Modeling and Design of an Adaptive Stiffness Wave Energy Converter

Carson McGuire, Olivia Mabe, and Dr. Matthew Bryant

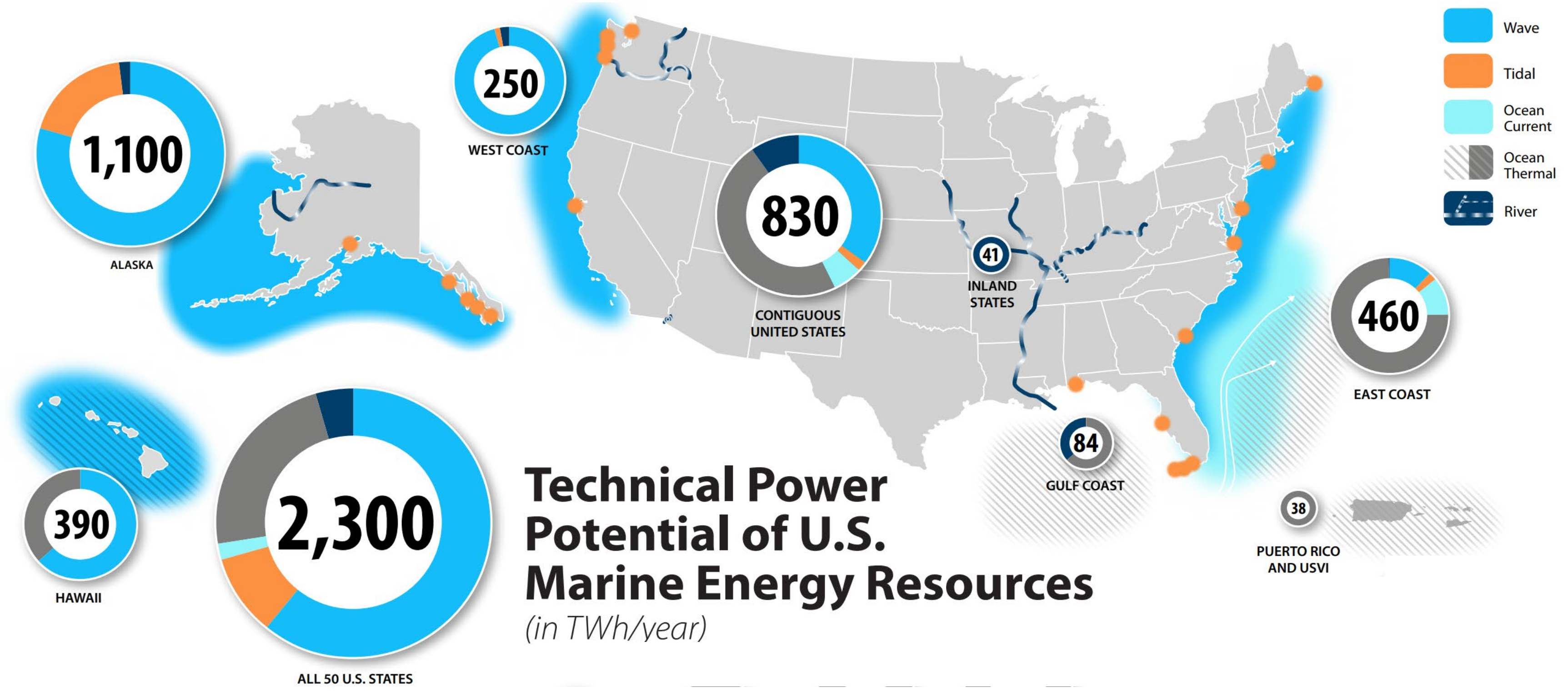
Aug. 14, 2025

UMERC+OREC 2025

NC STATE UNIVERSITY
Mechanical and Aerospace Engineering

Ocean waves offer a substantial source of renewable energy

- Wave power availability in the US: 1400 TWh/yr [1]
  - Sufficient for 130 million homes
- 55 TWh/yr on East Coast alone
- Underutilized source of renewable energy



National Renewable Energy Laboratory overview of U.S. marine energy resource [1]

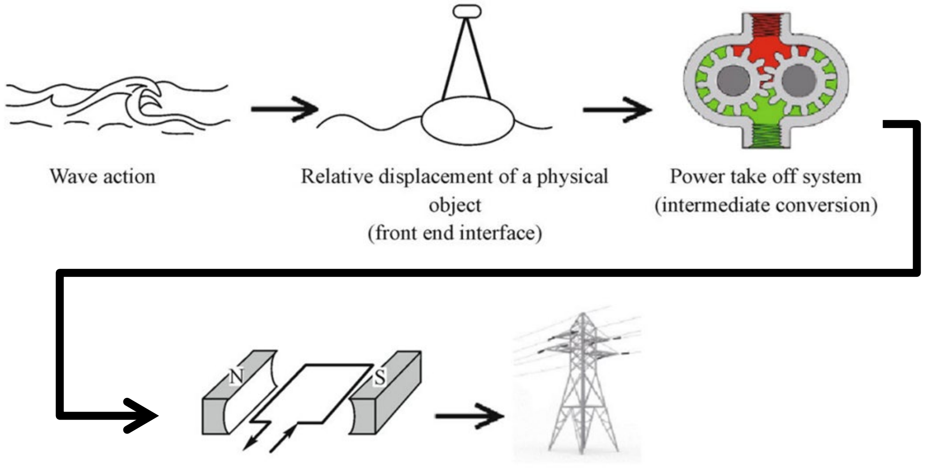
[1] L. Kilcher, M. Fogarty, and M. Lawson, "Marine Energy in the United States: An Overview of Opportunities," 2021. Available: https://www.nrel.gov/docs/fy21osti/78773.pdf

Carson McGuire • cmmcguir@ncsu.edu

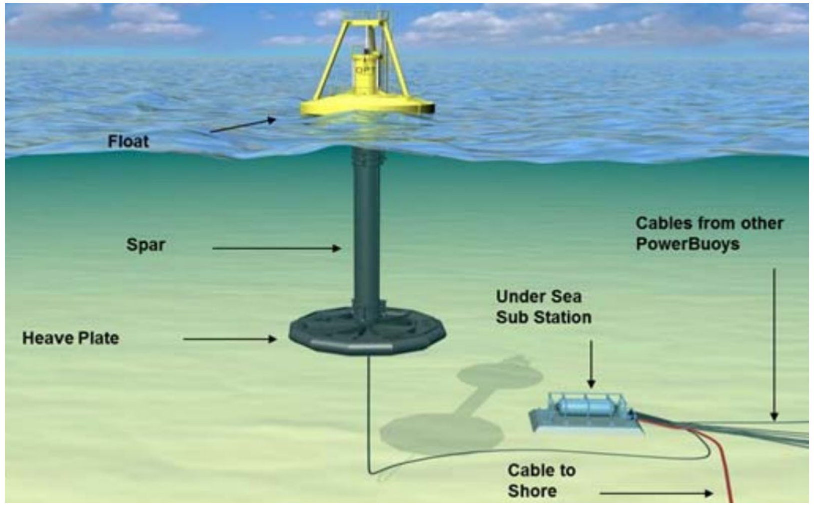
Ocean waves offer a substantial source of renewable energy

- Wave power availability in the US: 1400 TWh/yr [1]
  - Sufficient for 130 million homes
- 55 TWh/yr on East Coast alone
- Underutilized source of renewable energy

- **Wave energy converters (WECs)**: Generate usable work from wave energy
- **Point absorbers**: Buoy heaves up and down due to ocean wave motion to drive a power take-off element



[2]



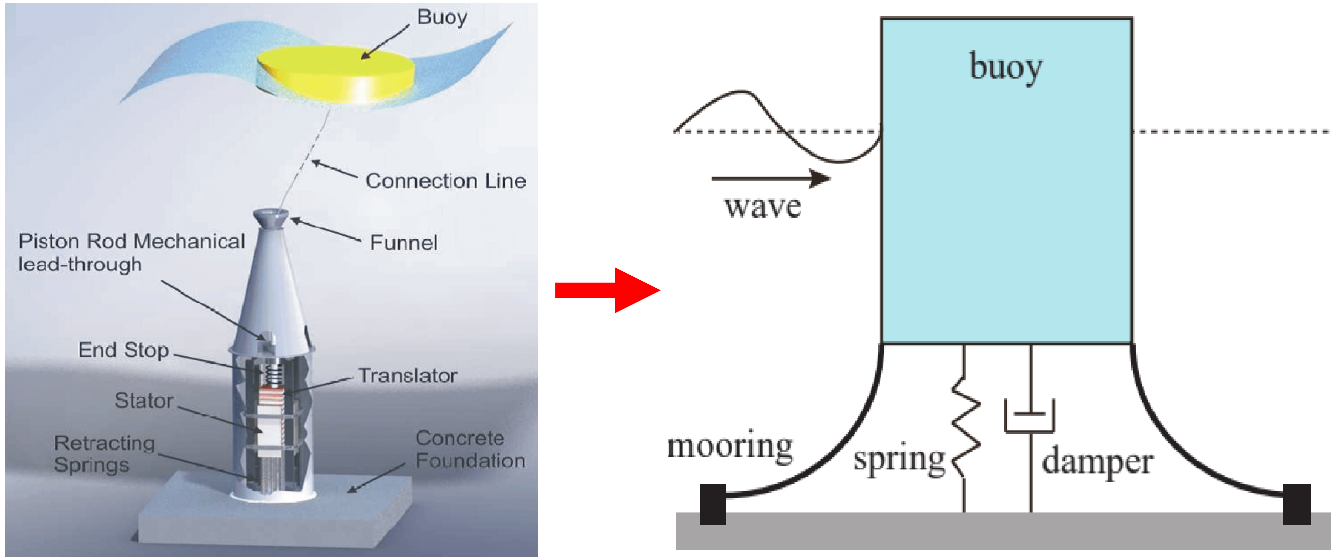
PowerBuoy point absorber [3]

[2] N. Santhosh, V. Baskaran, A. Amarkarthik, "A review on front end conversion in ocean wave energy converters," Front. Energy, vol. 9, no. 3, pp. 297-310, Oct. 2015, doi: 10.1007/s11708-015-0370-x.
[3] M. Mekhiche and K. Edwards, "Ocean Power Technologies PowerBuoy: System-Level Design, Development and Validation Methodology," in Proc. 2nd Marine Energy Tech. Symposium, Seattle, WA, USA, Apr. 15-18, 2014. [Online]. Available: http://hdl.handle.net/10919/49232

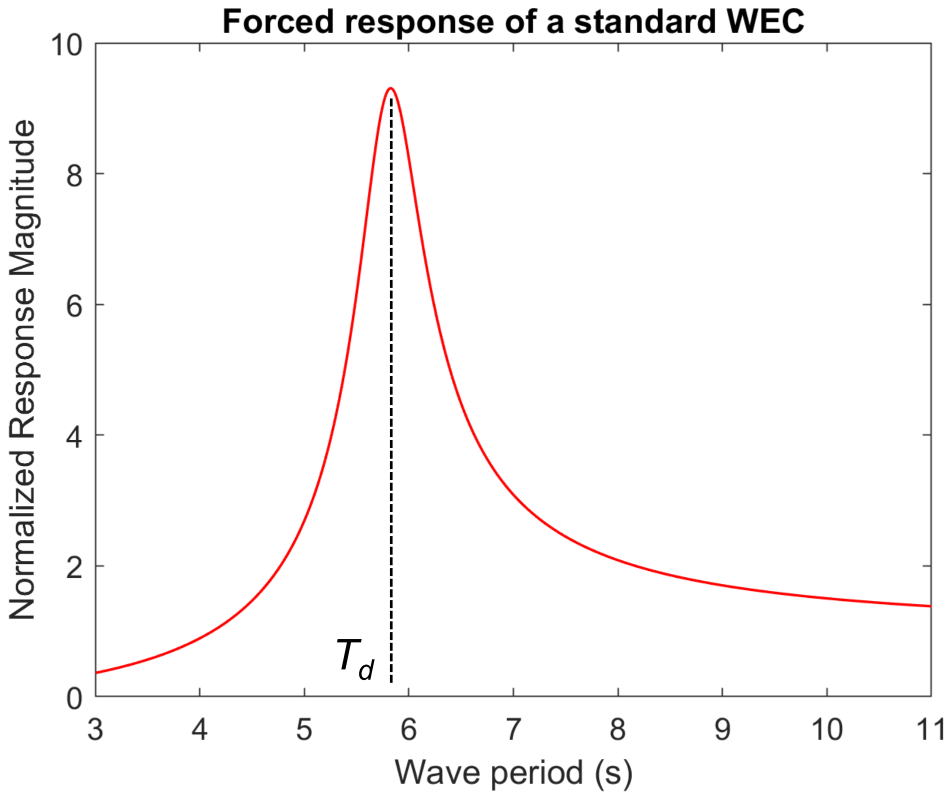
A fundamental limitation of point absorbers: narrowband response

- Point absorber dynamics are analogous to mass-spring-damper systems
  - **Resonant period**: Best performance at one particular driving period
  - **Narrowband response**: Displacement falls off away from the resonant period
  - Most are tuned to one driving period

$$T_d = \frac{2\pi}{\sqrt{\frac{\boldsymbol{k}}{m} - \frac{c^2}{4m^2}}}$$



Mass-spring-damper representation of a point absorber [4]

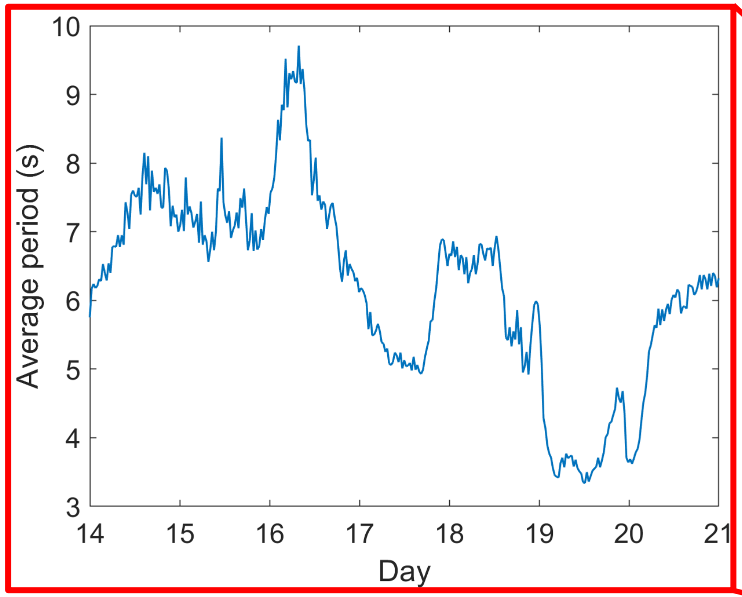


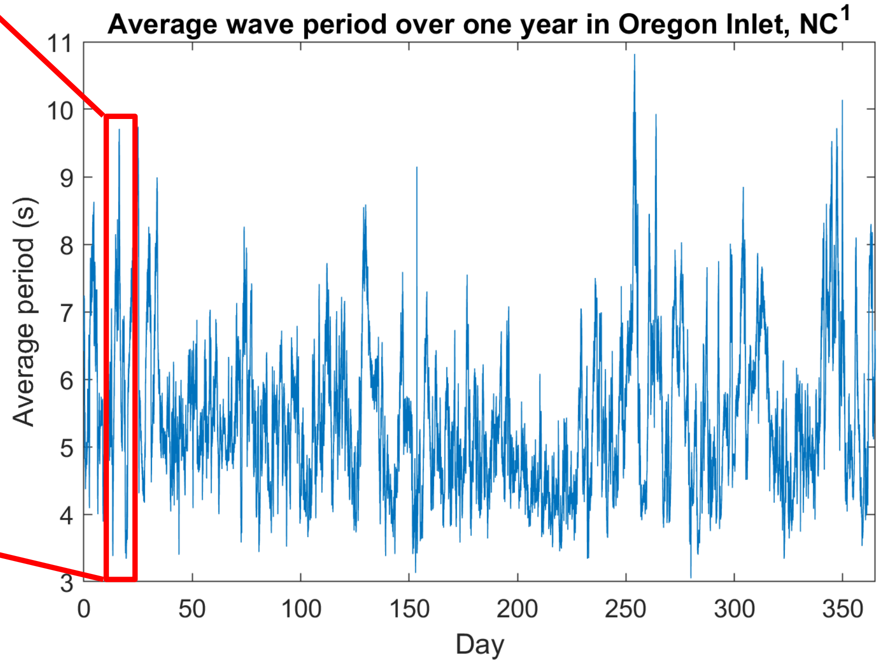
[4] B. Guo, T. Wang, S. Jin, S. Duan, K. Yang, and Y. Zhao, “A Review of Point Absorber Wave Energy Converters,” Journal of Marine Science and Engineering, vol. 10, no. 10, p. 1534, Oct. 2022, doi: https://doi.org/10.3390/jmse10101534.

Carson McGuire • cmmcguir@ncsu.edu

Motivation for developing an adaptive-stiffness point absorber

- Ocean wave periods vary significantly with time
  - Example: Wave periods off Oregon Inlet vary from 3 – 10 seconds ($\text{Mean} = 5.54\ \text{s}, \sigma = 1.22\ \text{s}$)
- WECs cannot perform optimally much of the time
  - Capacity factor = $\frac{\text{Actual energy output over time}}{\text{Theoretical maximum energy output over time}}$
- Performance would improve by adjusting resonant period dynamically to match driving waves
  - Focus of this work: **Control mooring stiffness to improve WEC performance with a "hose-pump"**





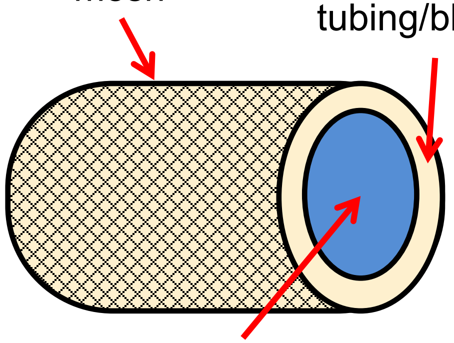
Data collection location: CDIP Station 192 [5]

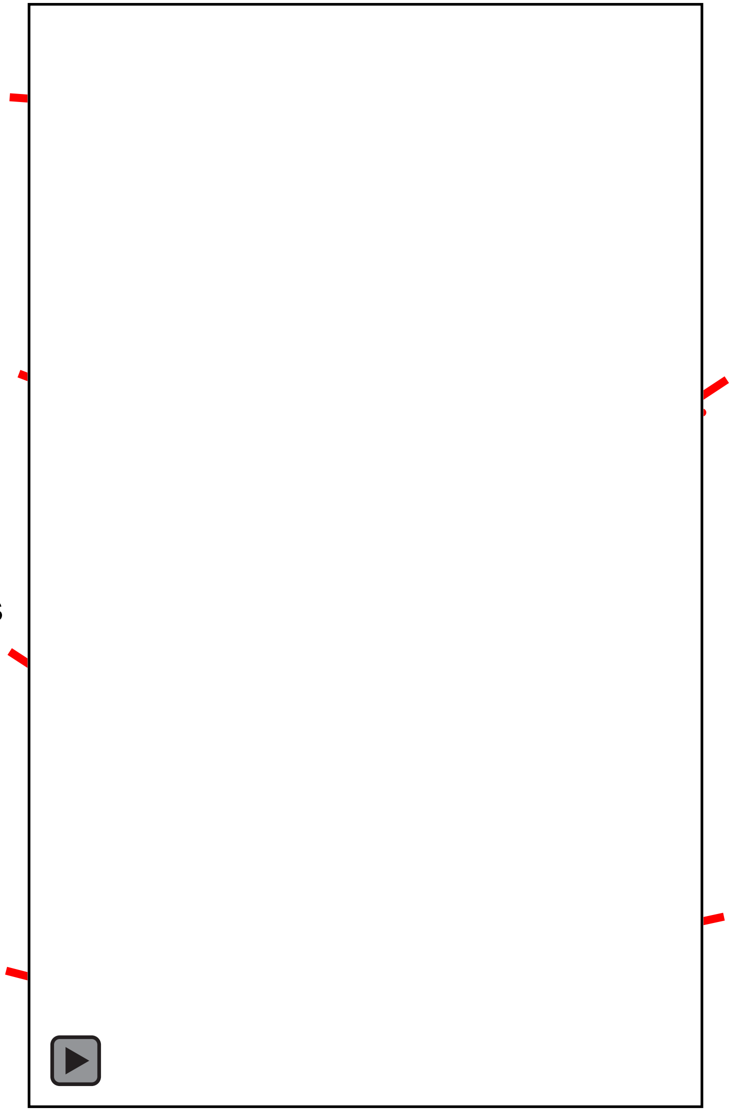
[5] Coastal Data Information Program, https://cdip.ucsd.edu/m/products/?stn=192p1

Carson McGuire • cmmcguir@ncsu.edu

Hose-pump material: Fluidic flexible matrix composite (F2MC)

- F2MC pump:
  - Helically braided fiber mesh tube embedded in a rubber elastomer matrix
  - Fiber kinematics produce volume change when stretched/relaxed

