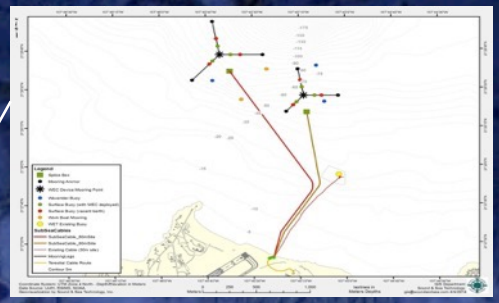
U.S. Navy Wave Energy Test Site (WETS)



WETS ROV

Dedicated Support Vessel

Intro for National Shipbuilding Research Program

Patrick Cross
Hawaii Natural Energy Institute
University of Hawaii
14 September 2021

Projects to Date

NWEI Azura
6/15 – 12/16

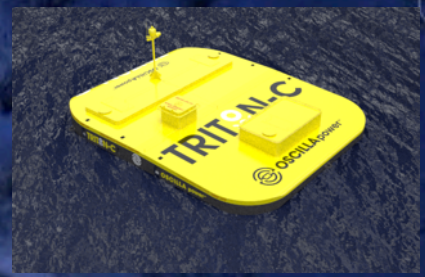
Modified Azura
2/18 – 8/18

Fred. Olsen Lifesaver
3/16 – 4/17

Lifesaver w/UW AMP Integration
10/18 – 3/19

Up Next – Ocean Energy In Hawaii – to WETS in Spring

Acoustic Monitoring



Projects Ahead

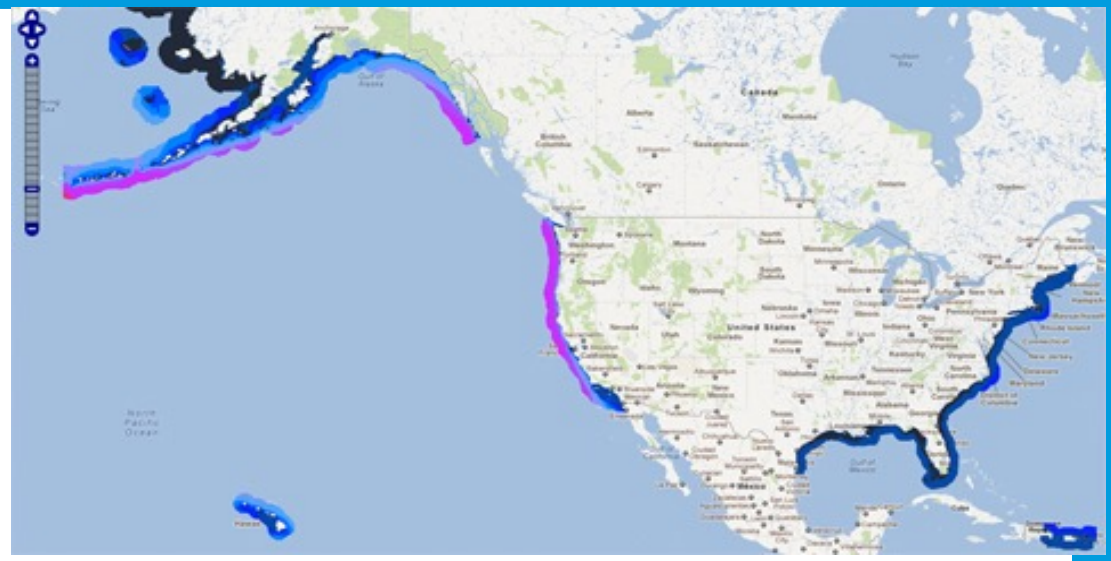
Oscilla Power
C Power
Aquaharmonics
NWEI Grid Scale

