Experimentally observed subharmonic motions of a submerged point absorber wave energy converter

Raza Ali, Dr. Aeron Roach, Dr. Bret Bosma, Dr. Bryson Robertson

PMEC
Pacific Marine Energy Center

UAF
UNIVERSITY OF ALASKA FAIRBANKS

Oregon State University

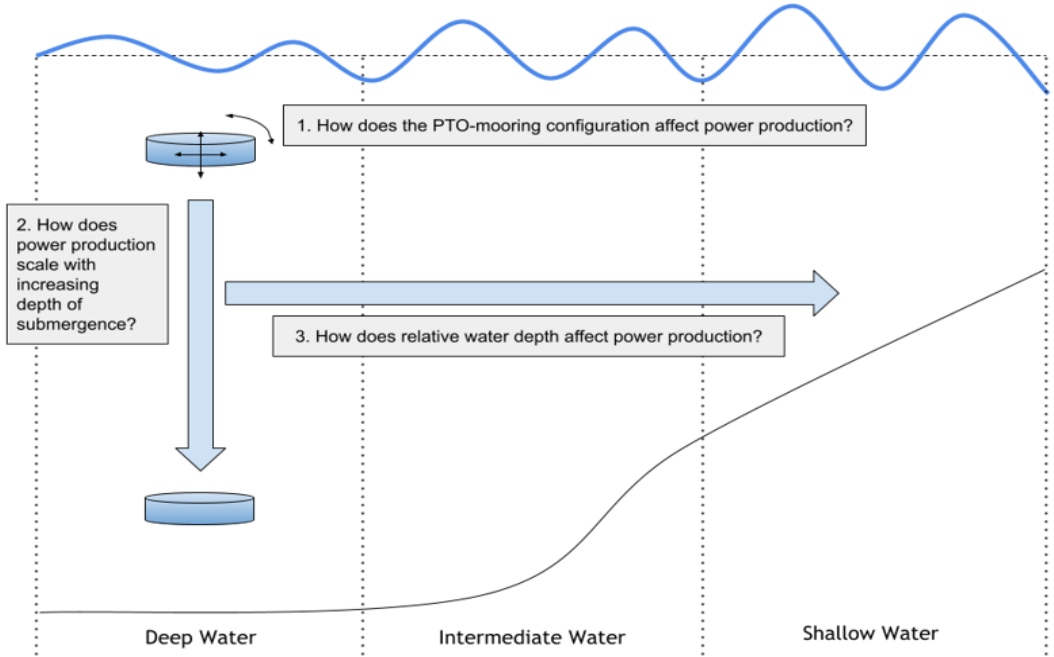
UNIVERSITY of WASHINGTON

Motivation

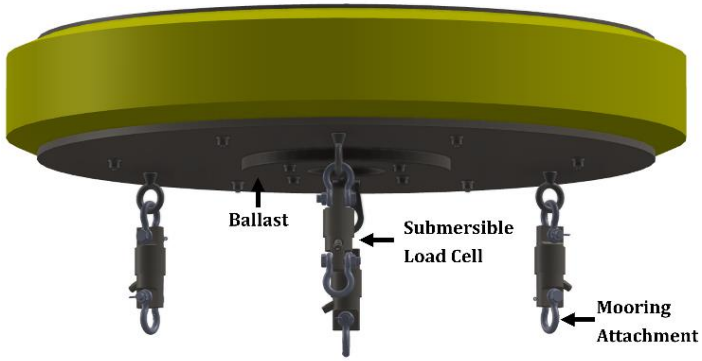
"Is there a technological ability to harness wave power subsurface, and what are the trade-offs in design and construction?"

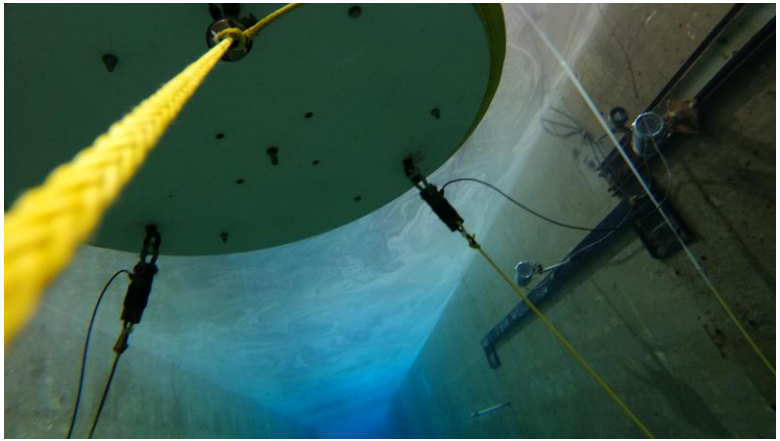
"Are their hydrodynamic opportunities to harness power in different DOF and wave-depth conditions?"

"How can academia-industry collaboration help identify the resource opportunities, develop functional requirements, and design-test-validate subsurface WEC archetypes?"



