HetWECS:
Open-source data and performance

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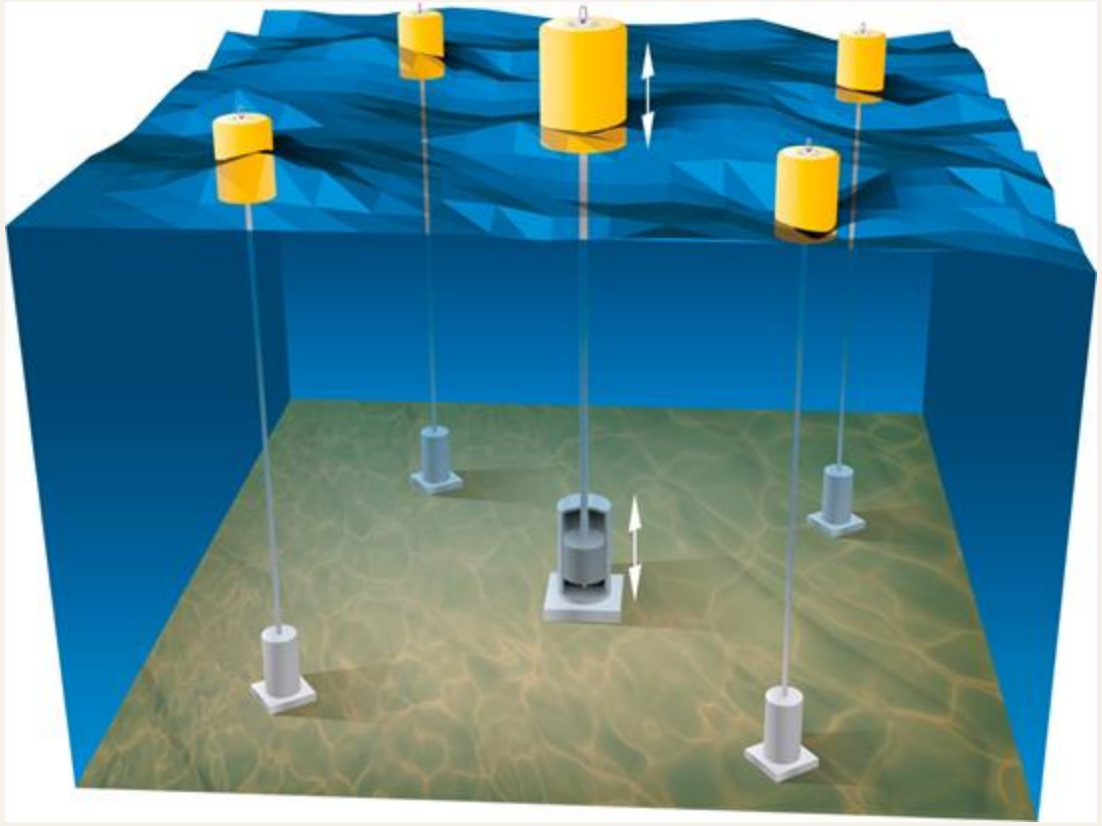
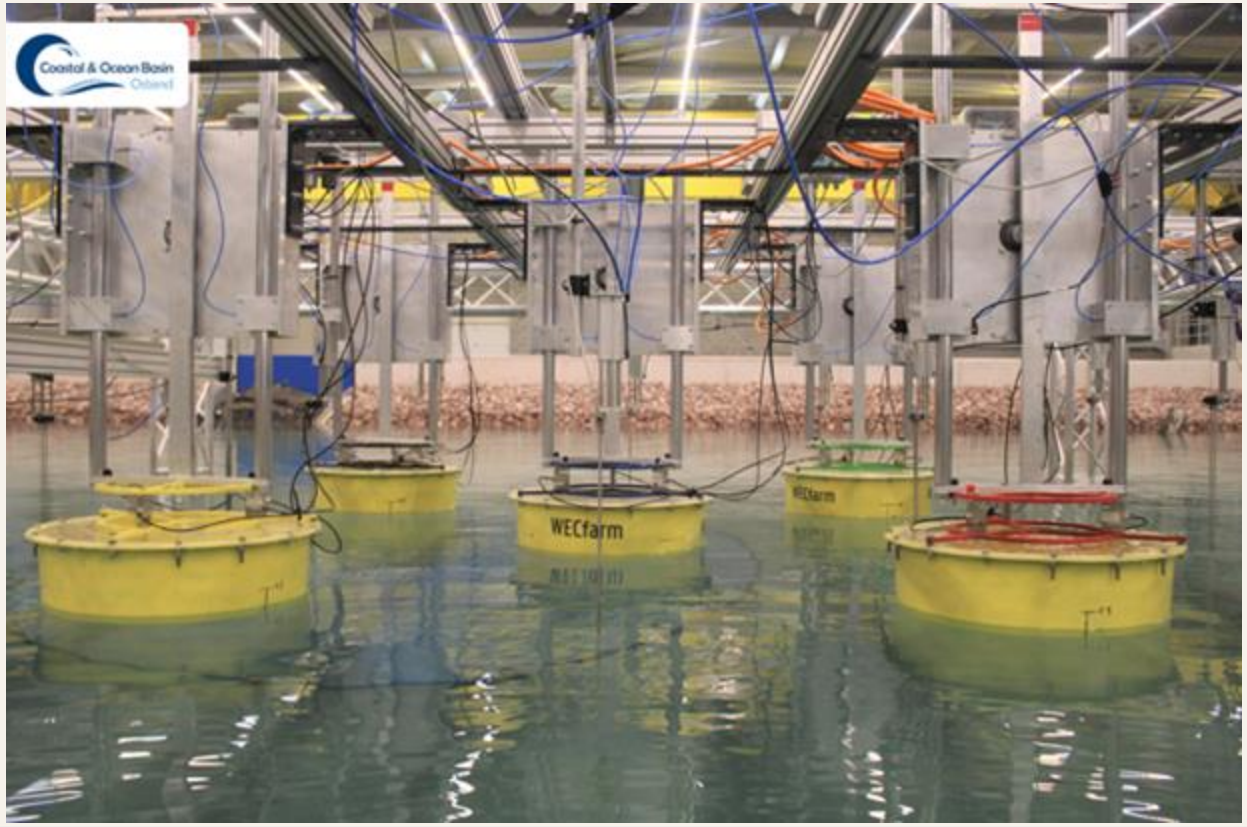
SEA Lab
Symbiotic Engineering and Analysis Lab

TEAMER
Testing & Expertise for Marine Energy

Background → WEC Arrays

- Wave energy converter (WEC) arrays have been extensively studied numerically. [1-3]
- These arrays have only consisted of WECs that extract power from the same degree of freedom (e.g., heave).[4-6]





[4] Ermakov et al. 2025

[6] Wecfarm 2025

Background → WEC Arrays

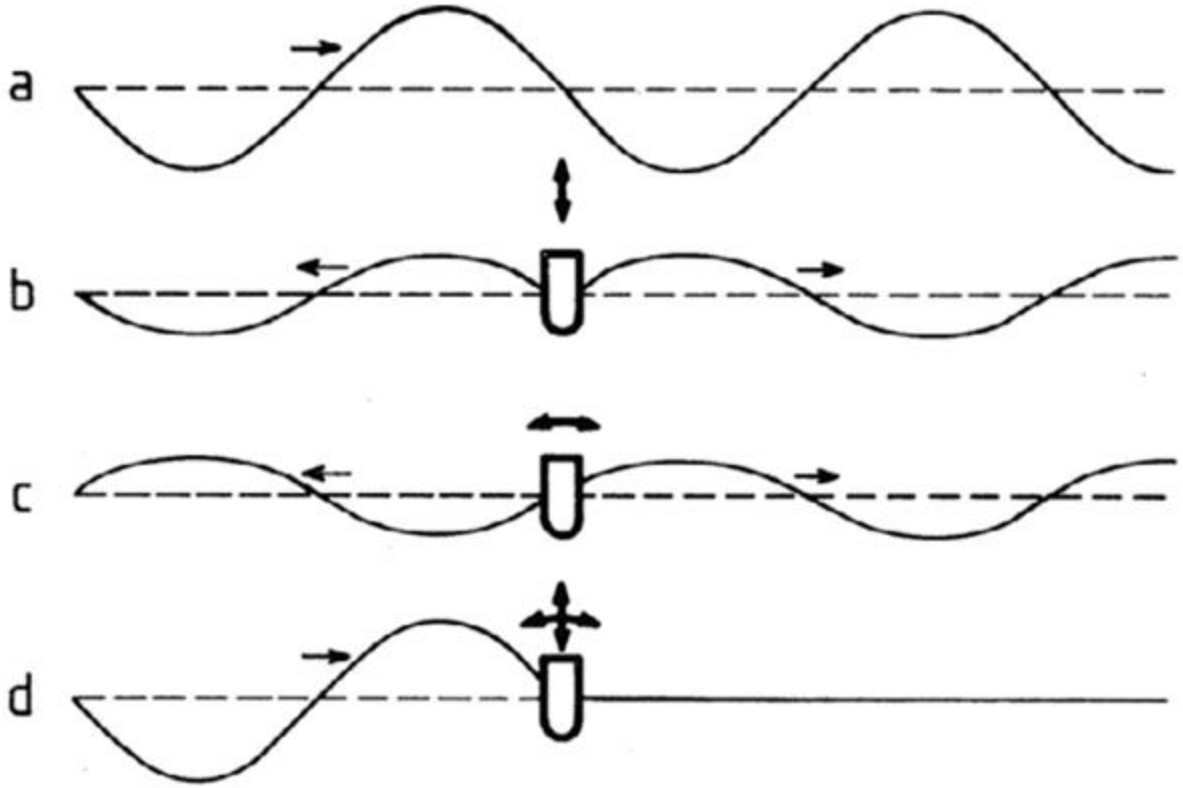
Our study hypothesized that **combining WECs that operate in different modes of motion** would improve the farms overall performance.

incident wave

radiated wave → heave

radiated wave → pitch

a + b + c → full absorption



[7] Falnes 2020

Background → WEC Architectures

We focused on two common WEC architectures:

- heaving point absorbers (PAs)
- oscillating surge WECs (OSWECs)

Used Latin Hypercube Sampling to conduct Monte Carlo Method optimization to **systematically assess** dozens of array configurations in Boundary Element Method (BEM) software, **testing the heterogeneous hypothesis.**

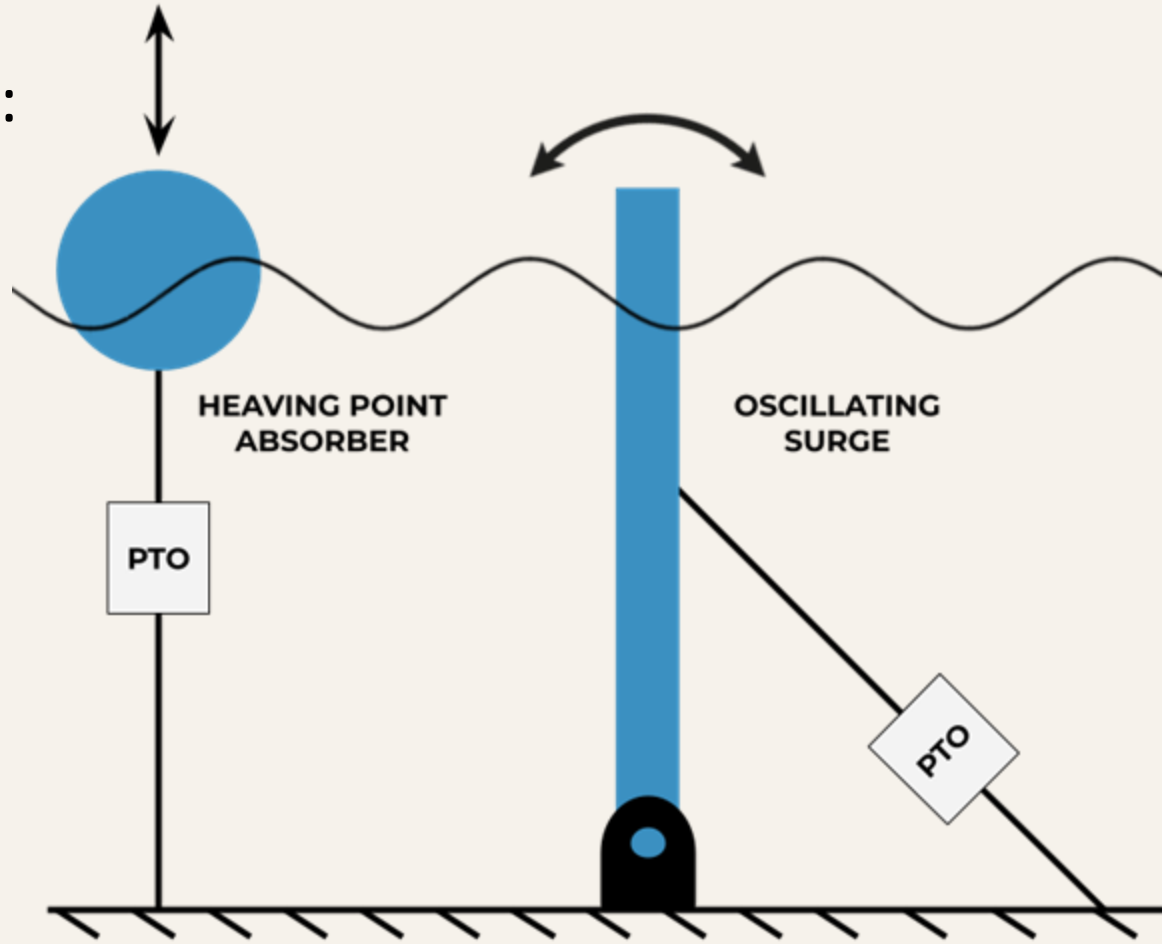


Fig. 1 Simplified version of heaving PA and OSWEC architectures.

