Comparison of experimental and BEM heave excitation forces for contrasting float geometries

Sarah May Palmer,

Sadie Kass, Curtis Rusch, Brittany Lydon, and Brian Polagye

PMEC
Pacific Marine Energy Center

UAF
UNIVERSITY OF ALASKA FAIRBANKS

Oregon State University

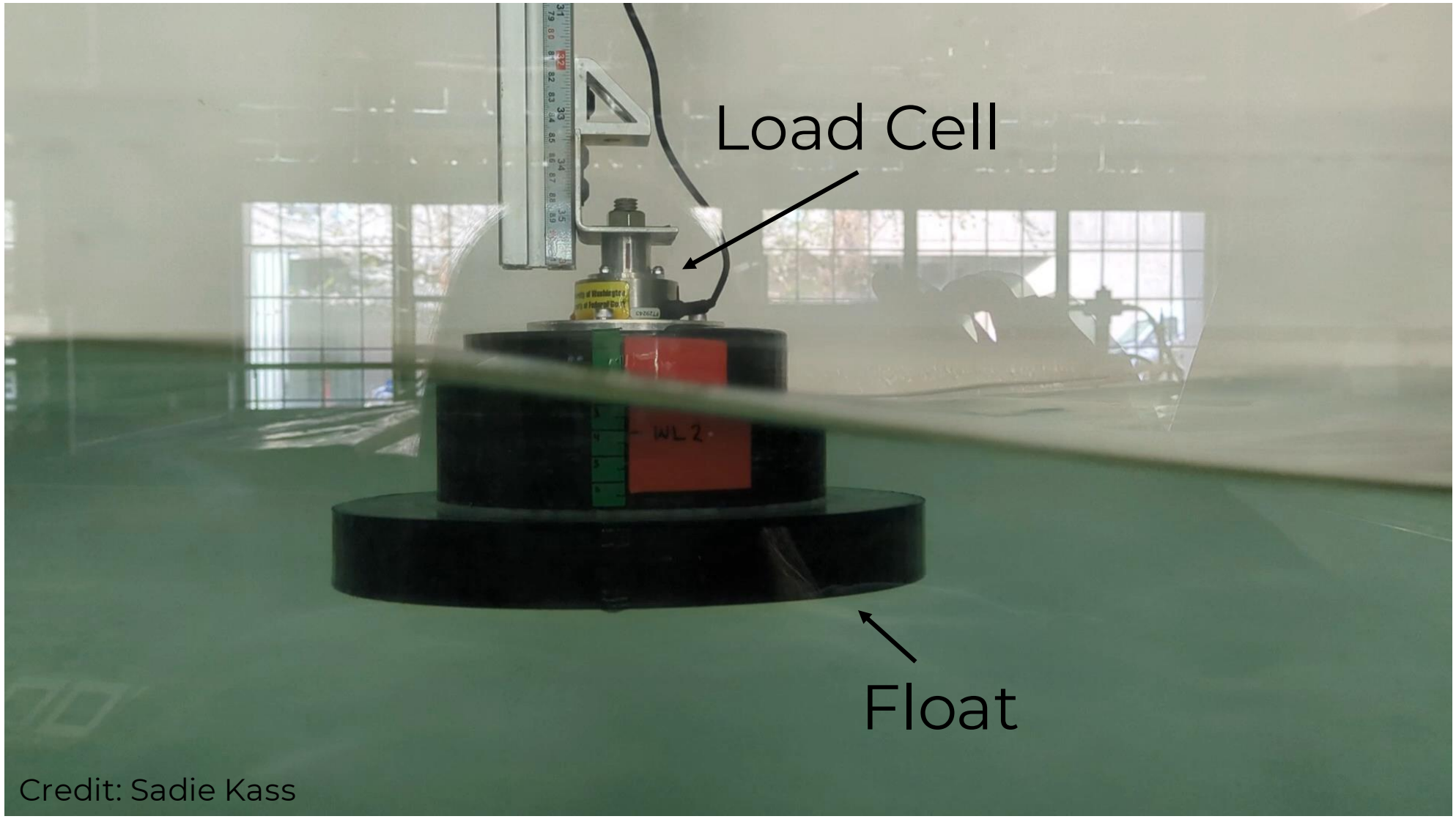
UNIVERSITY of WASHINGTON

Project Goal

Boundary-Element-Methods (BEM) are widely used in WEC design

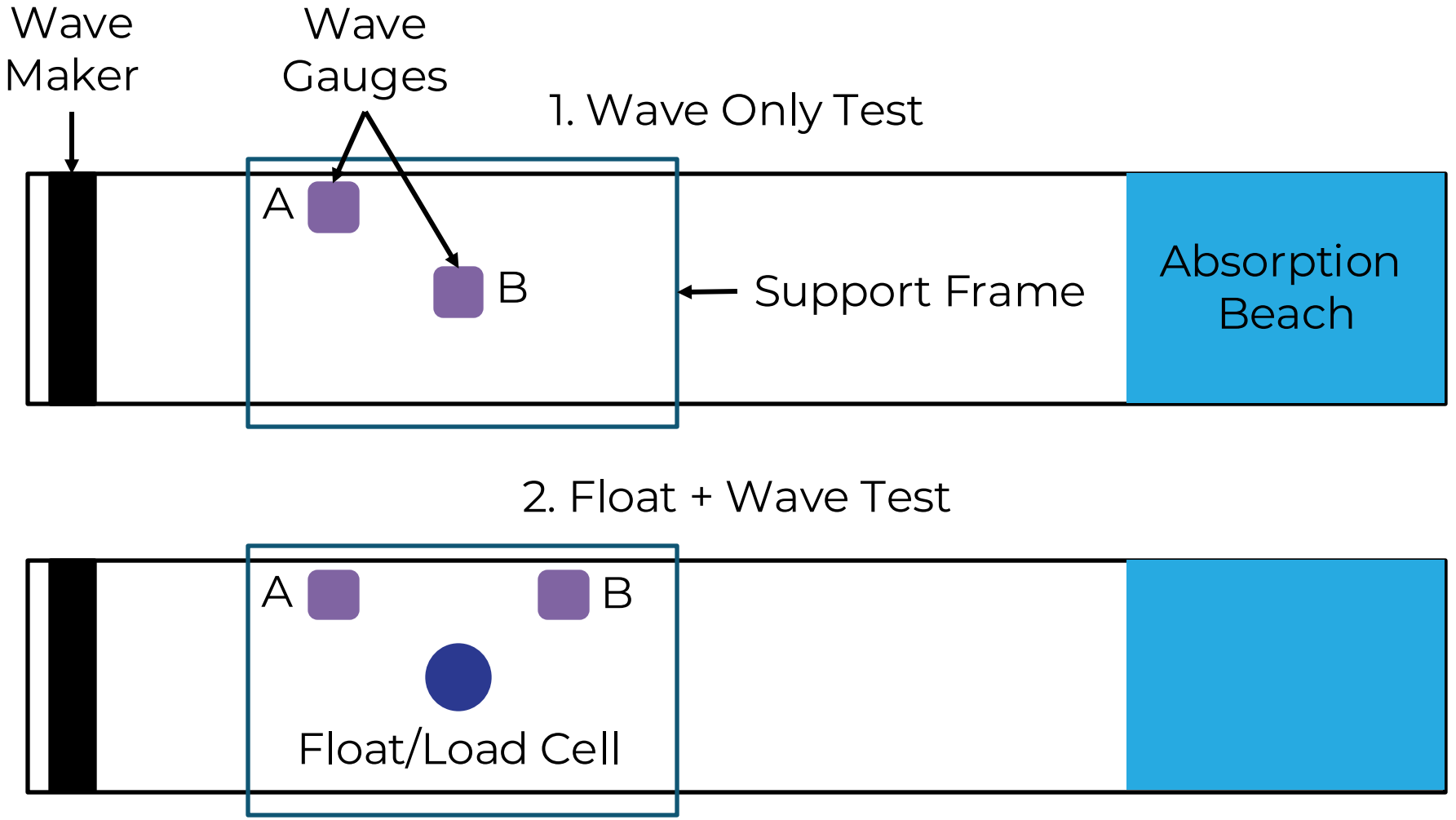
How accurate is BEM for more complex float geometries?