HNEI Hawai'i Natural Energy Institute University of Hawai'i at Mānoa

NAVFAC Naval Facilities Engineering Command

APPLIED RESEARCH LABORATORY UNIVERSITY OF HAWAI'I

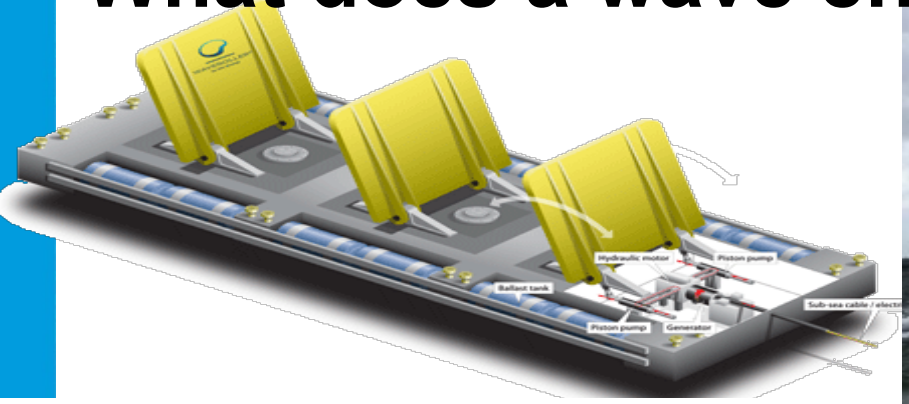
Wave Energy Intro

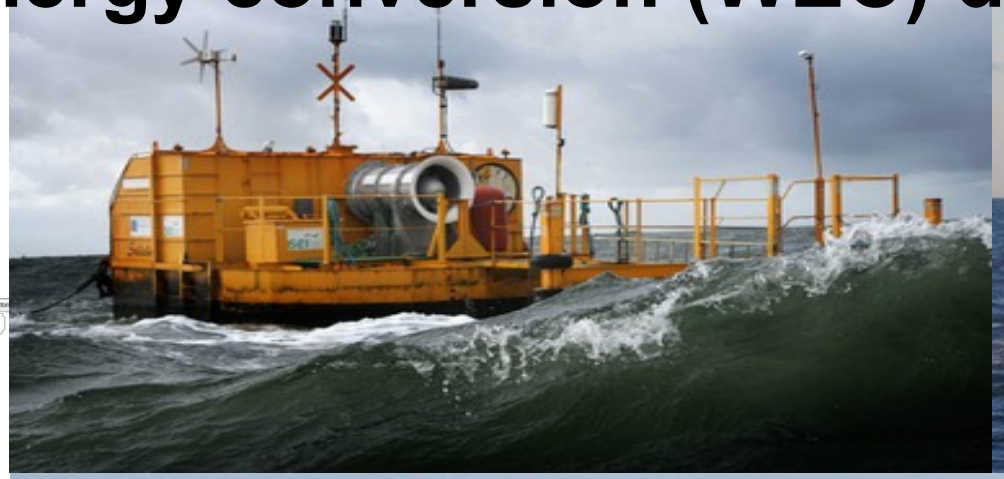


- "Recoverable" resource is vast
  - 1170 TWh/year nationally*
  - 80 TWh/year in Hawaii*
- Challenges abound
  - Large devices/deployment challenges
  - Marine environment/survivability/serviceability
  - Cabling to shore
  - Cost of energy (LCOE) numbers remain daunting
- At-sea testing is essential, but costly, with limited permitted, grid-connected venues in the world
  - European Marine Energy Center in Orkney Islands, Scotland
  - Navy's Wave Energy Test Site (WETS) in Hawaii – first grid-connected site in US
- Not yet close to commercialization
  - ➢Efforts at WETS of high interest globally

* EPRI Report

What does a wave energy conversion (WEC) device look like?





Wave Energy – An Opportunity for the Shipbuilding Industry?

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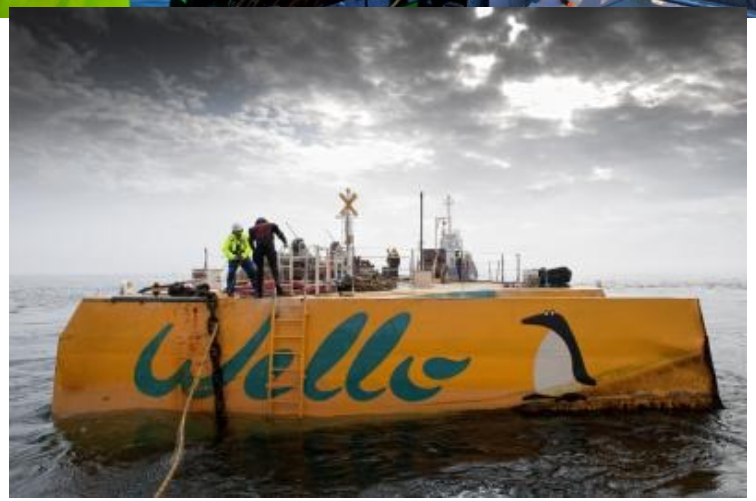

WETS Layout

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80m

CDIP 225

CDIP 198

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

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

HNEI Core Research Support to WETS

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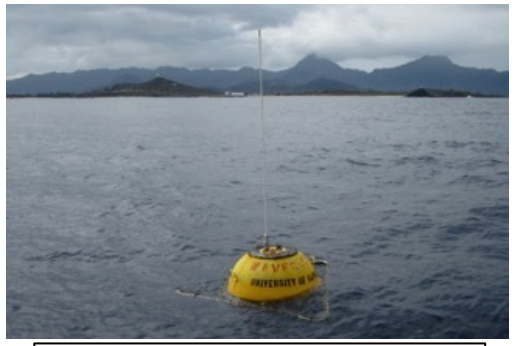
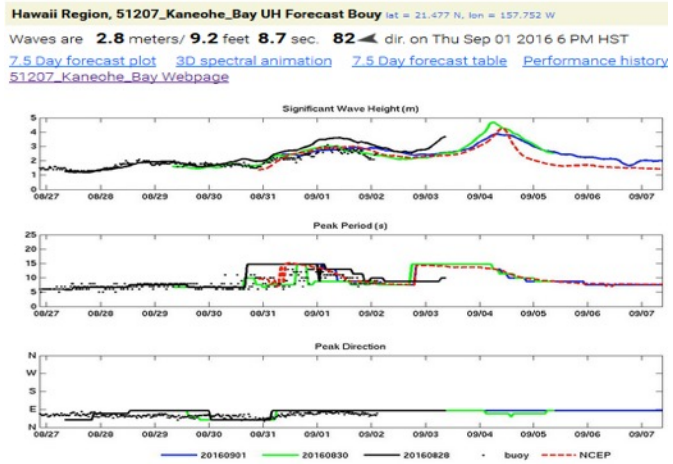
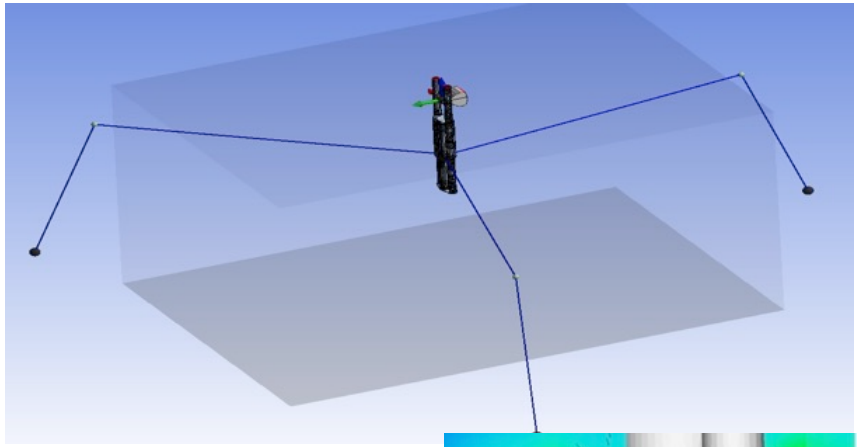
University of Hawai'i at Mānoa



