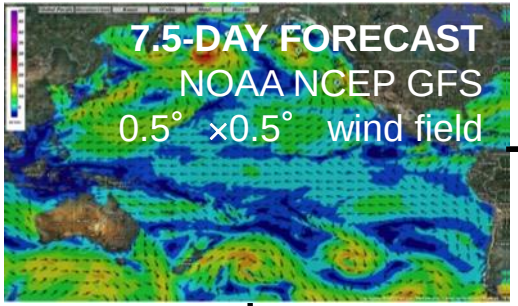
## Modeling tools employed

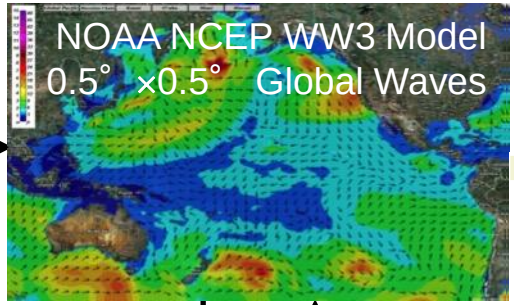
- WEC-Sim
- Flow3D
- OpenFOAM
- ANSYS SUITE
- In-house codes

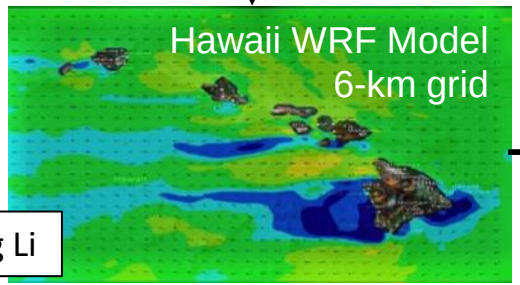



- Azura moored at 30m berth
- Mooring modeled in ANSYS AQWA

# Daily 7.5-day Wave Forecast (oceanforecast.org)



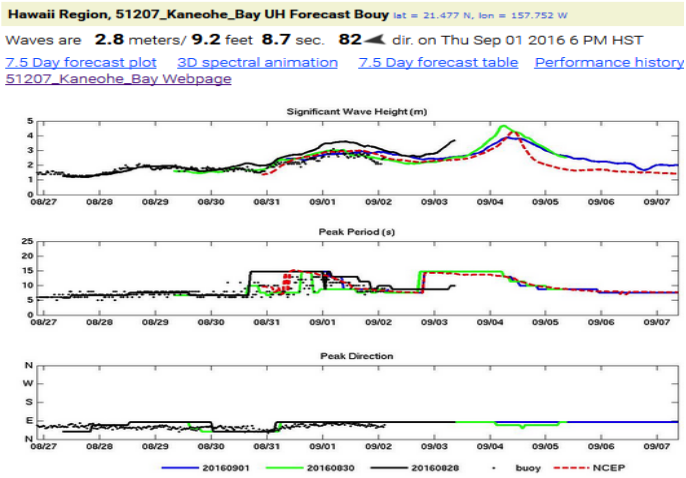



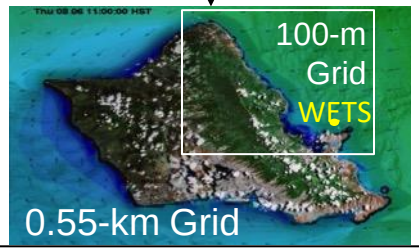


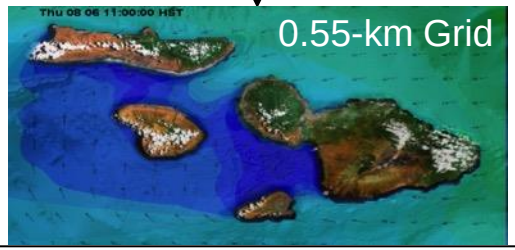
Dr. Ning Li

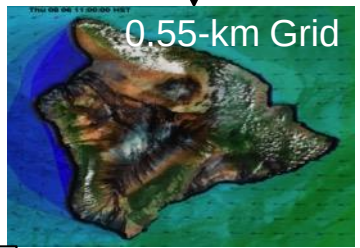
Real-time validation with measurements
- 30 buoys in the Pacific Basin
- Example on-line display for WETS