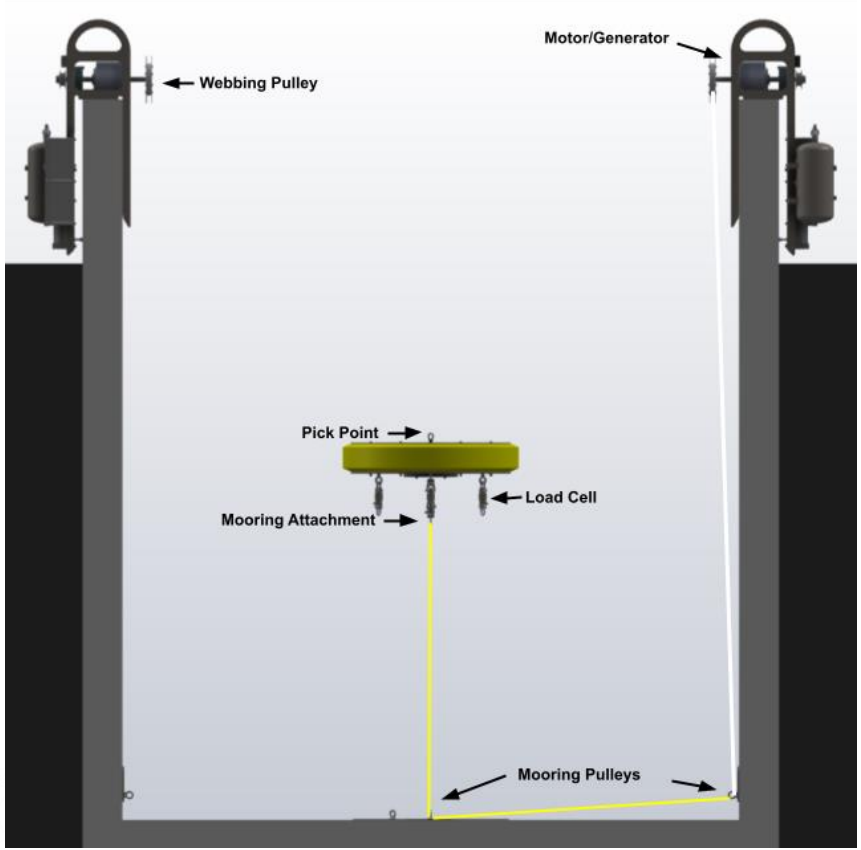
Device Design

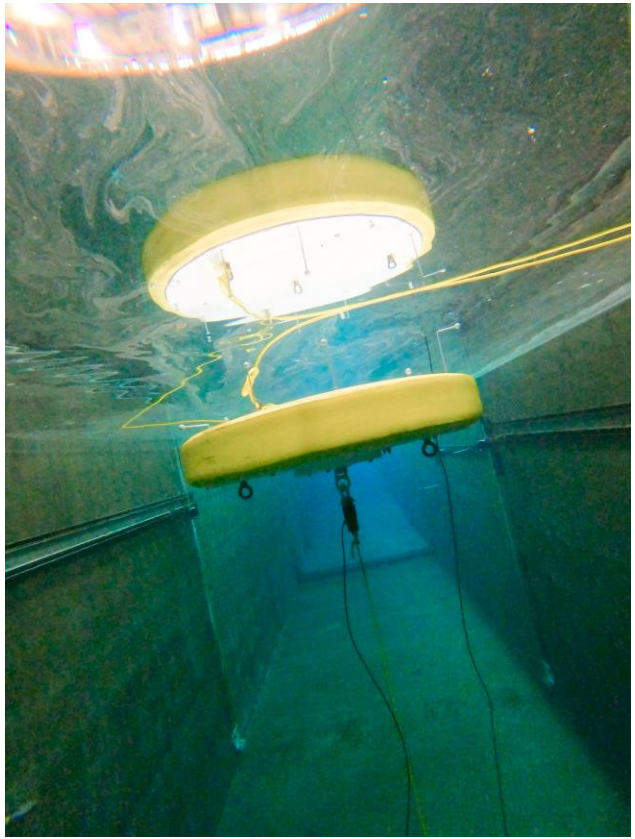




Parameter	Value	Units
Float diameter	1	m
Float height	0.2	m
Float Mass	136-172	kg
Float Buoyancy	326	N
Water Depth	3.69	m
Depth of submergence	0.5-2.5	m
Tether inclination angle	32-58	deg