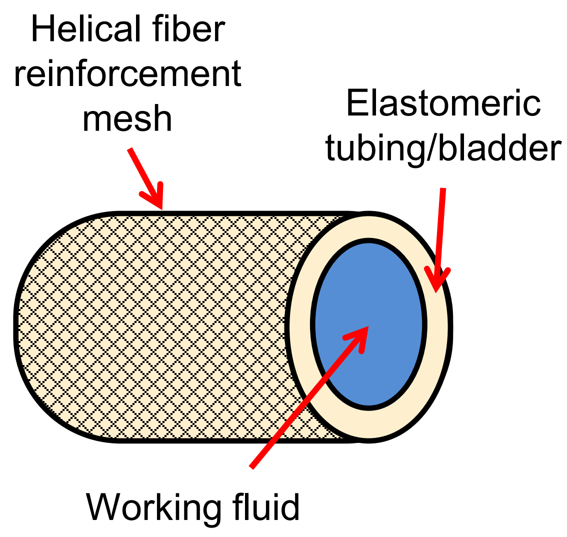


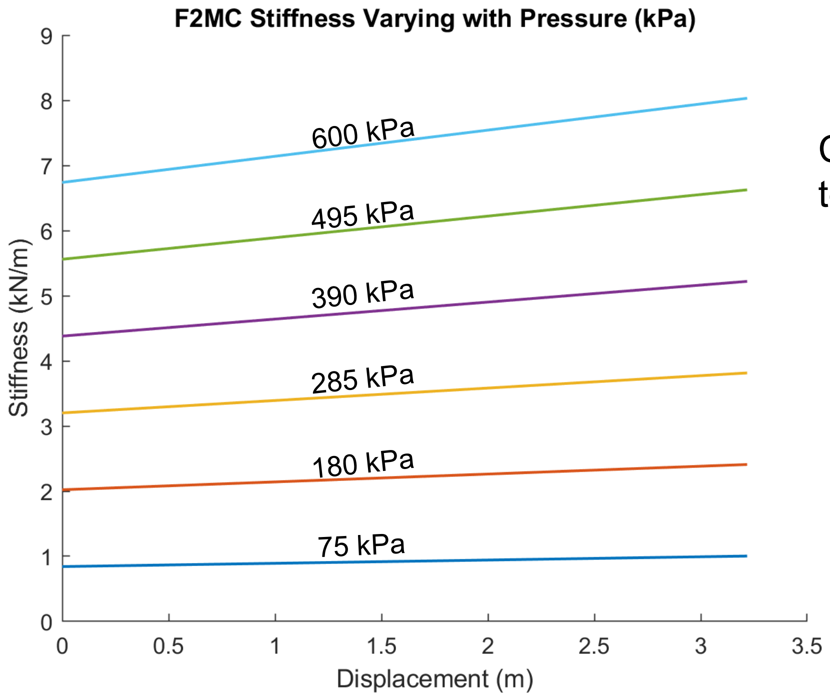


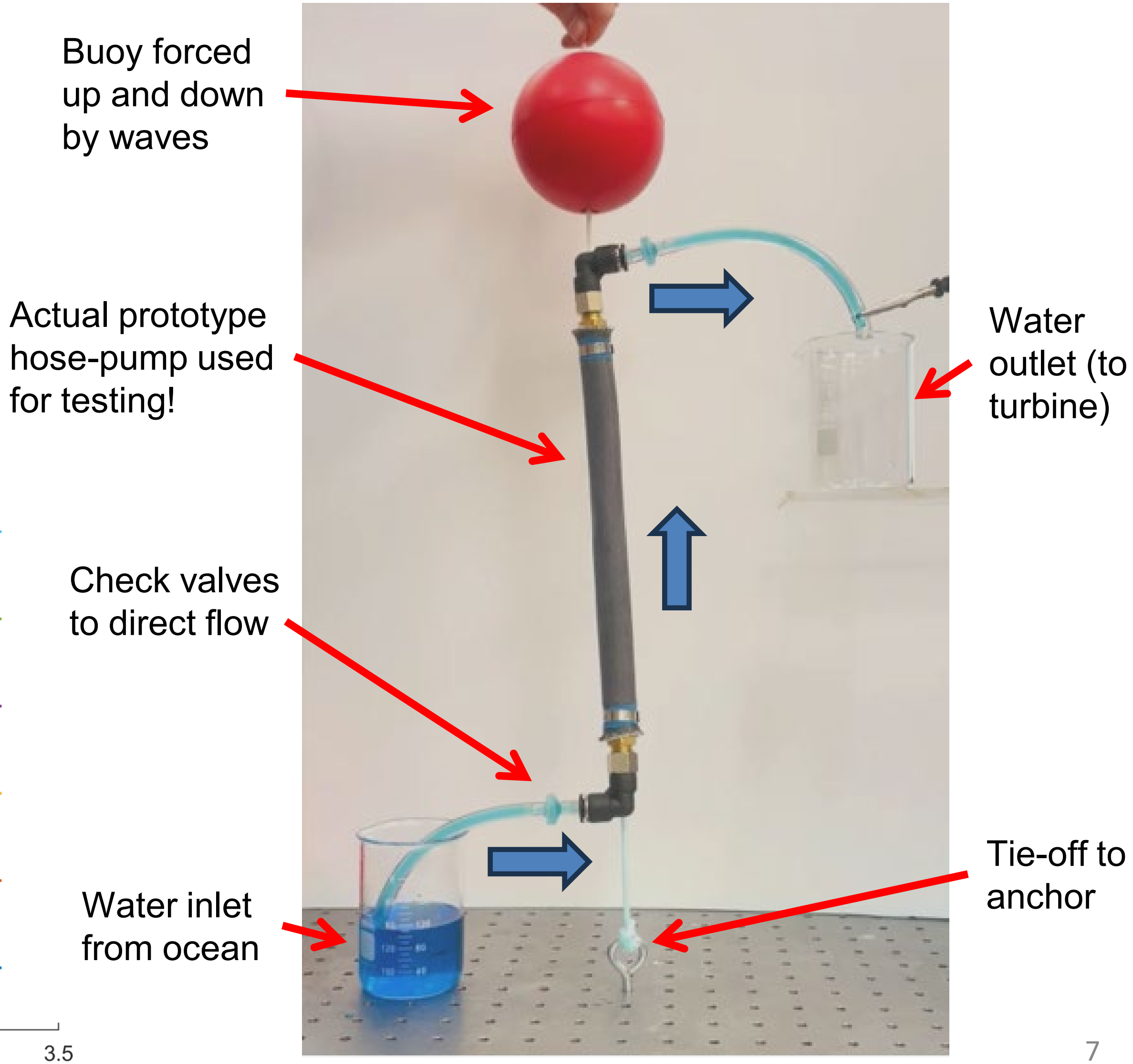
Carson McGuire • cmmcguir@ncsu.edu

Hose-pump material: Fluidic flexible matrix composite (F2MC)

- F2MC pump:
  - Helically braided fiber mesh tube embedded in a rubber elastomer matrix
  - Fiber kinematics produce volume change when stretched/relaxed
- **Useful property**: F2MC axial stiffness is strongly dependent on internal fluid pressure

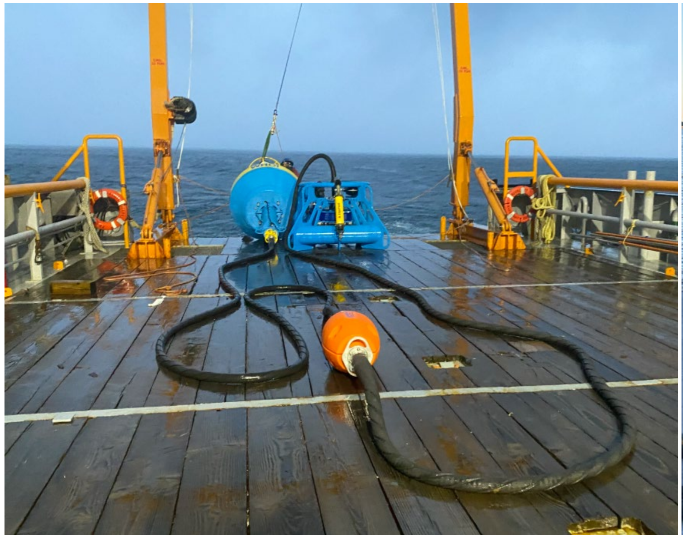


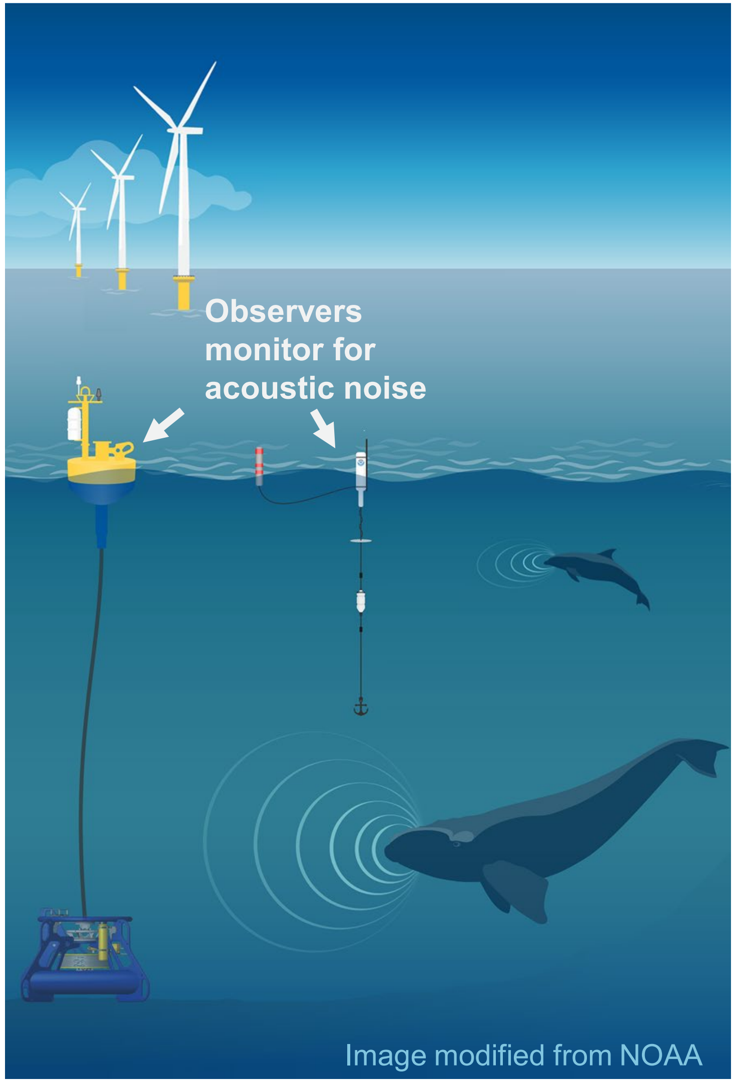




Reinforced hoses have been proven reliable for mooring use

- Woods Hole Oceanographic Institute (WHOI) has developed high-compliance reinforced rubber hoses as moorings
- Acoustically quiet
- Active deployments include:
  - OOI Coastal Pioneer Array
  - Robots4Whales whale monitoring buoys

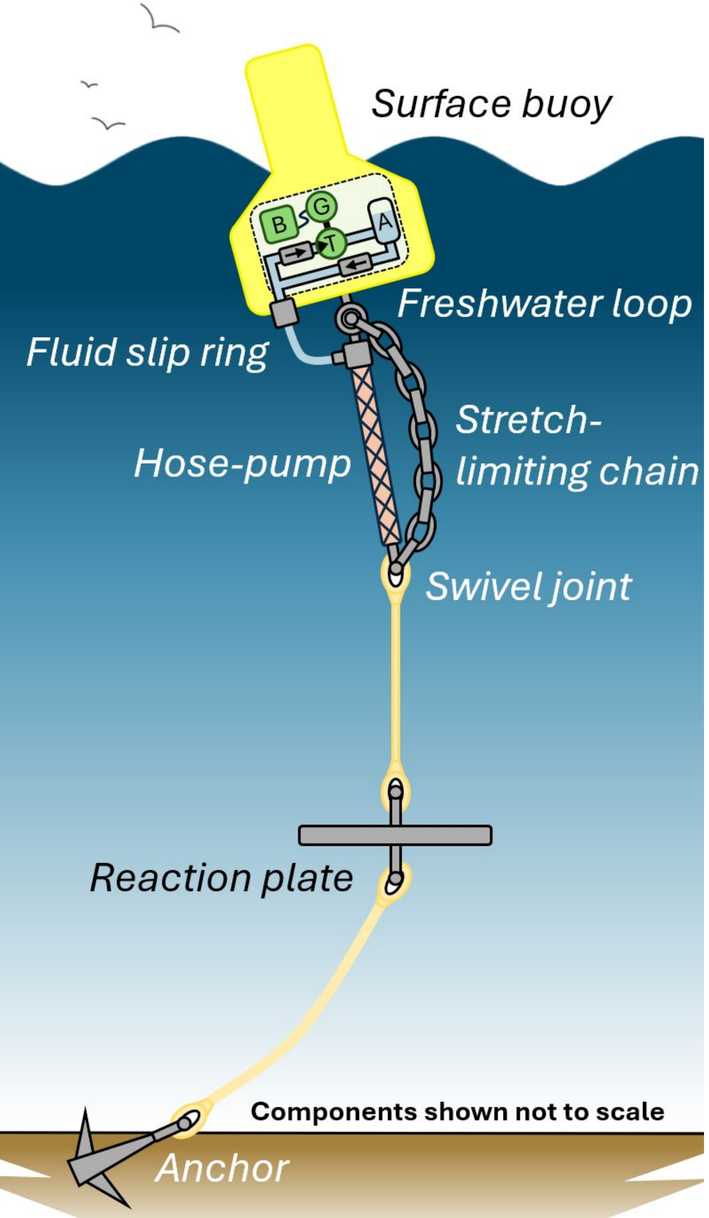




- Paul, Walter HG. "Hose elements for buoy moorings: Design, fabrication and mechanical properties." (2004).
- Baumgartner, Mark F., et al. "Persistent near real-time passive acoustic monitoring for baleen whales from a moored buoy: System description and evaluation." Methods in Ecology and Evolution 10.9 (2019): 1476-1489.
- https://www2.whoi.edu/site/mooringops/projects/

Carson McGuire • cmmcguir@ncsu.edu

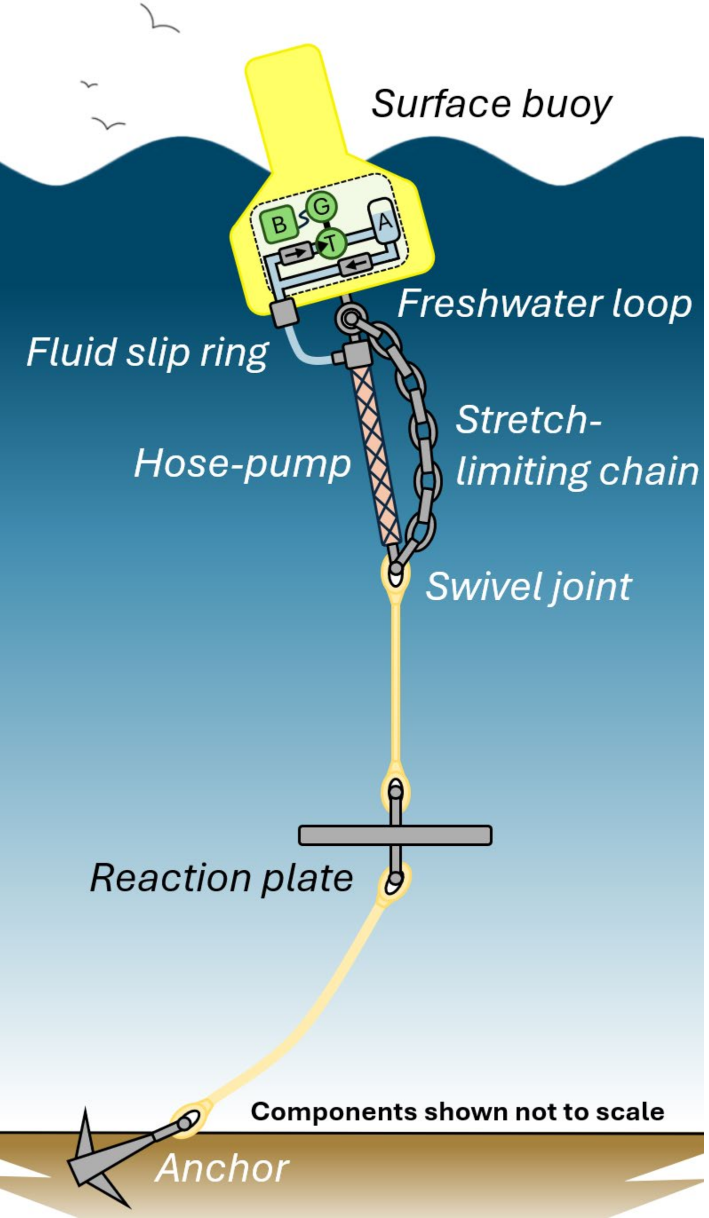
Proposed adaptive-stiffness hydraulic PTO system architecture



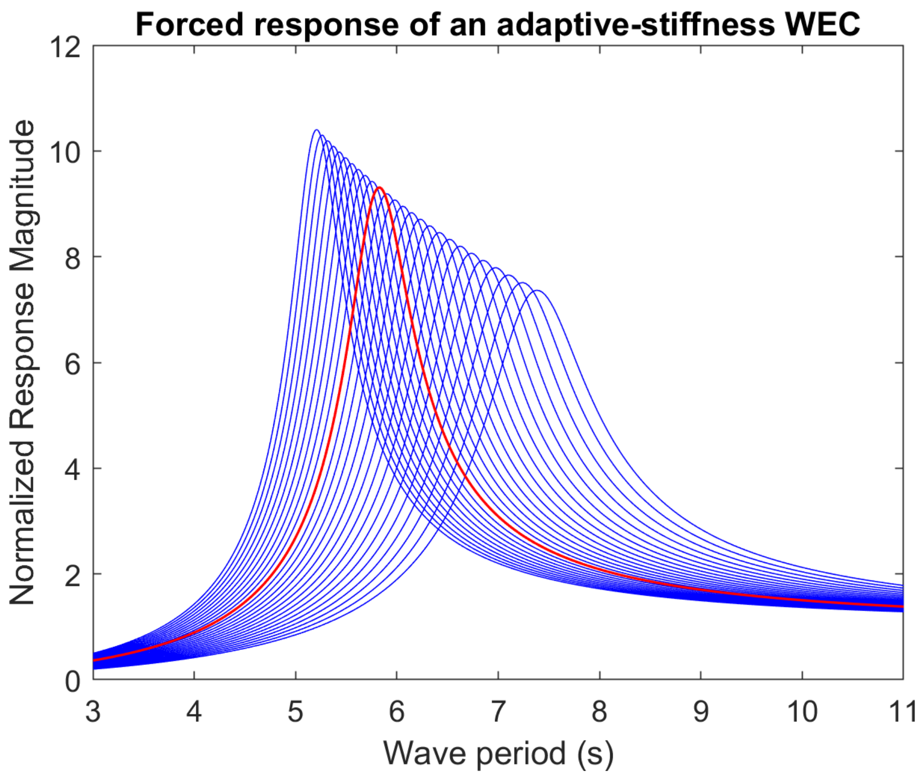
- Coupling hose-pump output to a hydraulic turbine and generator can create electrical output

- Additional potential benefits:
    - In rough seas, stiffness can be reduced to mitigate shock loads
    - Unlike piston pumps, there are no high precision sliding seals
    - Hose pump is corrosion resistant and can be fully coated to inhibit biofouling
    - Easy to transport and deploy
        - Hose pump can be coiled on a spool
    - Low environmental risk
        - Working fluid can captive freshwater
    - Reduced risk of entanglement for marine mammals

Proposed adaptive-stiffness hydraulic PTO system architecture



- Coupling hose-pump output to a hydraulic turbine and generator can create electrical output
- Pressure (and thus, stiffness) control: Add multi-speed gearing (such as a CVT) between the turbine and generator
    - Changing gear ratio alters torque-speed relationship, internal pressure-output flow rate relationship



- Additional potential benefits:
    - In rough seas, stiffness can be reduced to mitigate shock loads
    - Unlike piston pumps, there are no high precision sliding seals
    - Hose pump is corrosion resistant and can be fully coated to inhibit biofouling
    - Easy to transport and deploy
        - Hose pump can be coiled on a spool
    - Low environmental risk
        - Working fluid can captive freshwater
    - Reduced risk of entanglement for marine mammals

Project objectives for 2024-25

Refine model based on experimental data

Objective 1: Develop an open-source dynamic model of an adaptive stiffness WEC to: (a) assess adaptation strategies, (b) inform system sizing decisions, and (c) perform design case studies, all using historical wave data.

Inform buoy and hose-pump sizing

Objective 2: Design, fabricate, and component-test a lab-scale adaptive stiffness WEC.

Fabricate integrated system for testing

Objective 3: Perform an experimental campaign in the CSI wave tank to demonstrate changes in WEC system dynamics when the PTO hydraulic impedance is adapted.

Carson McGuire • cmmcguir@ncsu.edu

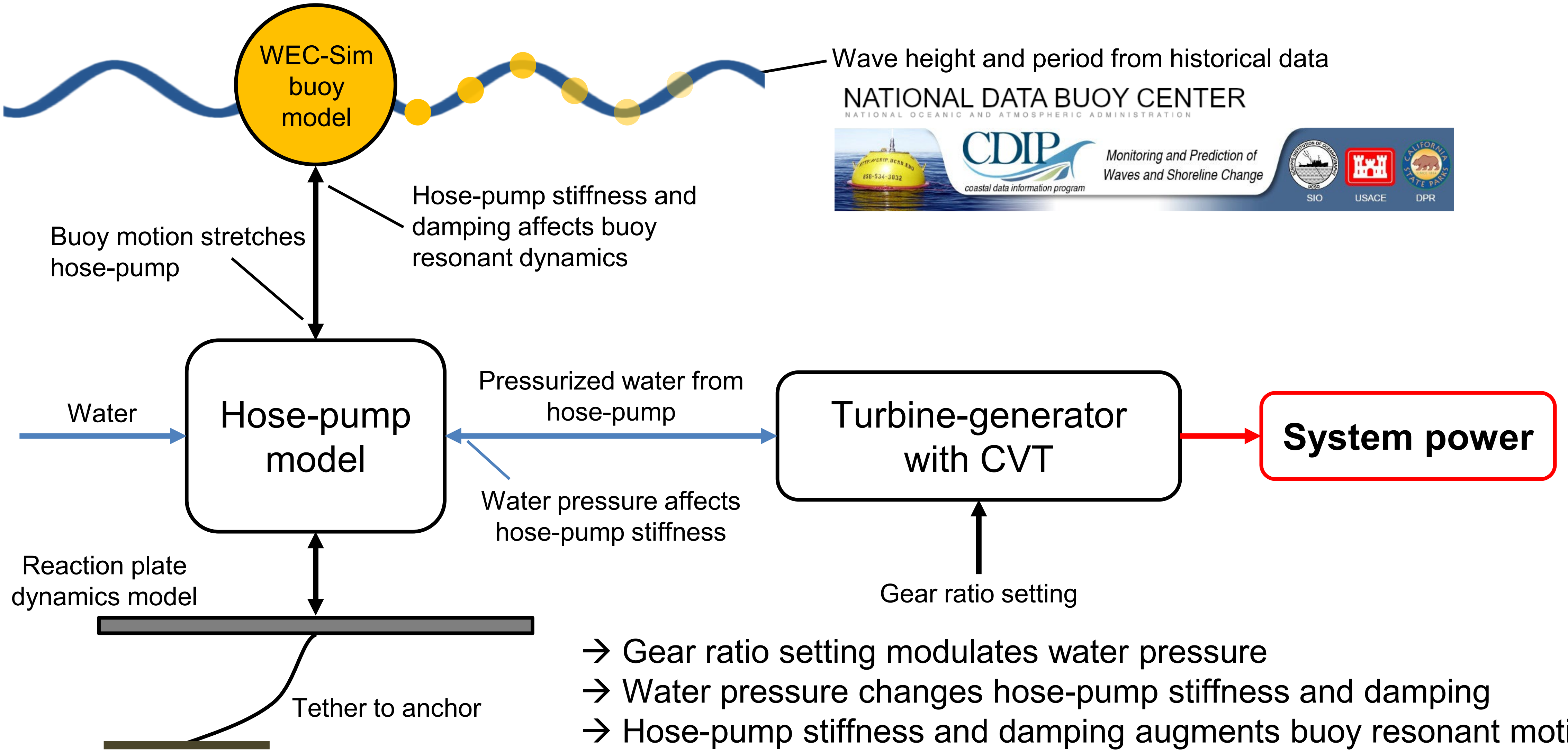
Project objectives for 2024-25

Objective 1: Develop an open-source dynamic model of an adaptive stiffness WEC to: (a) assess adaptation strategies, (b) inform system sizing decisions, and (c) perform design case studies, all using historical wave data.

Objective 2: Design, fabricate, and component-test a lab-scale adaptive stiffness WEC.