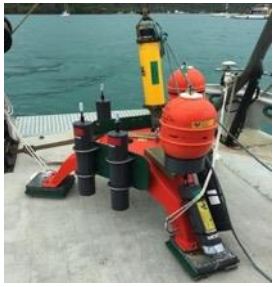


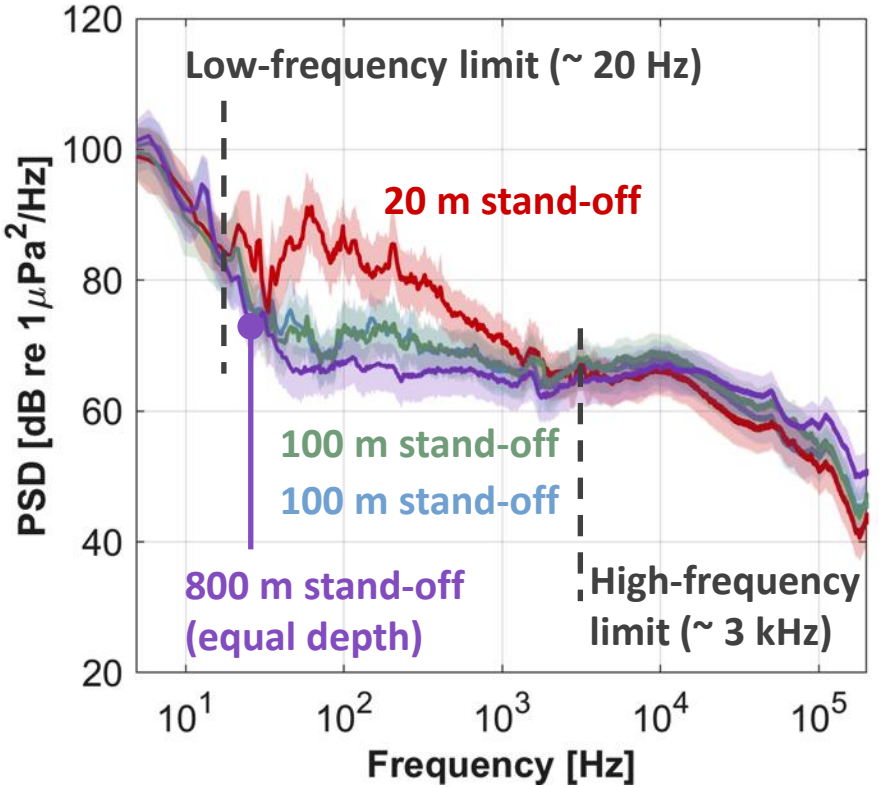




34-year Hindcast paper – N. Li, et al, *Ocean Modelling*, vol. 100, pp. 78-95, Feb. 2016.