Device Design





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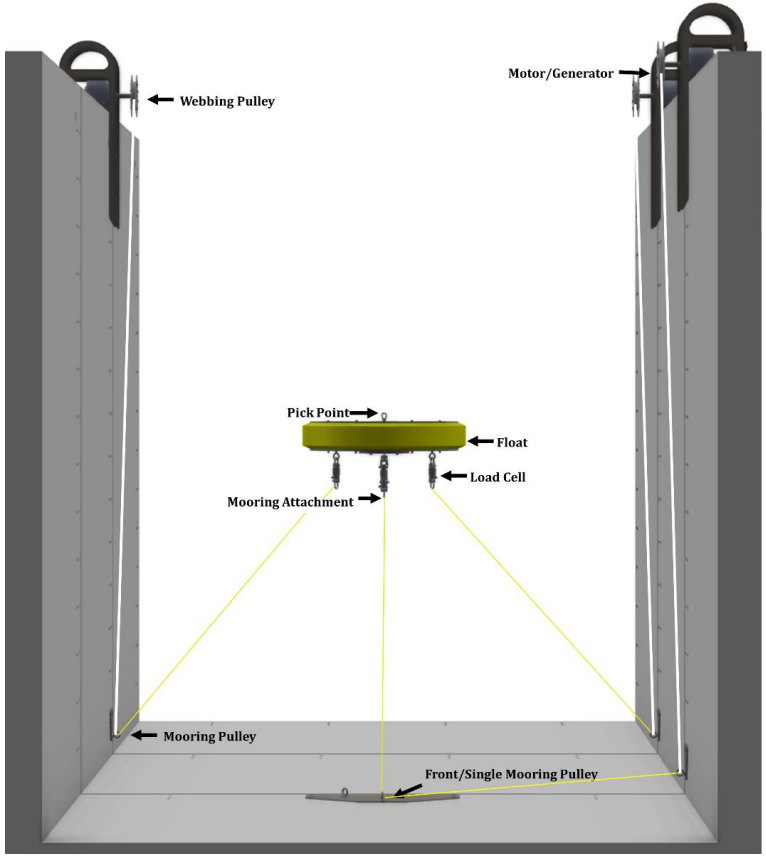
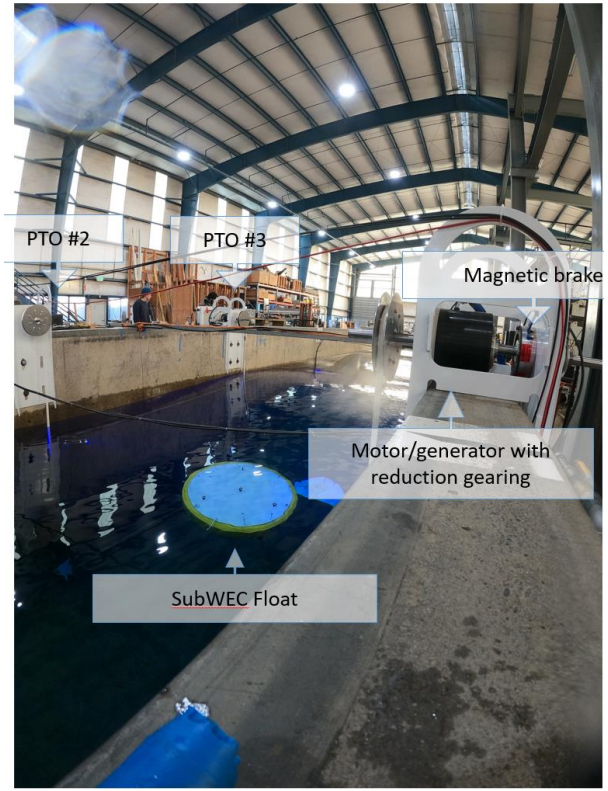
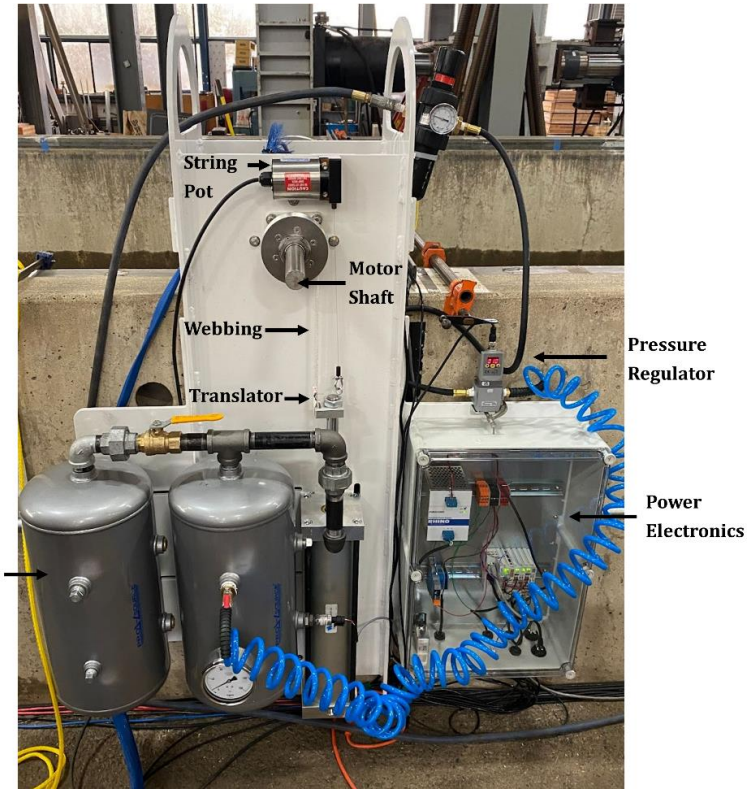
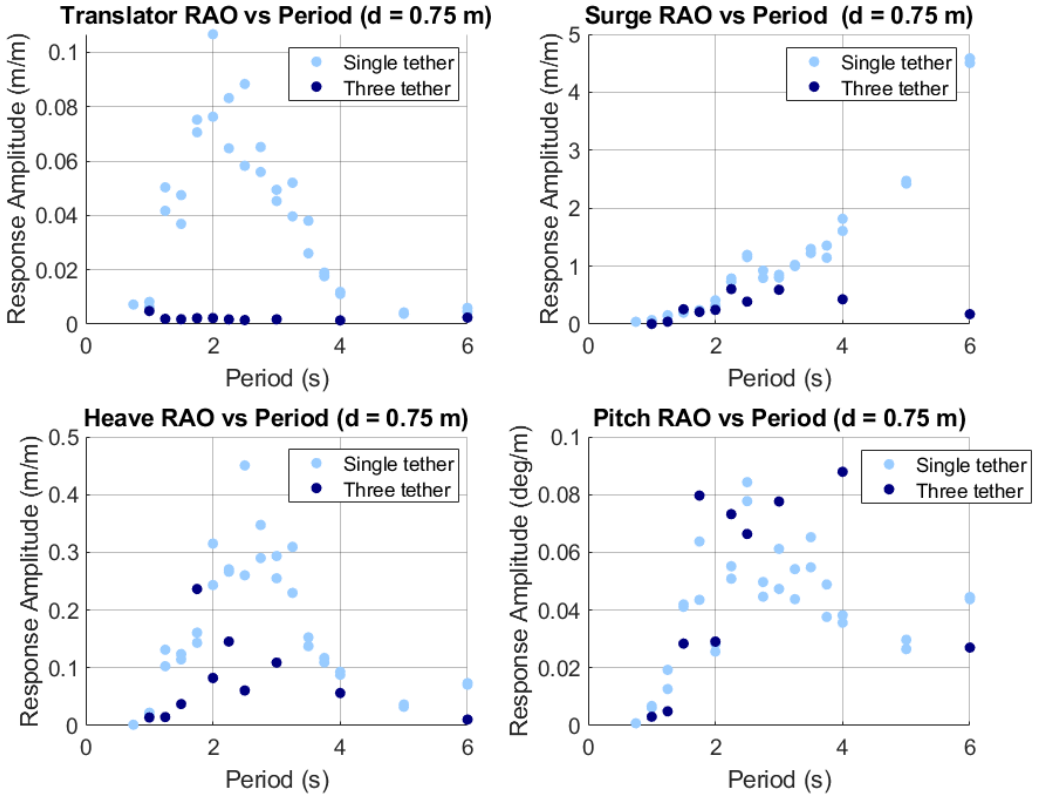