PTO = Power Take-Off

Background → Experimentation

Numerical **BEM models supported our hypothesis;** however, they employ several simplifying assumptions, including ignoring viscous effects.

Experiments provide high-fidelity data, used to validate numerical models and gain practical insights models cannot provide.

A few open-source, WEC array experimental datasets exist[8,9]; however, **all are for homogeneous arrays** (predominantly PAs).

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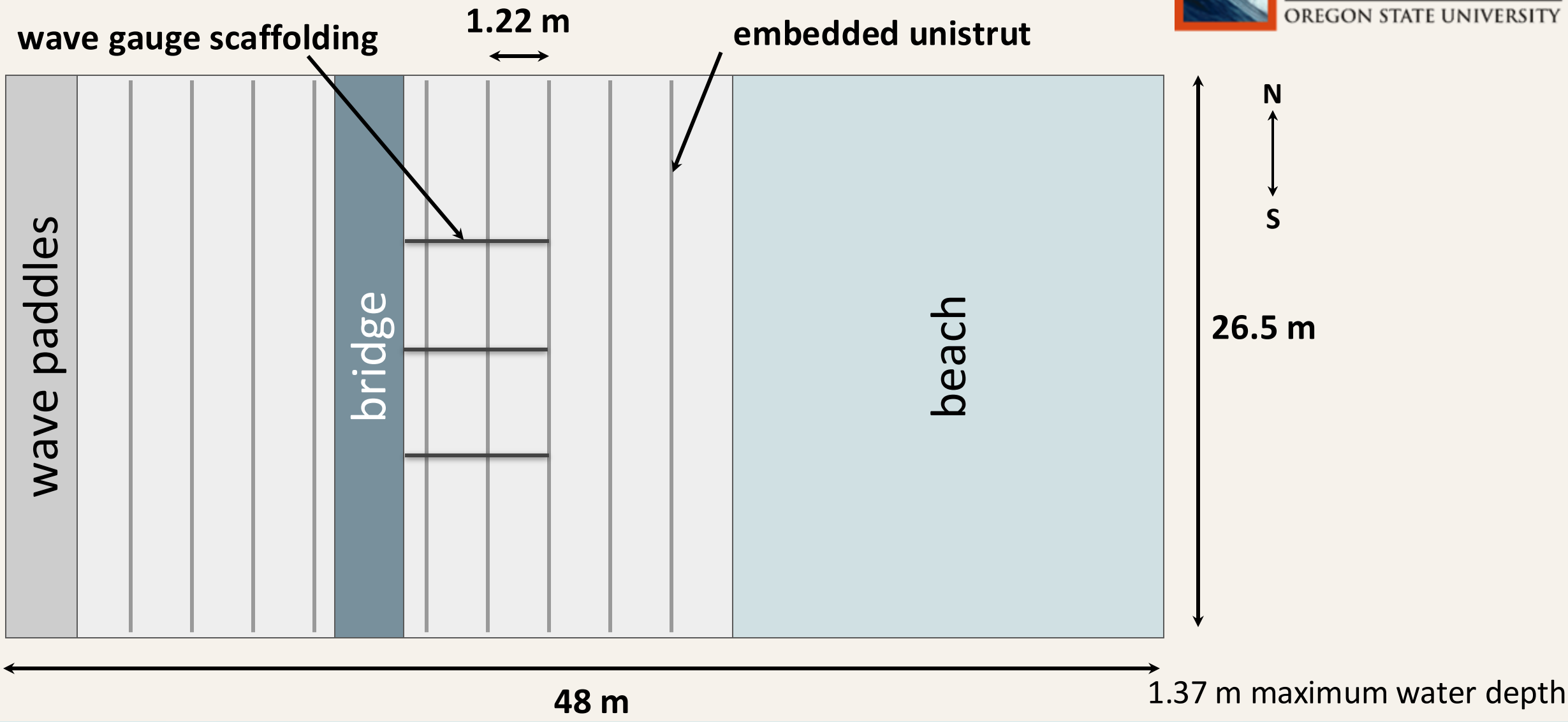
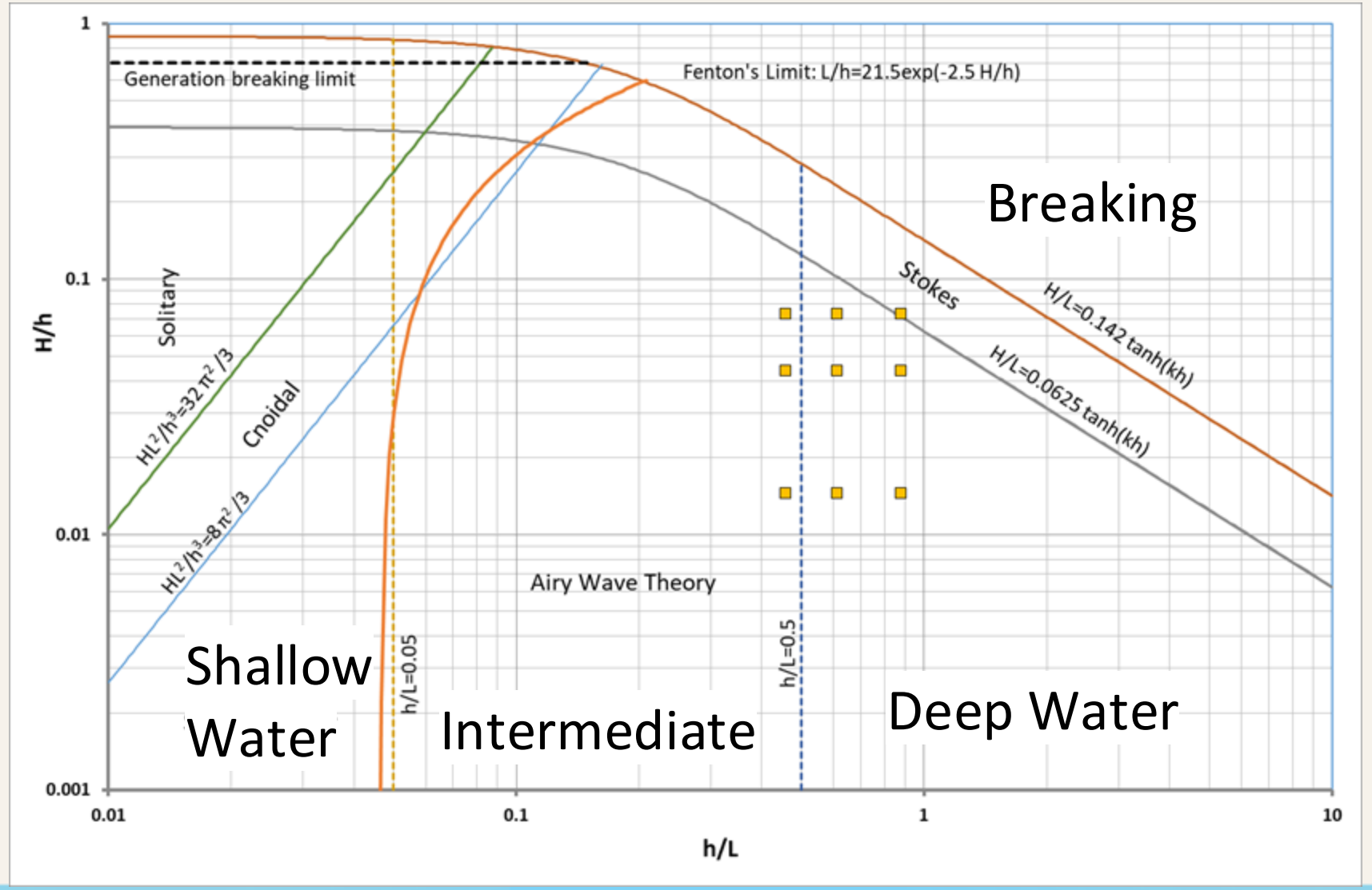
Our goal is to **evaluate the validity of our hypothesis** and provide a **robust experimental dataset** for two types of WEC architectures.

Test Facility Directional Wave Basin



Fluid Regime

dependent on relationships between **water depth, wave height, and wavelength**

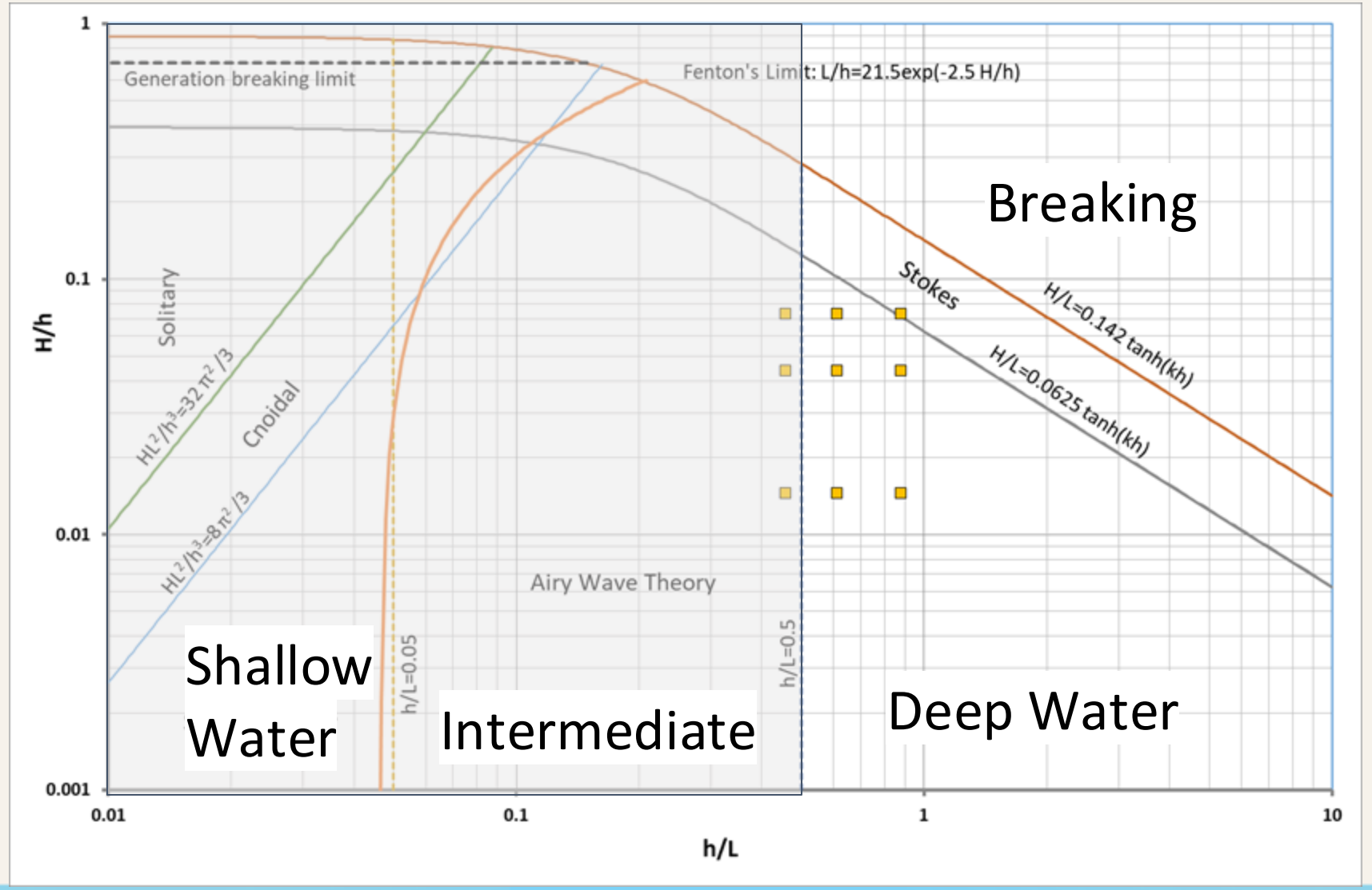


Fluid Regime

deep water:

$$\frac{h}{L} > 0.5$$

h: water depth
L: wavelength

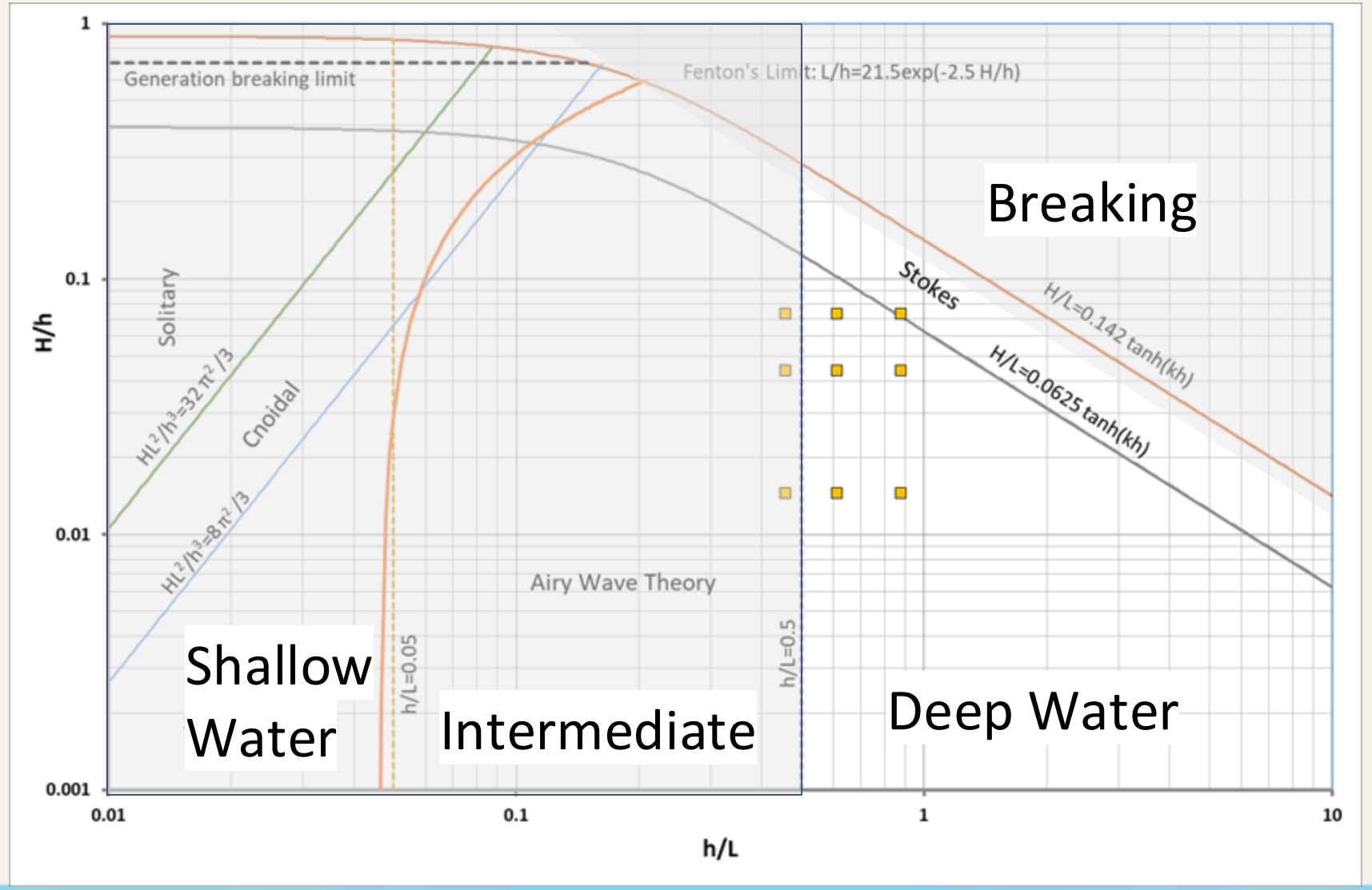


Fluid Regime

non-breaking:

$$\frac{H}{h} < 0.142\tanh(kh)$$

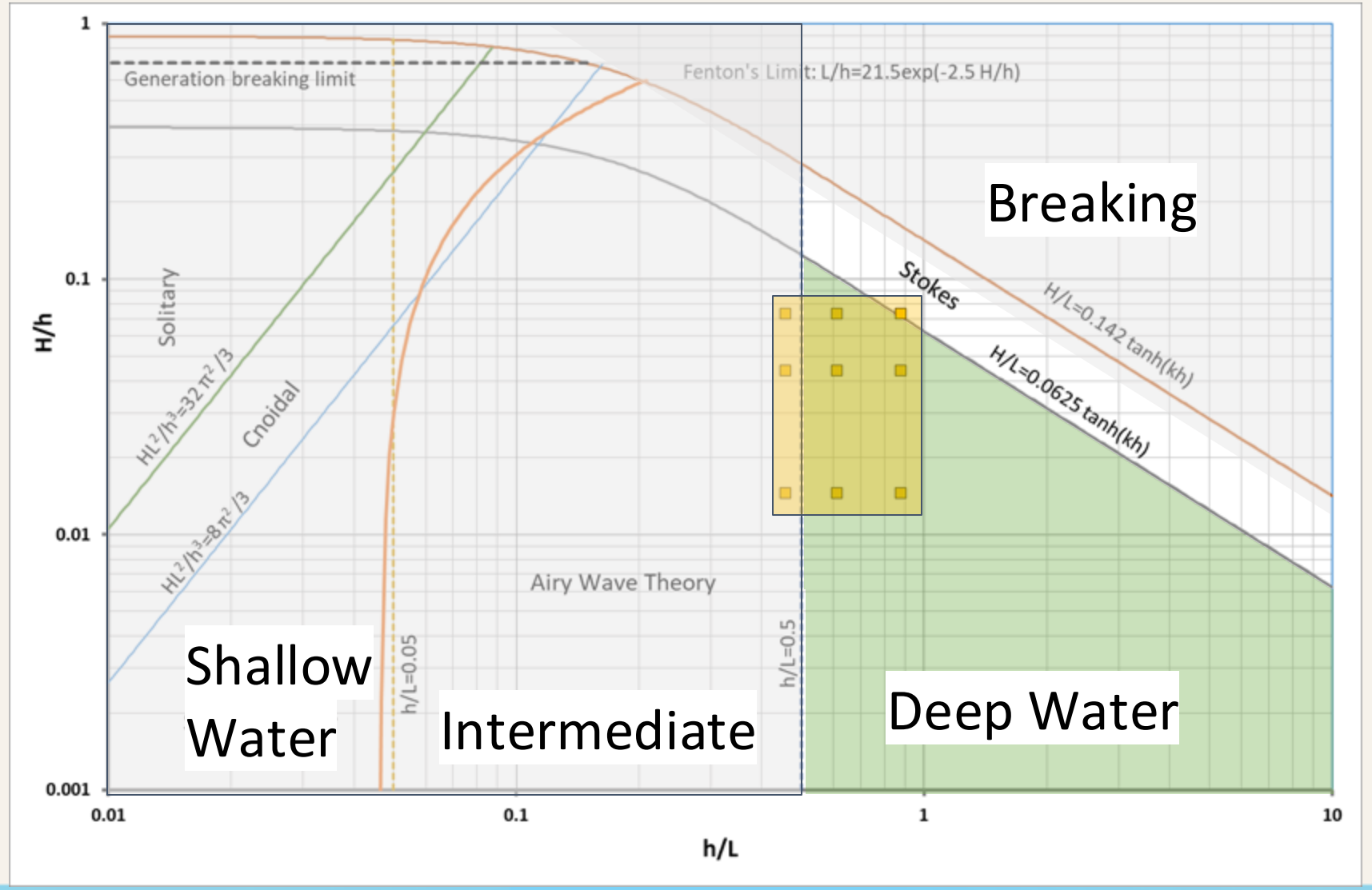
H: wave height
k: wave number



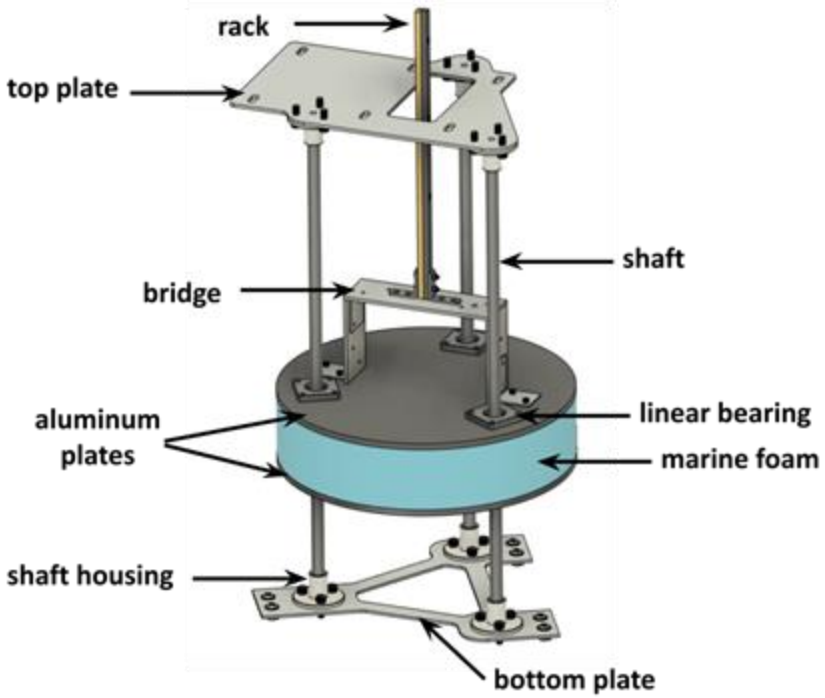
Fluid Regime

desired fluid regime

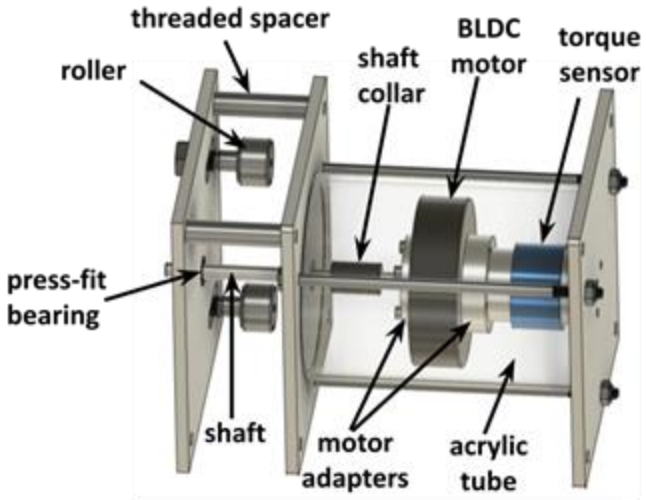
experimental region



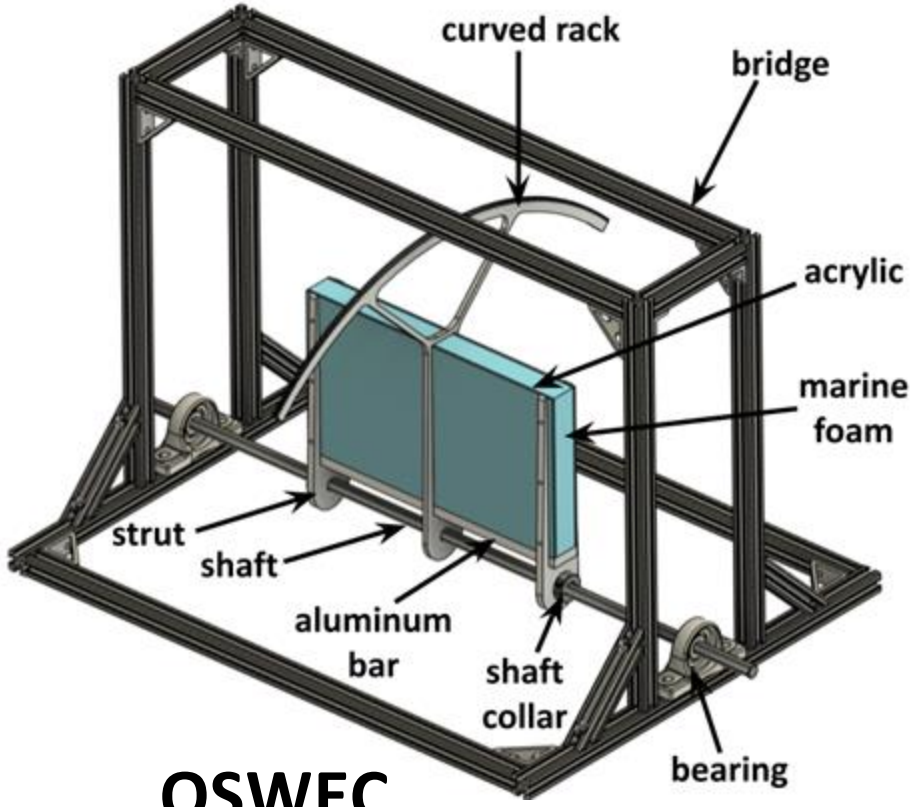
Devices → 1:50 scale



PA
power ~mW
diameter: 11.5”
length: 3.5”
T_n= 0.70-0.72 s

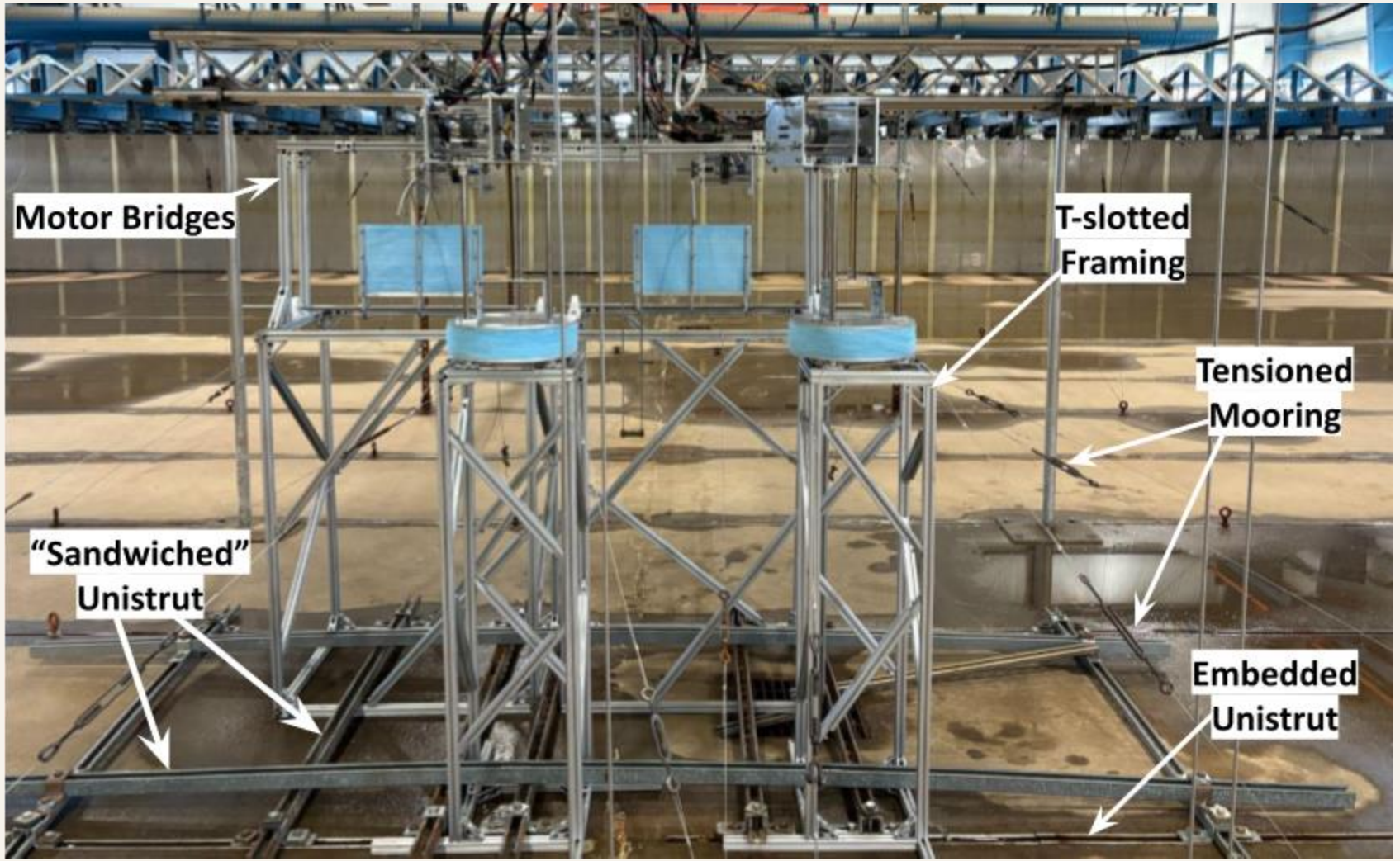


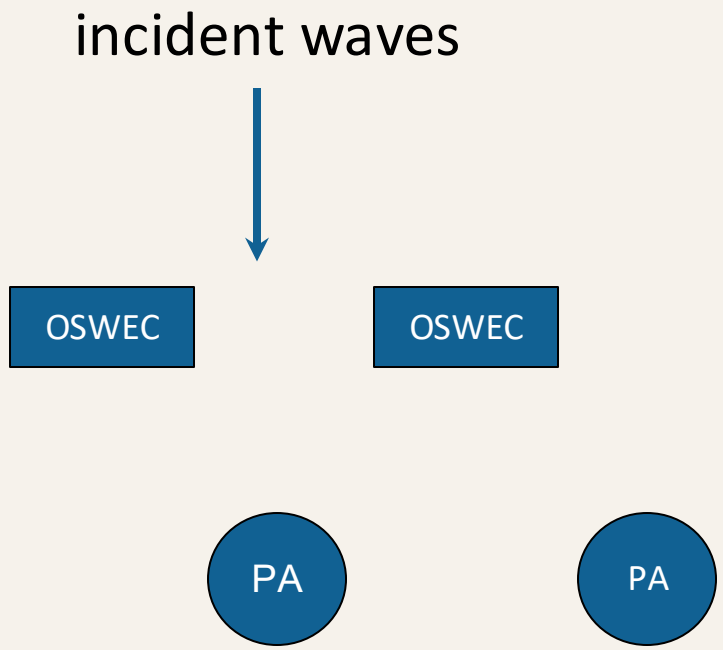
Motor subassembly
used for both architectures



OSWEC
power ~mW
width: 14.2”
height: 8.5”
thickness: 1.5”
T_n = 2.893-3.163 s

4-body Heterogeneous Configuration





Tests and Wave Conditions

- → **regular wave excitation** (PTO engaged and disengaged)
  - T = 1.0-1.39 s
  - A = 0.01-0.05 m
  - B = 0-30 deg
- → **random wave excitation (JONSWAP)**
  - conditions near SCRIPPS, **Pacific ocean**
  - conditions near Georges Bank, **Atlantic ocean**

completed for heterogeneous arrays, homogeneous arrays, and single device testing

- → **fixed-device regular wave excitation**
- → **individual forced oscillation**

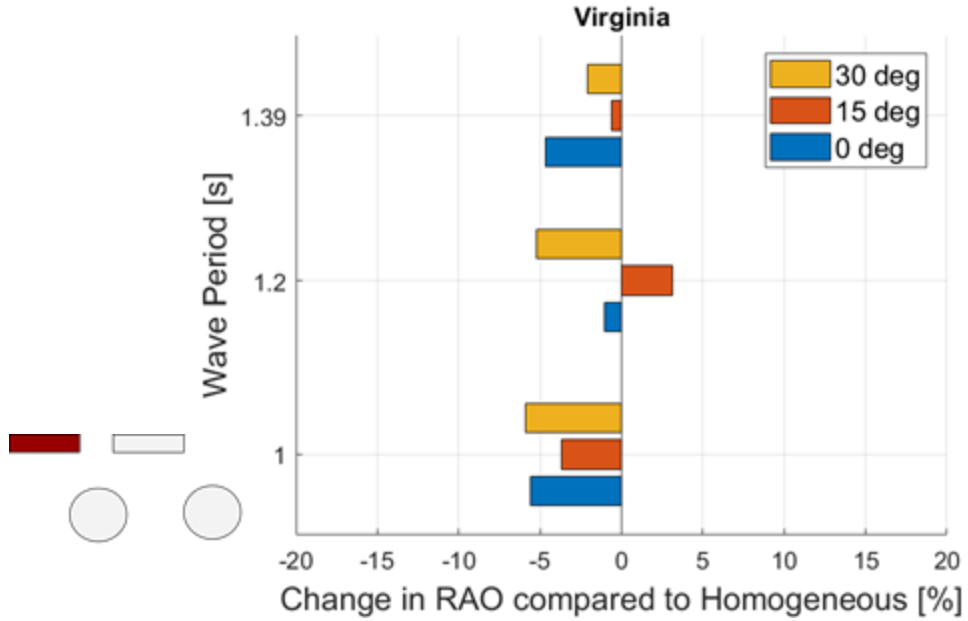
completed only for 4-body heterogeneous configuration