# 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

  Jun 2015 – Dec 2016

- Fred. Olsen Bolt Lifesaver

  Mar 2016 – Apr 2017

- NWEI Modified Azura

  Feb – May 2018

- Bolt Lifesaver Redeployment

  May – Nov 2018

- Ocean Energy USA, LLC

  Nov 2018 – Nov 2019

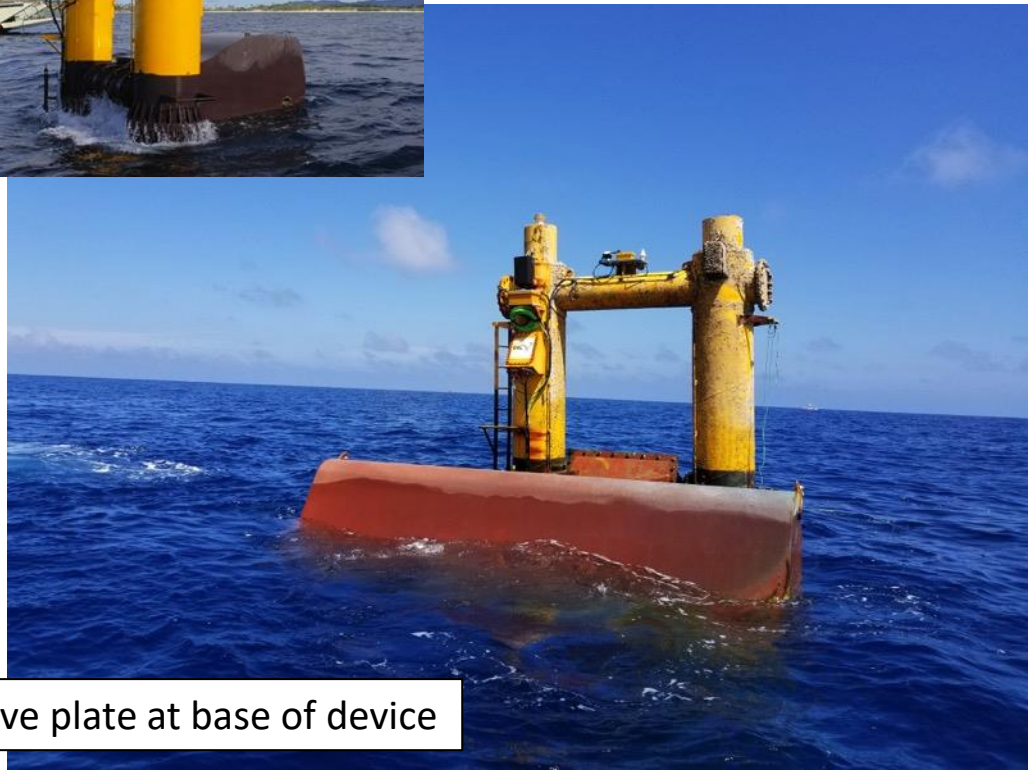
- Columbia Power Technologies

  Apr 2019 – Apr 2020

- NWEI (grid-scale device)

