THE UNIVERSITY OF AUCKLAND
Te Whare Wānanga o Tāmaki Makaurau
NEW ZEALAND

ENGINEERING

Wave and Tidal Energy Harvesters for Marine Farms

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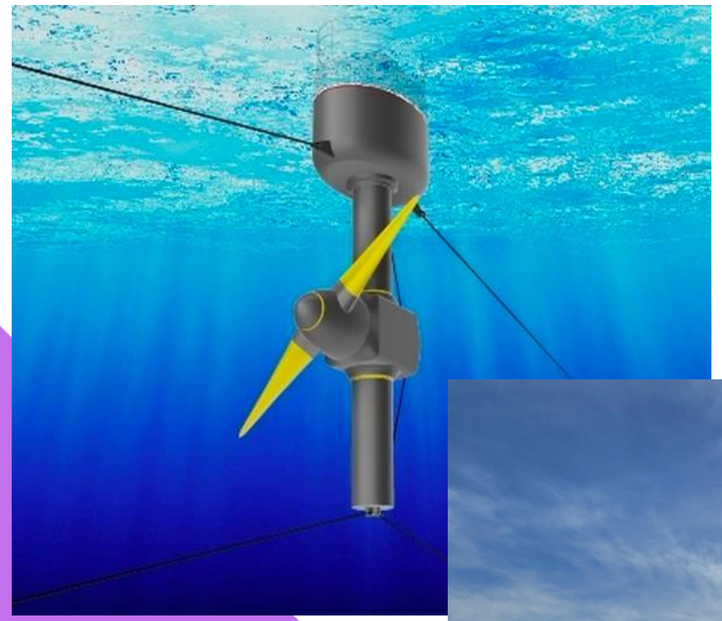
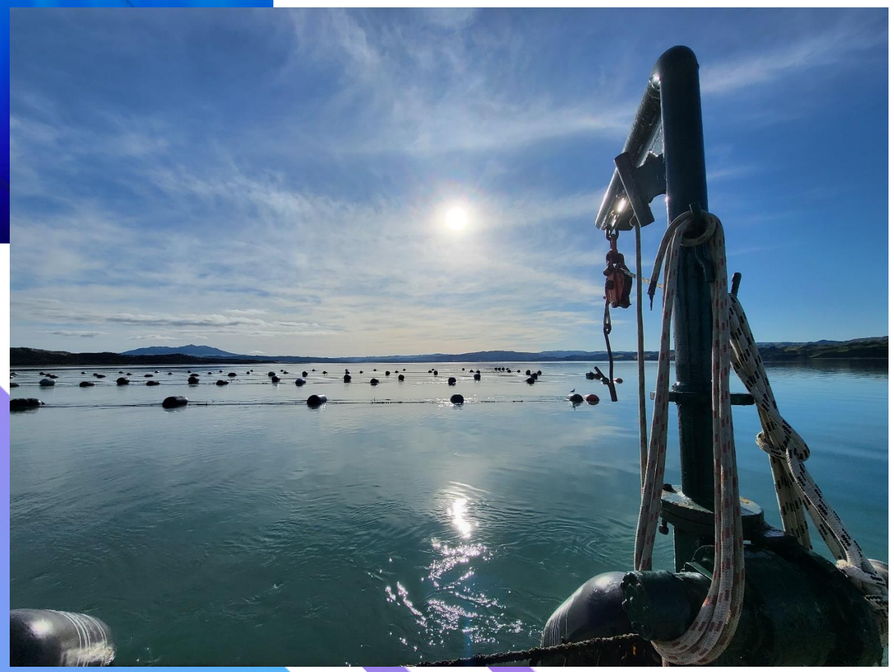
Background

- Growth of NZ aquaculture industry
- Increasing energy demand
- Need to move from fossil fuels to renewables
- Solar panels not reliable, not suitable for certain locations

- Marine energy:
  - Can provide a steady and predictable energy resource
  - Can utilize exsiting floating structures as attachment sites