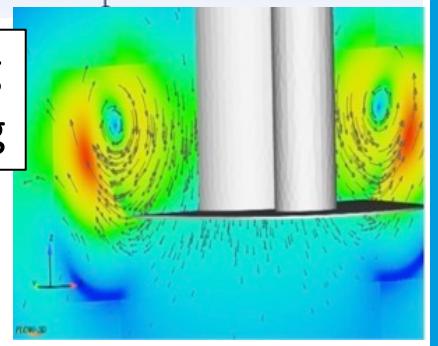
Wave Measurement

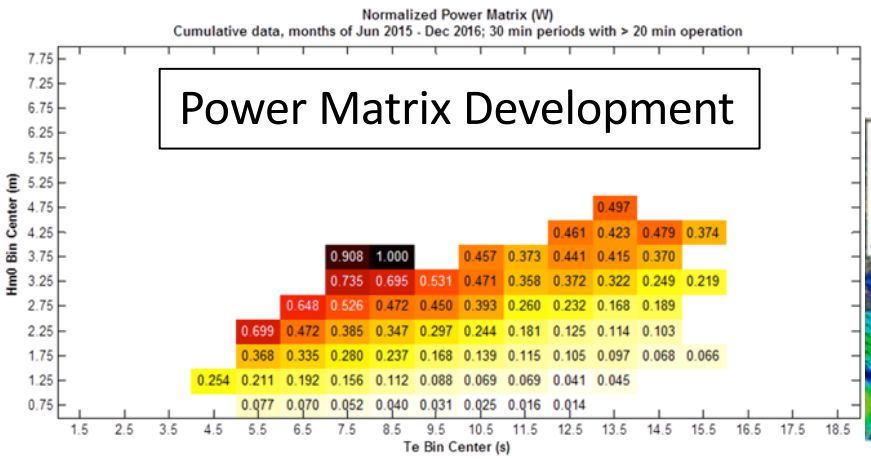
Performance assessed in accordance with IEC Technical Specification 62600-100





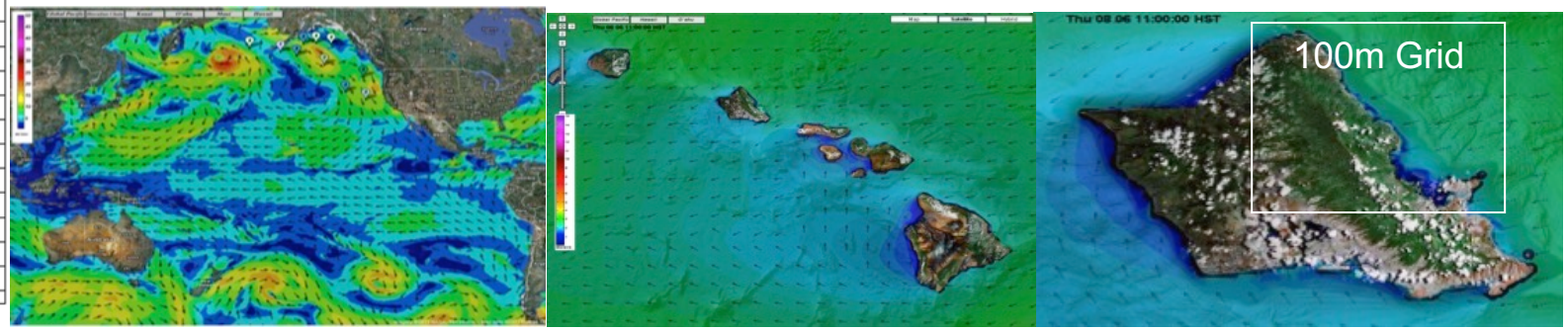
Device and Mooring Numerical Modeling





Power Matrix Development

Global to Local Wave Modeling/Hindcasting



Acoustic Data Collection

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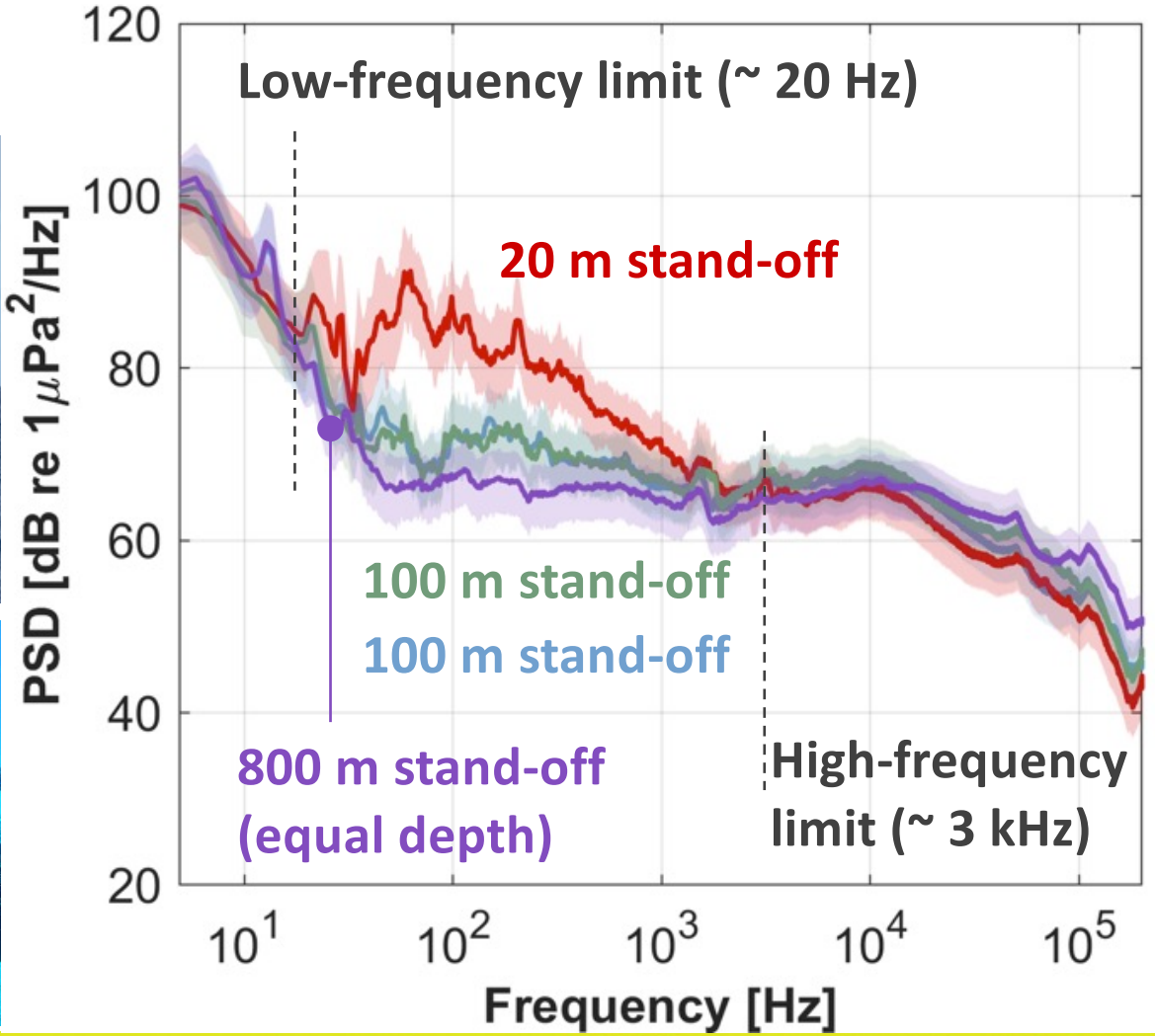
- Device acoustic signatures
  - Bottom-mounted and drifting hydrophone systems
- Sediment transport
- Ecological surveys
- Protected marine species monitoring