Projects receive support funding from Navy and/or DOE

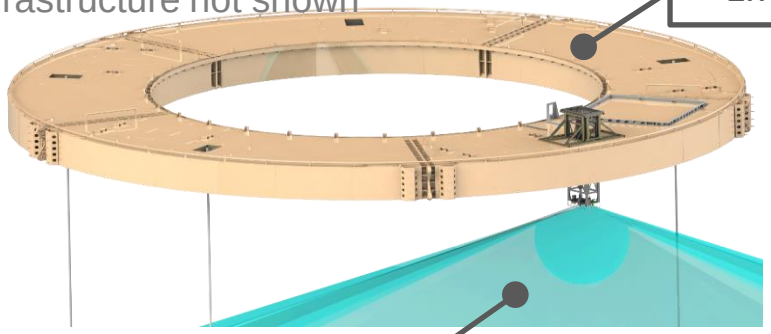
# Azura Modification



Also added heave plate at base of device

# UW AMP Integrated w/Fred. Olsen Lifesaver

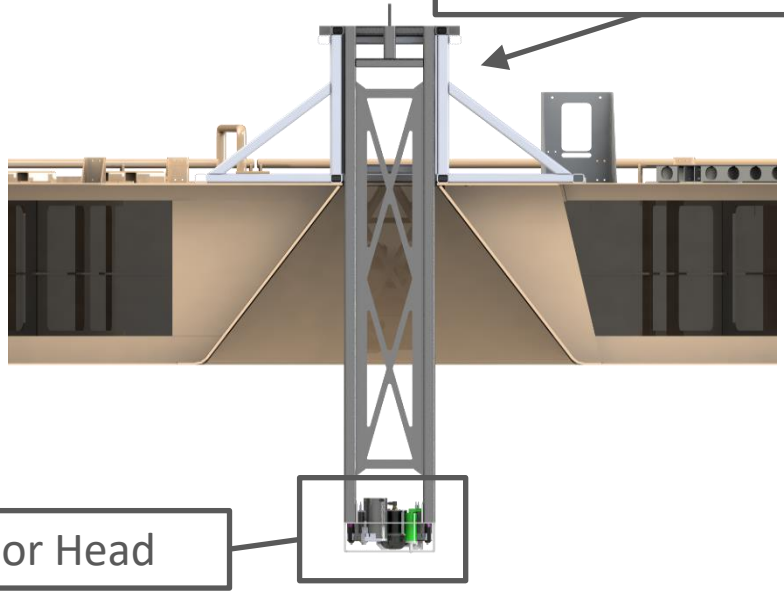
Power take-off infrastructure not shown



Fred. Olsen Lifesaver hull

WAMP Field of View

Adjustable-height Support Tower

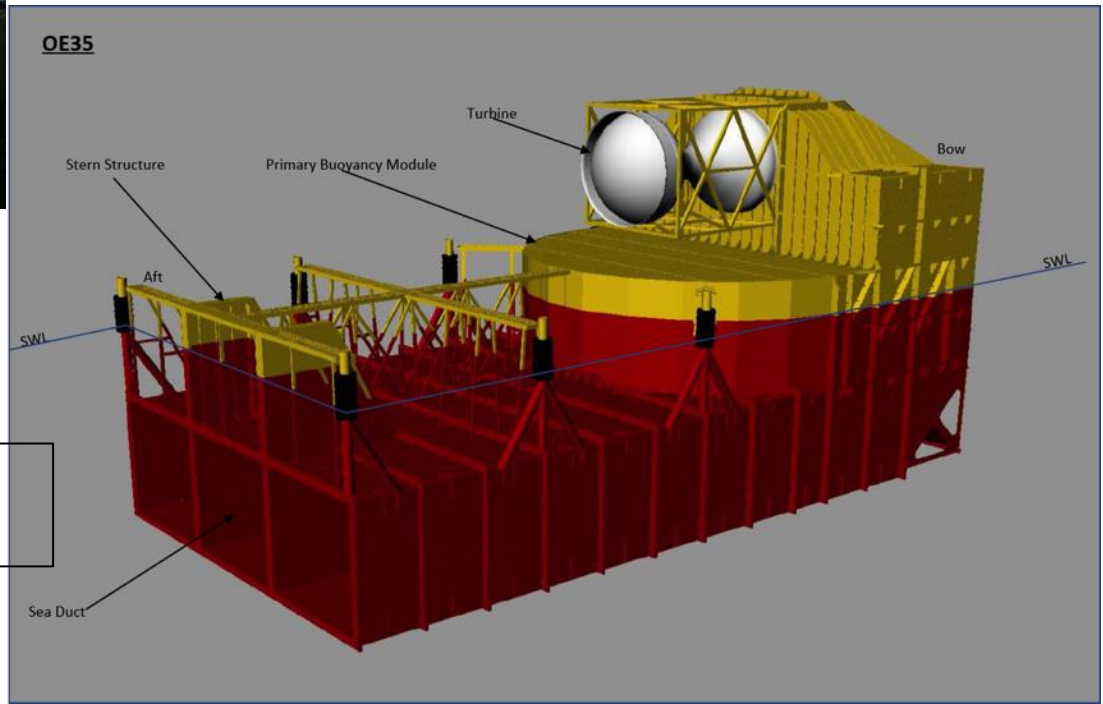


WAMP Sensor Head

NNMREC Northwest National Marine Renewable Energy Center

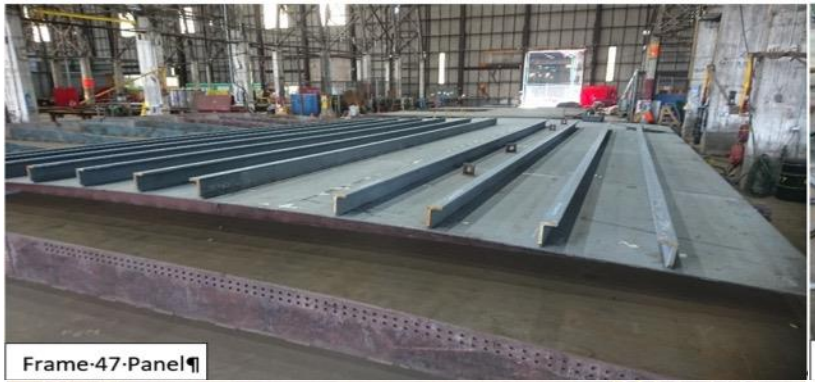
# Ocean Energy OE35


Quarter-scale device in Galway Bay




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

# Ocean Energy's OE35



Frame·47·Panel¶

Forward·Towing·Padeye·Insert·Plates¶

Forward·Ballast·Tank·Assembly¶

Longitudinal·Bulkheads·Internal·Stiffening·Sub-Assembly·

# Questions?