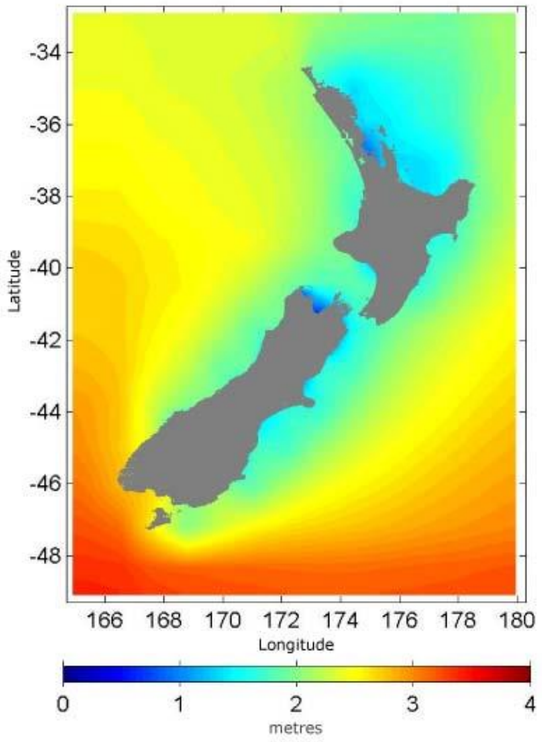
Background



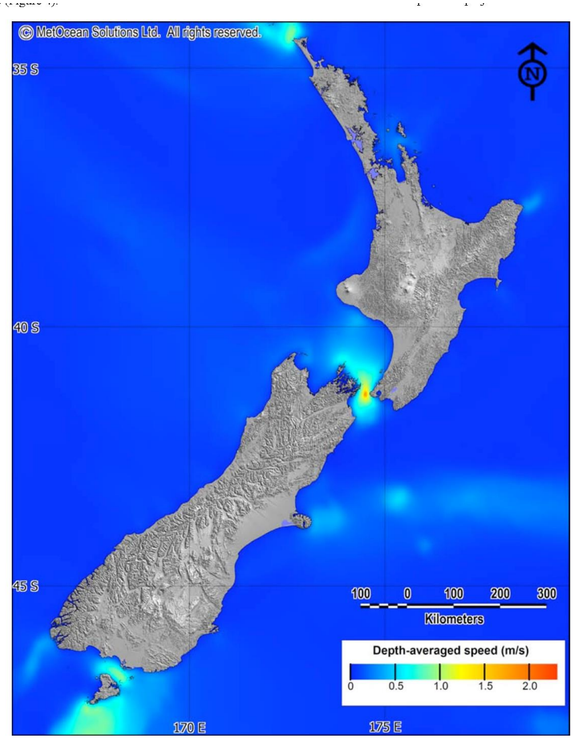


- Existing WEC and TEC developers: Little interest in small-scale tidal and wave energy systems
- No integration with marine farms
- We have 6 NZ industry partners – aquafarms

Specific Focus on the New Zealand Coastline



Significant wave height around NZ



Depth-averaged Tidal Current Speeds

01 **Calm/moderate wave ocean conditions**

02 **NZ Tidal Properties**

- Average current of 1.12 m/s.