WETS Support Vessel – Kupa'a (Sea Engineering, Inc.)

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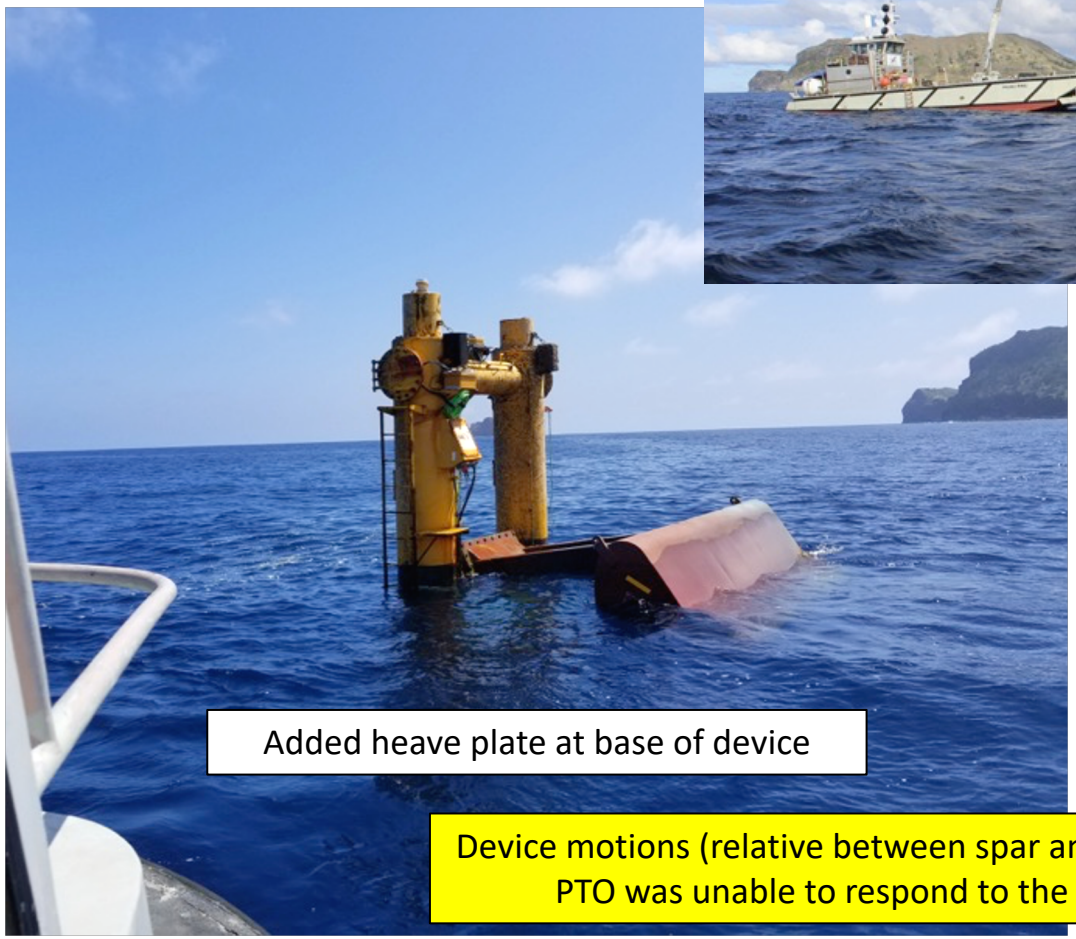
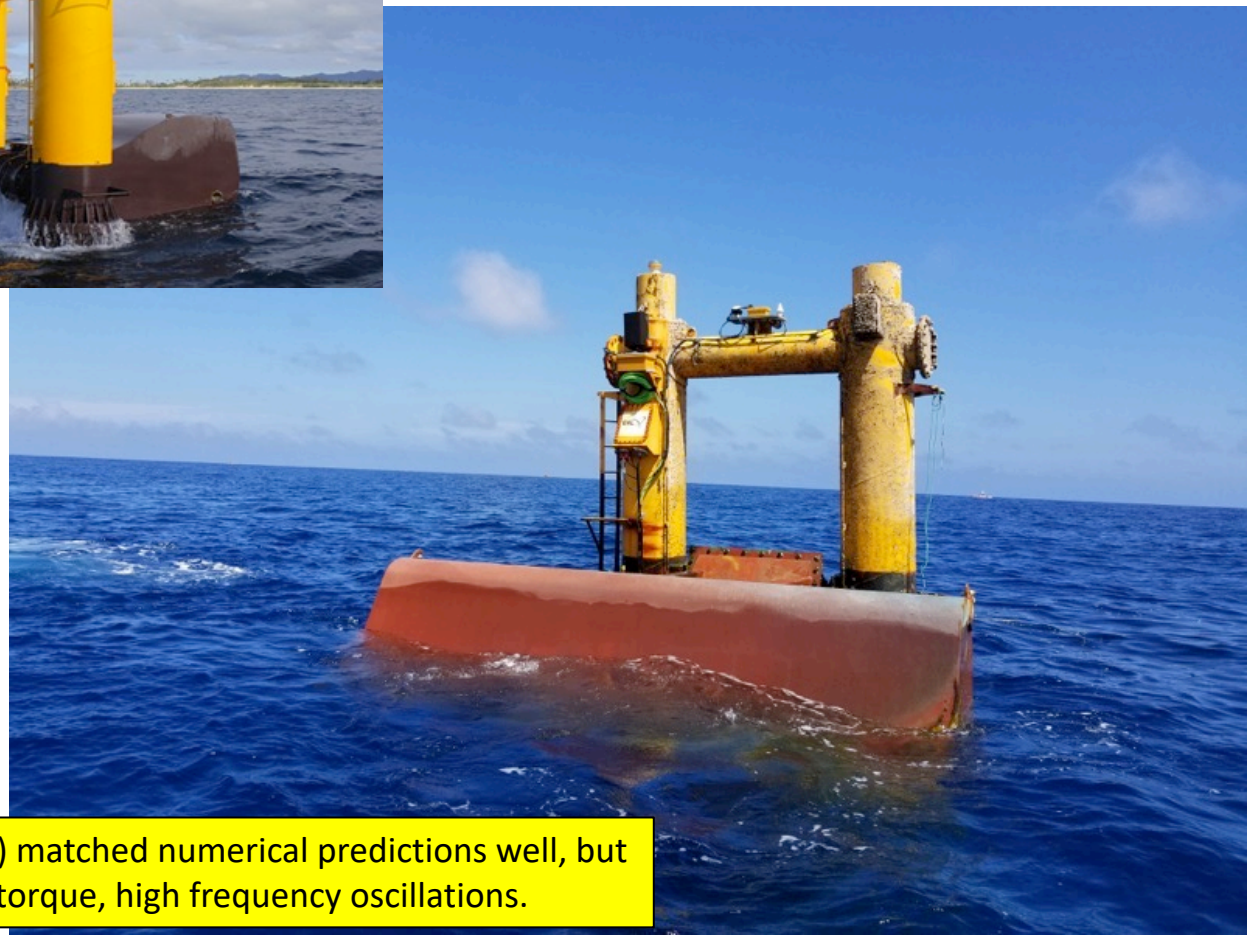
Super Mohawk ROV