Mooring & PTO Design

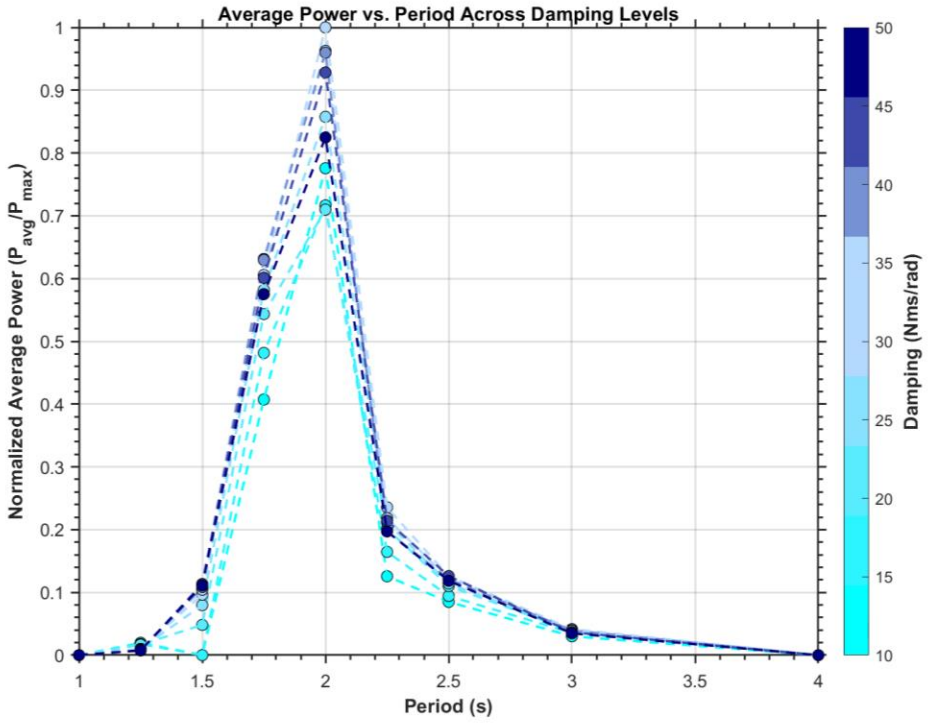


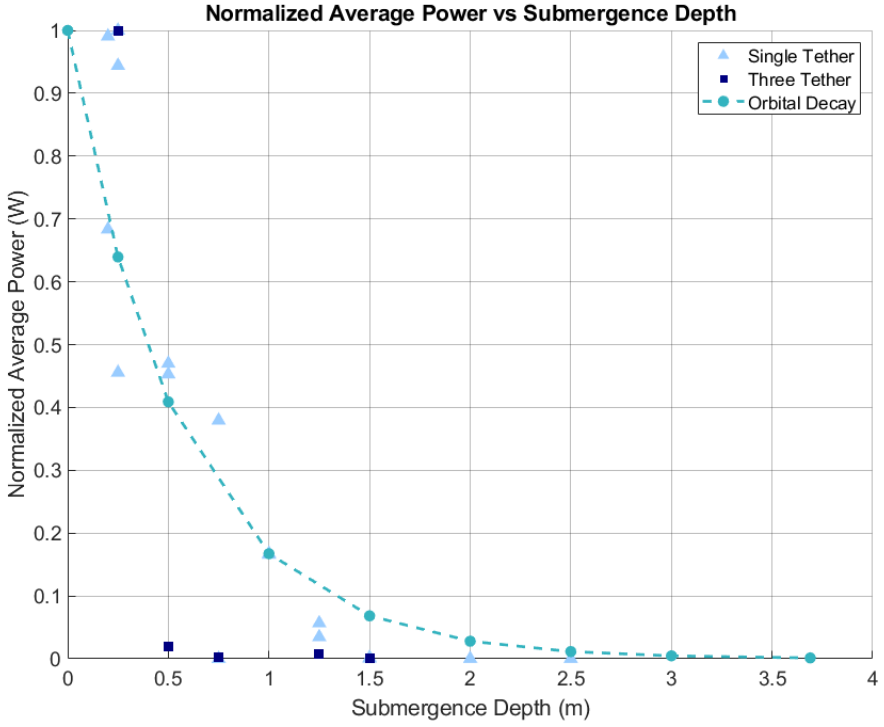


Response Amplitude Operators



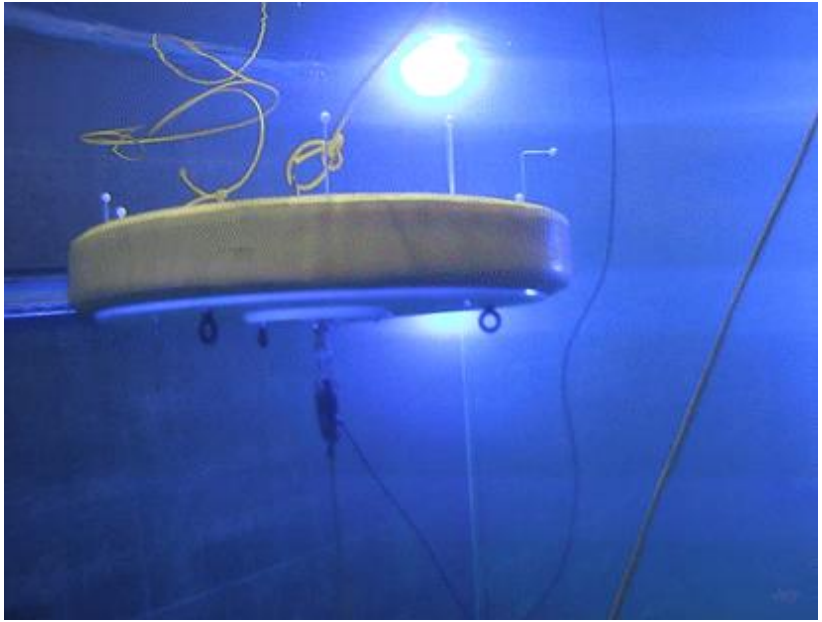
Power Analysis



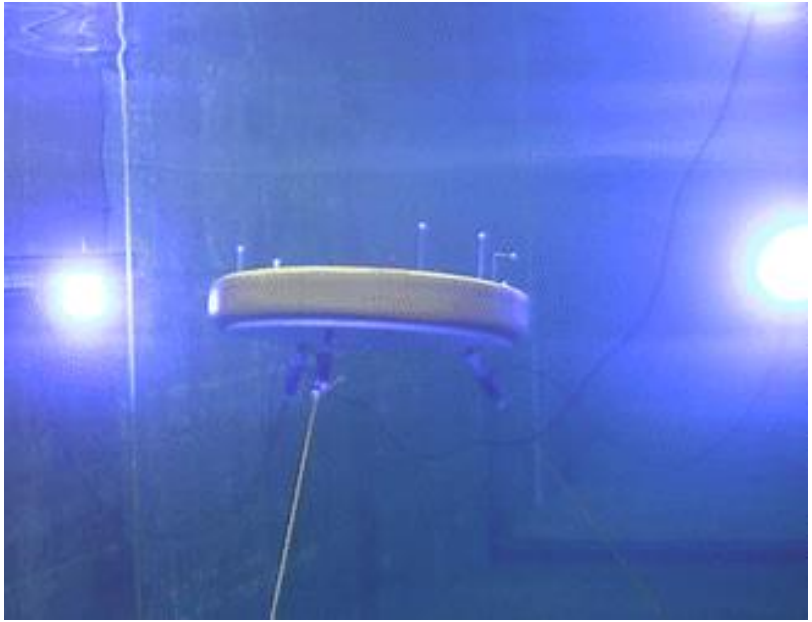