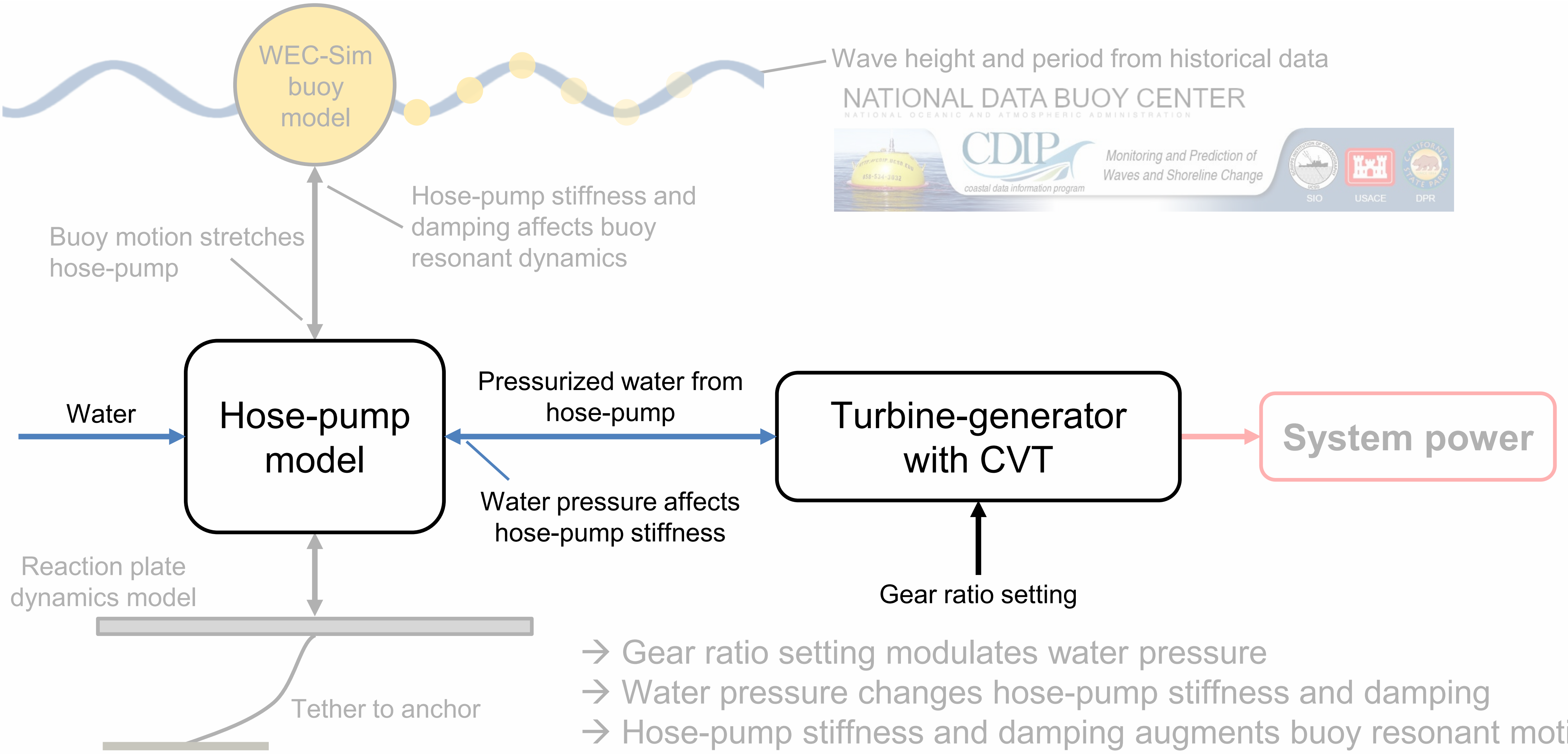
Objective 3: Perform an experimental campaign in the CSI wave tank to demonstrate changes in WEC system dynamics when the PTO hydraulic impedance is adapted.

Objective 1: Dynamic modeling framework for the F2MC WEC



→ Gear ratio setting modulates water pressure
→ Water pressure changes hose-pump stiffness and damping
→ Hose-pump stiffness and damping augments buoy resonant motion
→ **Actively tune system performance via CVT gear ratio setting**

Objective 1: Dynamic modeling framework for the F2MC WEC



→ Gear ratio setting modulates water pressure
→ Water pressure changes hose-pump stiffness and damping
→ Hose-pump stiffness and damping augments buoy resonant motion
→ **Actively tune system performance via CVT gear ratio setting**

Carson McGuire • cmmcguir@ncsu.edu

Objective 1: Quasistatic fluid flow modeling of hose-pump system

Flow rate of an ideal hose-pump [6]:

$$V_{pump} = \pi r_u^2 l_u \left(\frac{-\left(1+\frac{x}{l_u}\right)^3}{tan^2(a_u)} + \frac{1+\frac{x}{l_u}}{sin^2(a_u)} \right)$$

$$Q_{out} = \frac{-dV_{pump}}{dt}$$

Force and stiffness due to internal pressure of an ideal hose-pump [1]:

$$F_{axial} = \pi r_u^2 P \left(\frac{3\left(1+\frac{x}{l_u}\right)^2}{tan^2(a_u)} - \frac{1}{sin^2(a_u)} \right)$$

$$k_{overall} = \frac{dF_{axial}}{dx}$$

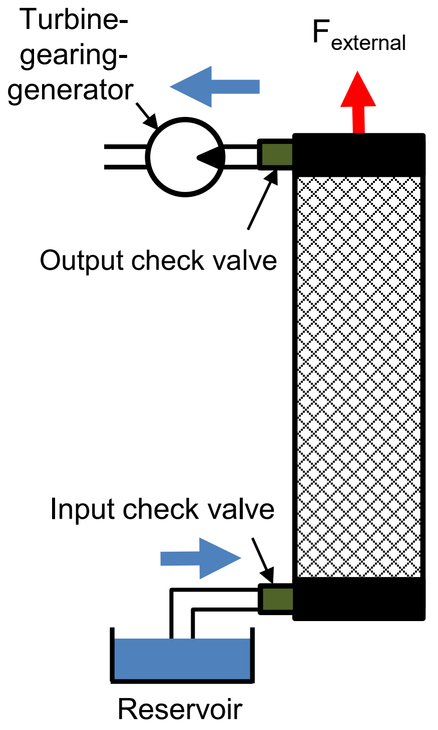
Simple hydraulic turbine with gearing:

$$Q_{out} = \frac{D\omega_1}{2\pi} \qquad \tau_1\omega_1 = \tau_2\omega_2$$

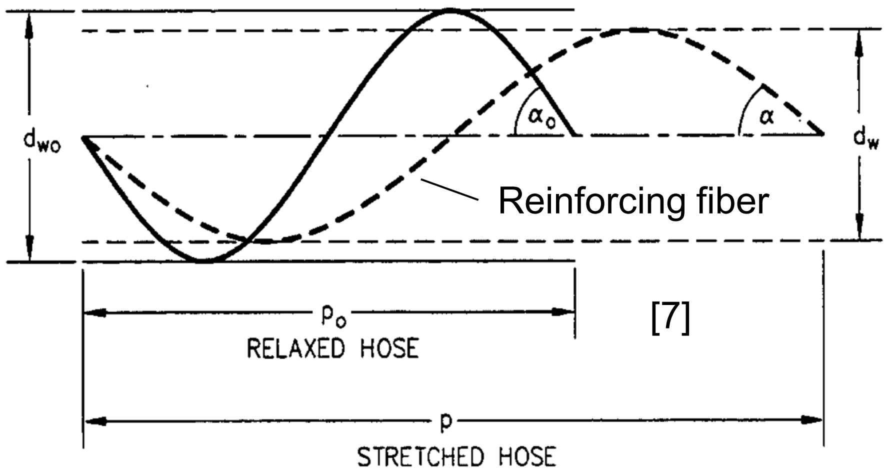
$$P = \frac{2\pi}{D}\tau_1 \qquad G = \frac{\omega_2}{\omega_1}$$

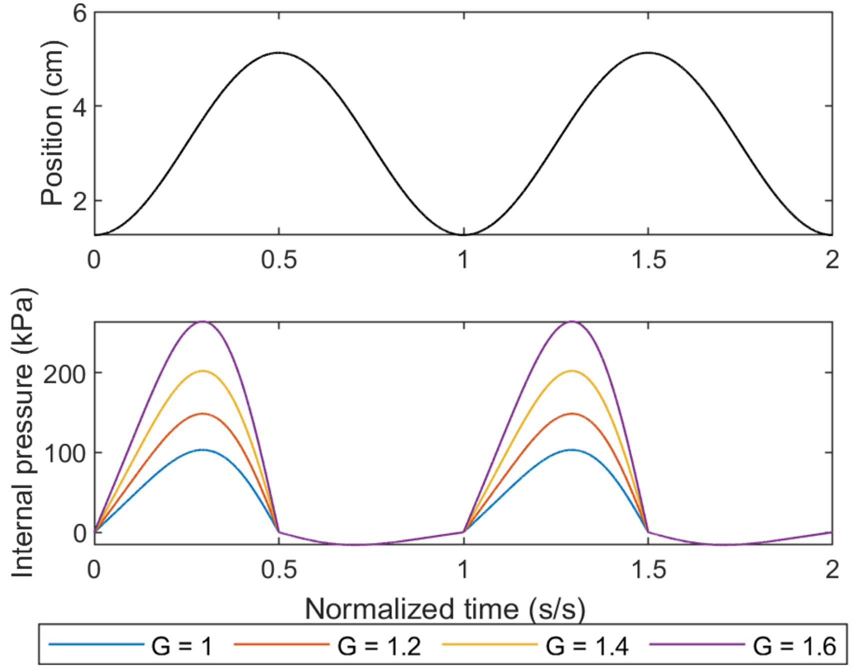
Assumptions:

- Ideal pantograph network
- Negligible mass
- No flow effects from check valves



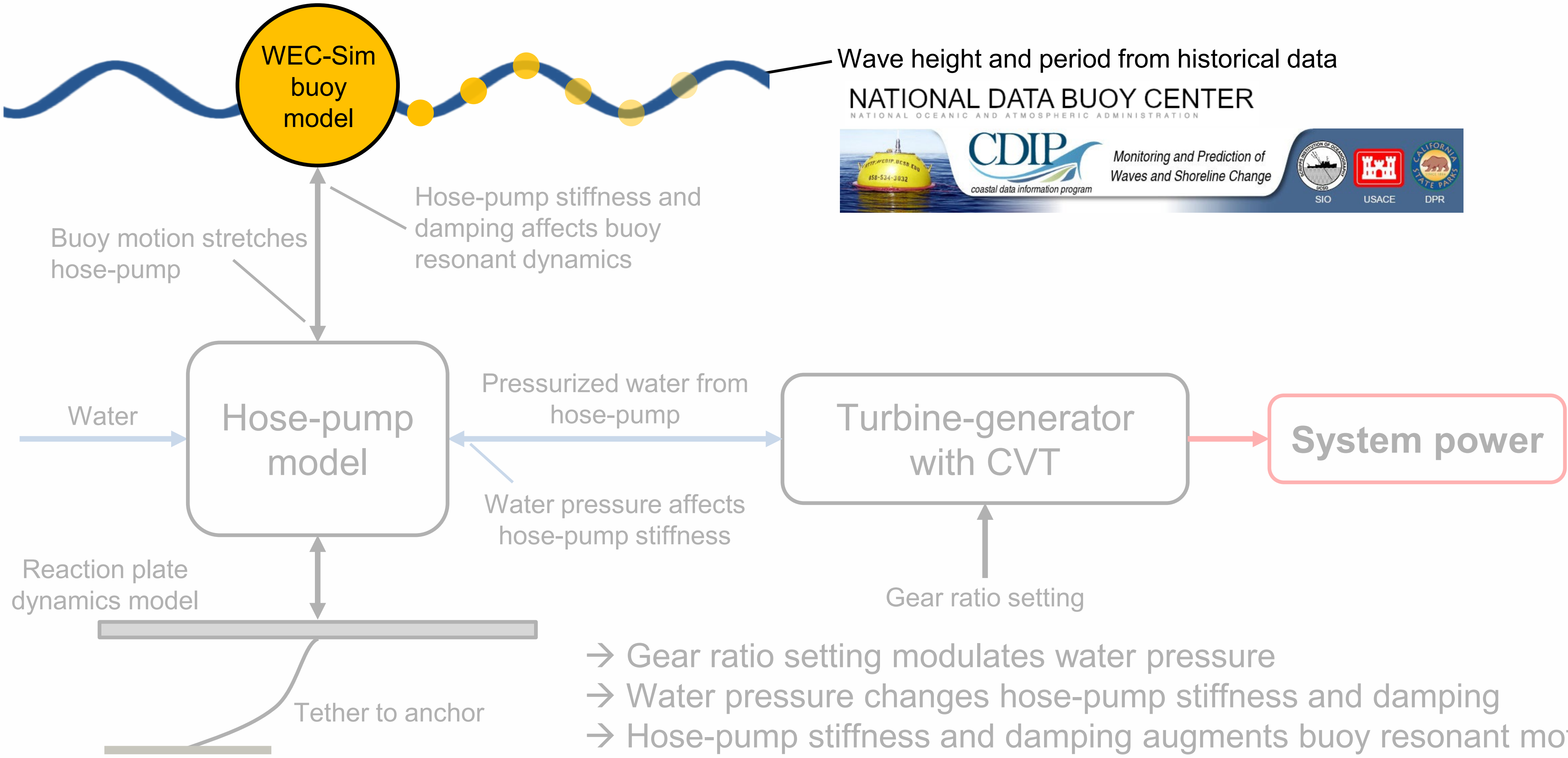
Lab-scale system





[6] B. Tondu, "Modelling of the McKibben artificial muscle: A review" Journal of Intelligent Material Systems and Structures, vol. 23, no. 3. p. 225-253, Mar. 2012.
[7] Paul, Walter HG. "Hose elements for buoy moorings: Design, fabrication and mechanical properties." (2004).

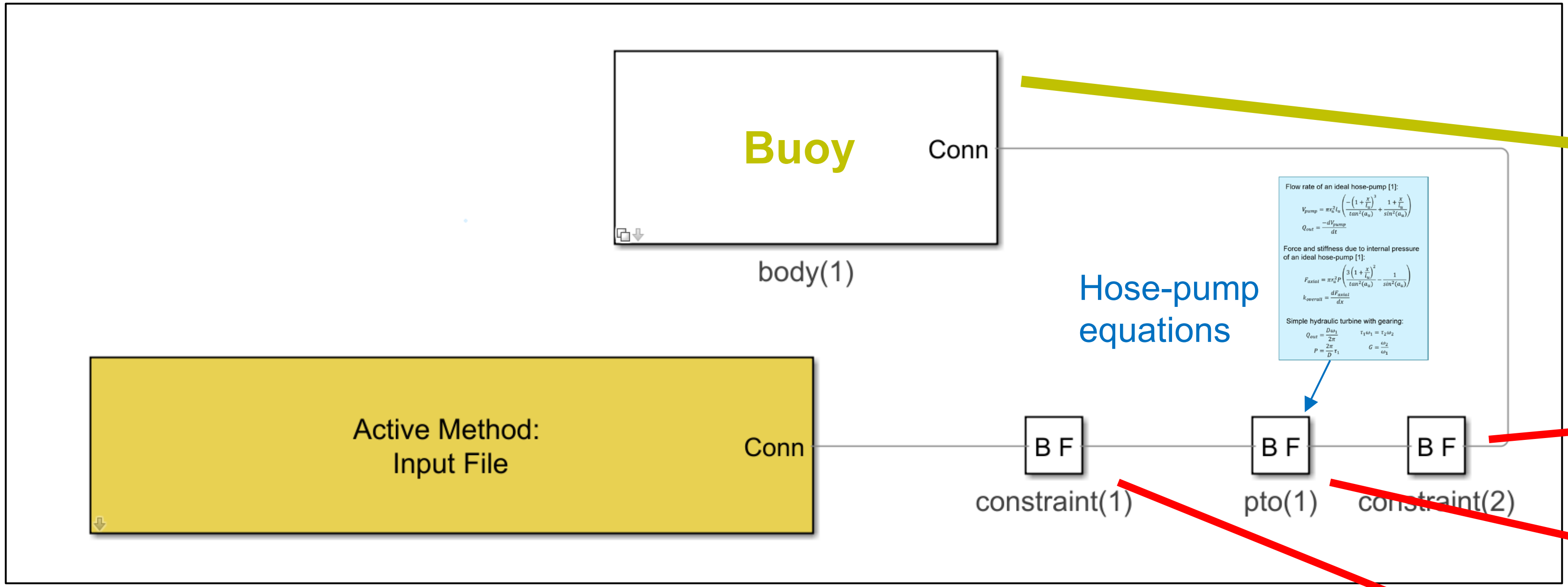
Objective 1: Dynamic modeling framework for the F2MC WEC

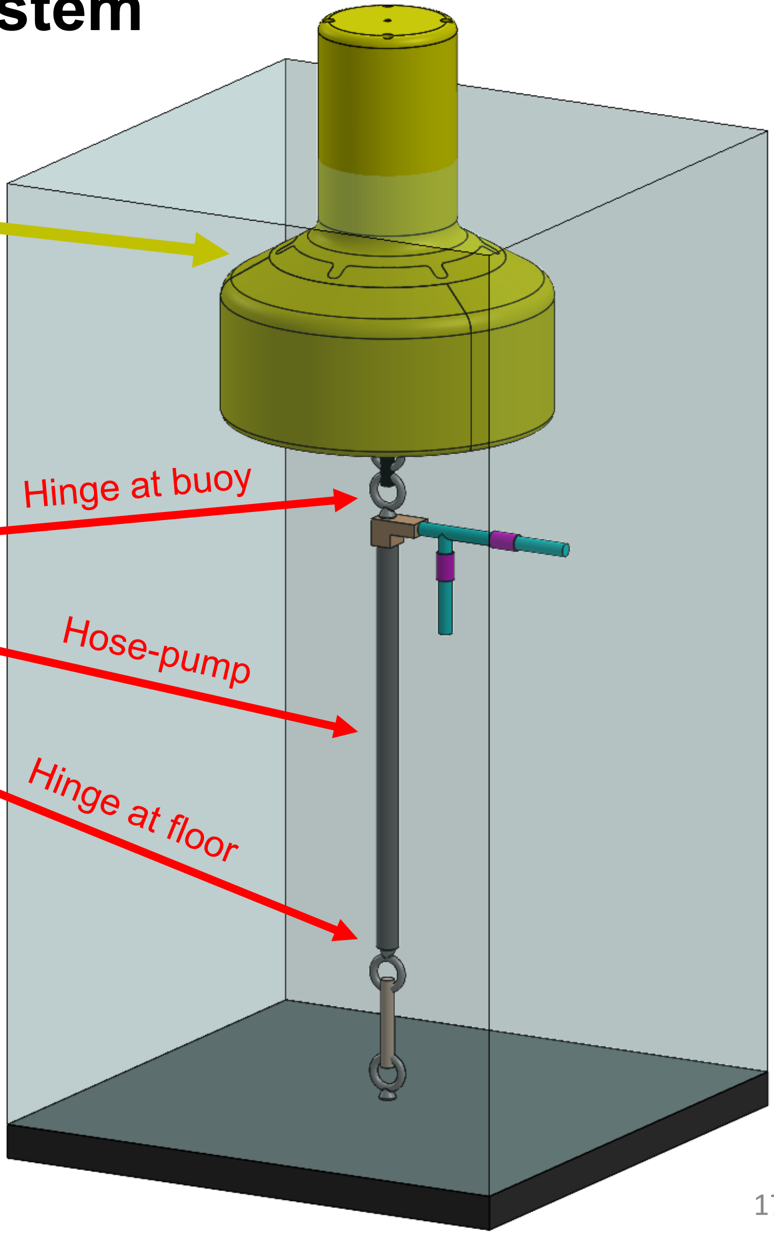


→ Gear ratio setting modulates water pressure
→ Water pressure changes hose-pump stiffness and damping
→ Hose-pump stiffness and damping augments buoy resonant motion
→ **Actively tune system performance via CVT gear ratio setting**

Carson McGuire • cmmcguir@ncsu.edu

Objective 1: WEC-Sim Simulink model of integrated system





- Buoy is constrained to move in 3DOF
  - Surge, heave, pitch
  - This captures the principal motions of the system
- For small-scale (based on CSI wave-tank capabilities):
  - Wave height = 80-120 mm
  - Wave period = 0.75 – 2 sec.

Carson McGuire • cmmcguir@ncsu.edu

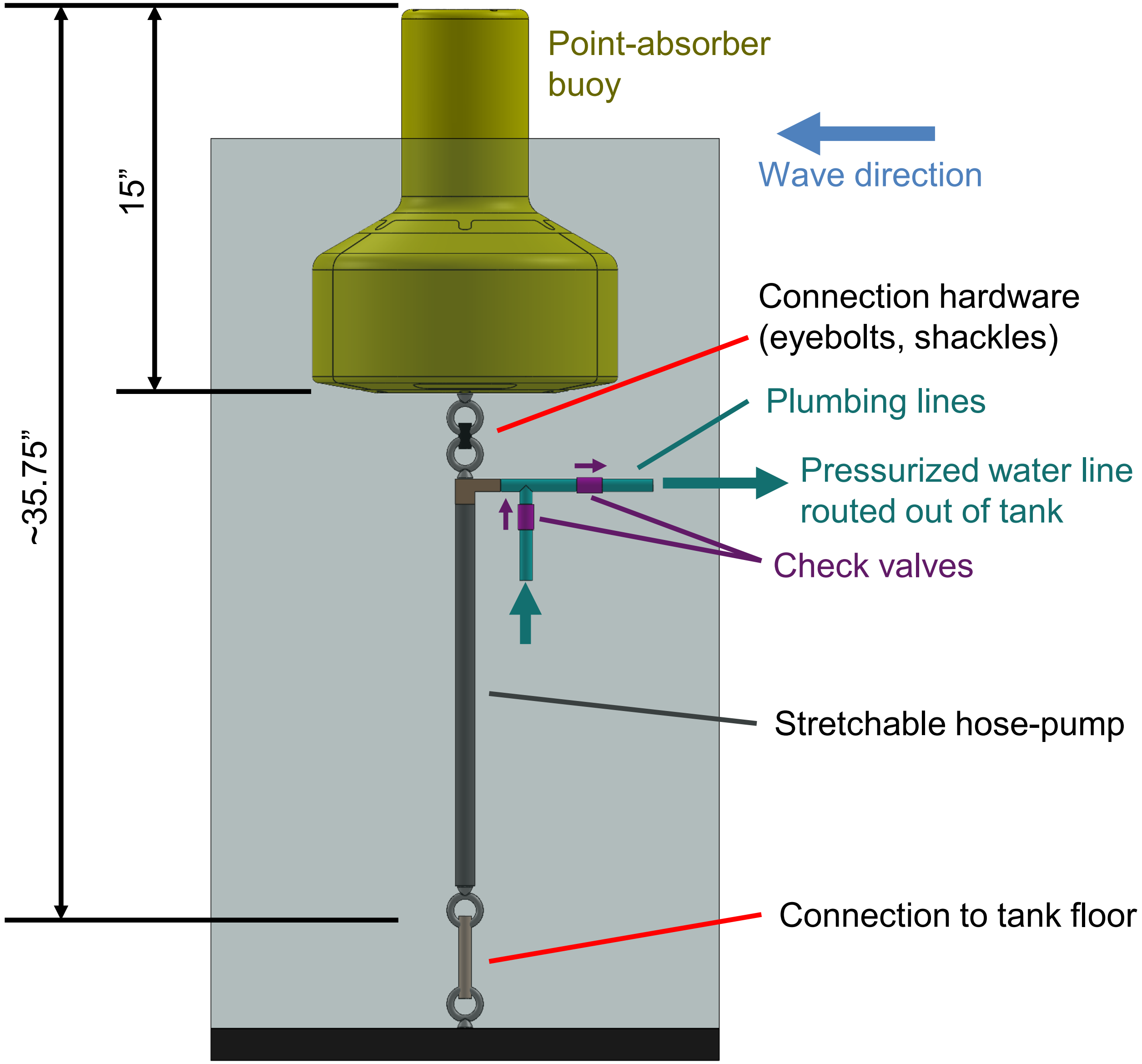
Project objectives for 2024-25

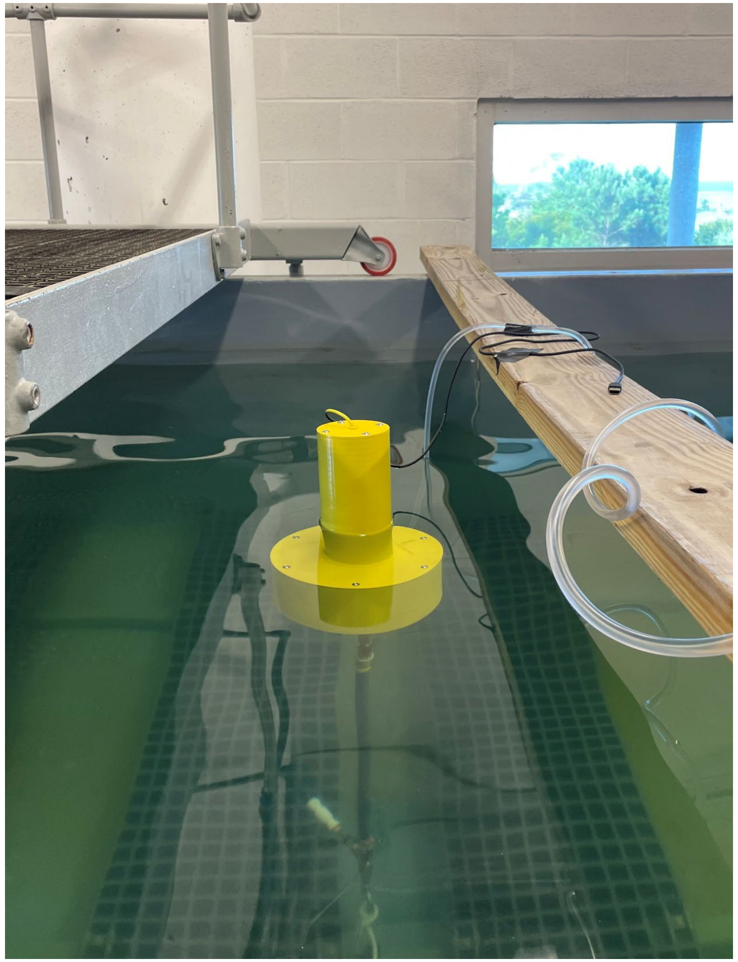
Objective 1: Develop an open-source dynamic model of an adaptive stiffness WEC to: (a) assess adaptation strategies, (b) inform system sizing decisions, and (c) perform design case studies, all using historical wave data.