03 **Potential for small scale marine energy applications along NZ Coastline**

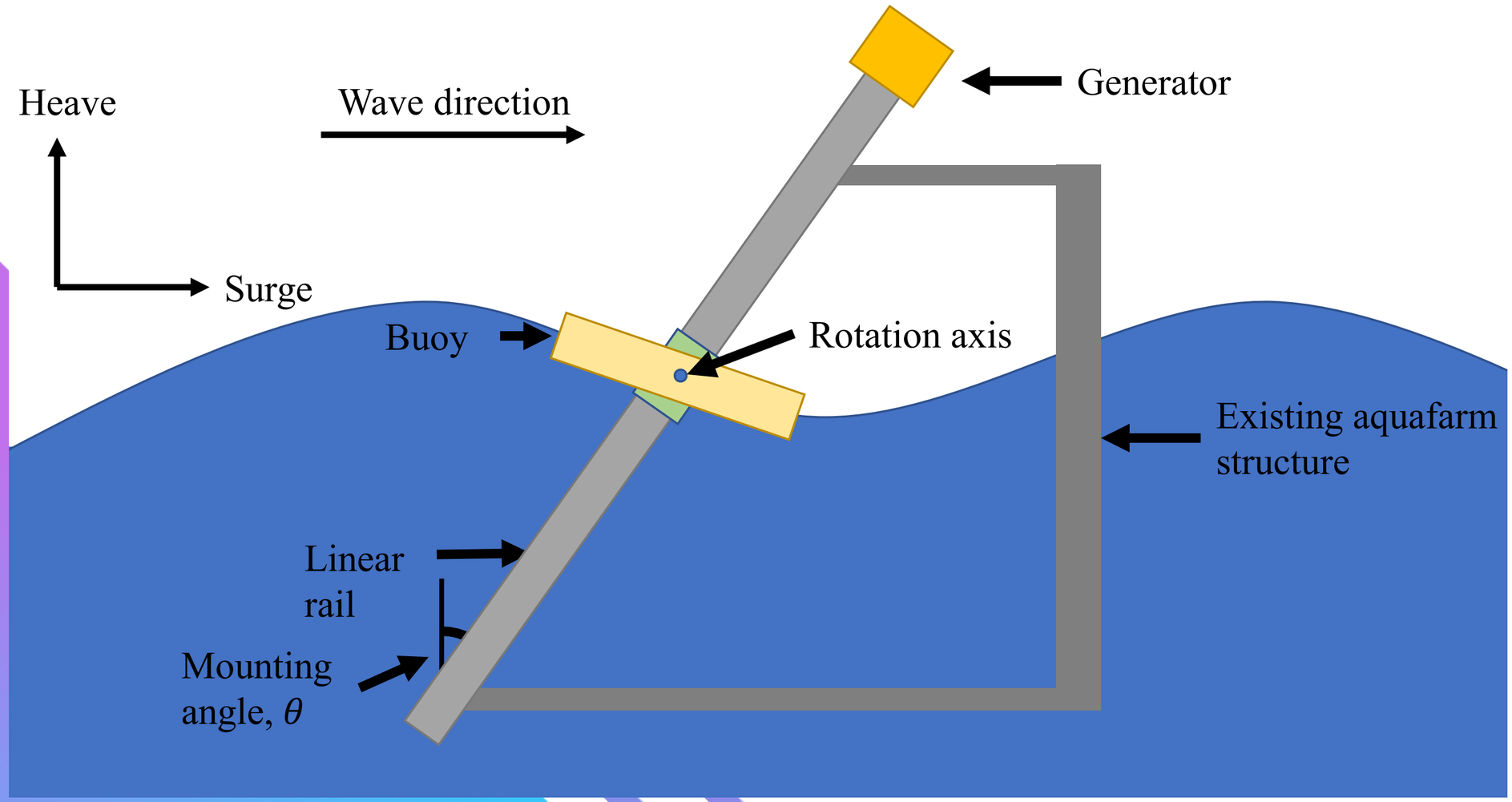
- Approx. 1147 marine farms across NZ

Objectives

Short-term:
100 watt device for charging batteries at aquafarms

Long-term:
Larger scale device for feeding/storage systems at fish farms

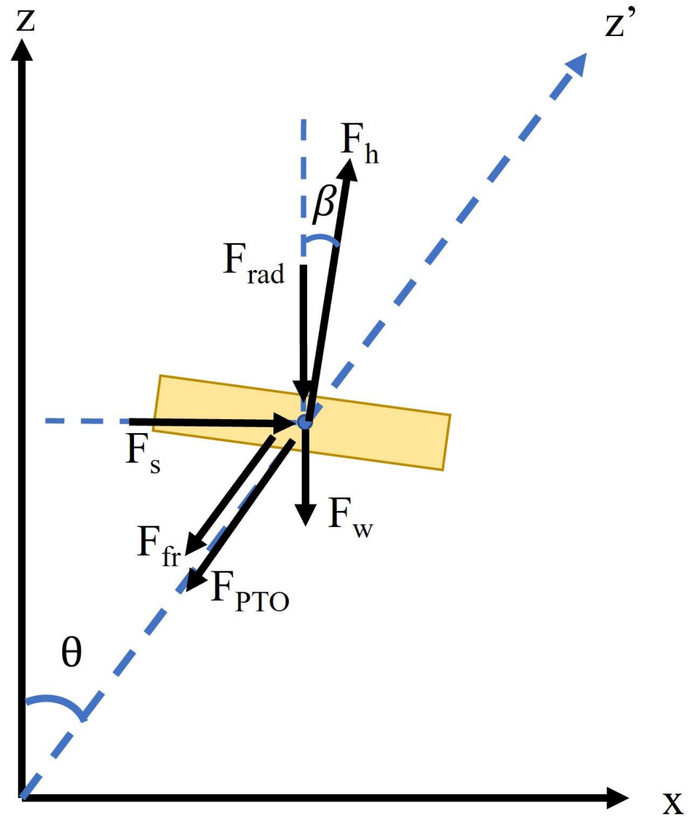
Wave energy device



Wave energy device

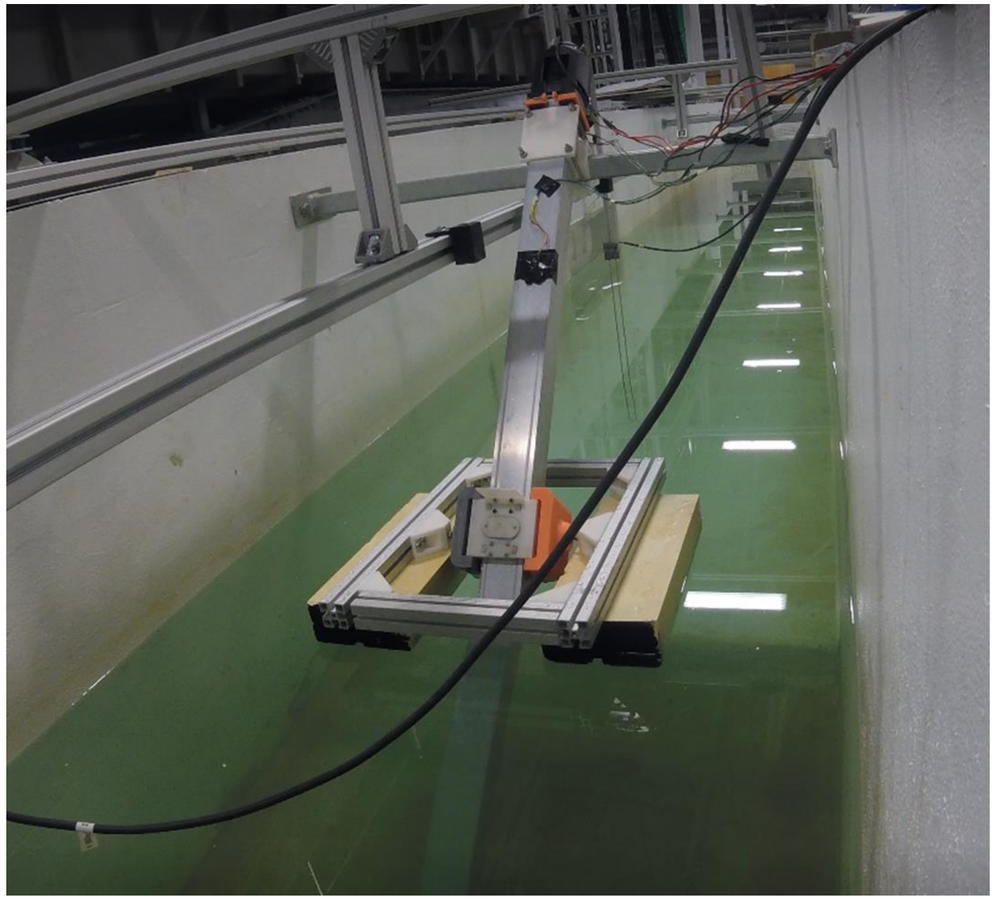
$$m\ddot{z}' = F_h \cos(\theta - \beta) + F_s \sin(\theta) + F_{PTO} + F_{fr} + F_m + F_{rad} \cos(\theta) - F_w \cos(\theta)$$