Single vs Three Tether Response

H = 0.30m, **T = 2.25s**, d = 0.75m



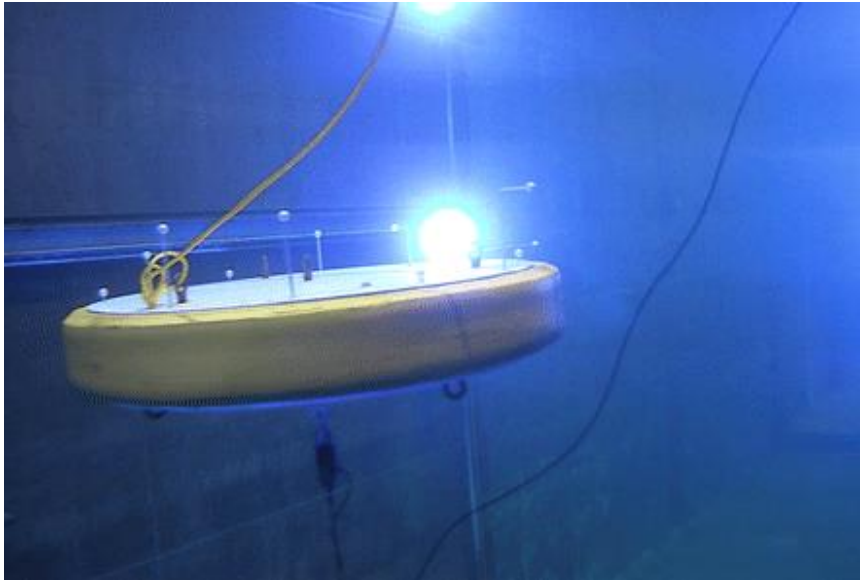
Single Tether



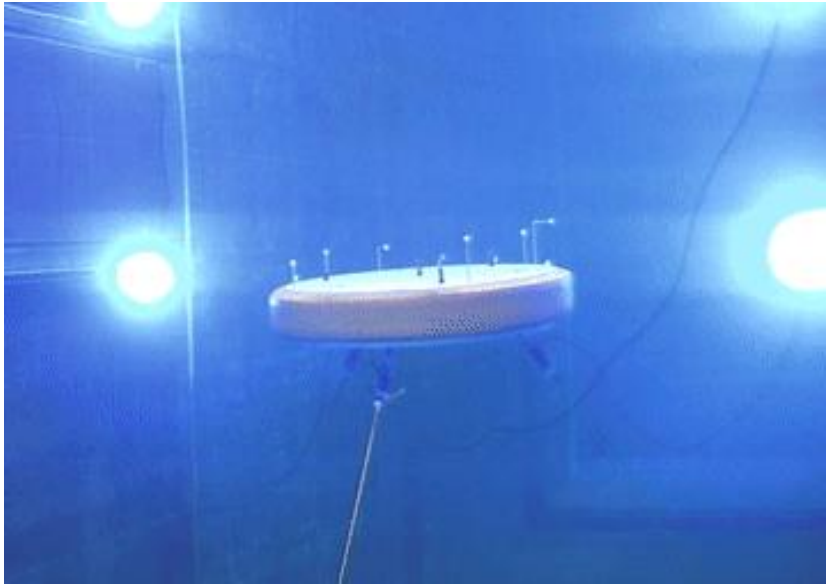
Three Tether

Single vs Three Tether Response

H = 0.30m, **T = 6.0s**, d = 0.75m