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

NWEI Azura



Added heave plate at base of device



Device motions (relative between spar and float) matched numerical predictions well, but PTO was unable to respond to the higher torque, high frequency oscillations.

Fred. Olsen Lifesaver – 2nd Deployment at WETS

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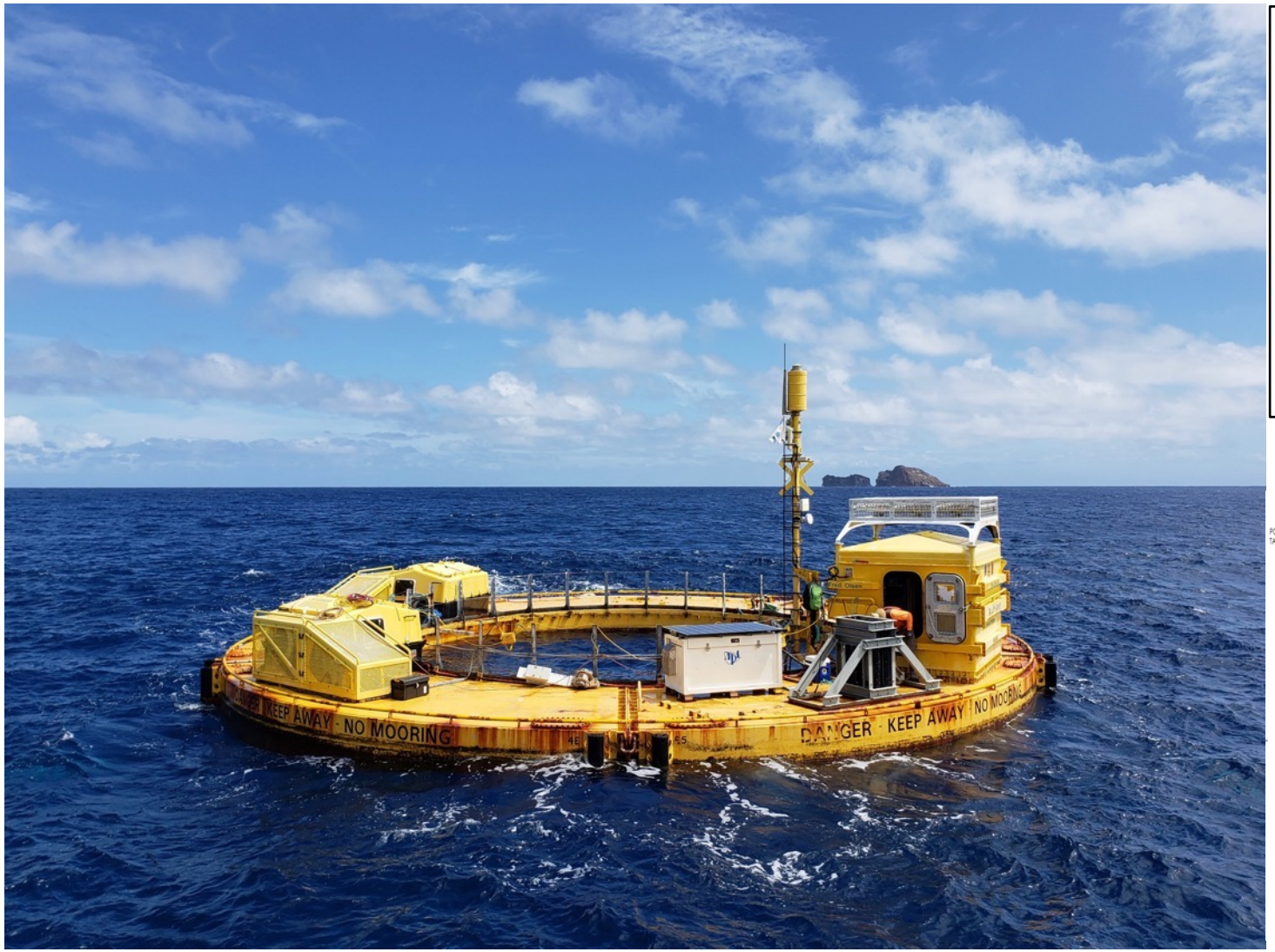
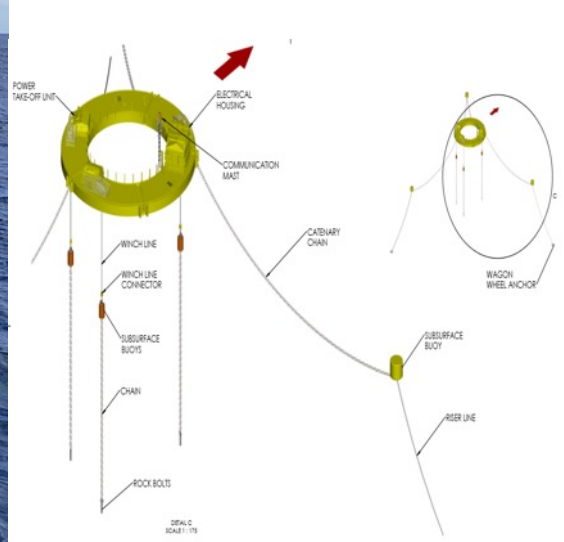
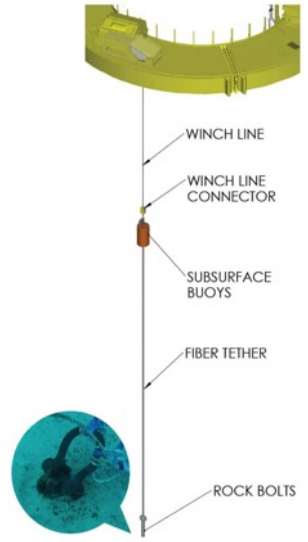