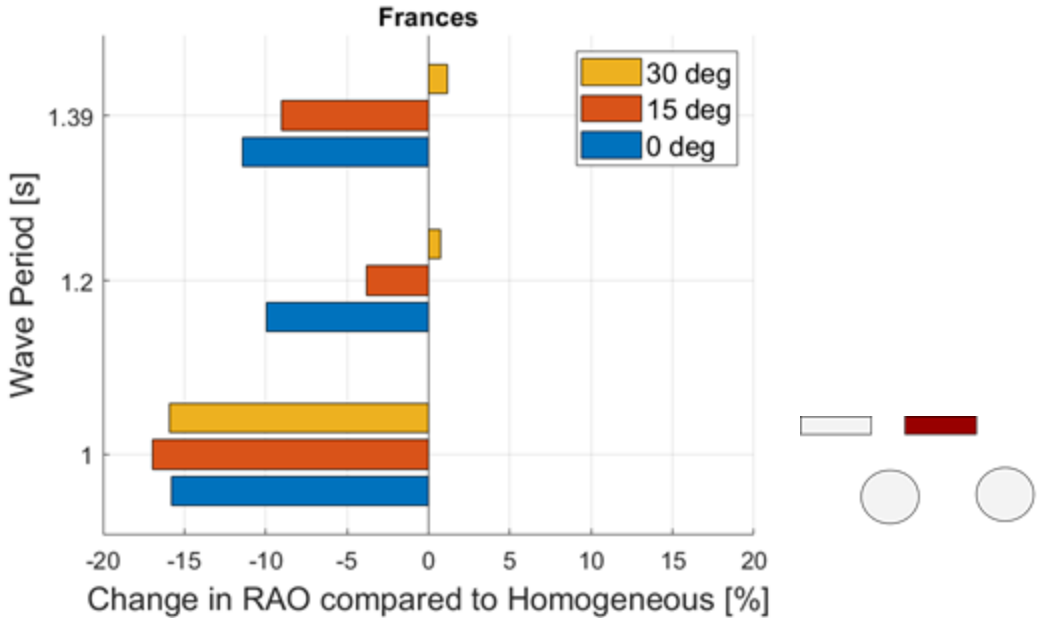
Data Acquisition

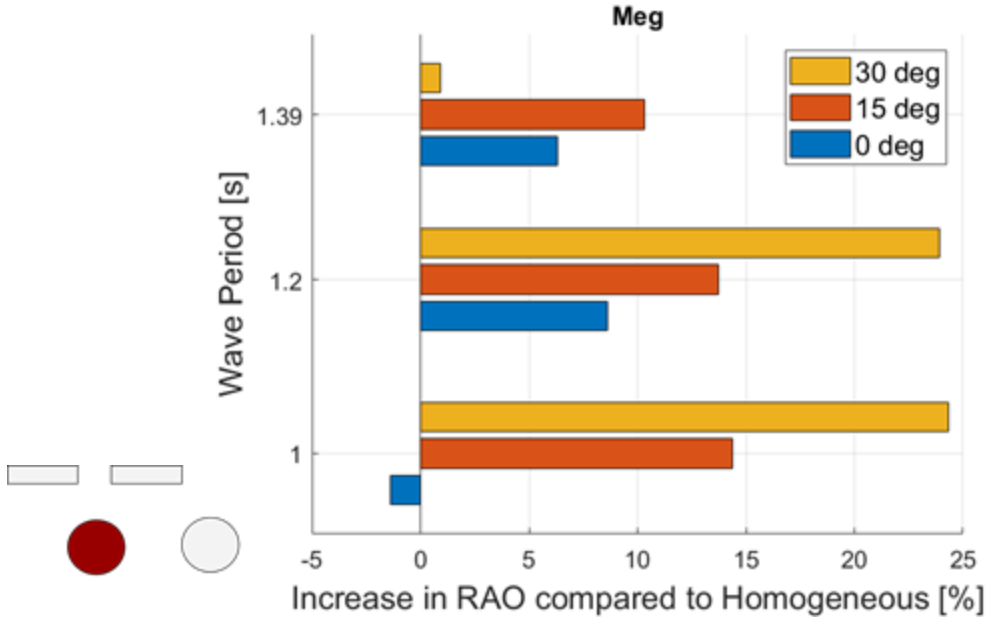
Measurement Method	Collected Data	Purpose
Resistive and optical wave gauges	Wave elevation throughout the basin	Near- and far-field model validation
Qualisys motion capture cameras	Device motion in 6 DoFs	Model validation, performance analysis
Vesc 6 75 (Electronic Speed Controller)	Motor current Motor angular velocity Input voltage FOC current	Forced oscillation testing, PTO controls, electrical power production
S-shaped load cell	Wave excitation force Radiation force	Model validation

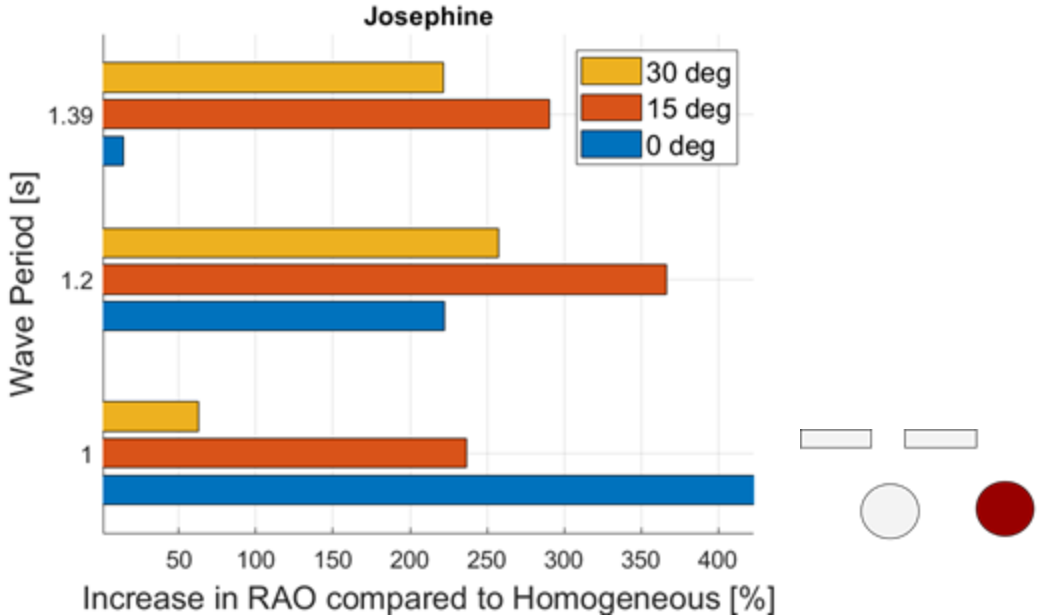
Results: RAO Comparisons

4-body heterogeneous array compared to homogeneous array performance in regular waves



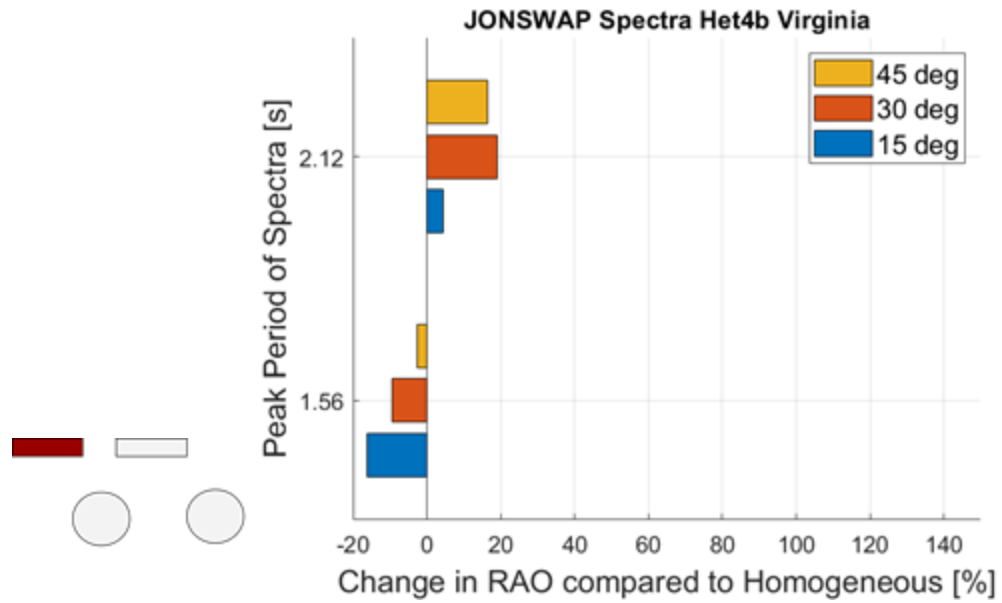


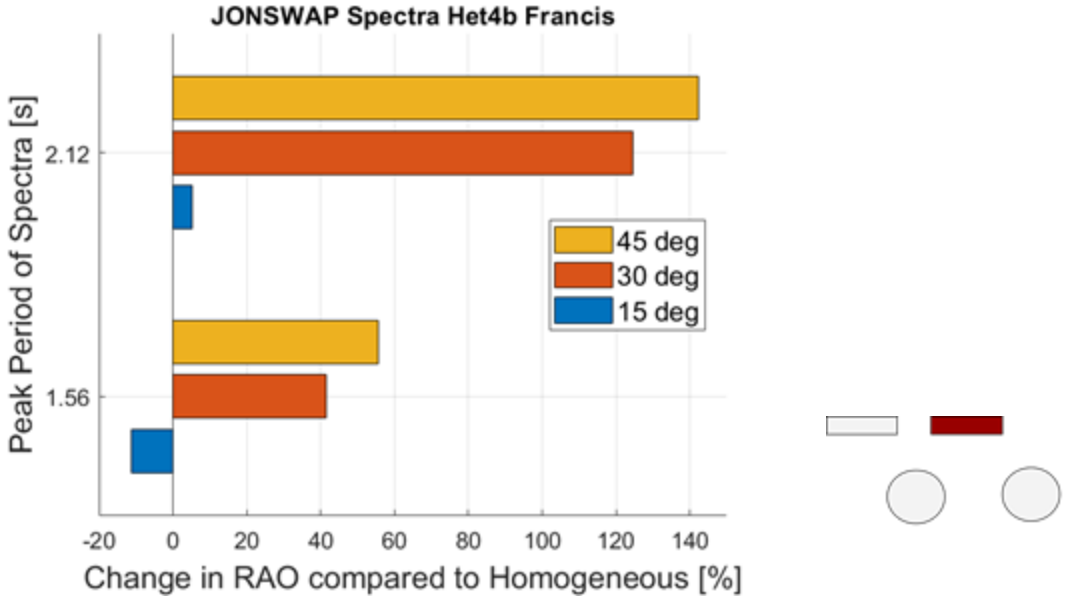


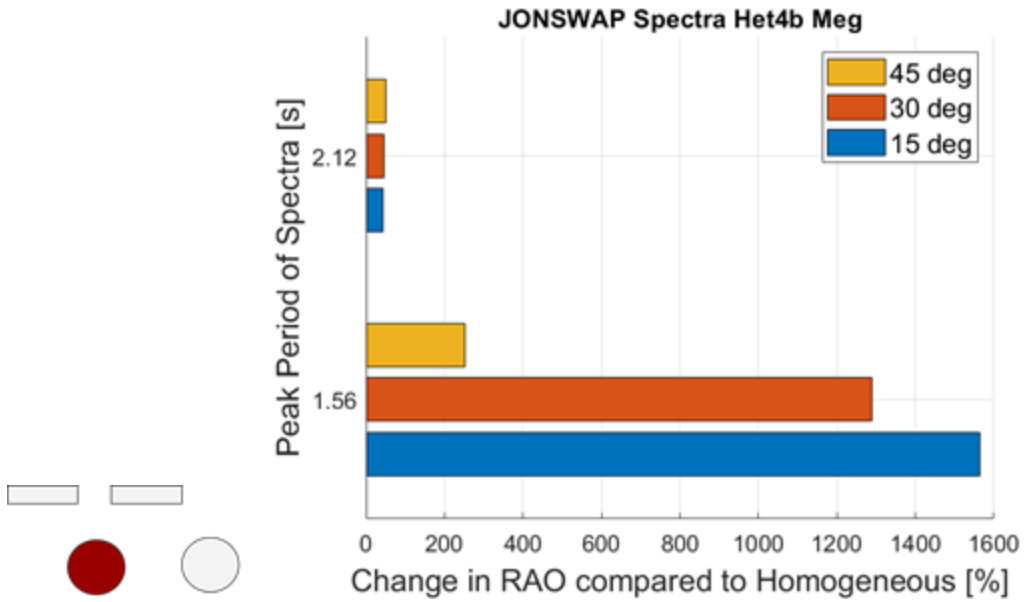


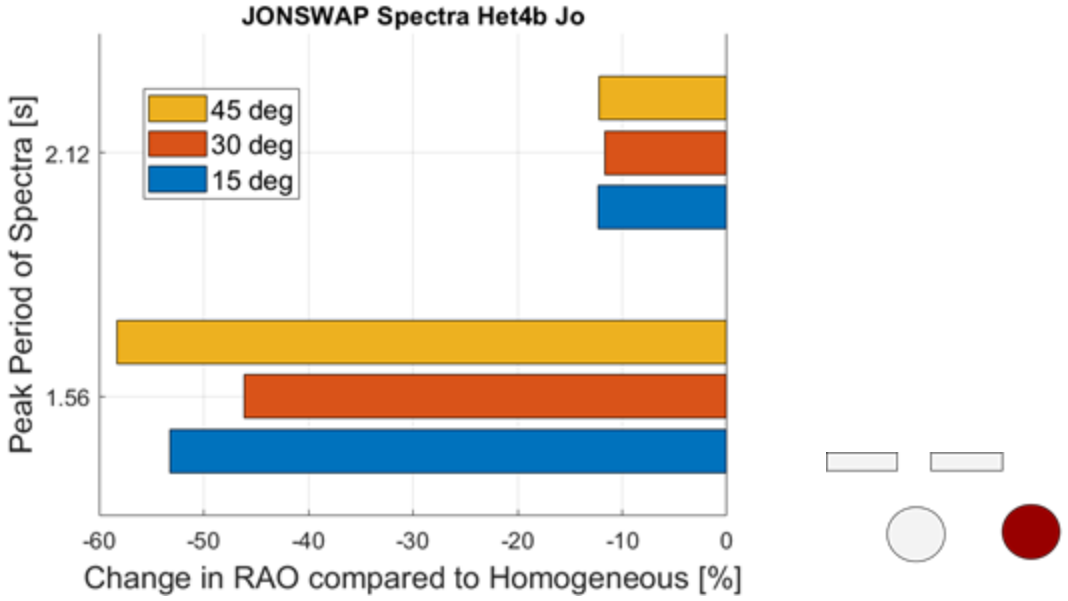
Results: RAO Comparisons

4-body heterogeneous array compared to homogeneous array performance in random waves