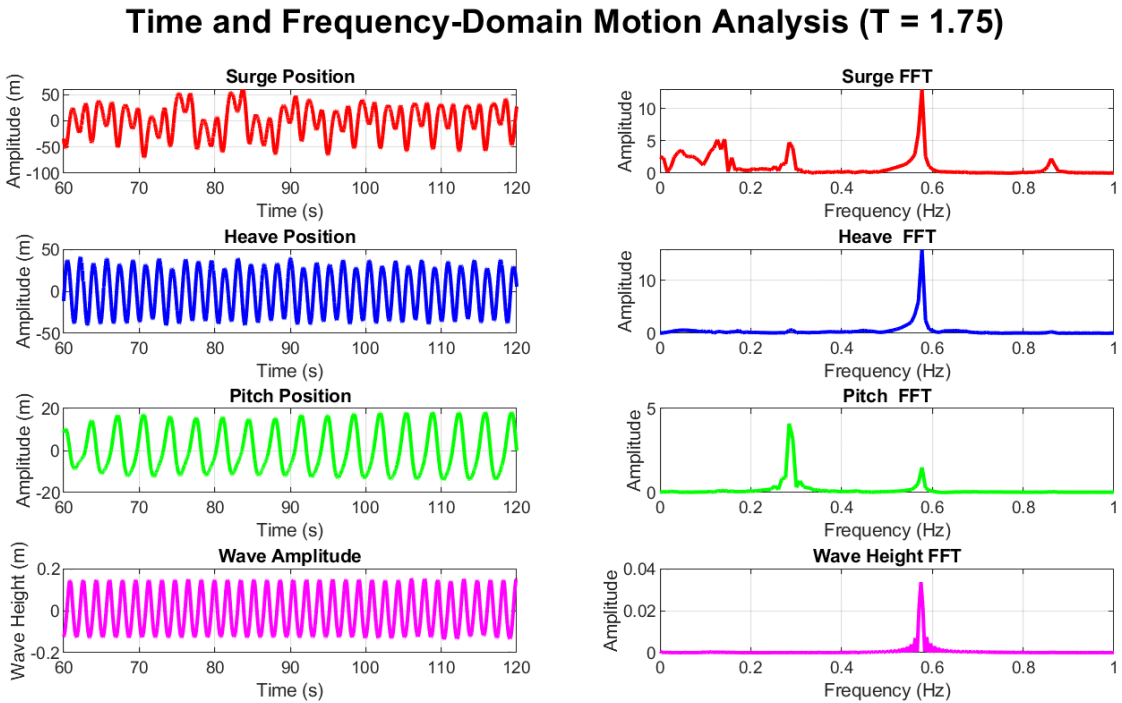


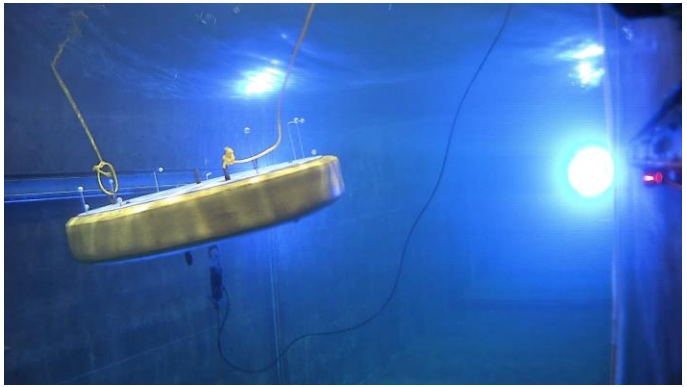
Single Tether

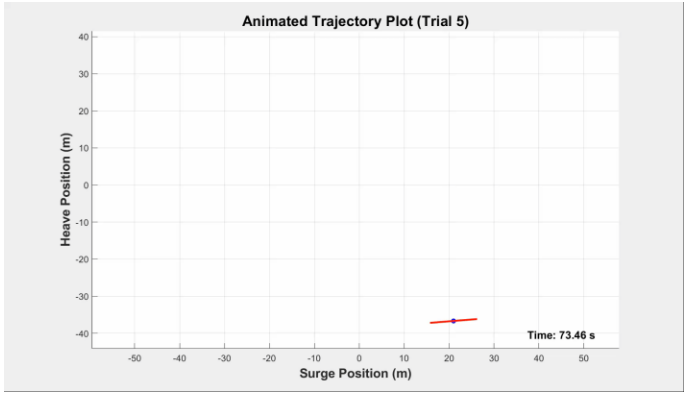


Three Tether

Subharmonic Motions







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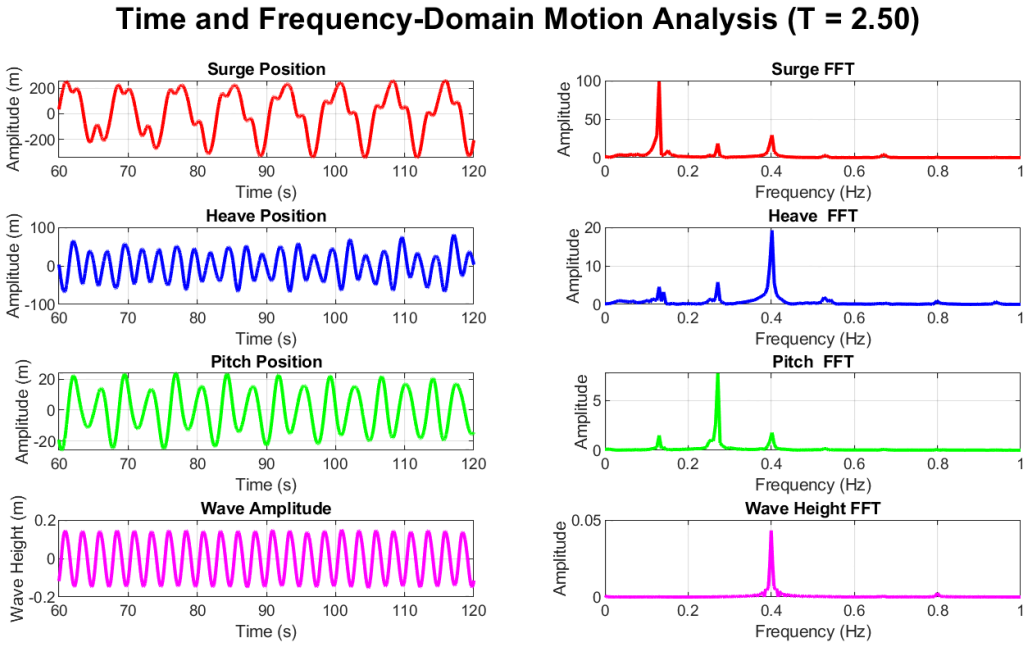