Motivations

- Address mooring issues from 1st deployment
  - PTO riser elasticity
  - Storm mooring hawser tension
- Use WEC electricity to power UW AMP and WiBotic subsea charging capability





Deep Berth Mooring Upgrades

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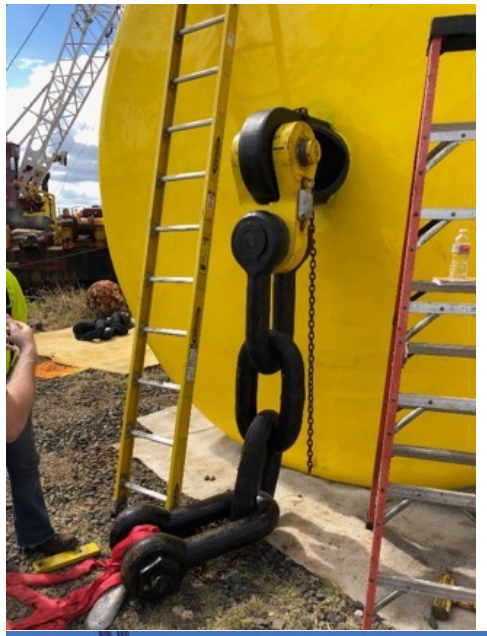
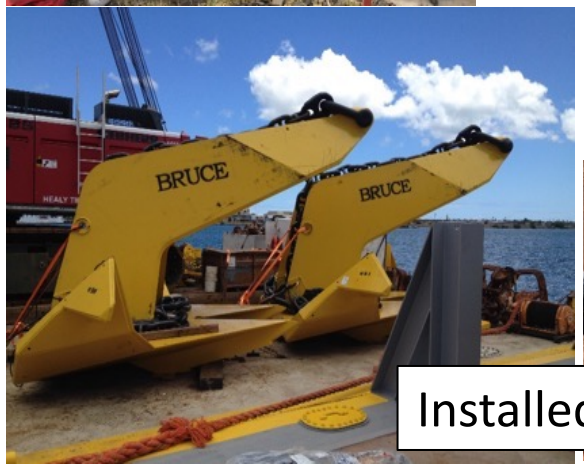
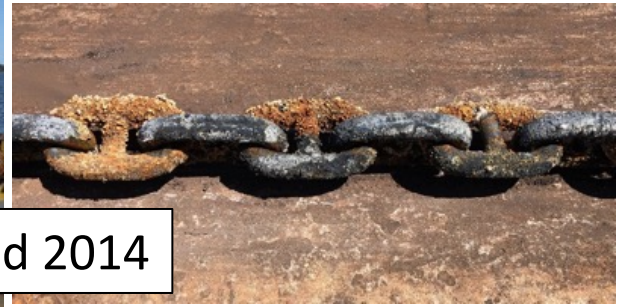