- Rotated coordinate system – 1DoF motion
- $F_h = \rho g A_w (\eta - z)$ is the heave force due to buoyancy, F_{rad} is the vertical radiation force (modelled via added mass and damping)
- Linear, Stokes and Stream function wave theories used to model the free surface elevation η

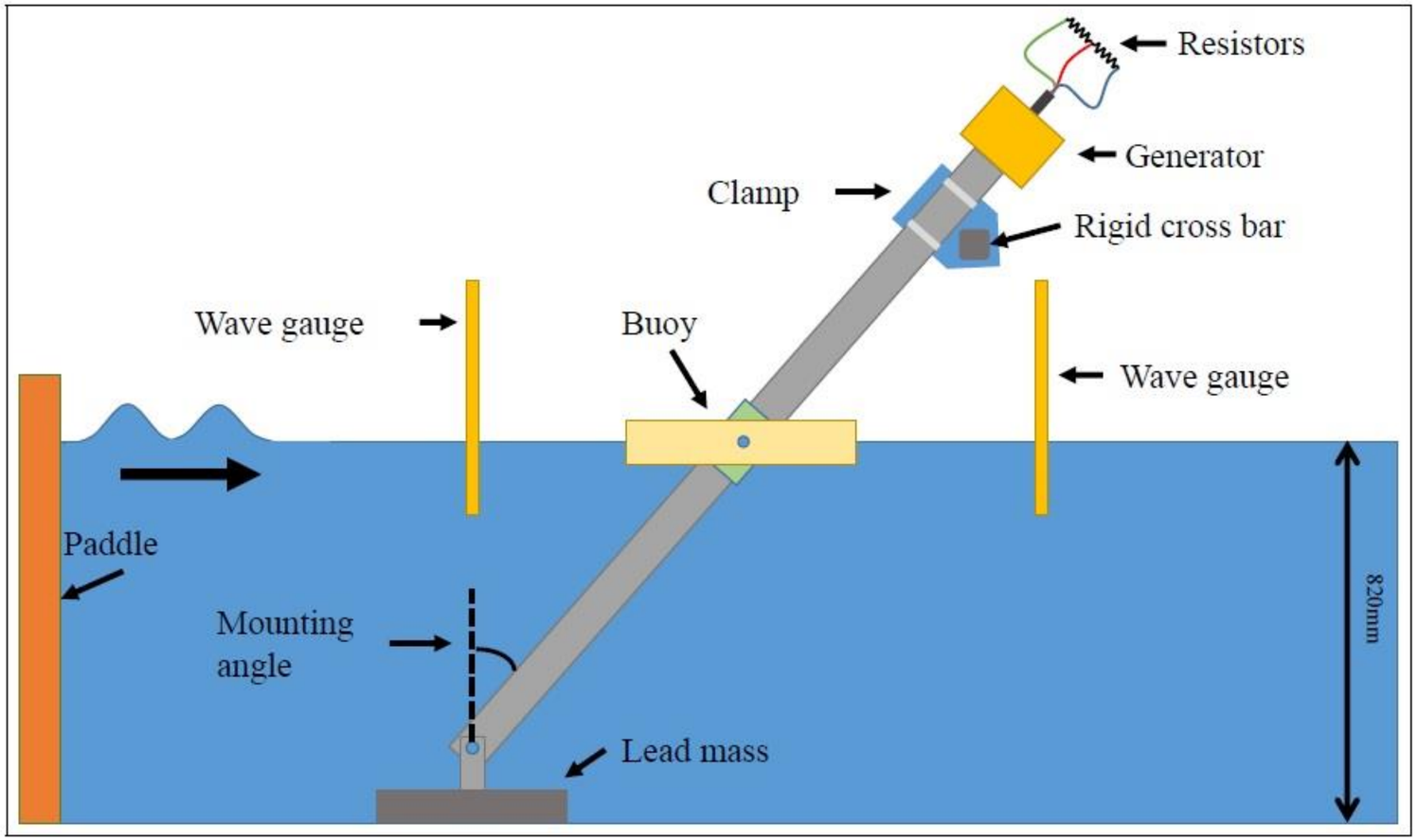


Wave energy device

- Designed to generate 50 to 100 watts under ideal conditions
- Designed for waves up to 1.5m in height
- Used dummy PTO as well as measuring electrical power