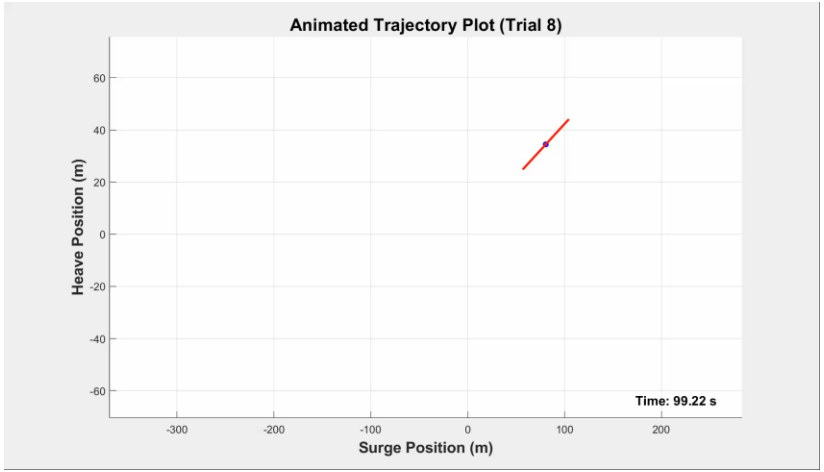

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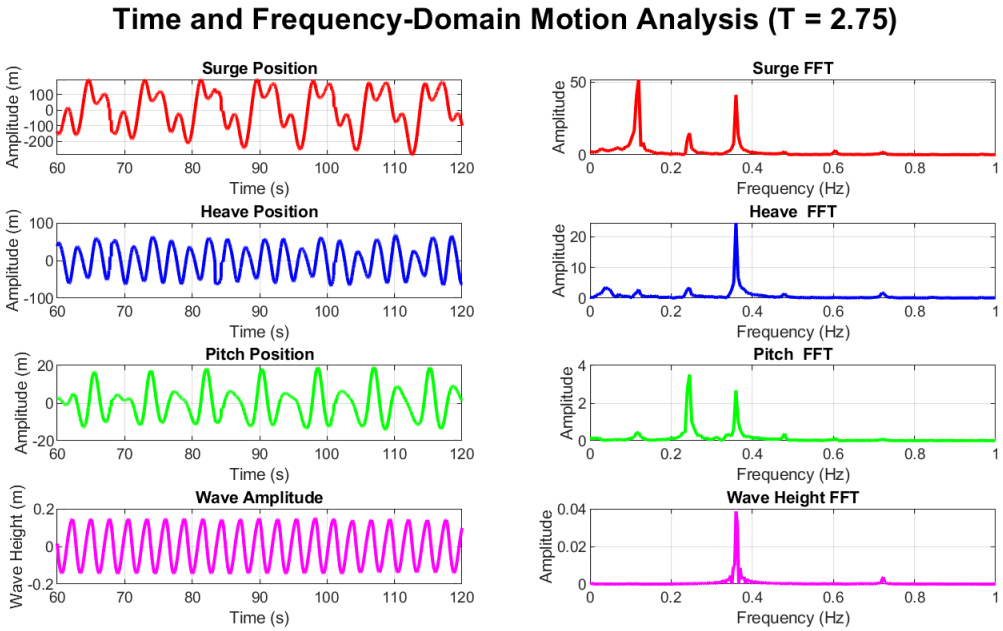

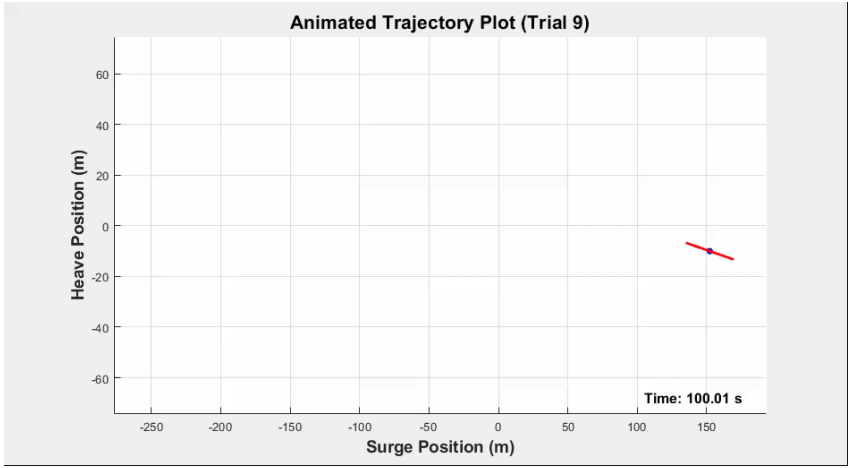

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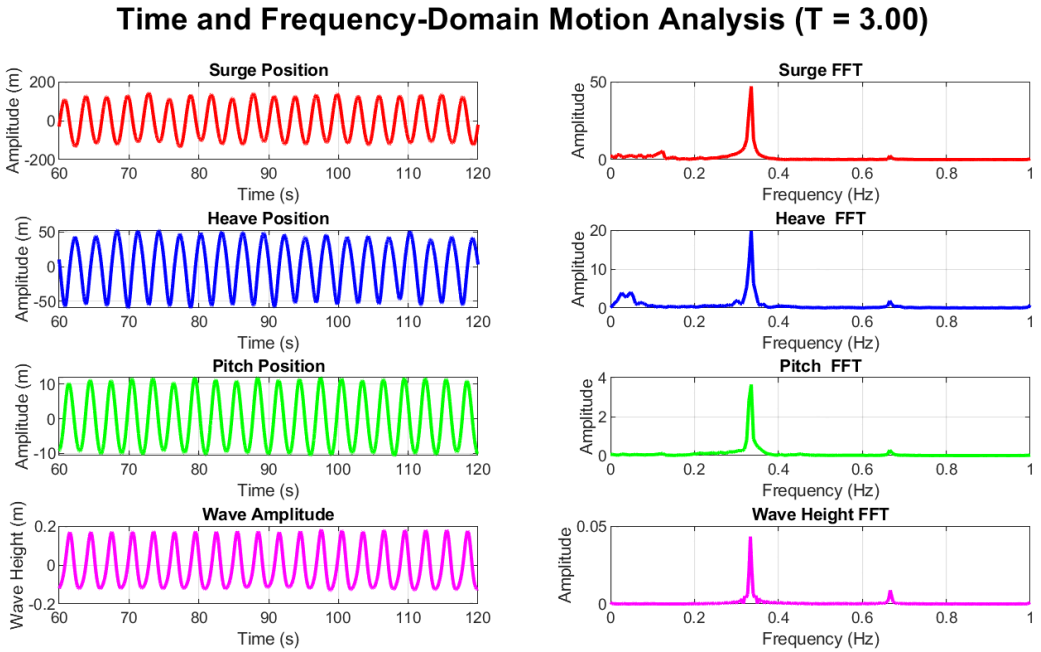