Installed 2019

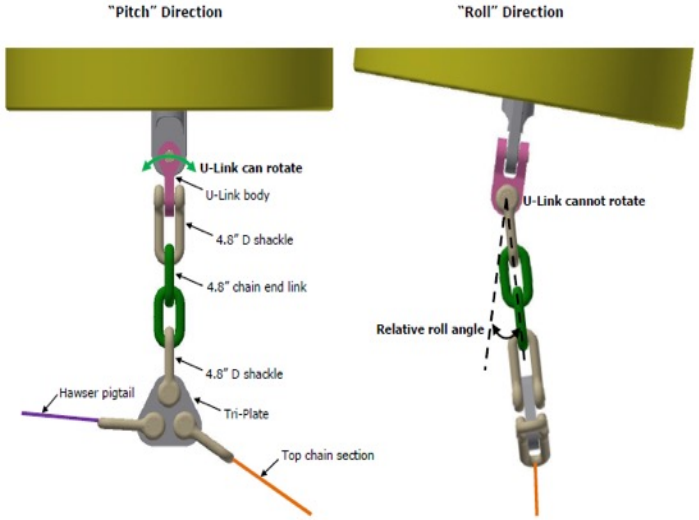


Installed 2014

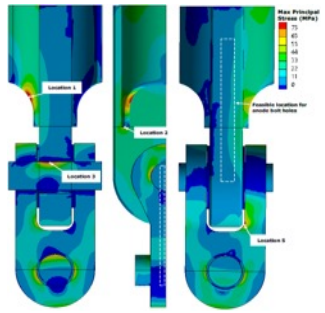


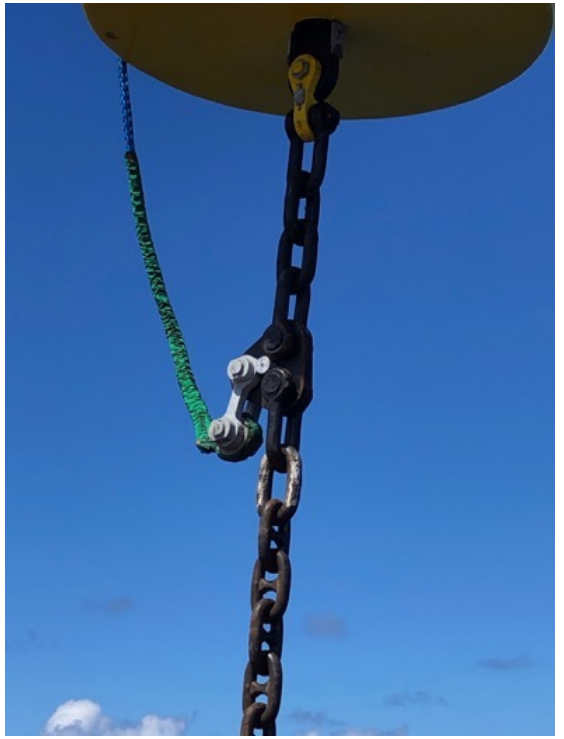
Surface Float Hardware

Customized padeye/weld



U-link to address bending stresses





60m Berth Repairs – May/June 2019

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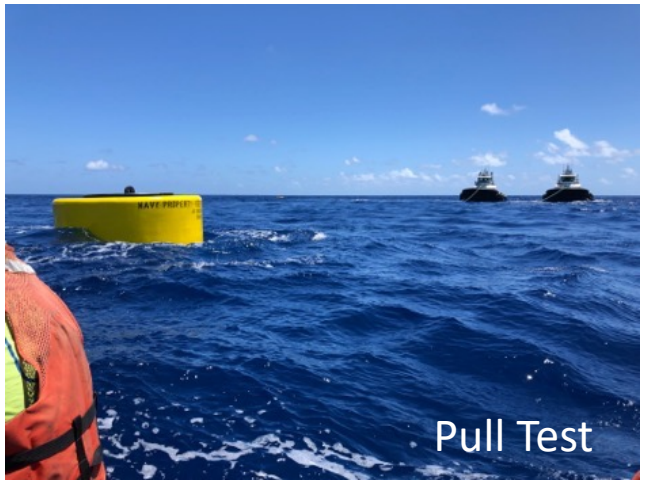
Crane Barge – Healy Tibbits



Pull Test

No-WEC Hawser Install

WEC Development Projects at UH/HNEI

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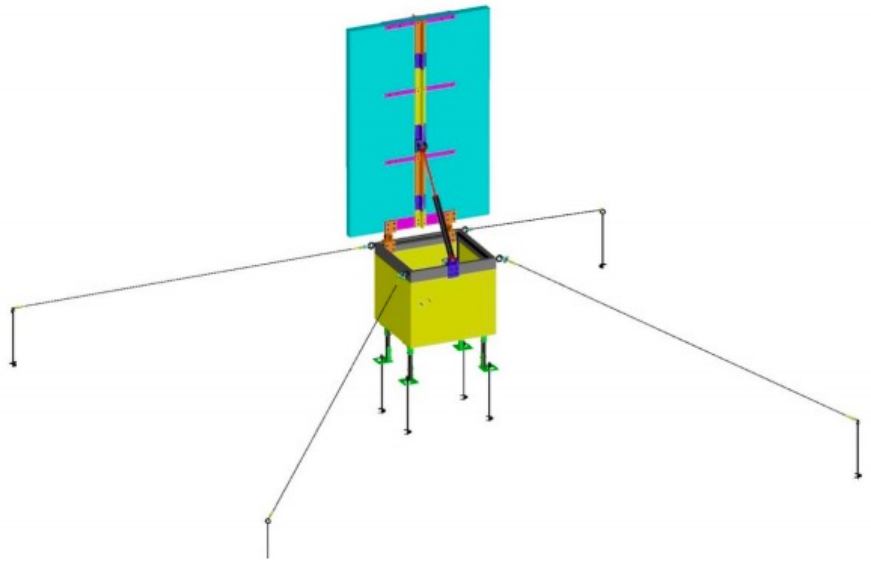
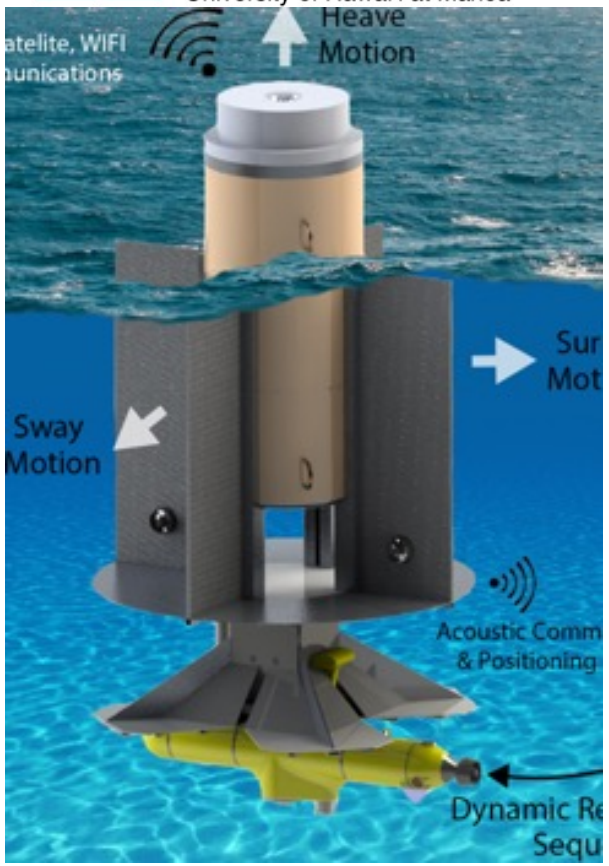
Hawaii Wave Surge Energy Converter