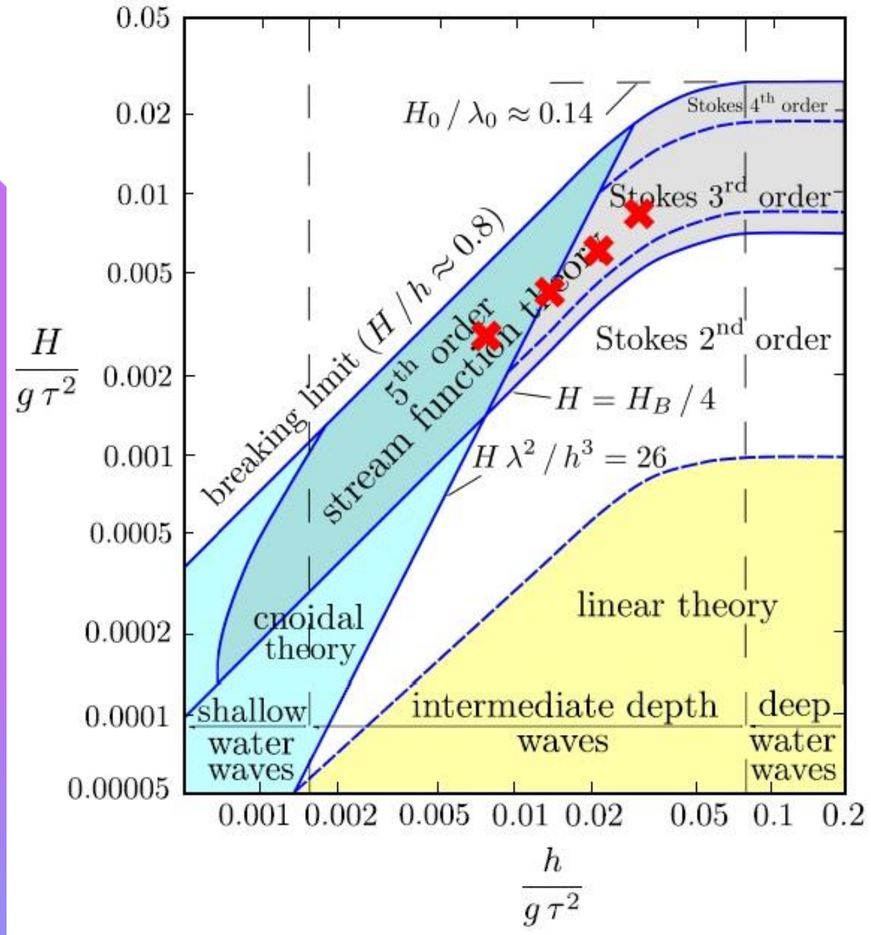
Wave energy device

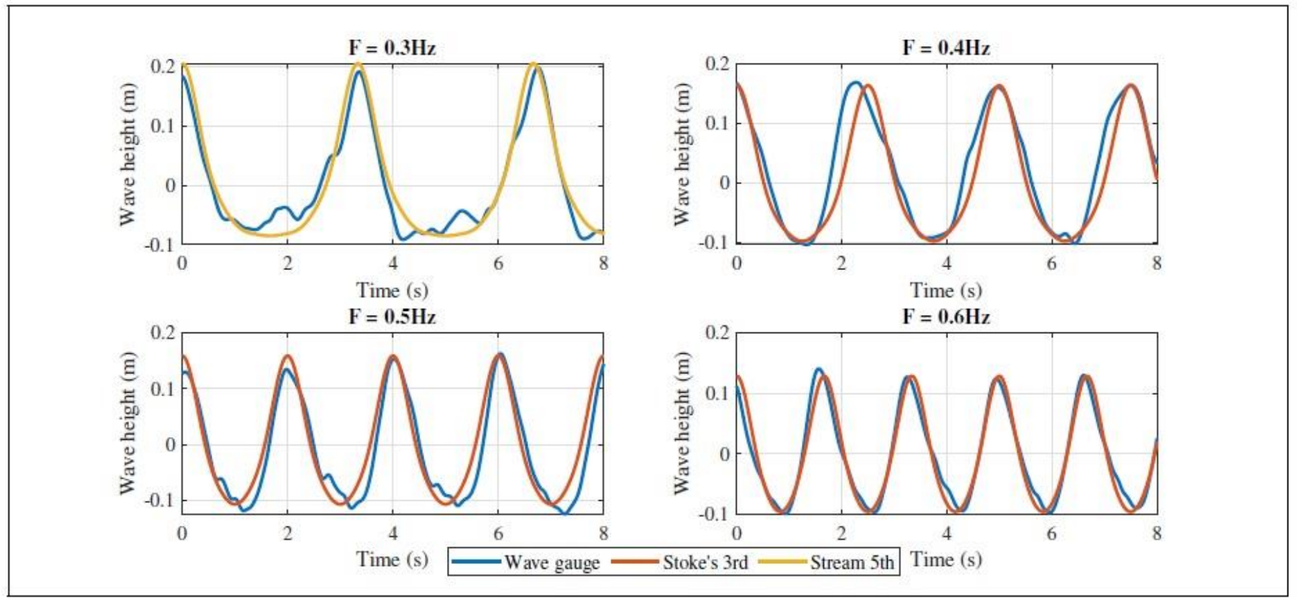


Adjusted Parameters:

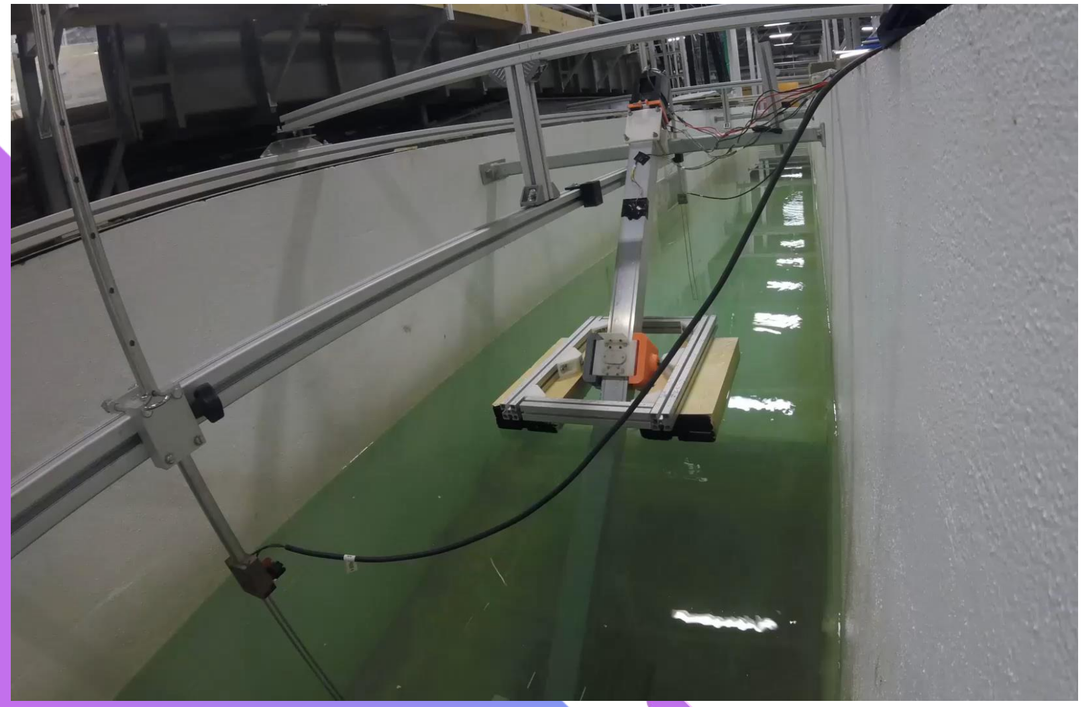
- Wave frequency/amplitude
- PTO damping coefficient
- Device mounting angle