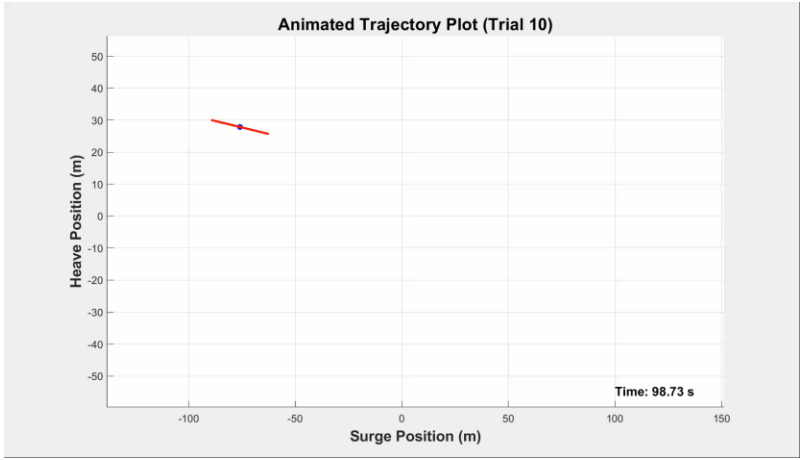

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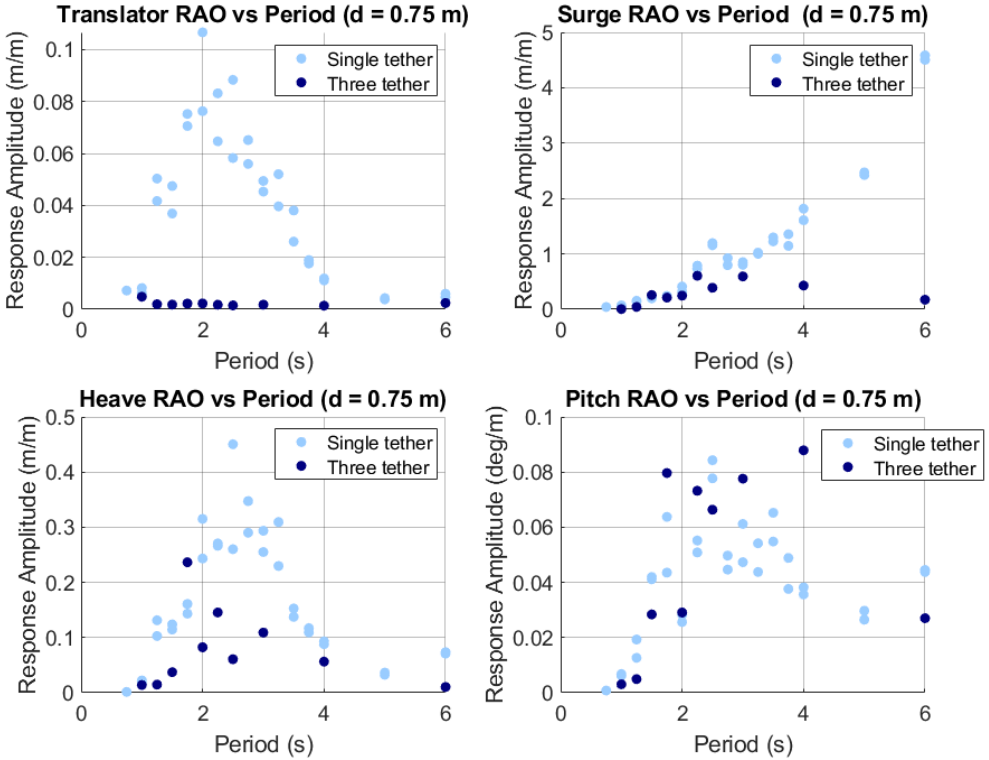

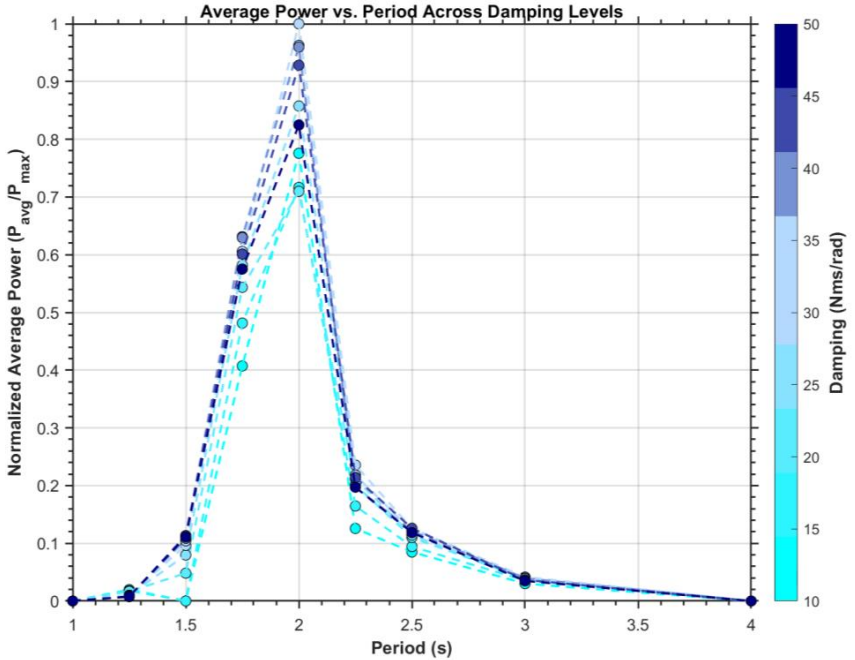

Takeaways & Future Work

Takeaway: Three tether set-up experiences less excitation and less efficient conversion to translator movement. Is this mainly due to increased stiffness in the mooring lines or the added PTO friction?

Future Work: Additional three-tether testing planned for Nov 2025 as well as Linear Test Bed (LTB) friction characterization of the PTO's completed .

Takeaways & Future Work

Takeaway: Subharmonic motions, or parametric resonance occurs at specific periods & significantly hampers device performance and device performance is not accurately predicted by linear models

Future Work: Update numerical models to more accurately reflect PTO spring stiffness dynamics as well as accounting for non-linearities associated with large pitch angles by calculating projected area in each DOF at each instant. Further three tether and irregular wave testing

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Future Work:

Takeaways & Future Work

Takeaway: Float-surface interactions occur when operating at a shallow submergence depth as deep as 0.5 m. Large impacts on device loading and dynamics.

Future Work: Explore the role device diameter, wave period, wavelength, and submergence depth play in this “spouting” phenomenon through SPH models. Help inform developers of the optimal operating depth for their devices.

Thank you!