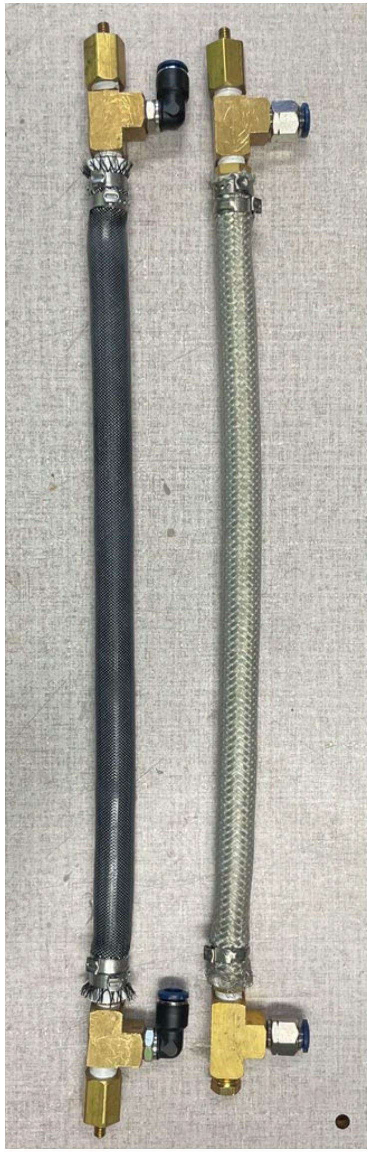
Objective 2: Design, fabricate, and component-test a lab-scale adaptive stiffness WEC.

Objective 3: Perform an experimental campaign in the CSI wave tank to demonstrate changes in WEC system dynamics when the PTO hydraulic impedance is adapted.

Objective 2: Lab-scale buoy/hose-pump integrated system in water

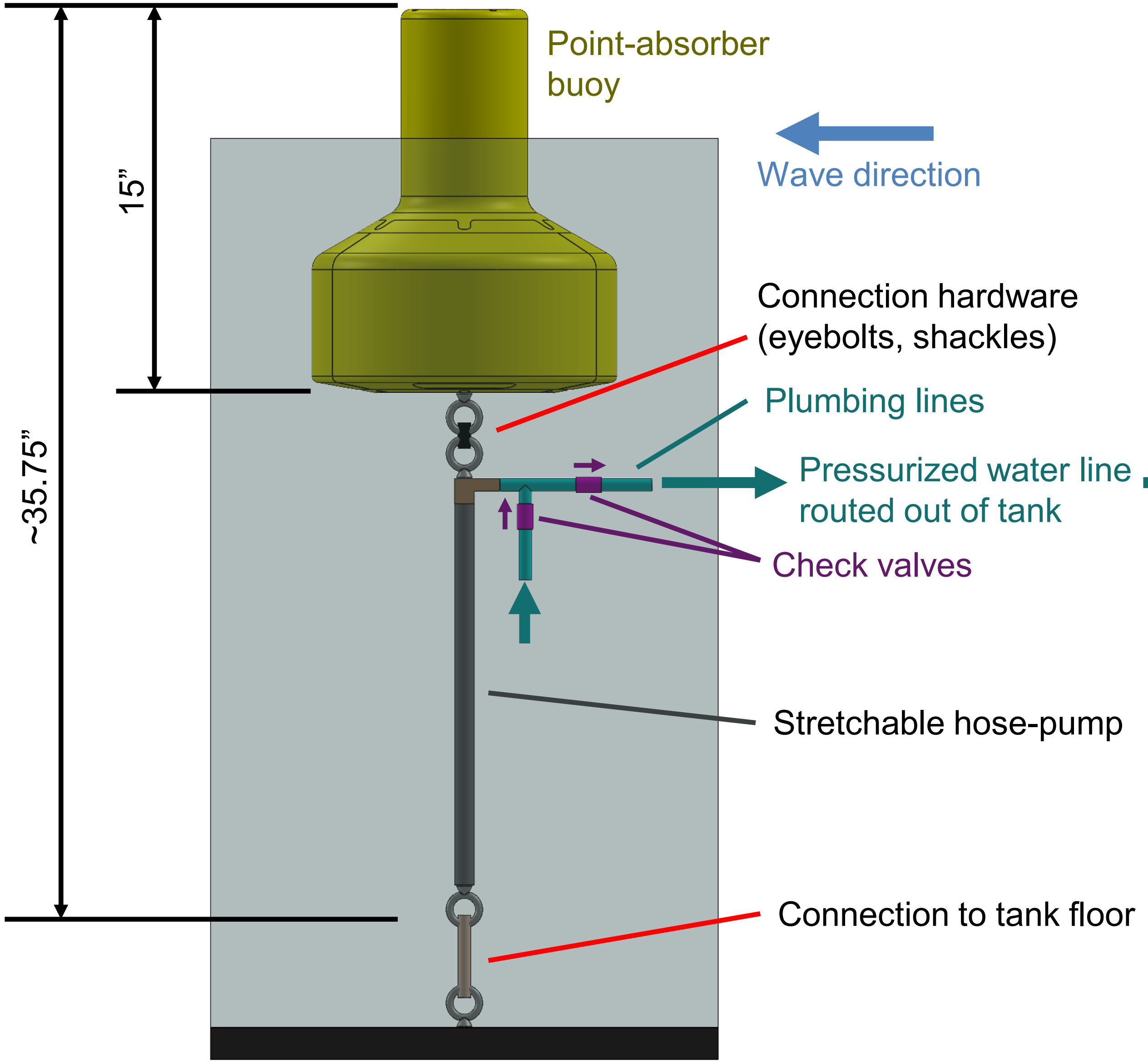


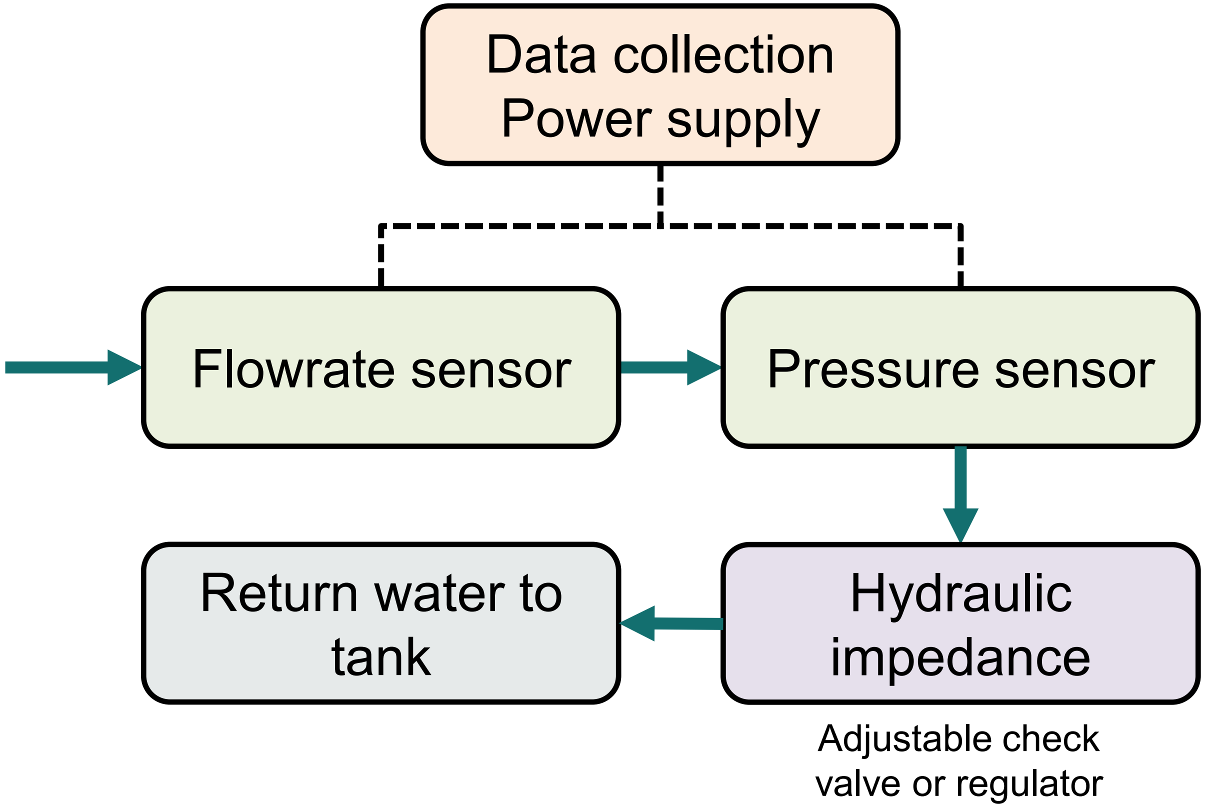




Carson McGuire • cmmcguir@ncsu.edu

Objective 2: Lab-scale buoy/hose-pump integrated system in water





Project objectives for 2024-25

Objective 1: Develop an open-source dynamic model of an adaptive stiffness WEC to: (a) assess adaptation strategies, (b) inform system sizing decisions, and (c) perform design case studies, all using historical wave data.

Objective 2: Design, fabricate, and component-test a lab-scale adaptive stiffness WEC.

Objective 3: Perform an experimental campaign in the CSI wave tank to demonstrate changes in WEC system dynamics when the PTO hydraulic impedance is adapted.

Carson McGuire • cmmcguir@ncsu.edu

Objective 3: First point absorber buoys (July, Oct. 2024)

- Captured side-view videos of wave-tank testing in addition to flow rate and pressure data
- Captured data and videos were used to fine-tune WEC-Sim model parameters

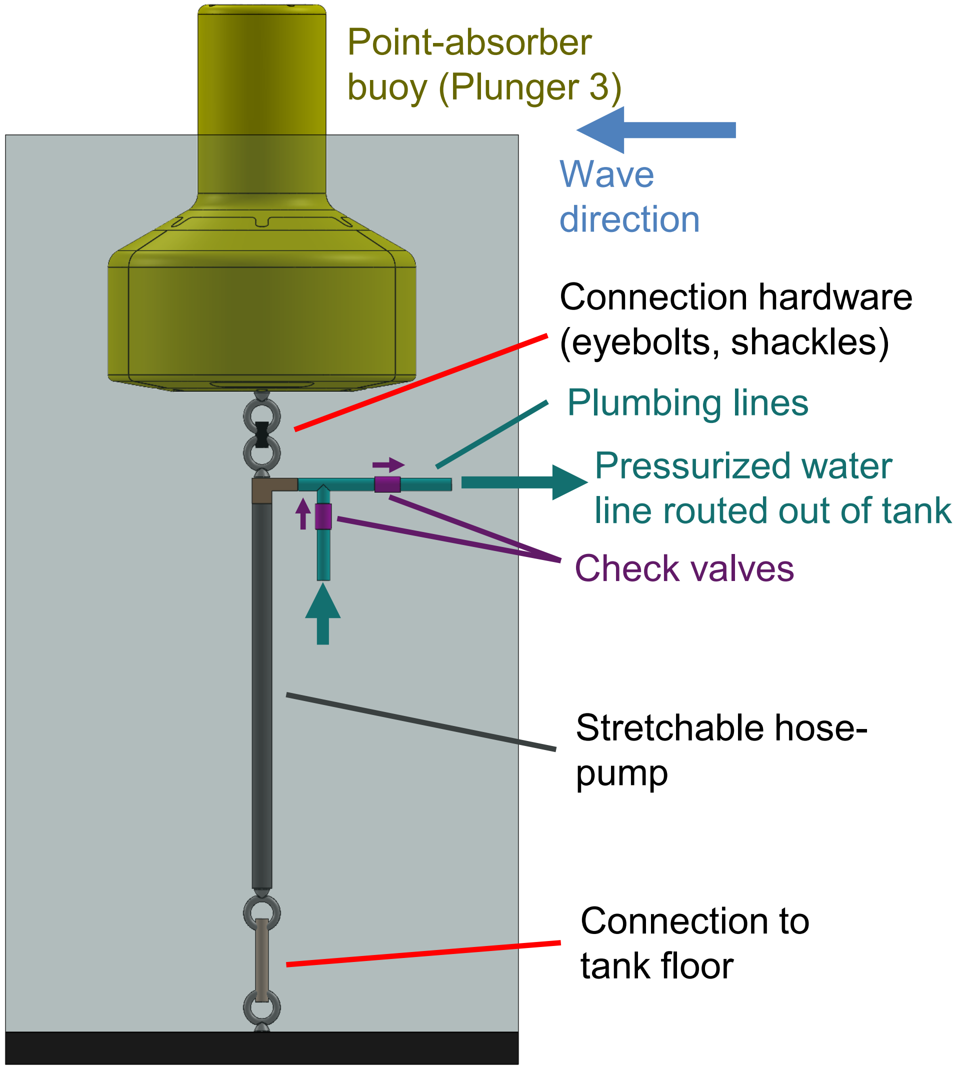
Carson McGuire • cmmcguir@ncsu.edu

Objective 3: Streamlined point absorber buoy (Feb. 2025)

<u>Feb. 18-21, 2025</u>

- Streamlined point-absorber buoy (Plunger 3)
- Adjustable check valve (ACV) to set hydraulic impedance
- Measured outflow rate and pressure

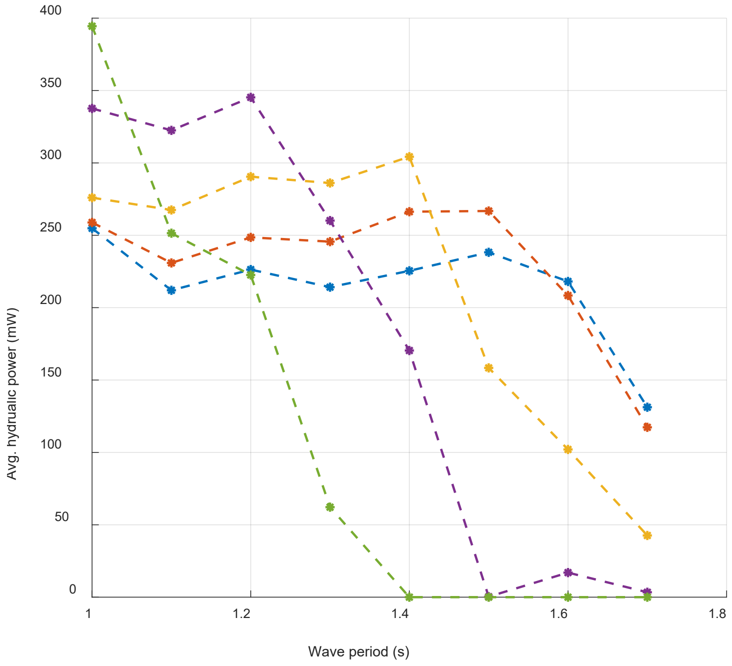
  → Calculate hydraulic power

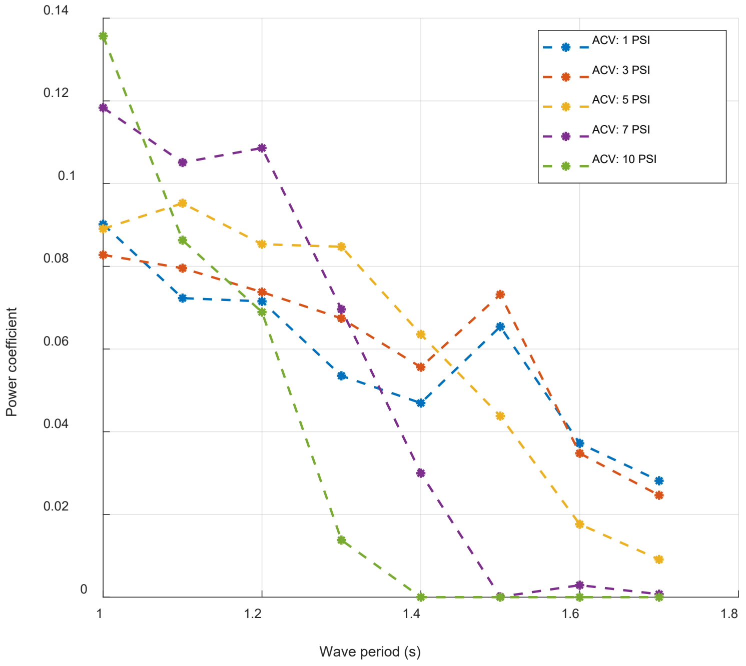


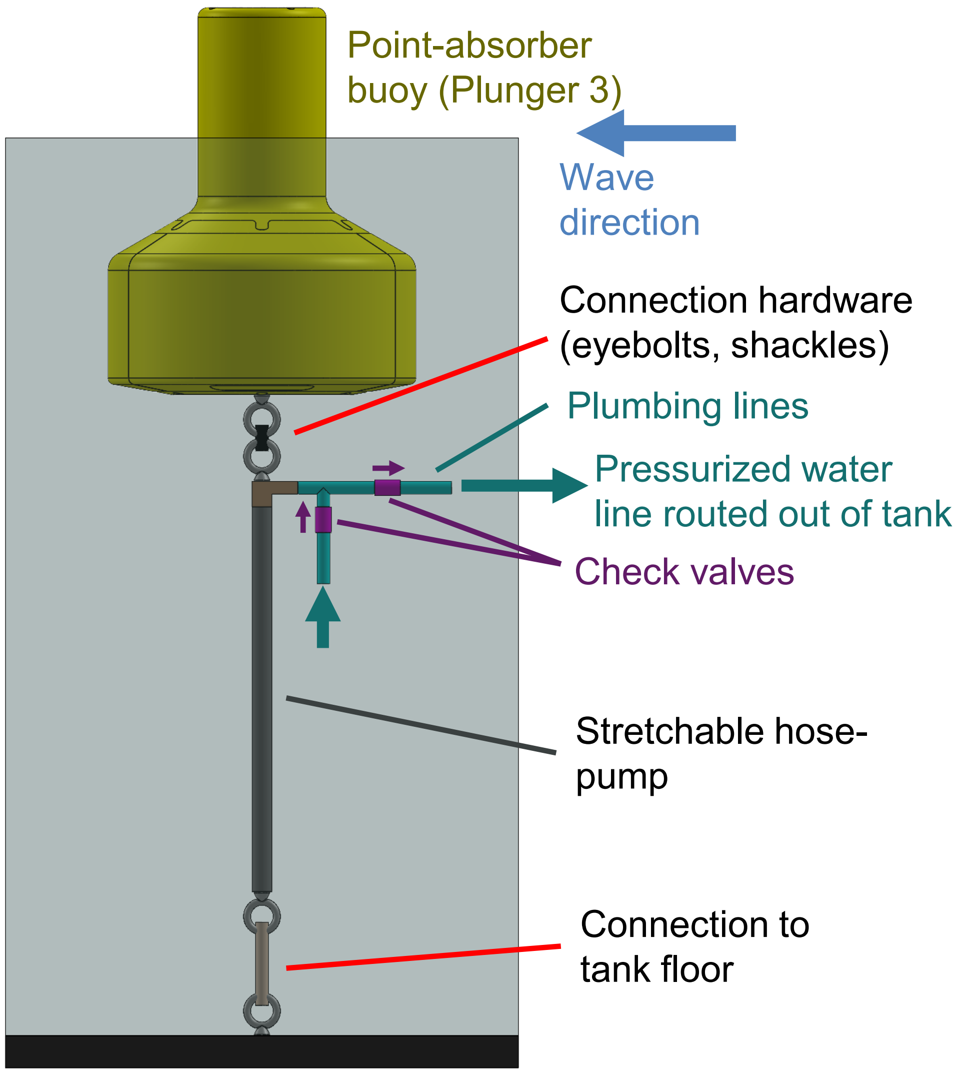
Objective 3: Streamlined point absorber buoy (Feb. 2025)

Feb. 18-21, 2025

- Streamlined point-absorber buoy (Plunger 3)
- Adjustable check valve (ACV) to set hydraulic impedance
- Measured outflow rate and pressure
  → Calculate hydraulic power