Wave energy device





Wave energy device

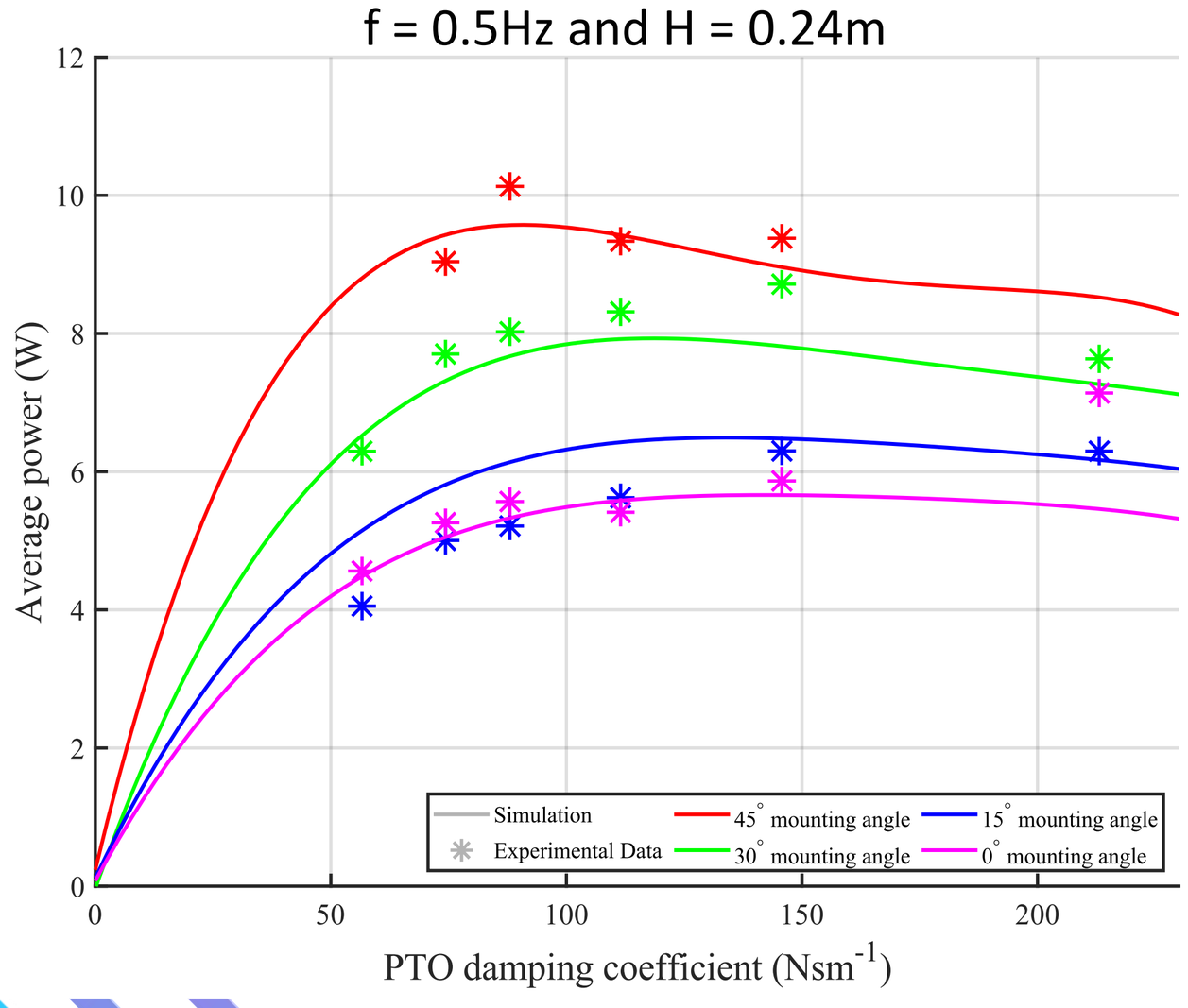


Achieved a maximum average dissipated power of 12W

Generated 6W electrical power

Wave energy device

- Higher angle results in more power
- Peak power occurs at lower damping
- Increased buoy travel distance