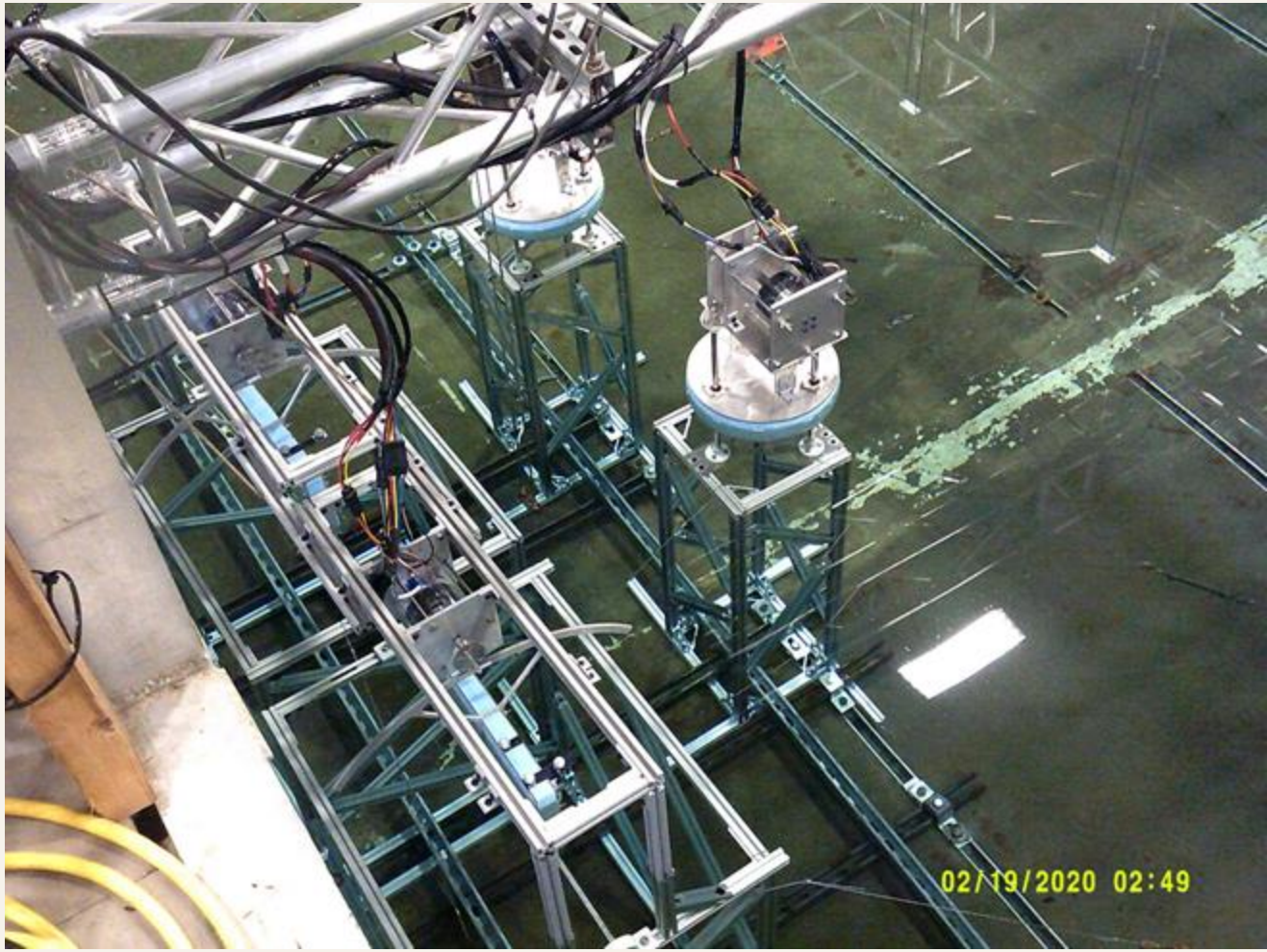
Preliminary Conclusions

heterogeneous arrays have a give-and-take effect

- a few devices suffer poorer performance while their neighbors experience enhanced motion

heterogeneous arrays are likely favorable to homogeneous arrays

- across several sea states in both regular and random wave excitation



Ongoing/Future Work

1. Model validation to BEM (Capytaine)
2. Quantification of empirically derived viscous drag coefficients
3. Analysis of PTO-engaged performance and mechanical power production
4. Analysis of harmonics in device motion spectra

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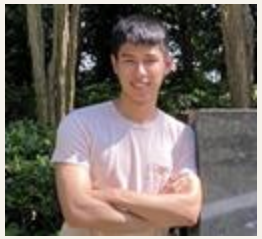
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Cornell Atkinson Center for Sustainability

Thank you!

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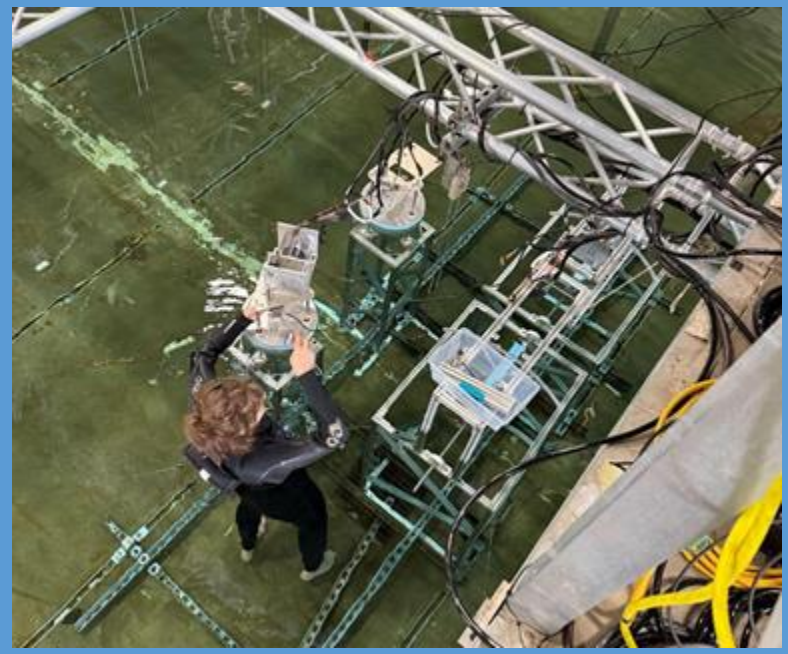
Research Website: https://ovitale35.wordpress.com/

dataset link:



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[8] Nicolás Faedo, Yerai Peña-Sanchez, Edoardo Pasta, Guglielmo Papini, Facundo D. Mosquera, Francesco Ferri, SWELL: An open-access experimental dataset for arrays of wave energy conversion systems, Renewable Energy, Volume 212, 2023, Pages 699-716, ISSN 0960-1481, https://doi.org/10.1016/j.renene.2023.05.069.

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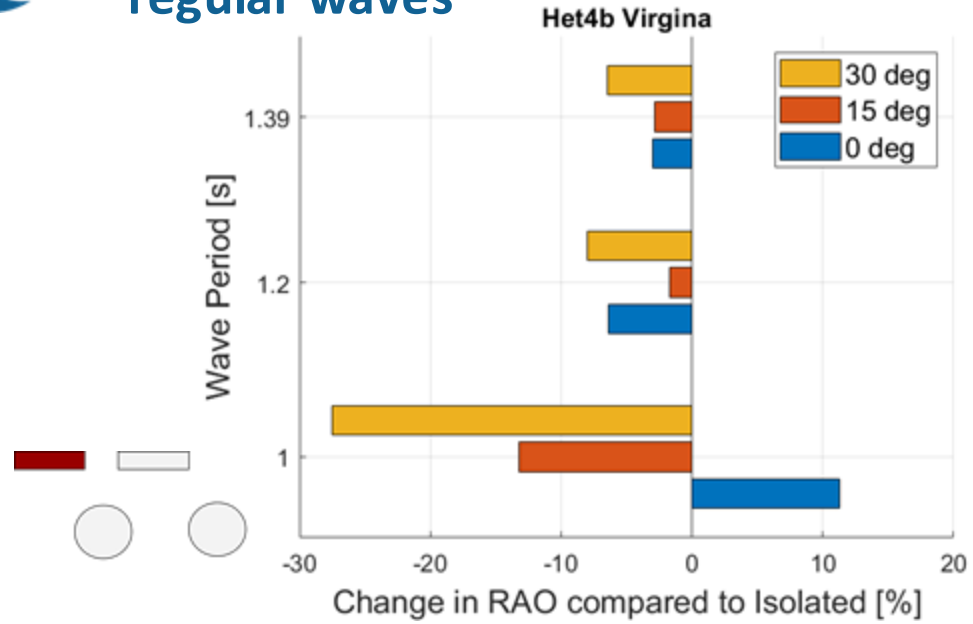
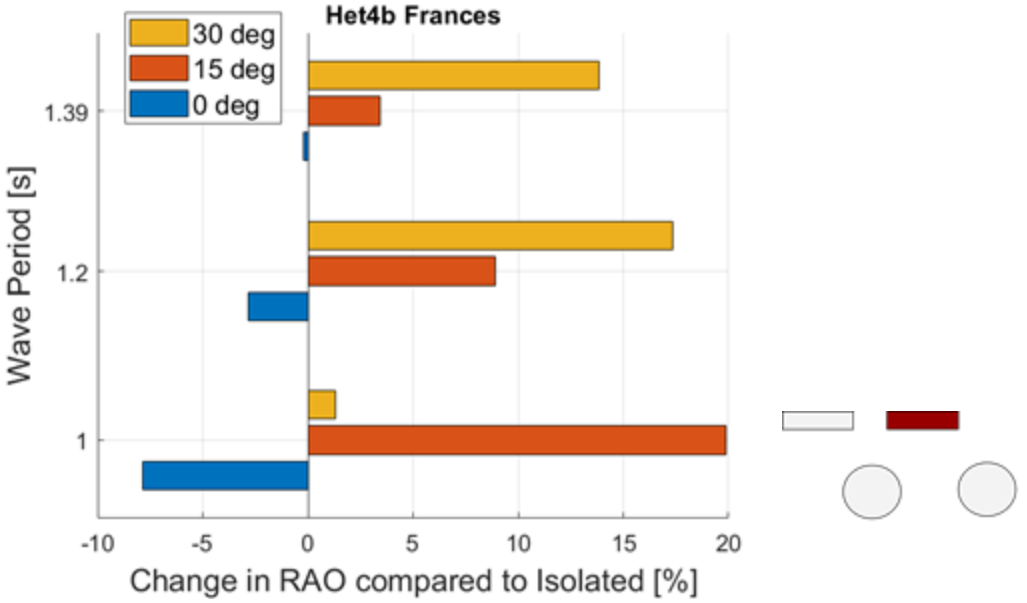
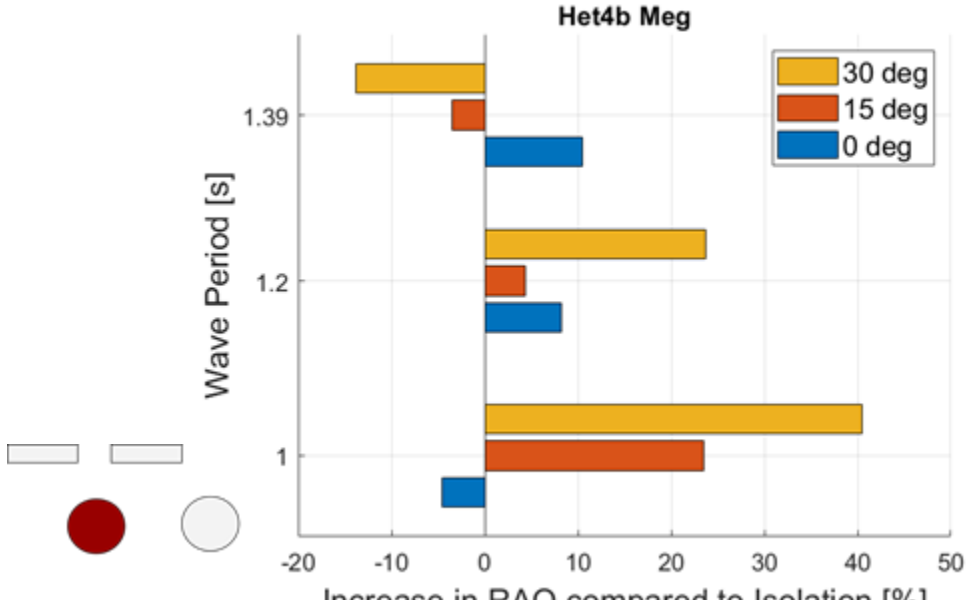
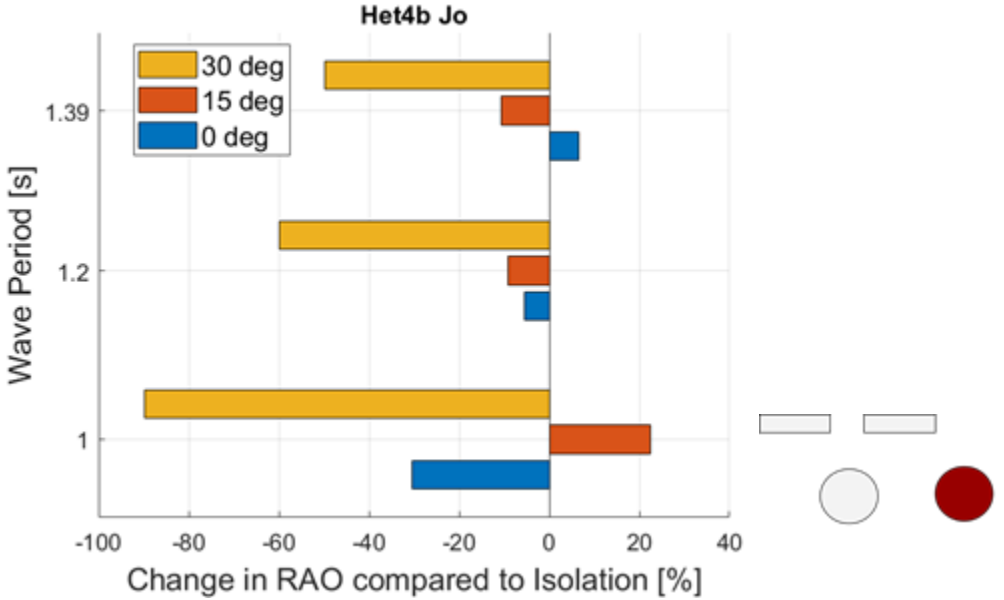
Results: 4-body heterogeneous array compared to isolated device performance