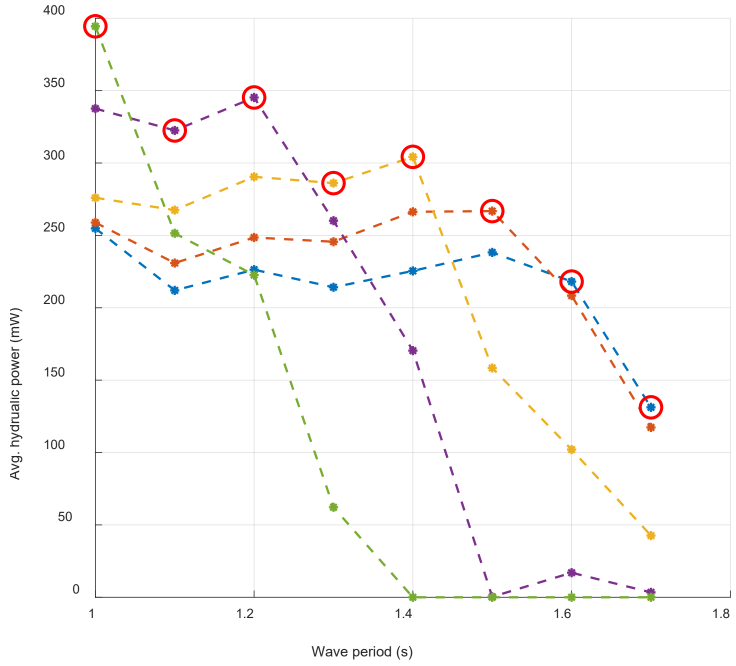
Carson McGuire • cmmcguir@ncsu.edu

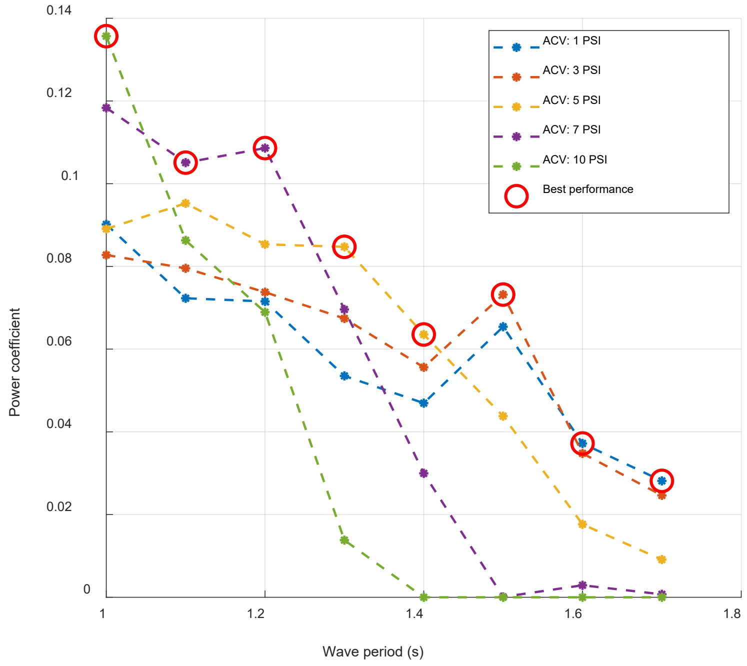
Objective 3: Streamlined point absorber buoy (Feb. 2025)

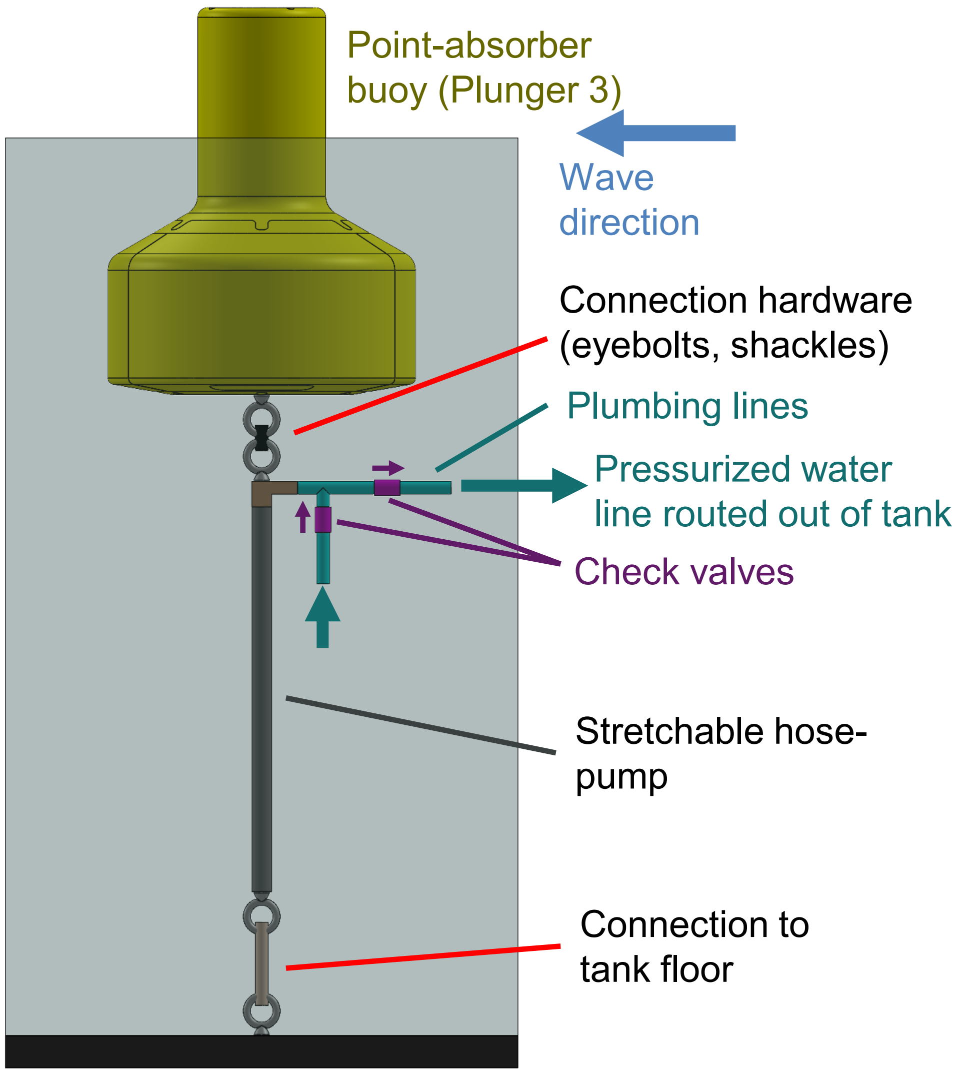
Feb. 18-21, 2025

- Streamlined point-absorber buoy (Plunger 3)
- Adjustable check valve (ACV) to set hydraulic impedance
- Measured outflow rate and pressure
  → Calculate hydraulic power

Each wave period has a best-choice for outflow hydraulic impedance setting to maximize hydraulic power







Carson McGuire • cmmcguir@ncsu.edu

Acknowledgements

- This research was supported by the North Carolina Renewable Ocean Energy Program.
- The authors would like to thank the Coastal Studies Institute for their generous technical support and the use of their facilities.
- We would also like to thank UMERC for providing travel support to attend UMERC+OREC 2025.

North Carolina Renewable Ocean Energy Program

Coastal Studies Institute
A Multi-Institutional Research Partnership
EAST CAROLINA UNIVERSITY | THE UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL | NC STATE UNIVERSITY
NORTH CAROLINA AQUARIUMS | NORTH CAROLINA SEA GRANT

ECU OUTER BANKS CAMPUS

umerc

Carson McGuire • cmmcguir@ncsu.edu

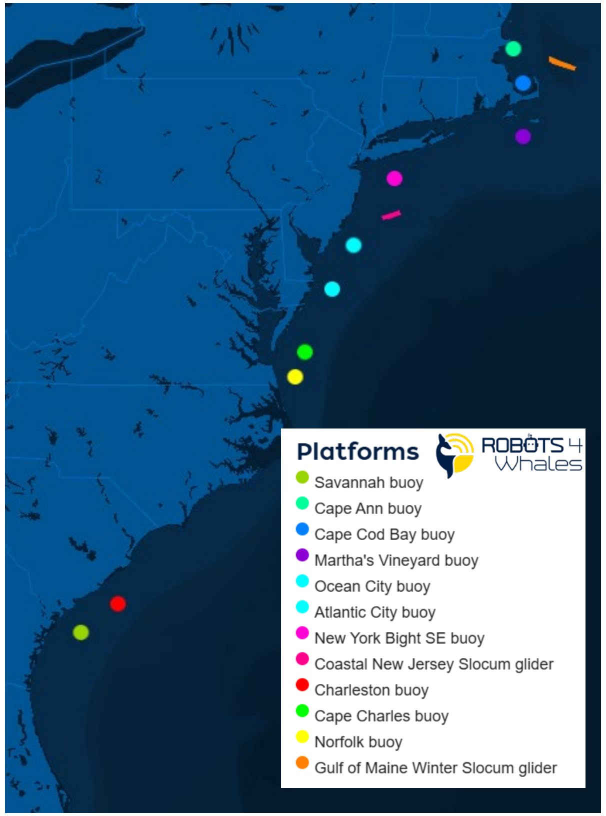
Thank you for your attention!

Questions?

Carson McGuire • cmmcguir@ncsu.edu

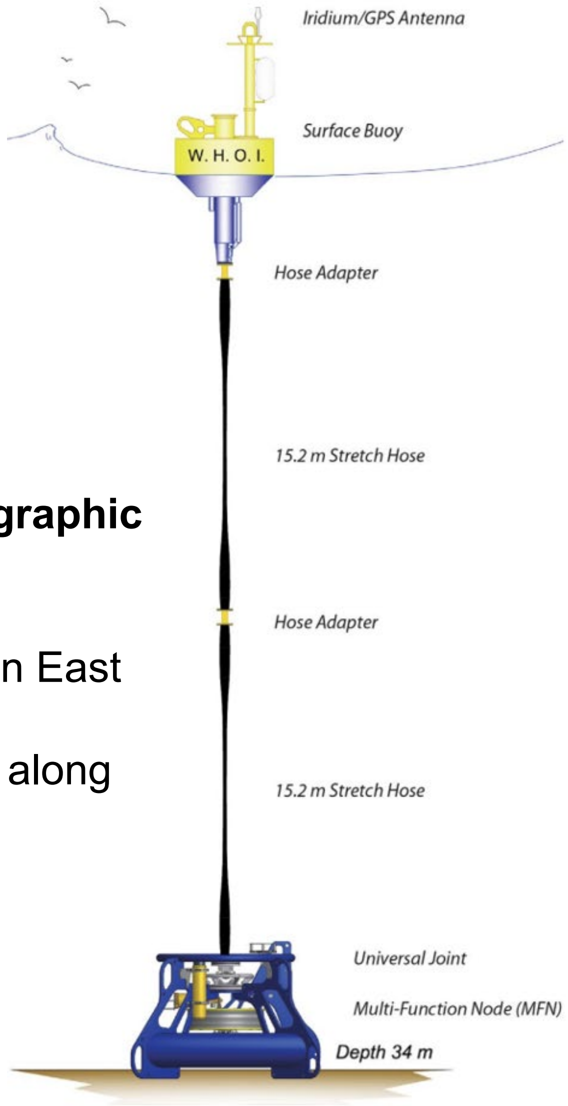
Application case study: Passive acoustic monitoring of marine mammals

Stretch hoses on existing moorings can be adapted for powering ocean monitoring sensors



Woods Hole Oceanographic Institute:

- Robots4Whales
- 10 moored buoys on East Coast
- 2 mobile observers along East Coast



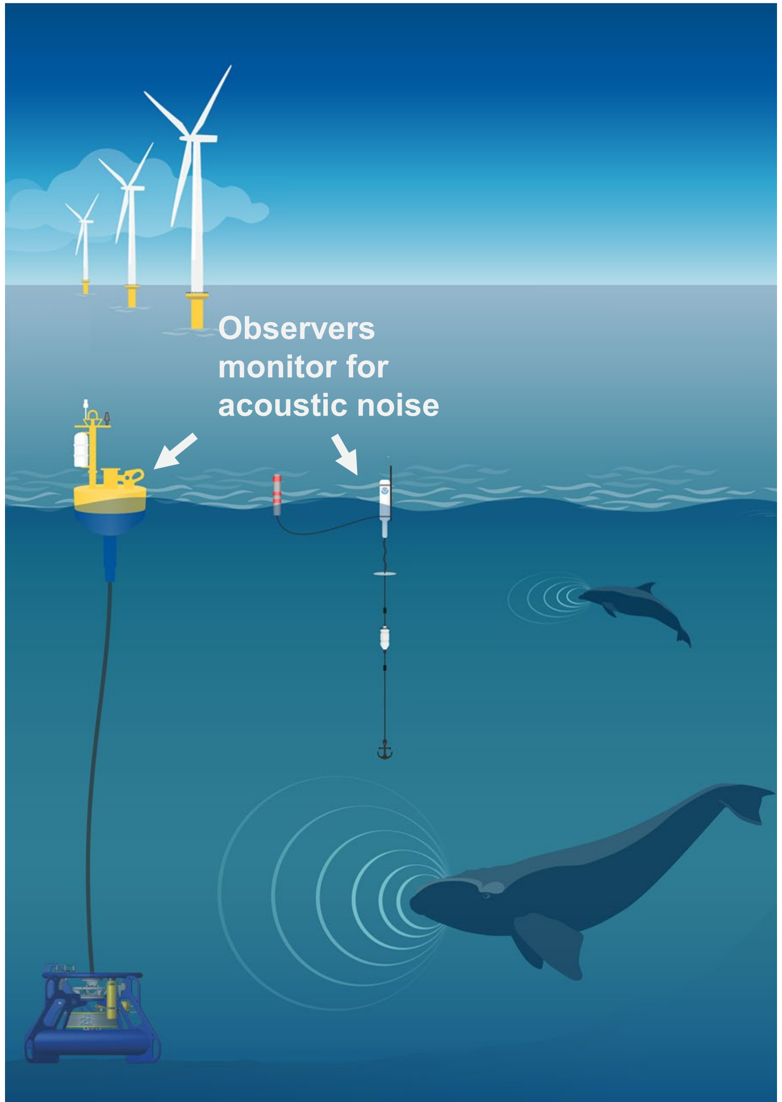


Image modified from NOAA

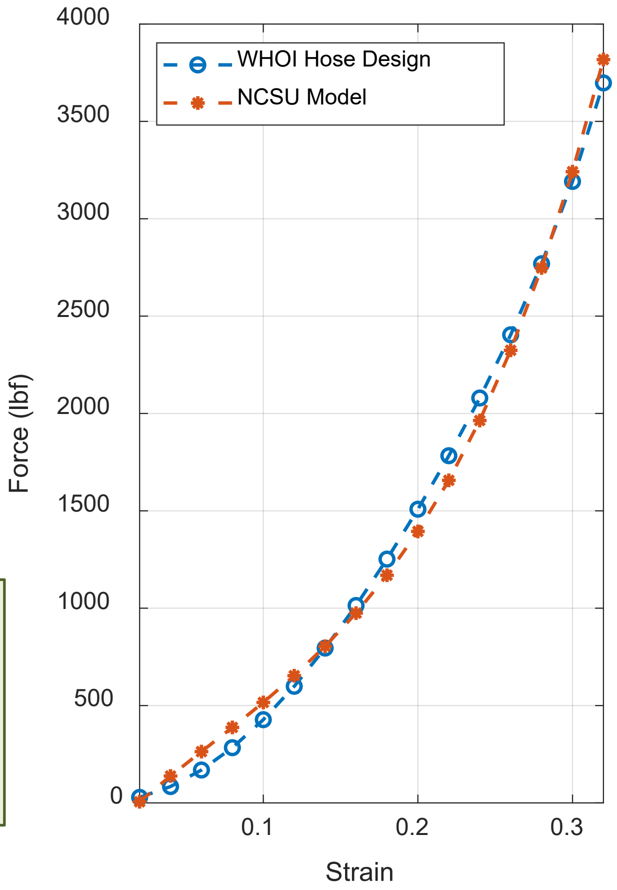
Carson McGuire • cmmcguir@ncsu.edu

Application case study: Passive acoustic monitoring of marine mammals

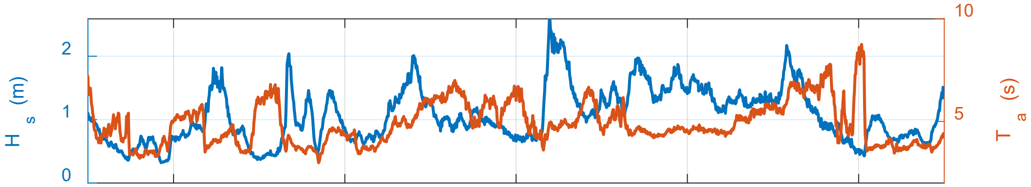
Stretch hoses on existing moorings can be adapted for powering ocean monitoring sensors

- Simulations of PAM buoy stretch hose WEC
  - Actual buoy system offshore of Norfolk, VA
  - Driven by historical sea-state data
  - **Capacity factor increases by 1.55x with adaptive stiffness**

Donald Peters
WHOI
Principal
Engineer



Hose-pump and WHOI stretch hose reaction force vs. strain

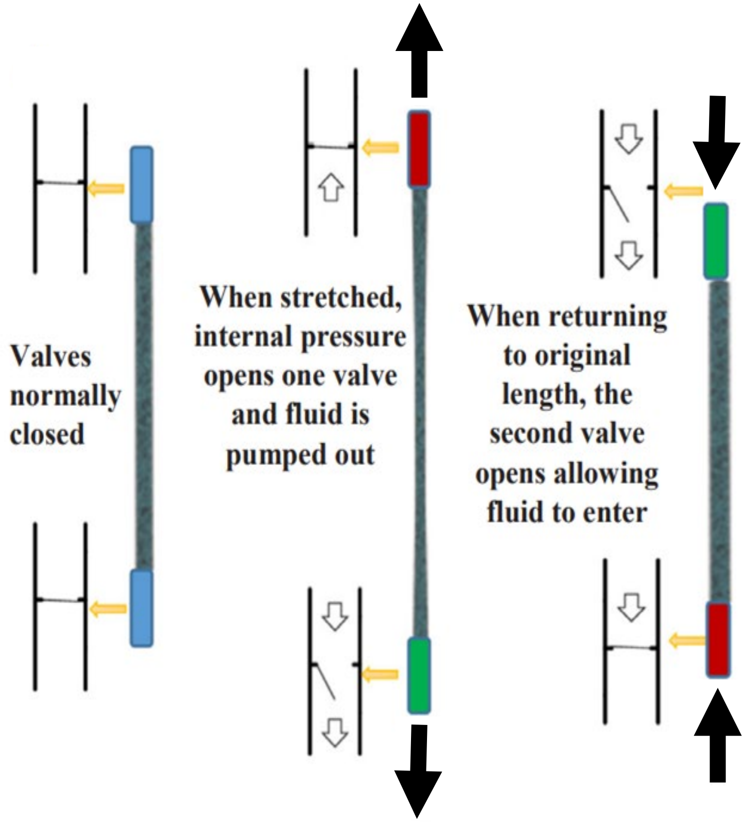


Result	Non-adaptive	Adaptive
Capacity factor	39.0%	**60.4%**
Avg. net annual production	332 kW-hr	**515 kW-hr**
Annual power requirement	16.2 kW-hr	

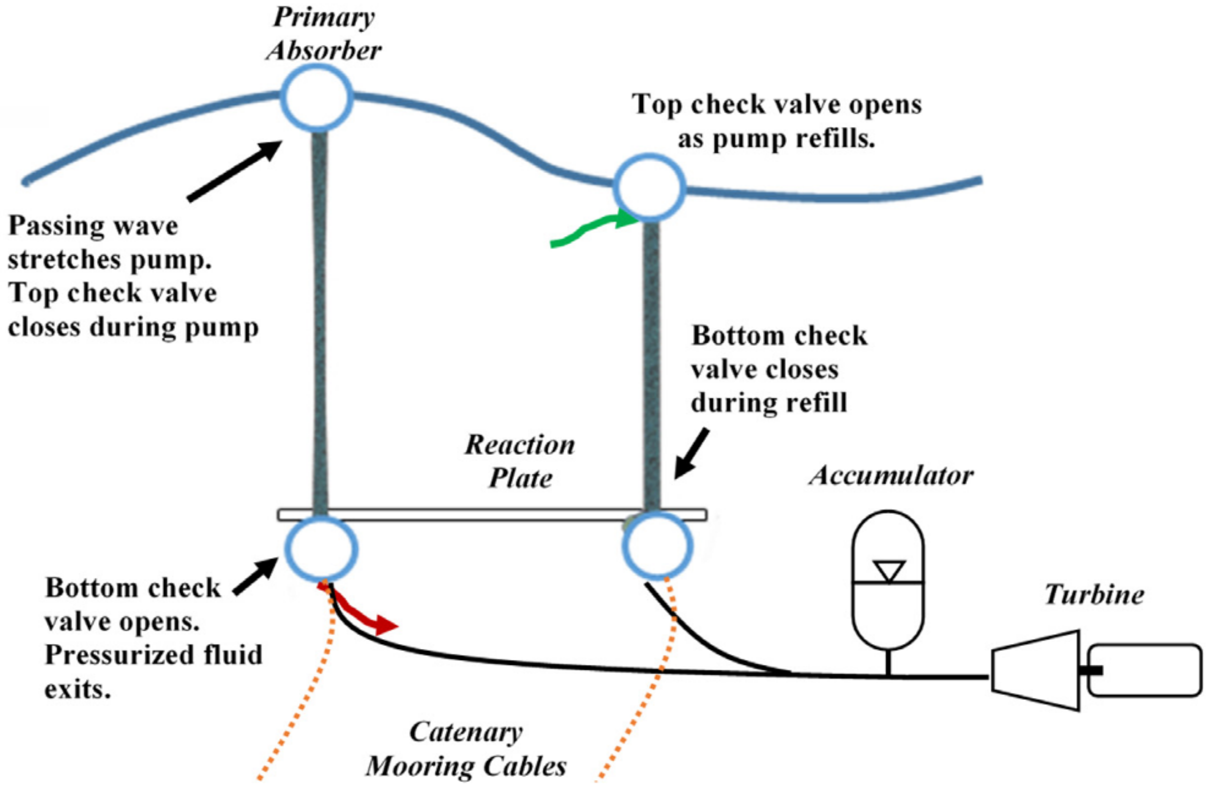
Simulation results for the WEC across 15.6 years of historical data from CDIP Station 147.