- OWSC (flap) WEC with novel electric PTO
- DOE-funded FOA award
- Will test at 2 scales



Nalu e Wai (waves into fresh water)

- Concept and Design winner in DOE Waves to Water competition
- OWSC-based desalination
- Compact (ships in 1m^3 container), rapidly deployable
- Seeking funds to develop and test prototype



Halona

- Free-floating or fixed OWC
- Intended for recharge of AUVs
- Tank testing of 1/10-scale at OSU just completed

WETS Testing Summary

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Northwest Energy Innovations (NWEI) Azura (30m)	Jun 2015 – Dec 2016
Fred. Olsen Bolt Lifesaver (60m)	Mar 2016 – Apr 2017
Modified NWEI Azura (30m)	Feb – Aug 2018
Bolt Lifesaver Redeployment (30m)	Oct 2018 – Mar 2019
C-Power SeaRay	~ Nov 2021 (6 months)
Oscilla Power (30m)	~ Nov 2021 (1 year)
Ocean Energy OE-35 (60m)	~ Apr 2022 (1 year)
C-Power StingRay	~ Fall 2022 (1 year)
AquaHarmonics (30m)	~ Fall 2022 (1 year)
NWEI grid-scale Azura (60m)	~ Apr 2023 (1 year)

Upcoming Deployments at WETS

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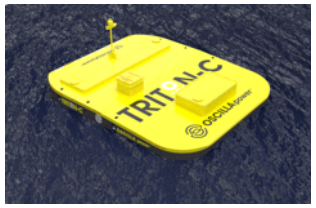
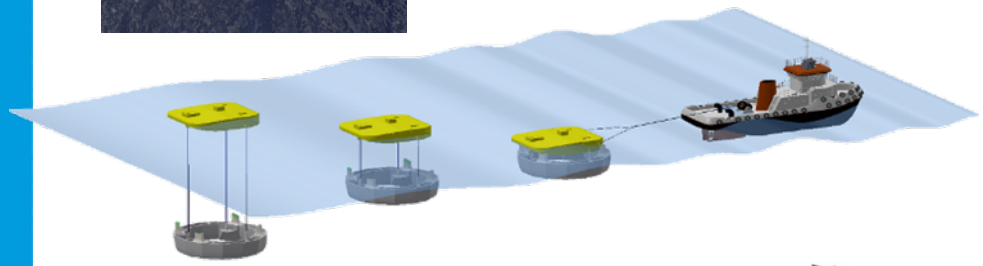
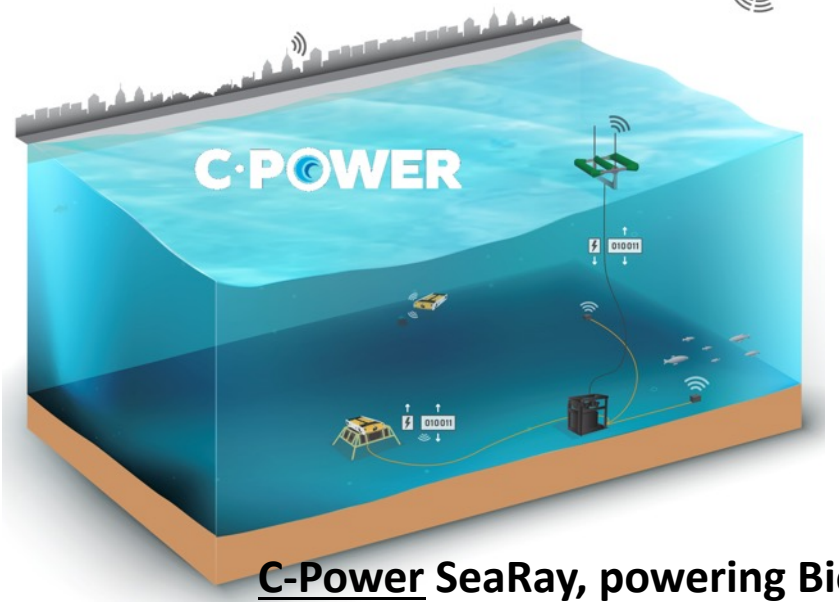


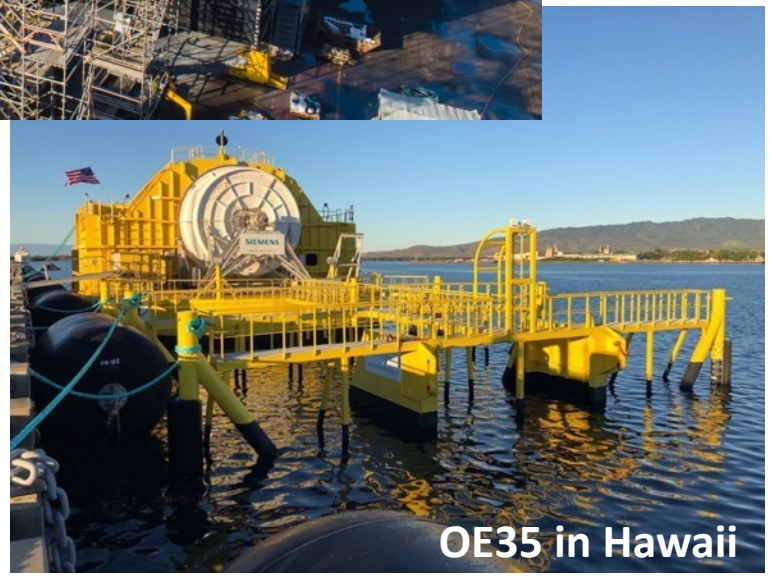
Oscilla Power





C-Power SeaRay, powering Biosonics acoustic Package and SAAB Sabertooth charging station

Ocean Energy



Questions?

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