regular waves

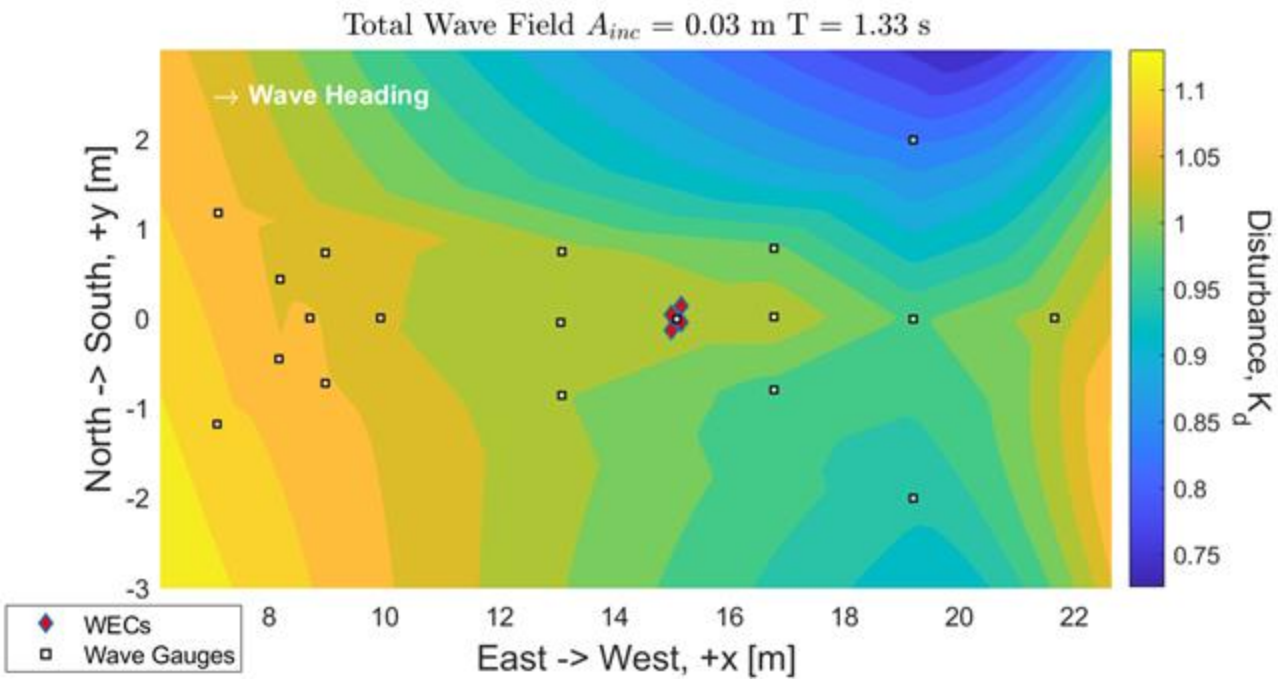


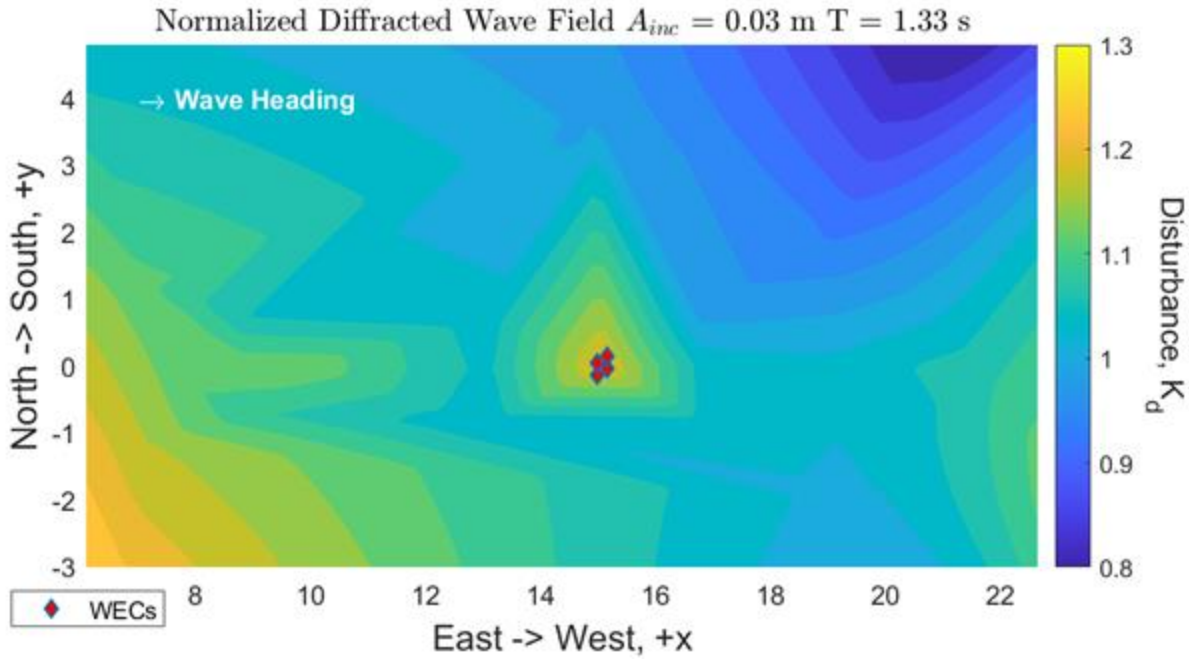




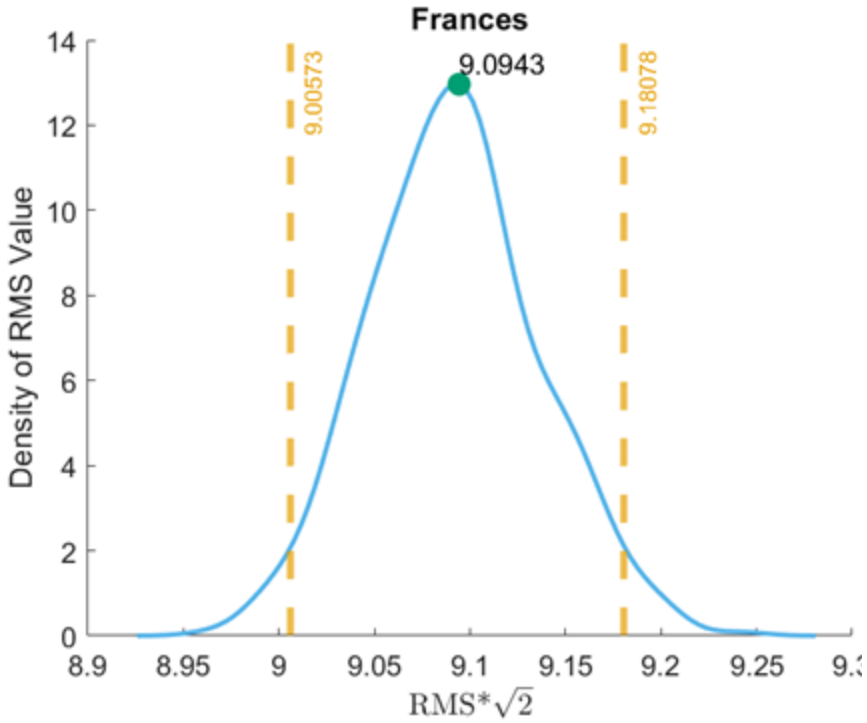


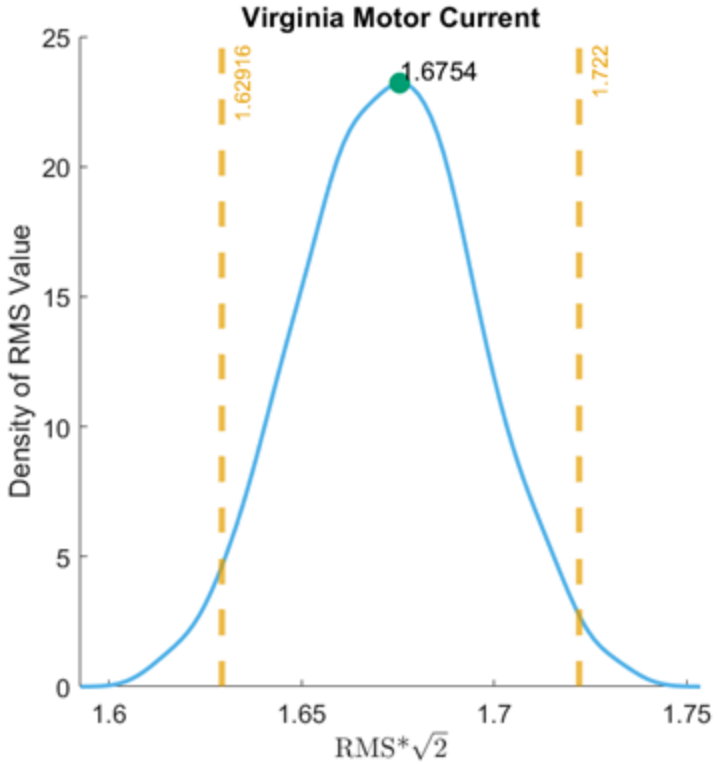
Results: Wave Field

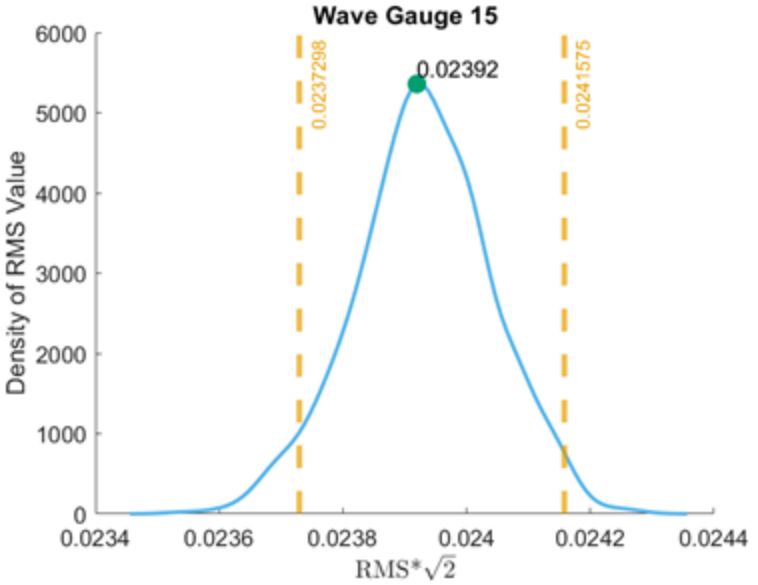


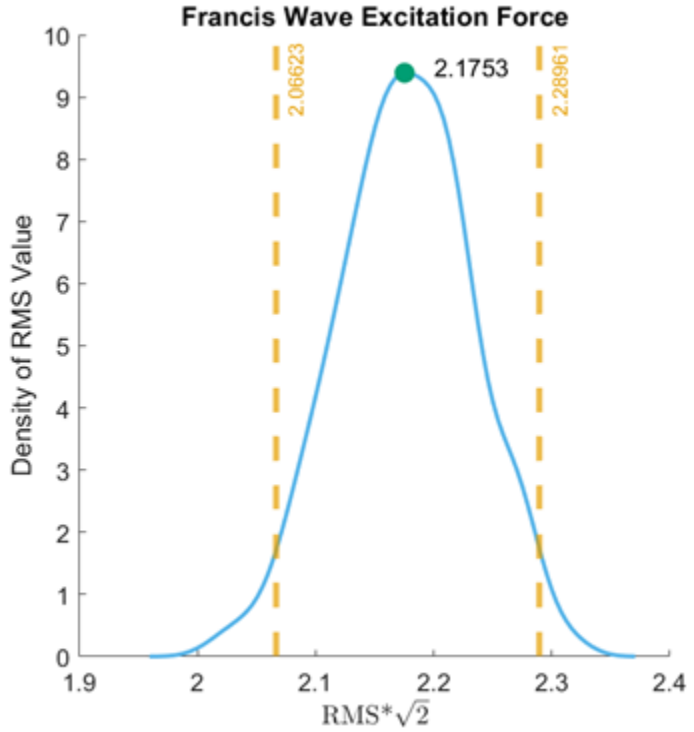


Results: uncertainty analysis

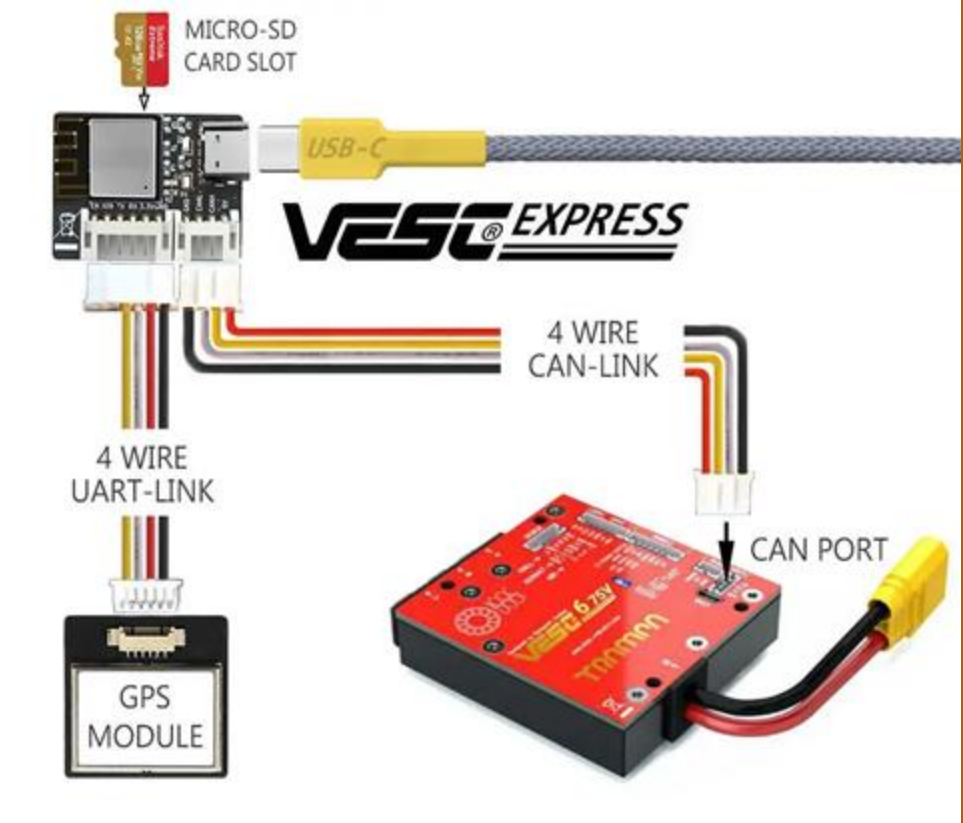








VescExpress DAQ



1. Motor Current

To measure torque in the motor, electrical power production and controller phase lag

2. Input Voltage

To measure electrical power

3. Motor RPM

To measure device motion; can also be used to obtain torque by knowing the operational power (current and voltage)

4. FOC Current