Hydro turbine hose-pump system architecture

- Philen et al. 2018: Coupling an F2MC hose-pump output to a hydraulic turbine and generator can create electrical output
- Axial stretch from heaving buoy ⟶ Internal volume decreases, pressurized water jets through turbine



Functionality of an F2MC pump [1]

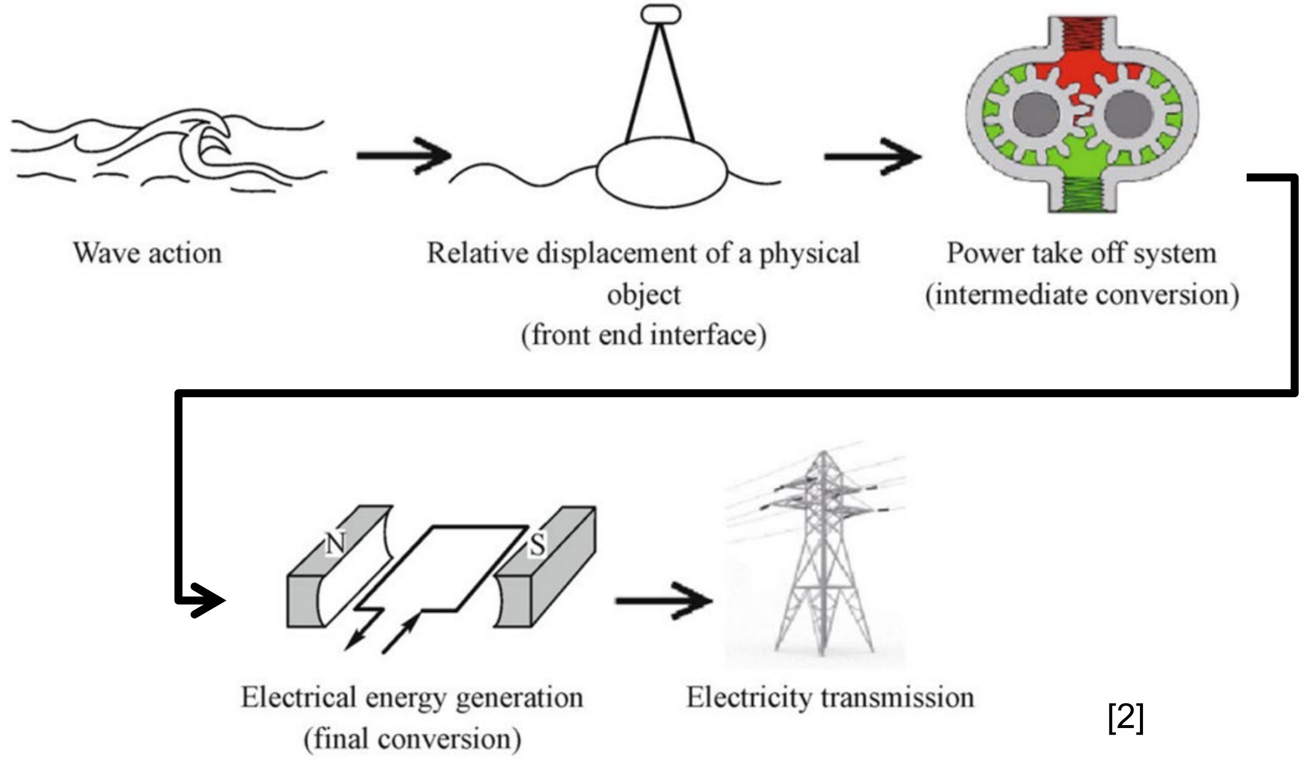


F2MC pumping WEC system [1]

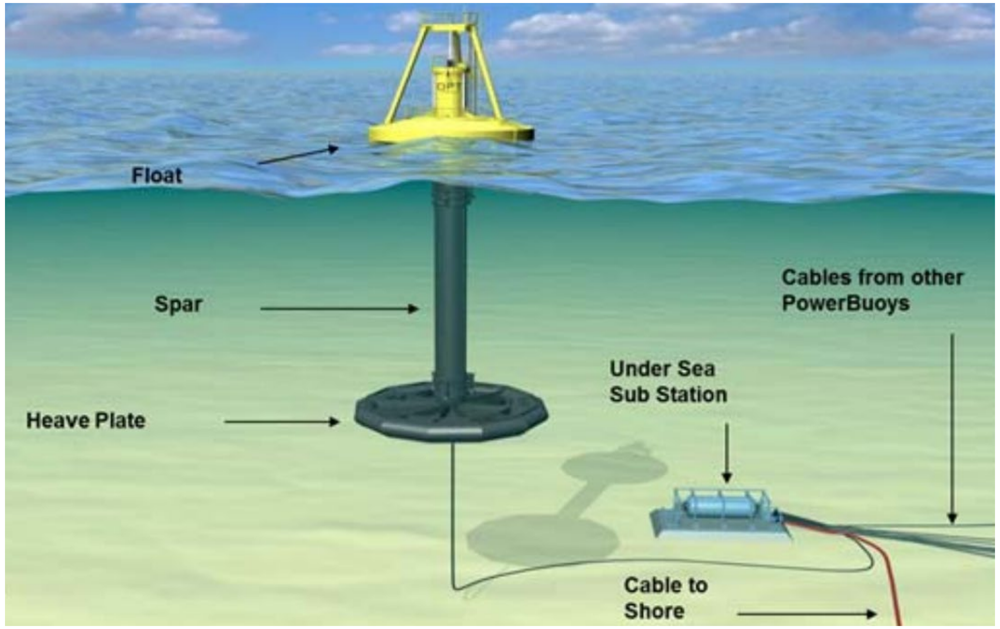
[1] M. Philen, C. Squibb, L. Groo, G. Hagerman, "Wave energy conversion using fluidic flexible matrix composite power take-off pumps," Energy Conversion and Management, vol. 171, p. 1773-1786, Sept. 2018, doi: https://doi.org/10.1016/j.enconman.2018.06.102.

Wave energy converter (WEC) design: Point absorbers

- **Wave energy converters (WECs)**: Generate usable work from wave energy
- **Point absorbers**: Buoy heaves up and down due to ocean wave motion to drive a power take-off element (omnidirectional)



[2]

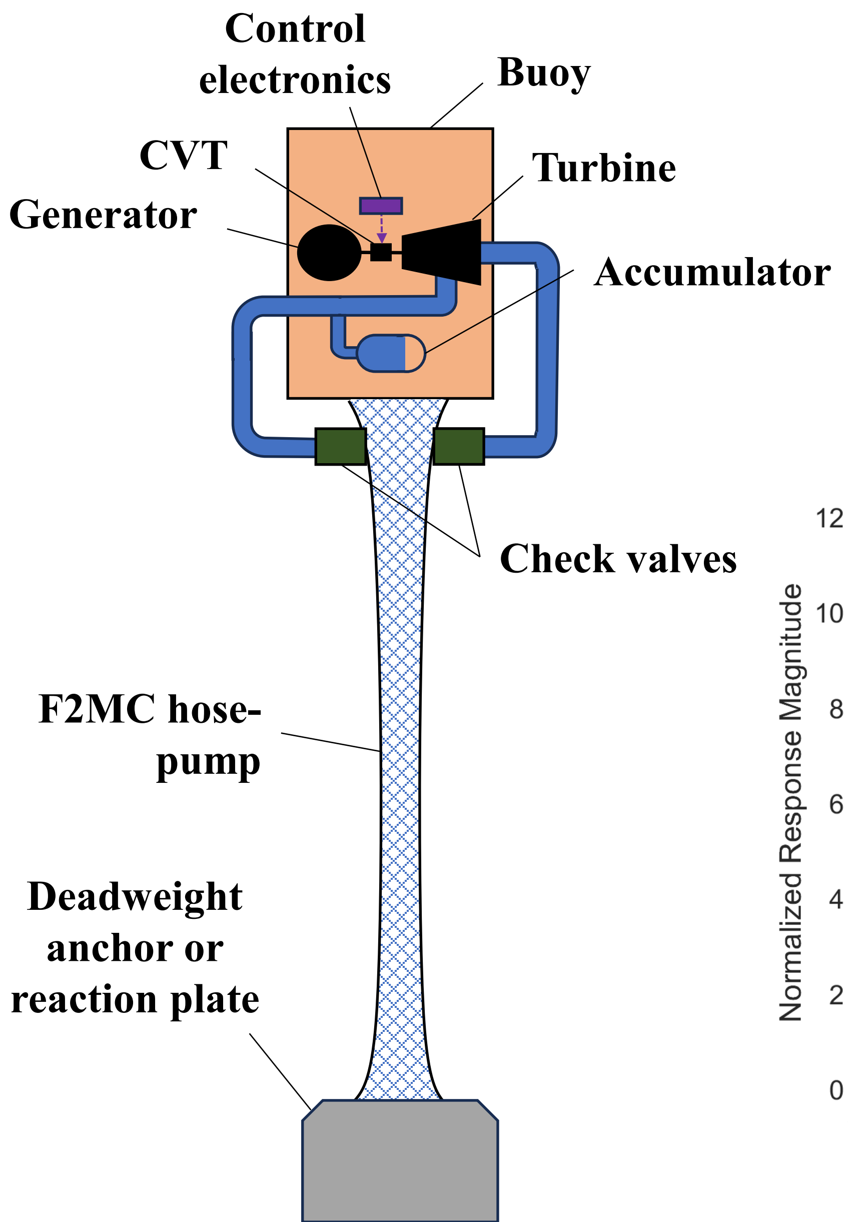


PowerBuoy point absorber [3]

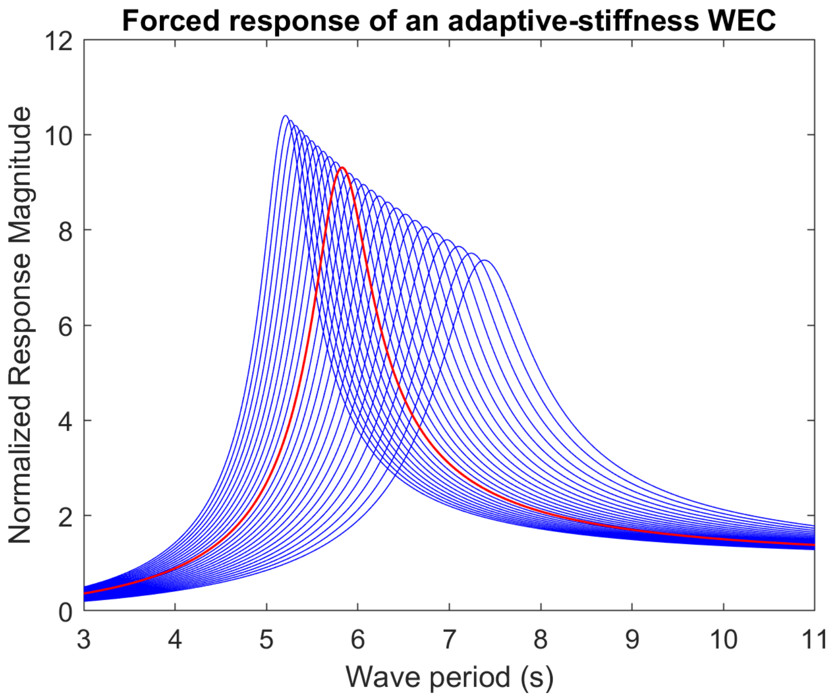
[2] N. Santhosh, V. Baskaran, A. Amarkarthik, “A review on front end conversion in ocean wave energy converters,” Front. Energy, vol. 9, no. 3, pp. 297-310, Oct. 2015, doi: 10.1007/s11708-015-0370-x.
[3] M. Mekhiche and K. Edwards, “Ocean Power Technologies PowerBuoy: System-Level Design, Development and Validation Methodology,” in Proc. 2nd Marine Energy Tech. Symposium, Seattle, WA, USA, Apr. 15-18, 2014. [Online]. Available: http://hdl.handle.net/10919/49232

Carson McGuire • cmmcguir@ncsu.edu

Proposed adaptive-stiffness hydraulic PTO system architecture



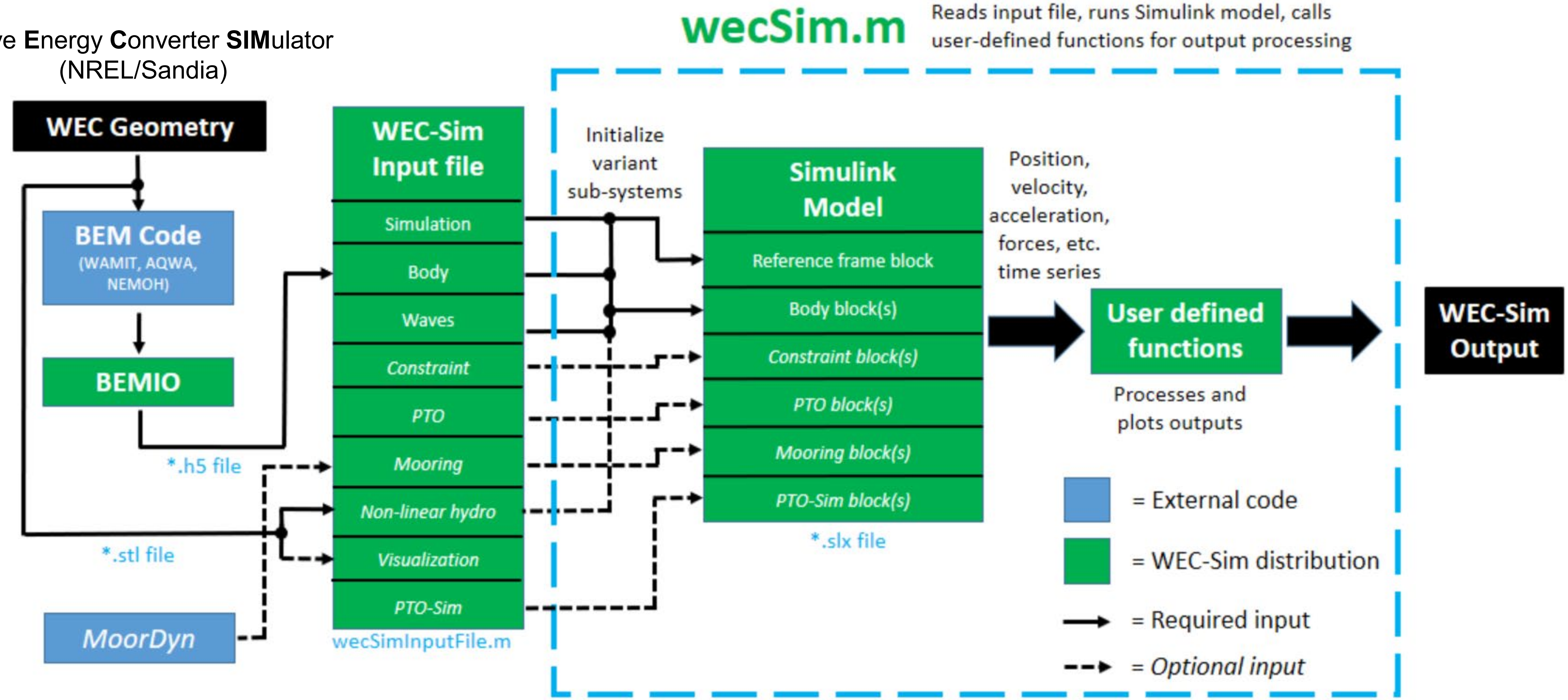
- Coupling hose-pump output to a hydraulic turbine and generator can create electrical output
- Pressure (and thus, stiffness) control: Add multi-speed gearing (such as a CVT) between the turbine and generator
  - Changing gear ratio alters torque-speed relationship, internal pressure-output flow rate relationship



- Additional potential benefits:
  - In rough seas, stiffness can be reduced to mitigate shock loads
  - Unlike piston pumps, there are no high precision sliding seals
  - Hose pump is corrosion resistant and can be fully coated to inhibit biofouling
  - Easy to transport and deploy
    - Hose pump can be coiled on a spool
  - Low environmental risk
    - Working fluid can captive freshwater
  - Reduced risk of entanglement for marine mammals

Objective 1: WEC-Sim analysis of integrated system

Wave **E**nergy **C**onverter **SIM**ulator
(NREL/Sandia)

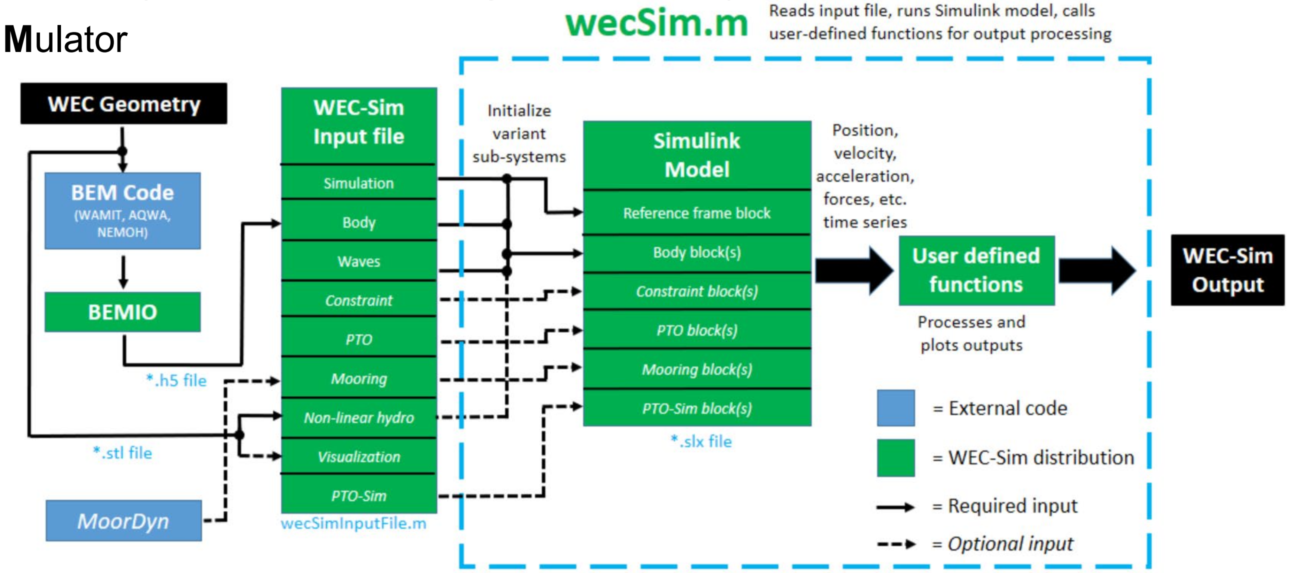


https://wec-sim.github.io/WEC-Sim/main/introduction/overview.html

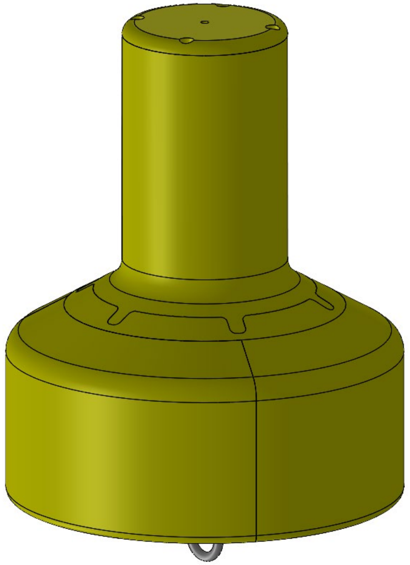
Carson McGuire • cmmcguir@ncsu.edu

Objective 1: WEC-Sim analysis of integrated system

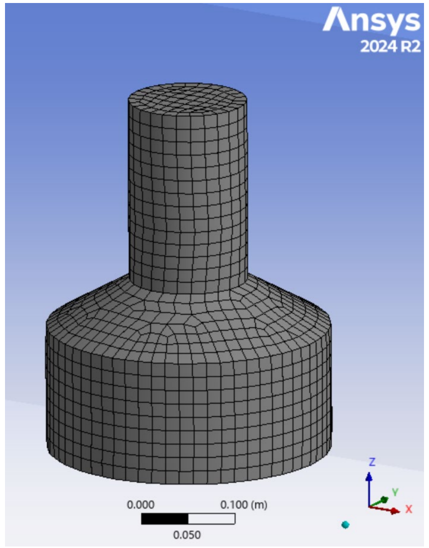
Wave **E**nergy **C**onverter **SIM**ulator
(NREL/Sandia)



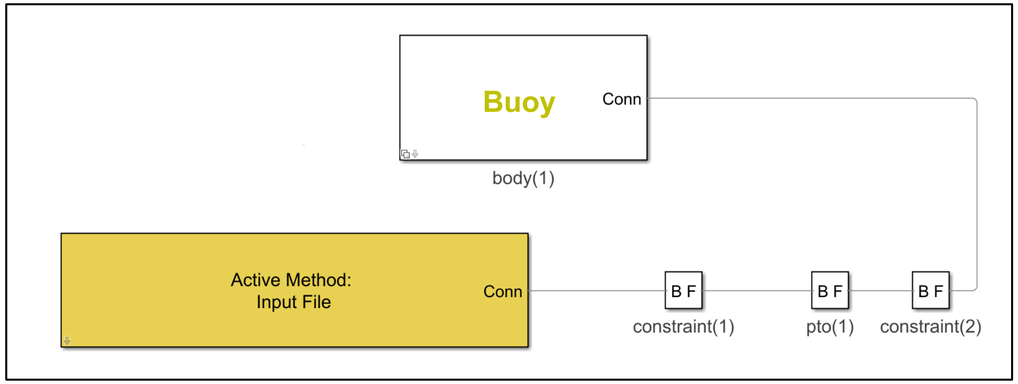
SolidWorks geometry:



Ansys Aqwa (BEM):

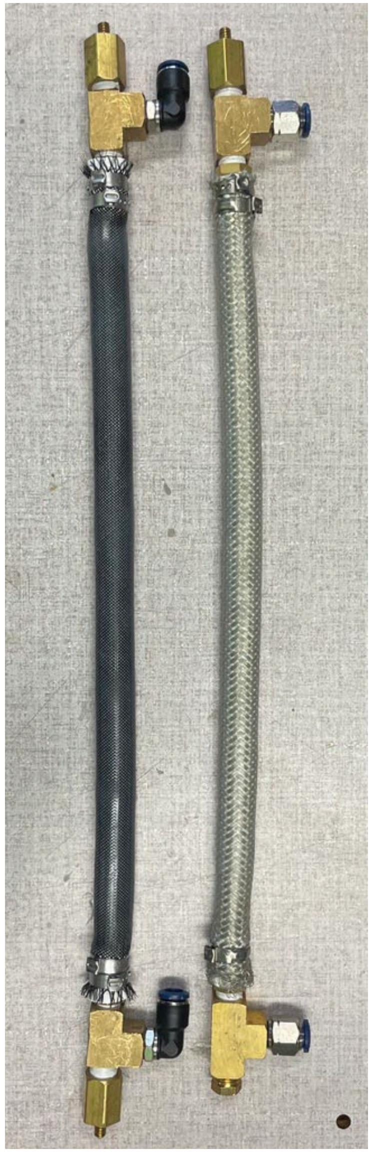


Simulink Model:

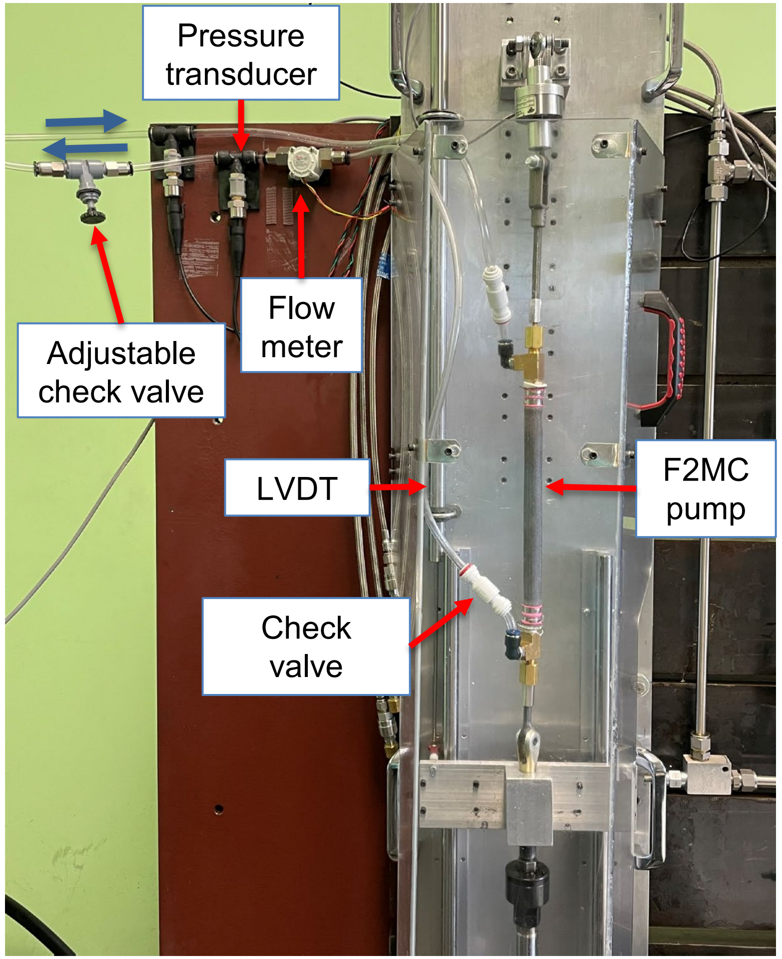


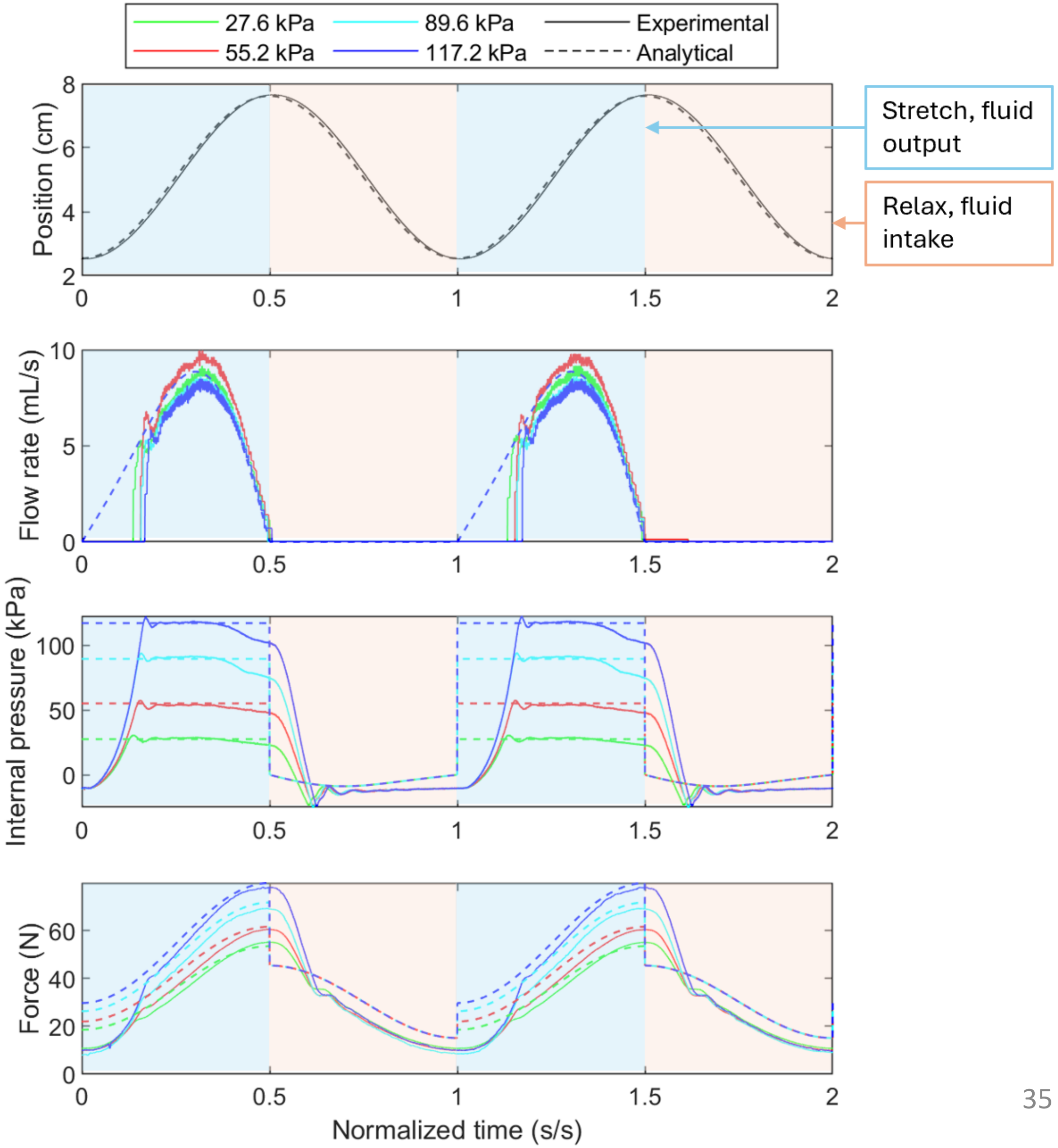
Carson McGuire • cmmcguir@ncsu.edu

Objective 2: Hose-pump testing - Stiffness control from pressure control



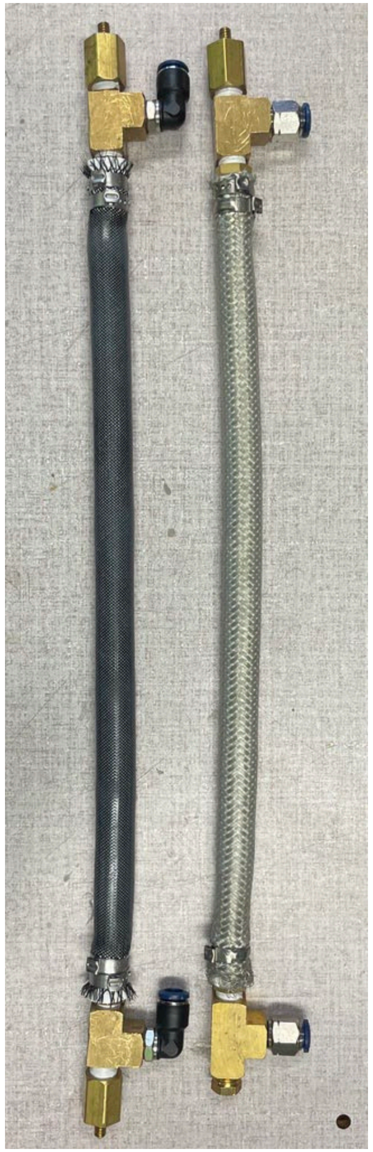
- Adjustable check valve on outlet
  - Direct control of internal pressure during stretch



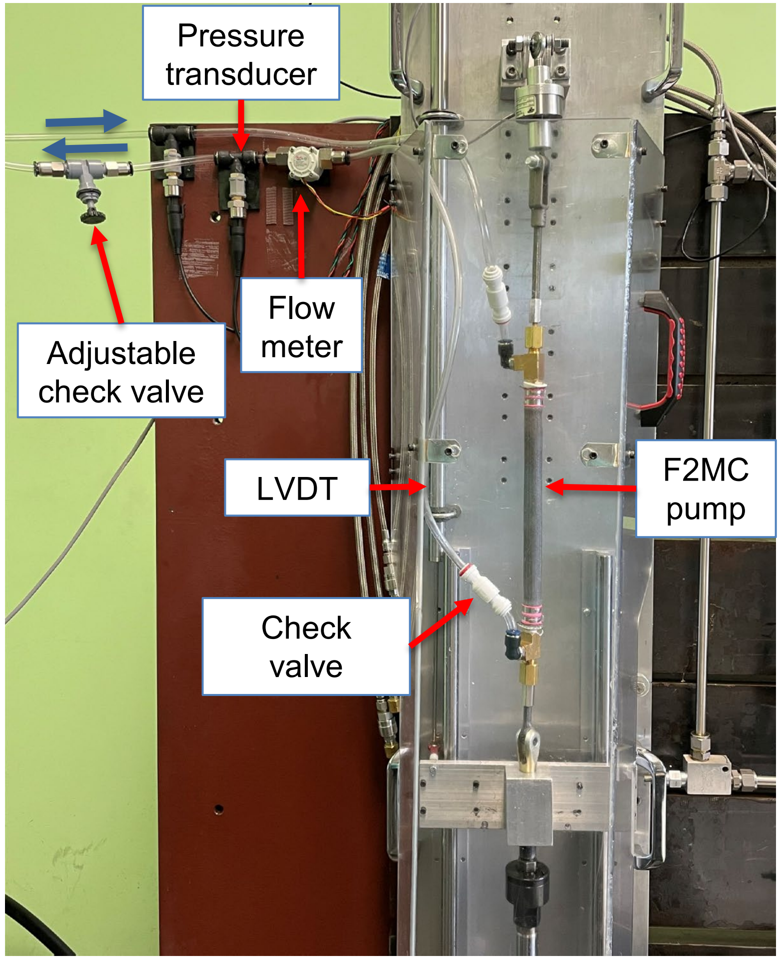


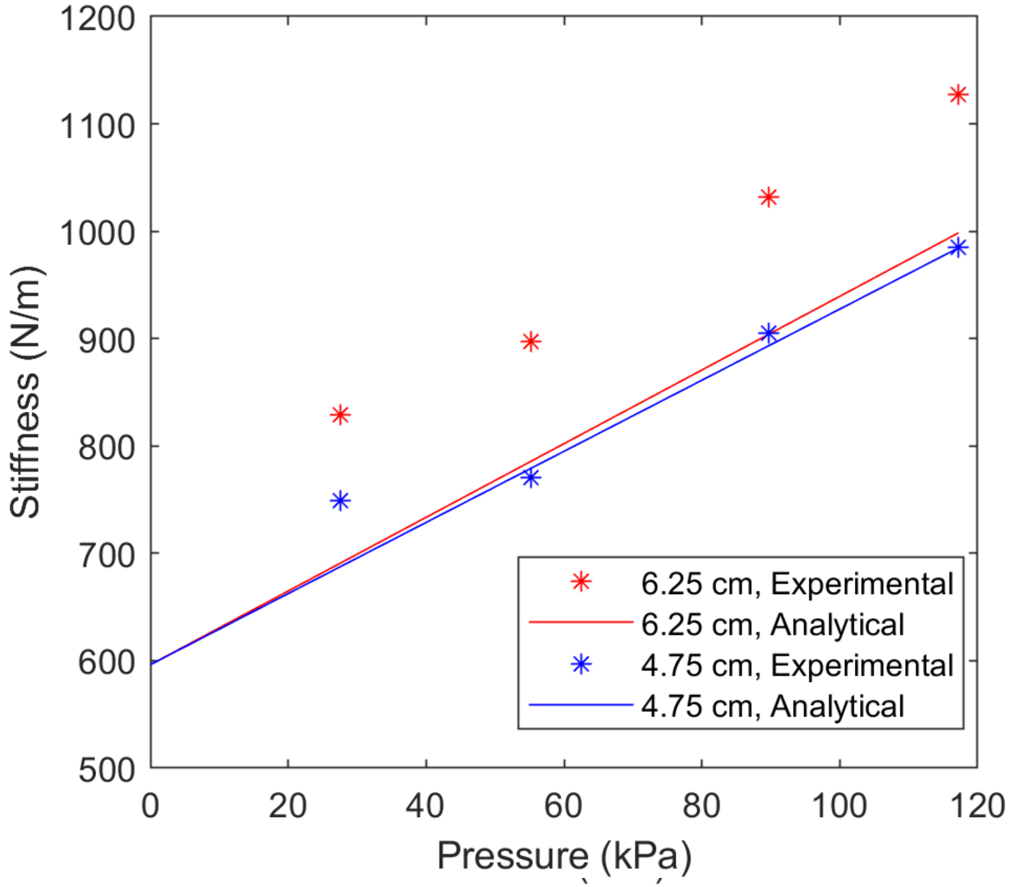
Carson McGuire • cmmcguir@ncsu.edu

Objective 2: Hose-pump testing - Stiffness control from pressure control



- Adjustable check valve on outlet
  - Direct control of internal pressure during stretch





Objective 3: First point absorber buoys (July, Oct. 2024)

Jul. 16-17, 2024

- First experiments with point-absorber buoy (Plunger 1)
- Issues with pressure regulator (used to apply hydraulic impedance)
- Buoy was undersized and could not adequately drive the hose-pump
- Failed to show benefits of adaptive stiffness

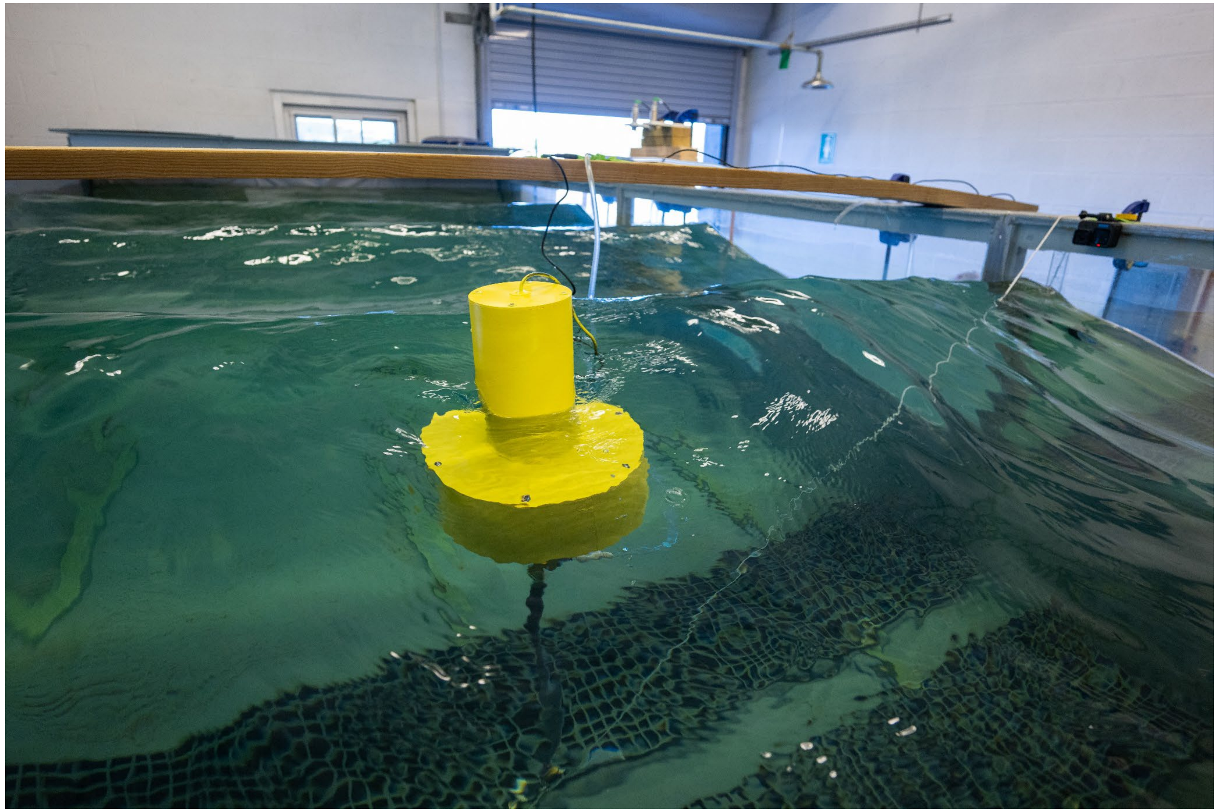


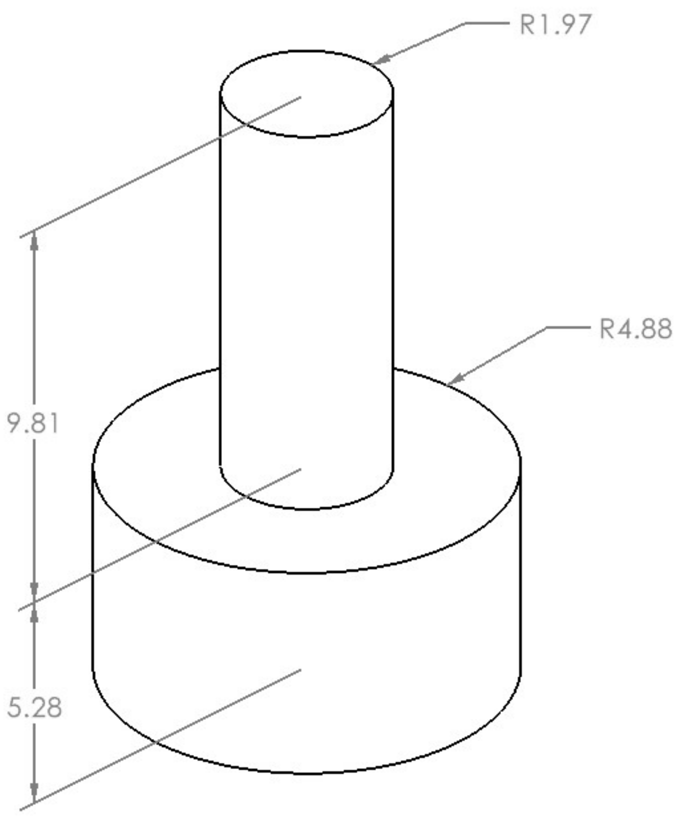
Photo credit: John McCord (CSI)

Carson McGuire • cmmcguir@ncsu.edu

Objective 3: First point absorber buoys (July, Oct. 2024)

Jul. 16-17, 2024

- First experiments with point-absorber buoy (Plunger 1)
- Issues with pressure regulator (used to apply hydraulic impedance)
- Buoy was undersized and could not adequately drive the hose-pump
- Failed to show benefits of adaptive stiffness



Plunger 1:

- Mass: 7.5 kg (buoy + PTO)
- $K_{hydro} = 77.2\ N/m$
- $K_{PTO} = 112\ N/m$
- $T_n = 1.25\ s$
- Max. buoyancy force: $82.7\ N$

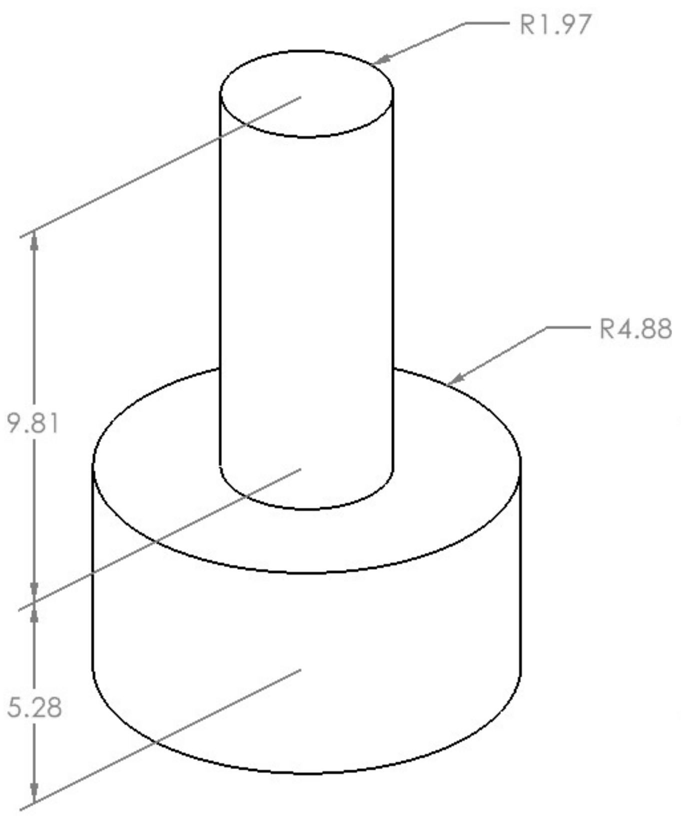
Objective 3: First point absorber buoys (July, Oct. 2024)

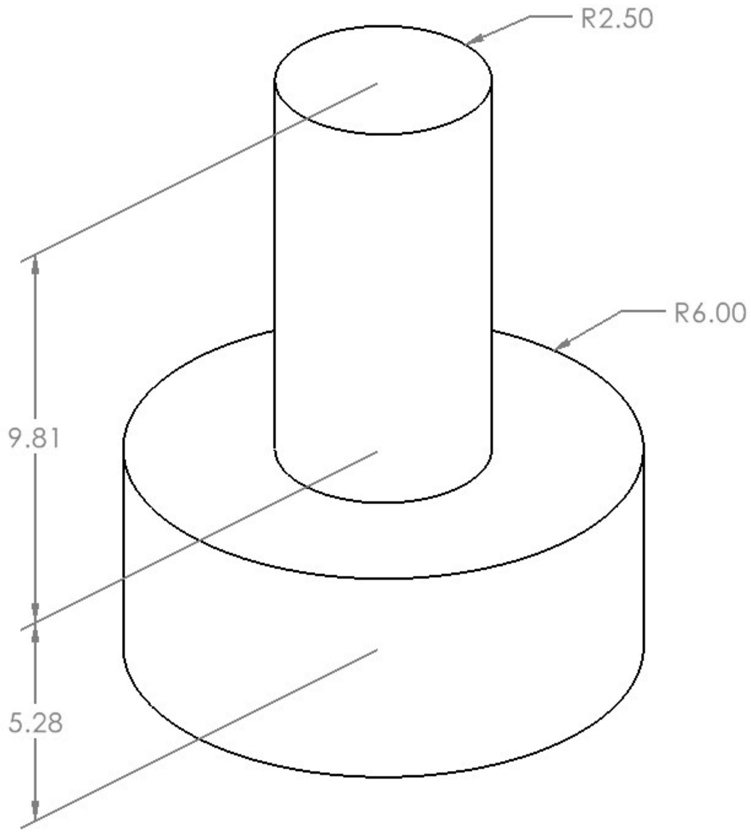
Jul. 16-17, 2024

- First experiments with point-absorber buoy (Plunger 1)
- Issues with pressure regulator (used to apply hydraulic impedance)
- Buoy was undersized and could not adequately drive the hose-pump
- Failed to show benefits of adaptive stiffness

Oct. 9-11, 2024

- Point-absorber buoy was scaled up (Plunger 2)
- Used an adjustable check valve (ACV)
- Chosen ACV was too small and over-throttled the flow
- Failed to show benefits of adaptive stiffness





Plunger 1:

- Mass: 7.5 kg (buoy + PTO)
- $K_{hydro} = 77.2\ N/m$
- $K_{PTO} = 112\ N/m$
- $T_n = 1.25\ s$
- Max. buoyancy force: $82.7\ N$

Plunger 2:

- Mass: 11.2 kg (buoy + PTO)
- $K_{hydro} = 124.6\ N/m$
- $K_{PTO} = 112\ N/m$
- $T_n = 1.36\ s$
- Max. buoyancy force: $126.9\ N$

Sidebar: What's the deal with the shape of that buoy?

Typical buoys have:

- Large cross-sectional area at waterline
- Ballast mass low on body

Hydrostatic stiffness:

$$K_{hydro} = \rho g A$$

→ Larger CSA causes the buoy to move stiffer w.r.t the relative wave motion

In rough water, buoy more closely follows water surface → less likely to have waves crest over the buoy.

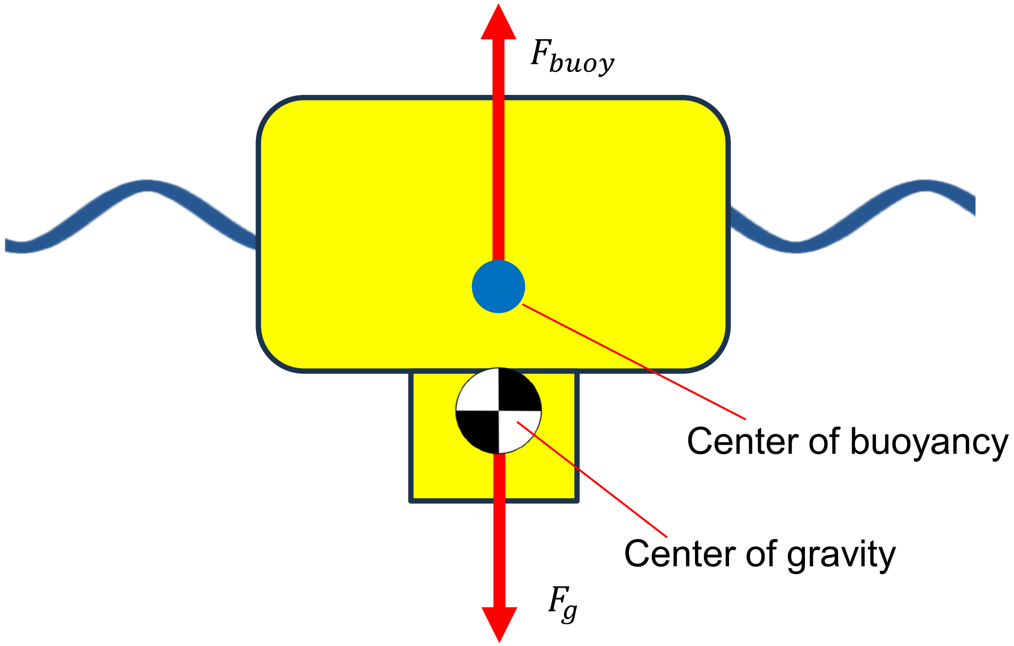
https://www.whoi.edu/press-room/news-release/ocean-observatories-initiatives-pioneer-array-relocating-to-southern-mid-atlantic-bight/

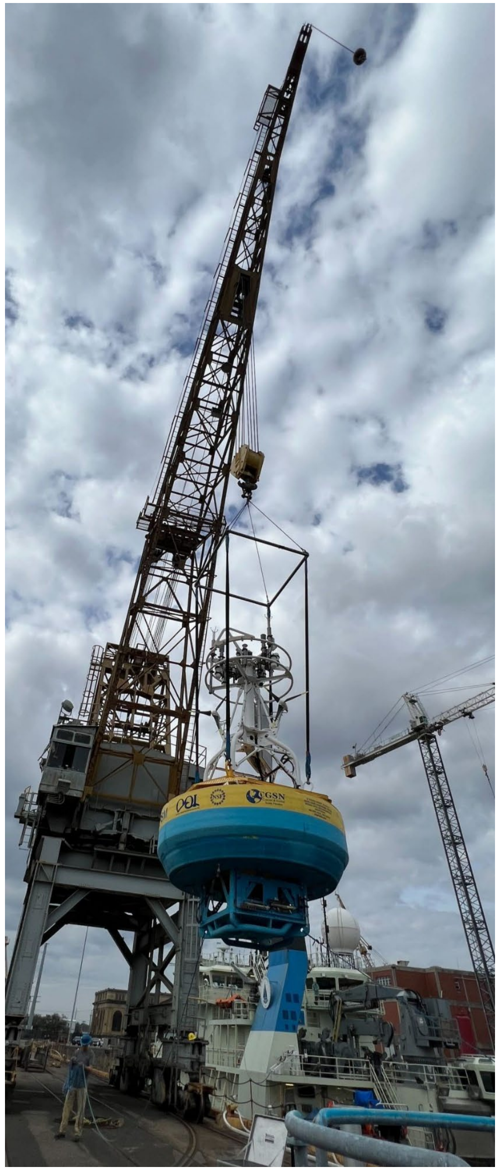
Sidebar: What's the deal with the shape of that buoy?