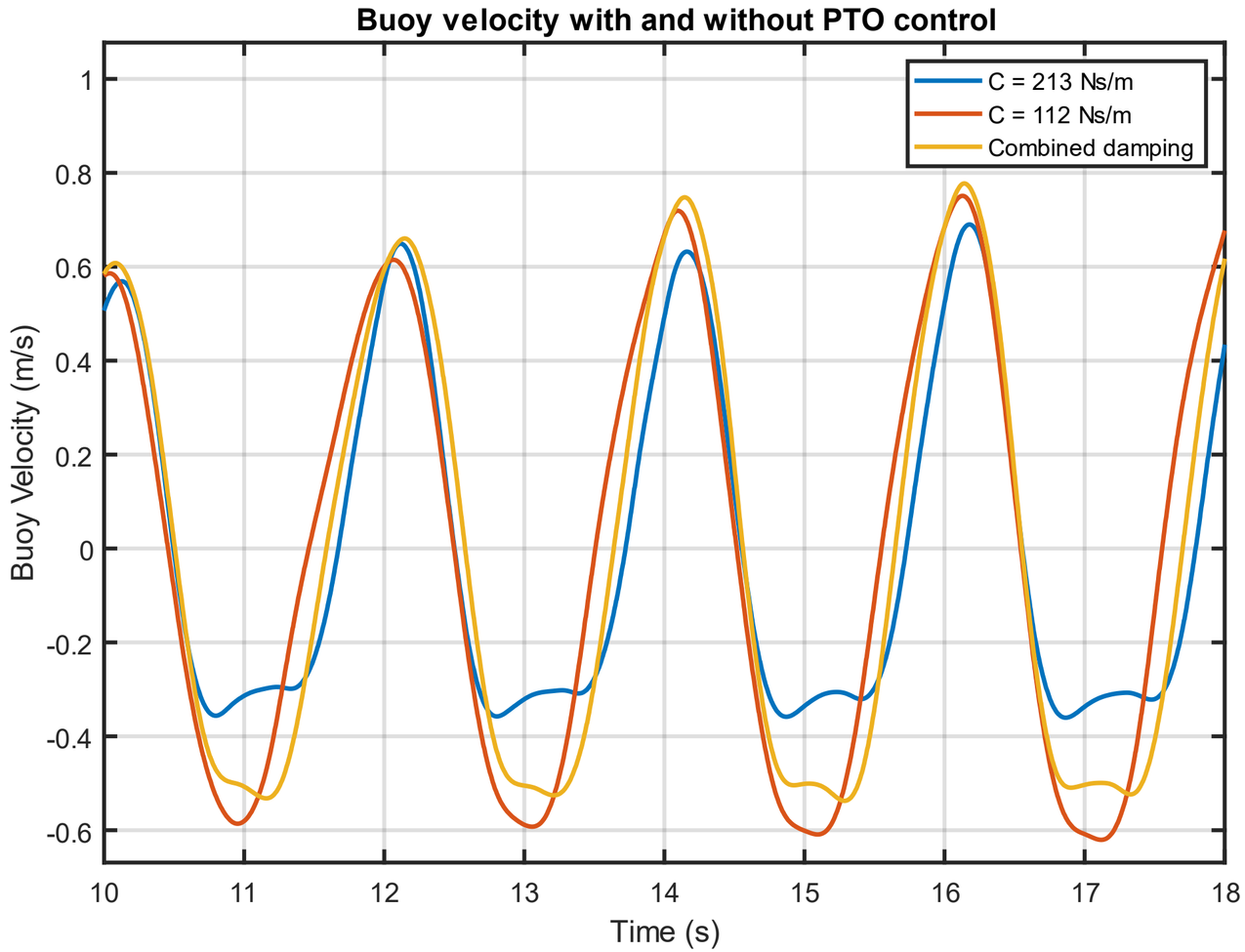


Wave energy device

- Basic control system allows higher velocities and higher PTO forces

$$P_{out} = F_{PTO} \times V_{buoy}$$

- Increased buoy volume for more heave force
- Can result in 25-50% power increase
- Up to 22W of power in wave flume



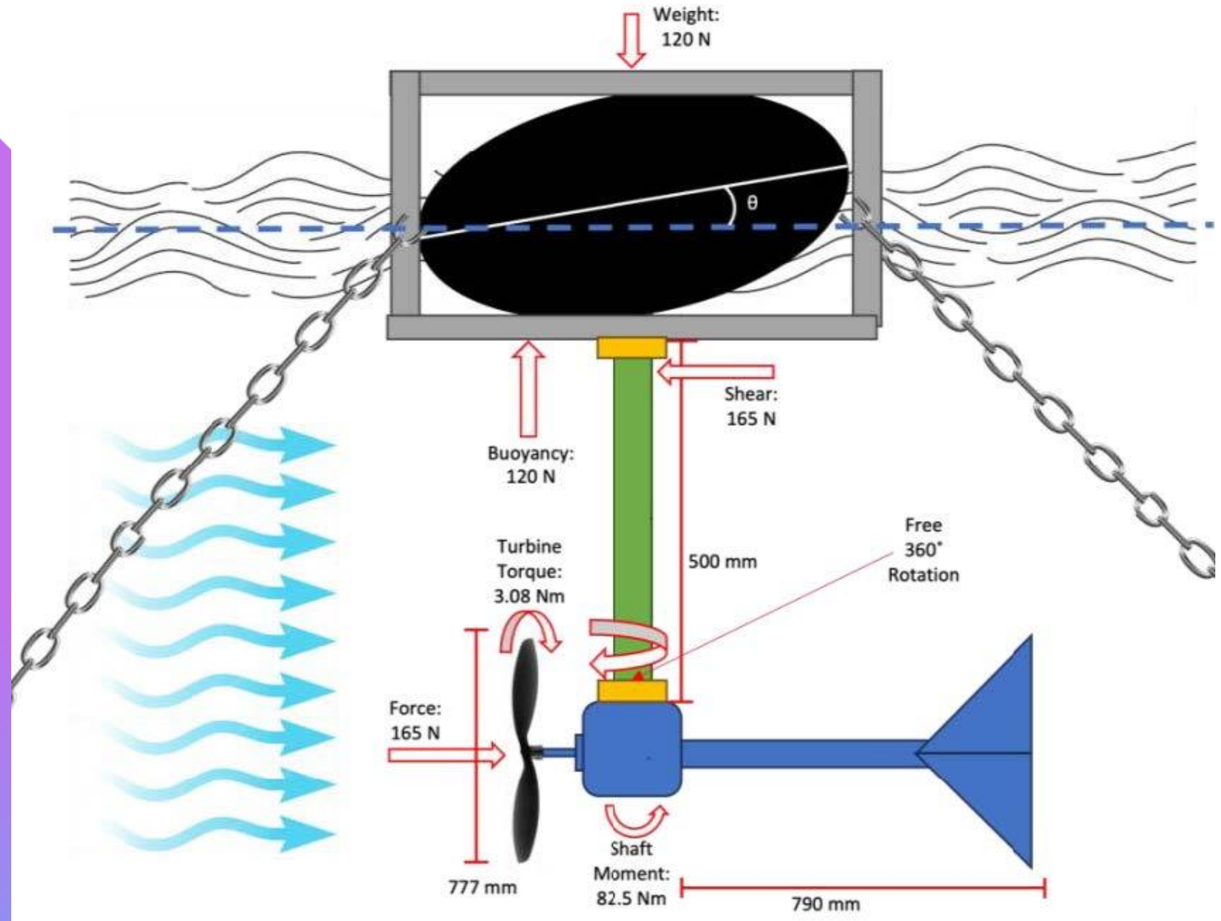
WTEHMF

Wave energy device

Wave energy device

- Device tested at Ōhope Beach in calm nearshore wave conditions
- 0.5m significant wave height with 12s period
- 10W of average power output for moving buoy mass of 6.4kg
- 50kg prototype will produce 125 watts in 1.0m waves

Tidal energy device



Tidal velocity 0.25 m/s
Generated power 2 watts

Moving Forward

01

By mid 2024

Integrate the device with a 300AH lead carbon battery and ocean test at the site of our industrial partner aquafarm

02

By end 2025

- Deployment of 100-200 watt prototypes at aquafarms for charging batteries

03

2026-2027

- Deployment of 1-5 kilowatt device for feeding/storage systems at fish farms