Field-oriented control (FOC) current. Not exactly sure what this will tell us, but we logged it because it may be useful

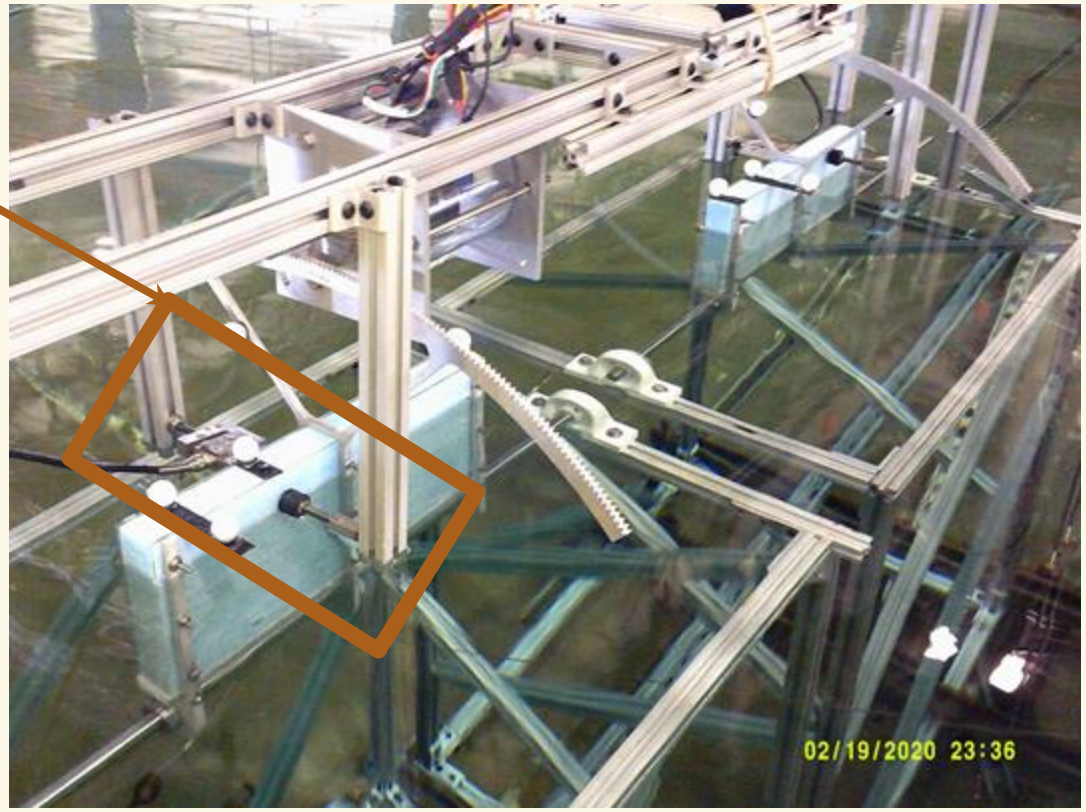
S-shaped Load Cells

These load cells measure tension and compression forces

They were implemented as a linkage which fixed the devices

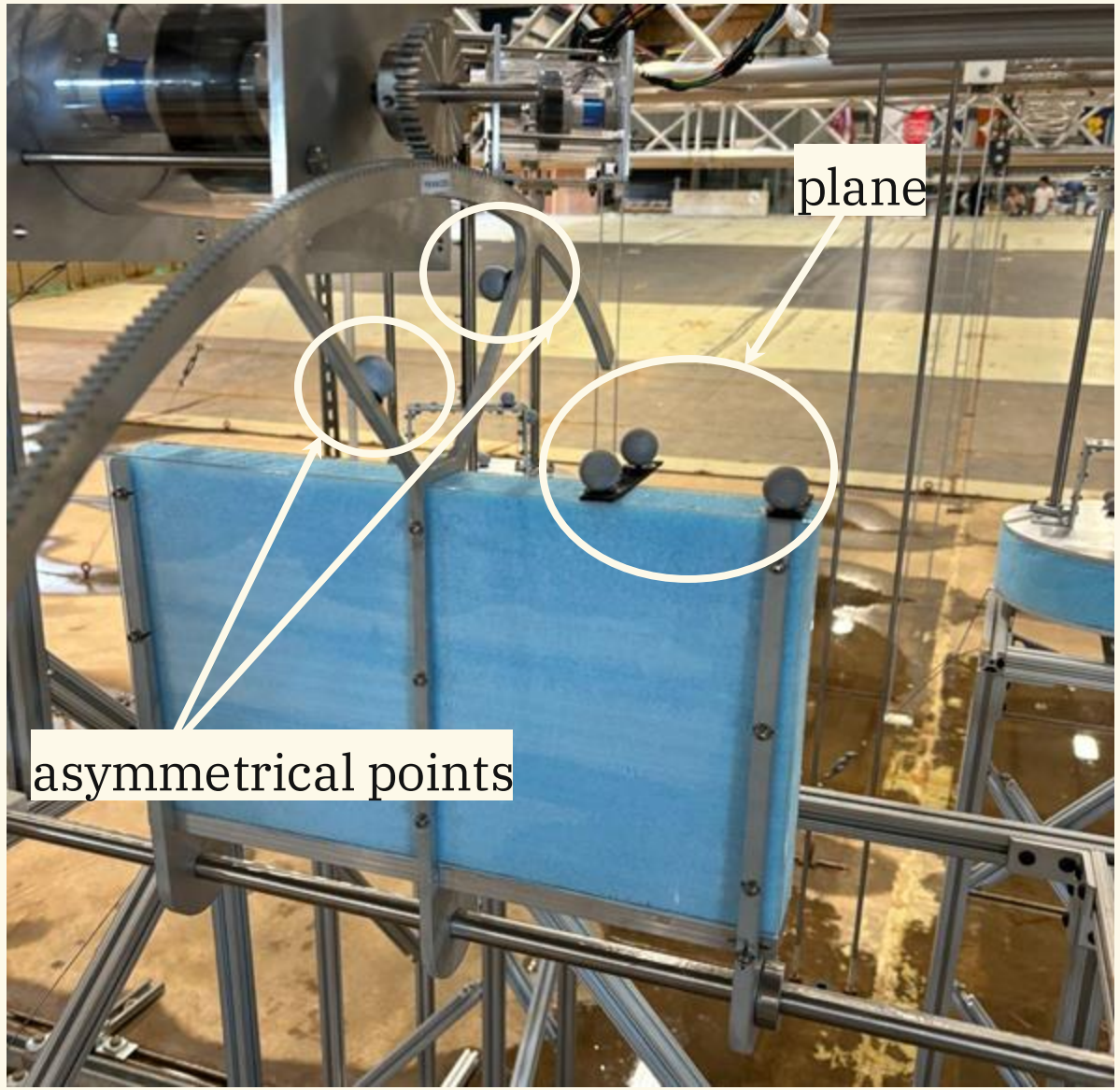
We measured wave excitation forces and radiation forces for each device

load cell fixtures



Qualysis Motion Capture

This tracks the device motion in 6 DOFs using small reflective balls that stick to your devices

You must create a plane on the device and add at least two additional, non-symmetrical points

Used during hydro tests, when PTO was not engaged and could not obtain device position measurements