Typical buoys have:

- Large cross-sectional area at waterline
- Ballast mass low on body

Low ballast mass moves CG far below buoyancy center
→ Buoy stays upright, even in heavy storm conditions

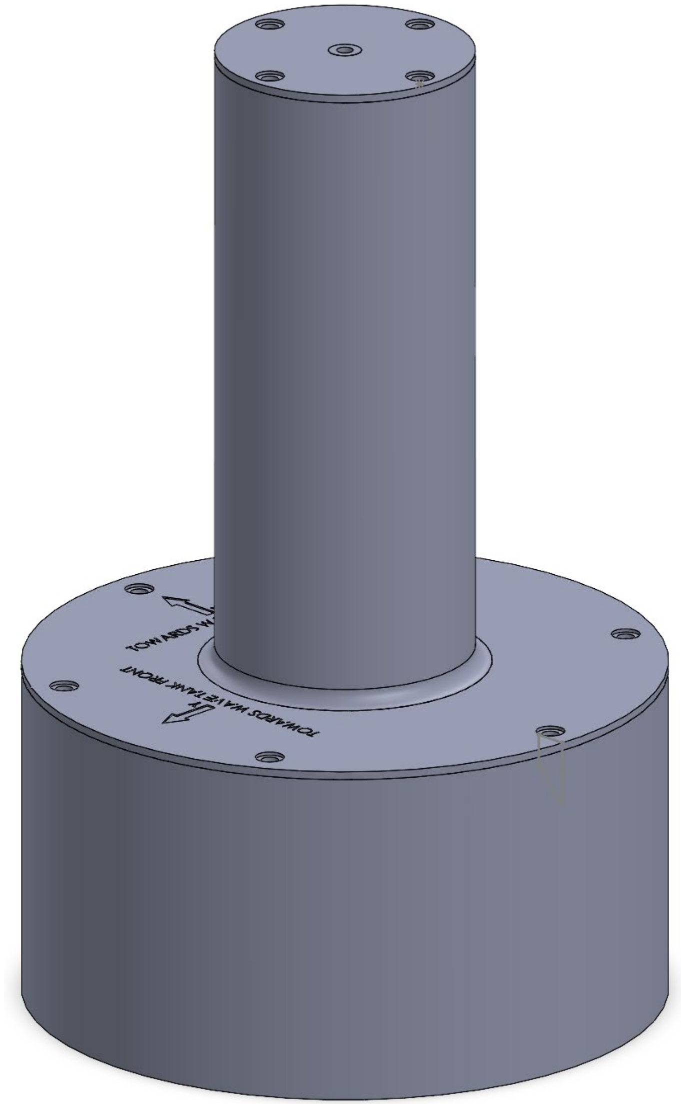




https://www.whoi.edu/know-your-ocean/ocean-topics/ocean-tech/moorings-buoys/

Carson McGuire • cmmcguir@ncsu.edu

Sidebar: What's the deal with the shape of that buoy?



For our point-absorber WEC, we want:

- A buoy that stays upright

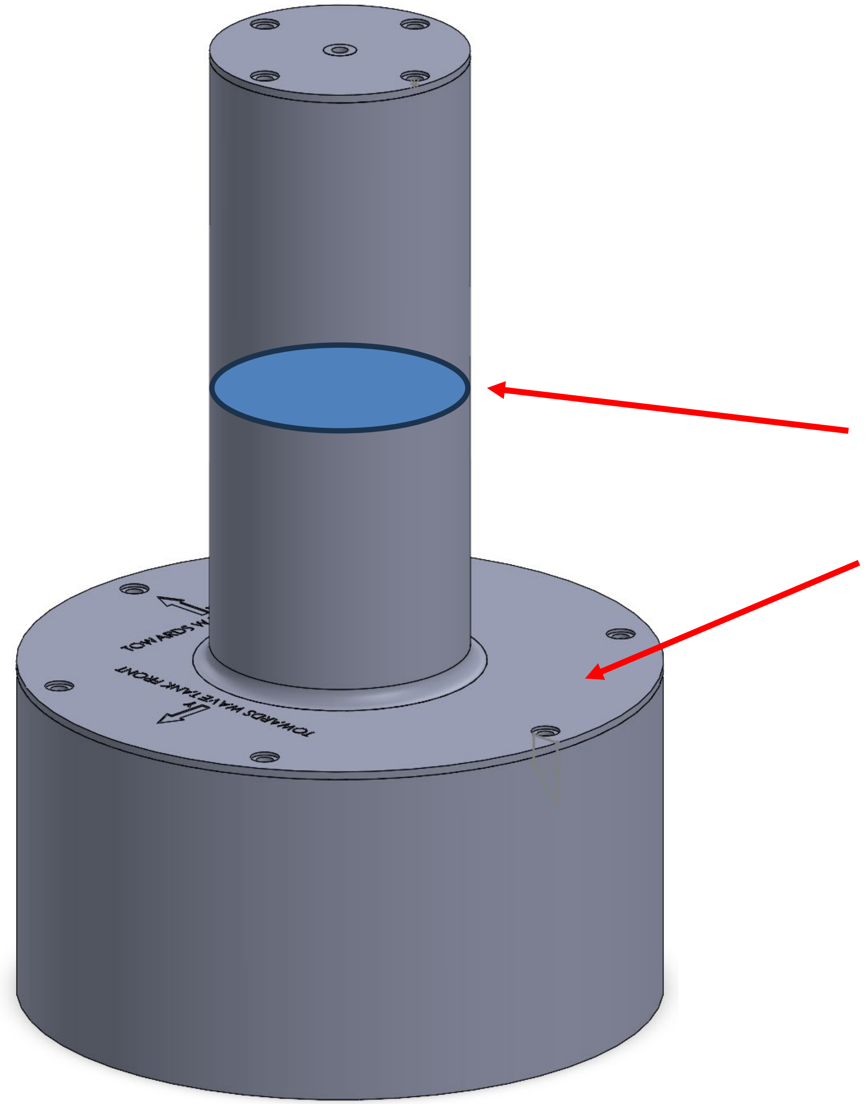
→ Keep a low CG

- A buoy that has a natural period longer than the maximum expected environmental wave period
  - The hose-pump PTO can only ever add stiffness
  - By adding stiffness, we shorten the overall WEC's natural period
  - Control the internal pressure of the PTO to add a certain amount of stiffness to target the instantaneous sea-state period

→ We need a low buoyancy stiffness

Carson McGuire • cmmcguir@ncsu.edu

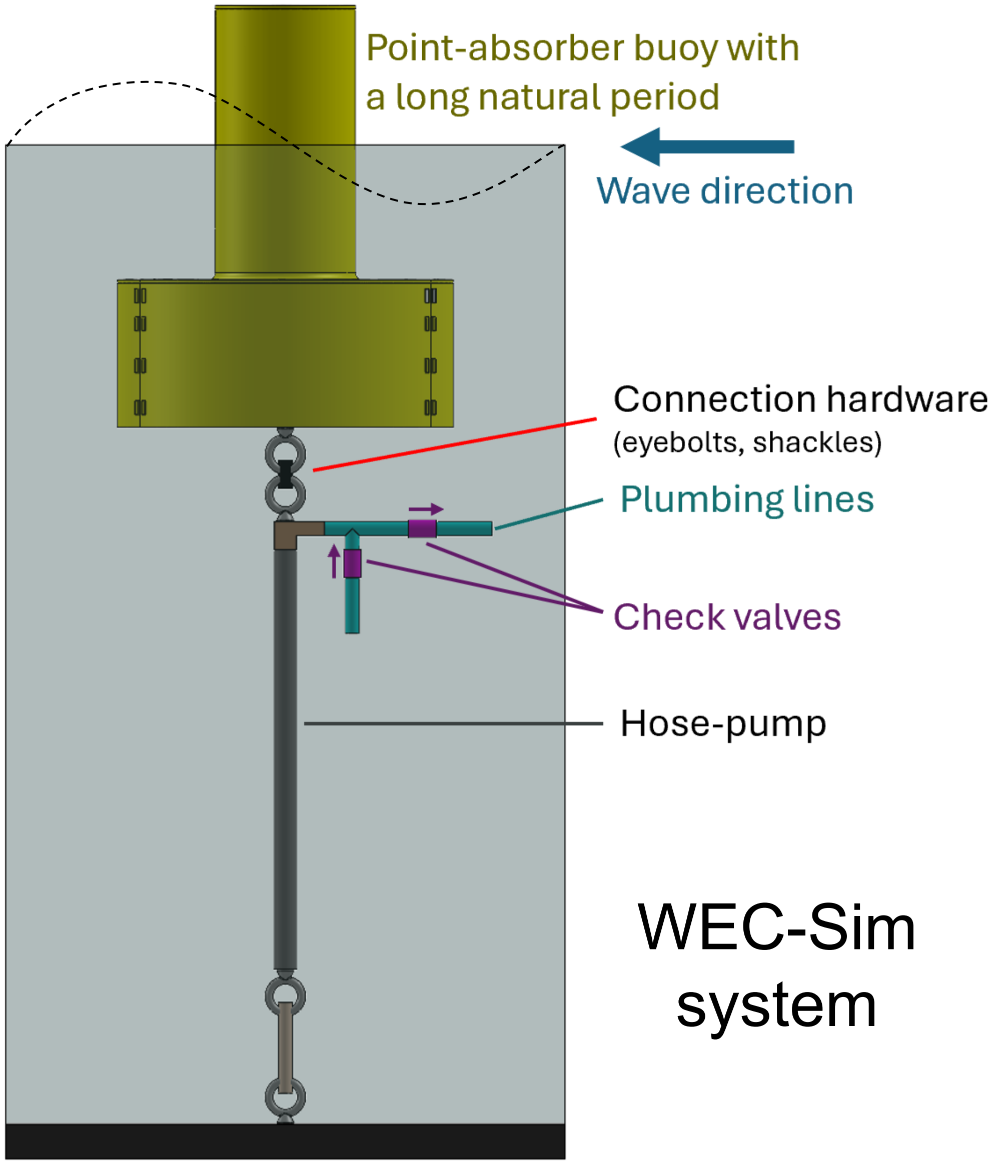
Sidebar: What's the deal with the shape of that buoy?



Result:
- Low CSA at the waterline to minimize buoyancy stiffness
- A large sub-sea compartment for ballast weight

Carson McGuire • cmmcguir@ncsu.edu

Case study: Small-scale turbine-gearing-generator system driven by a buoy



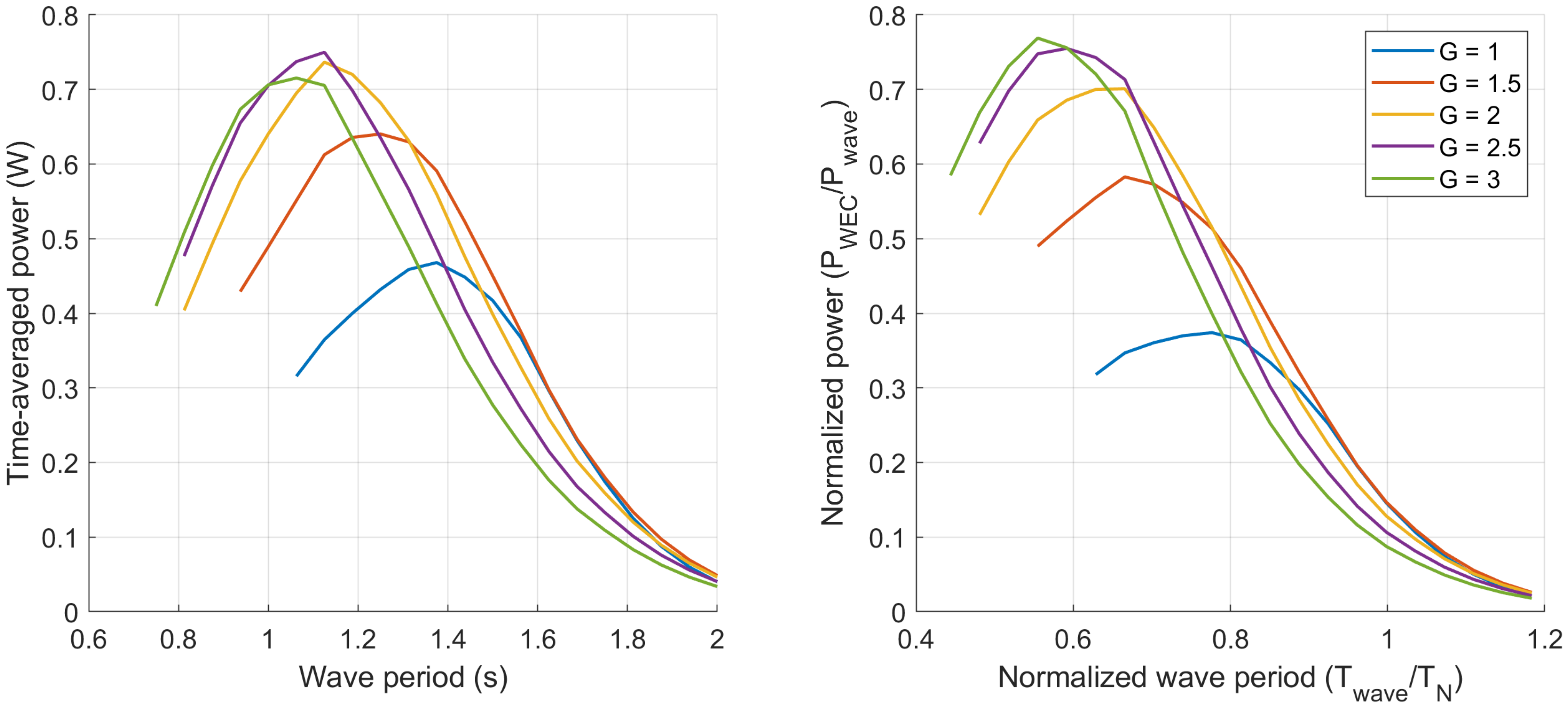
WEC-Sim system

$$\boldsymbol{k} = C_{p1}\frac{k_t k_e}{D^2 R}\boldsymbol{G}^2\left(\frac{3\left(1+\frac{x}{l_u}\right)^2}{tan^2(a_u)} - \frac{1}{sin^2(a_u)}\right)\dot{x} + k_{tube}$$

Stiffness increases with gear ratio, natural period decreases

Parameter	Value
k_t	0.0108 Nm/A
k_e	890 rpm/V
R	2.292 ohm
D	1 cm^3/rev

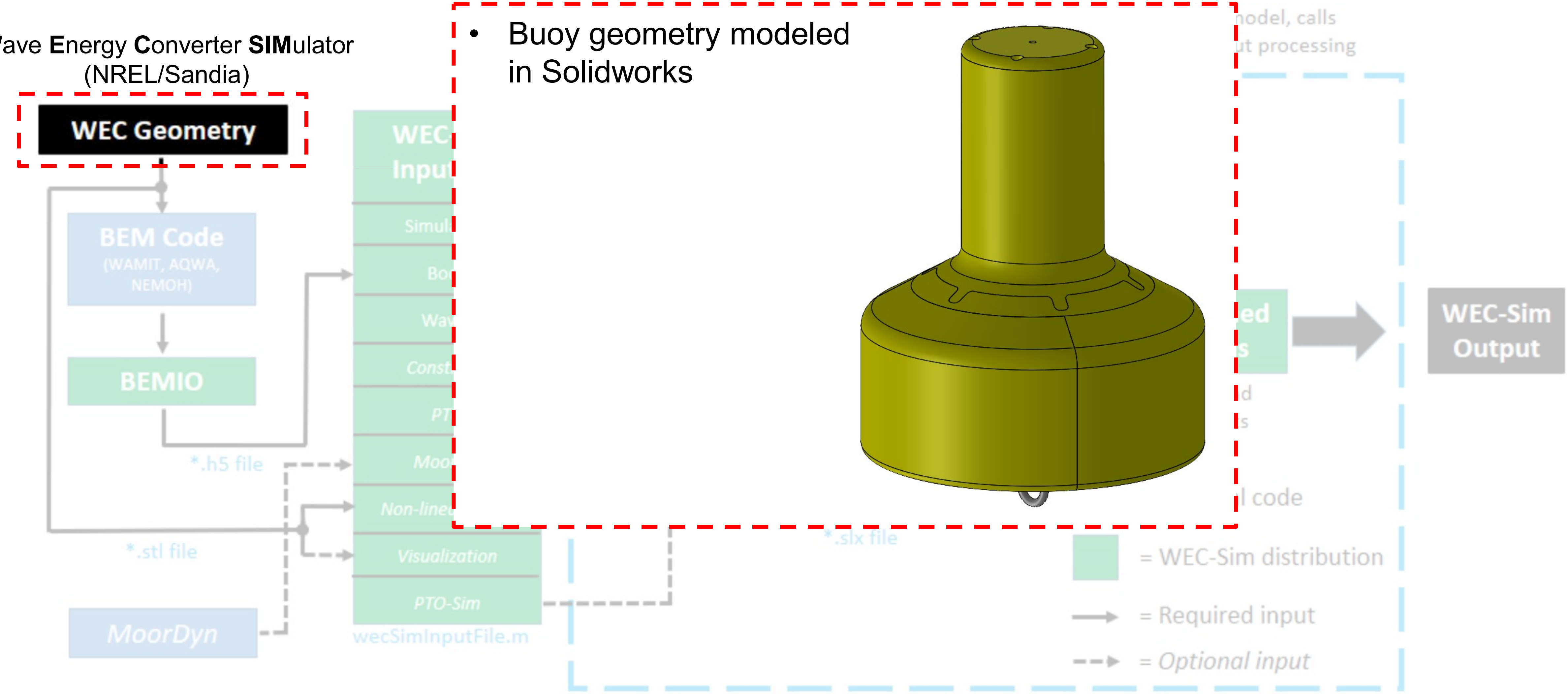
Case study: Small-scale turbine-gearing-generator system driven by a buoy



- Resonant period controllable via gear ratio
- Output power from a particular driving wave depends on gear ratio

Objective 1: WEC-Sim Simulink model of integrated system

Wave **E**nergy **C**onverter **SIM**ulator
(NREL/Sandia)



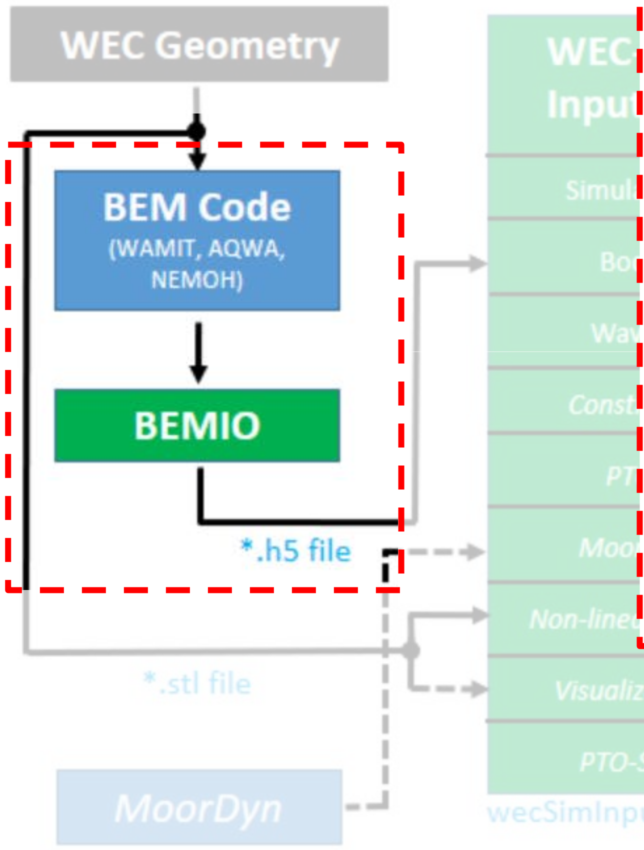
- Buoy geometry modeled in Solidworks

https://wec-sim.github.io/WEC-Sim/main/introduction/overview.html

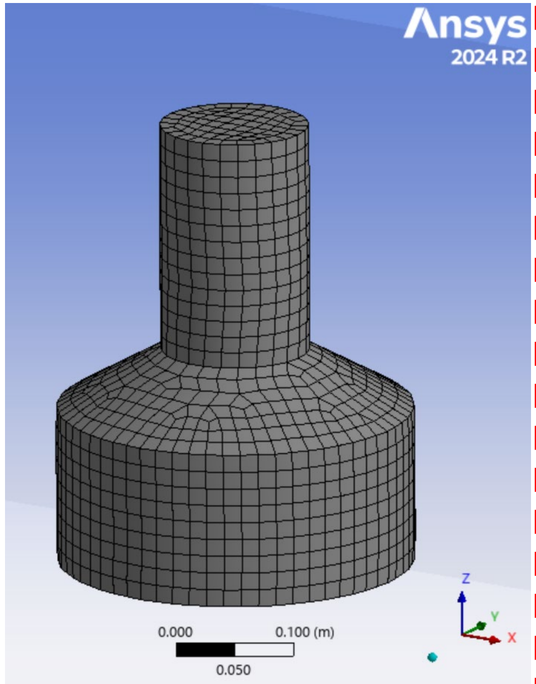
Carson McGuire • cmmcguir@ncsu.edu

Objective 1: WEC-Sim Simulink model of integrated system

Wave **E**nergy **C**onverter **SIM**ulator
(NREL/Sandia)



- Buoy geometry modeled in Solidworks
- Hydrodynamic coefficients pre-calculated using Ansys Aqwa
- Hydro data converted for use by WEC-Sim through BEMIO function



https://wec-sim.github.io/WEC-Sim/main/introduction/overview.html