Experimental Methods



Credit: Sadie Kass

Experimental Methods



WEC Hydrodynamics

$$F_{excitation} = F_{reaction}$$

From BEM:

$$F_{excitation} = H_3(\omega)\eta$$

Wave frequency

Wave elevation

Heave excitation coefficient

From Experiments:

Wave amplitude

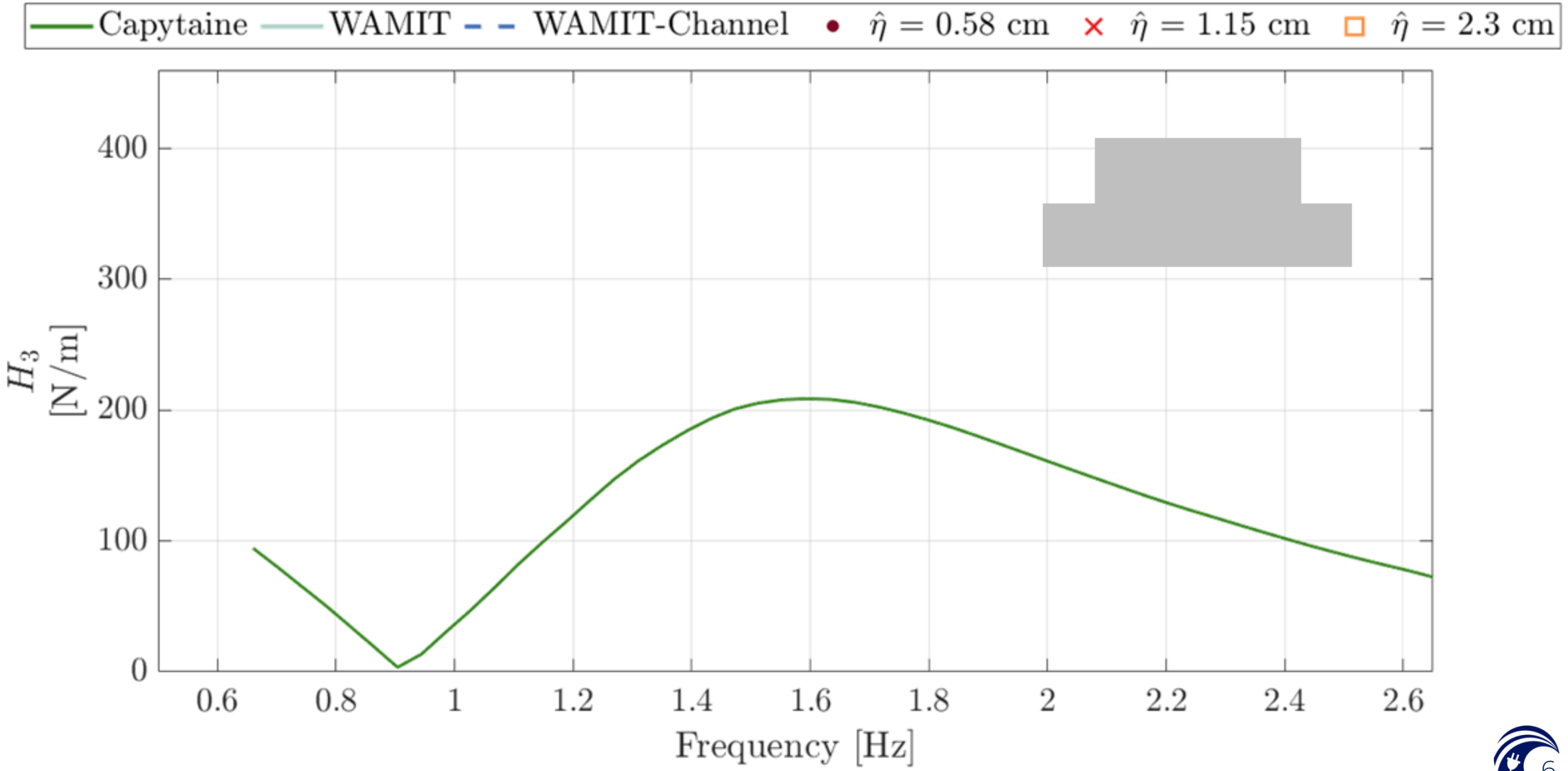
$$H_3(\omega, \hat{\eta})\eta = F_R$$

Measured heave force

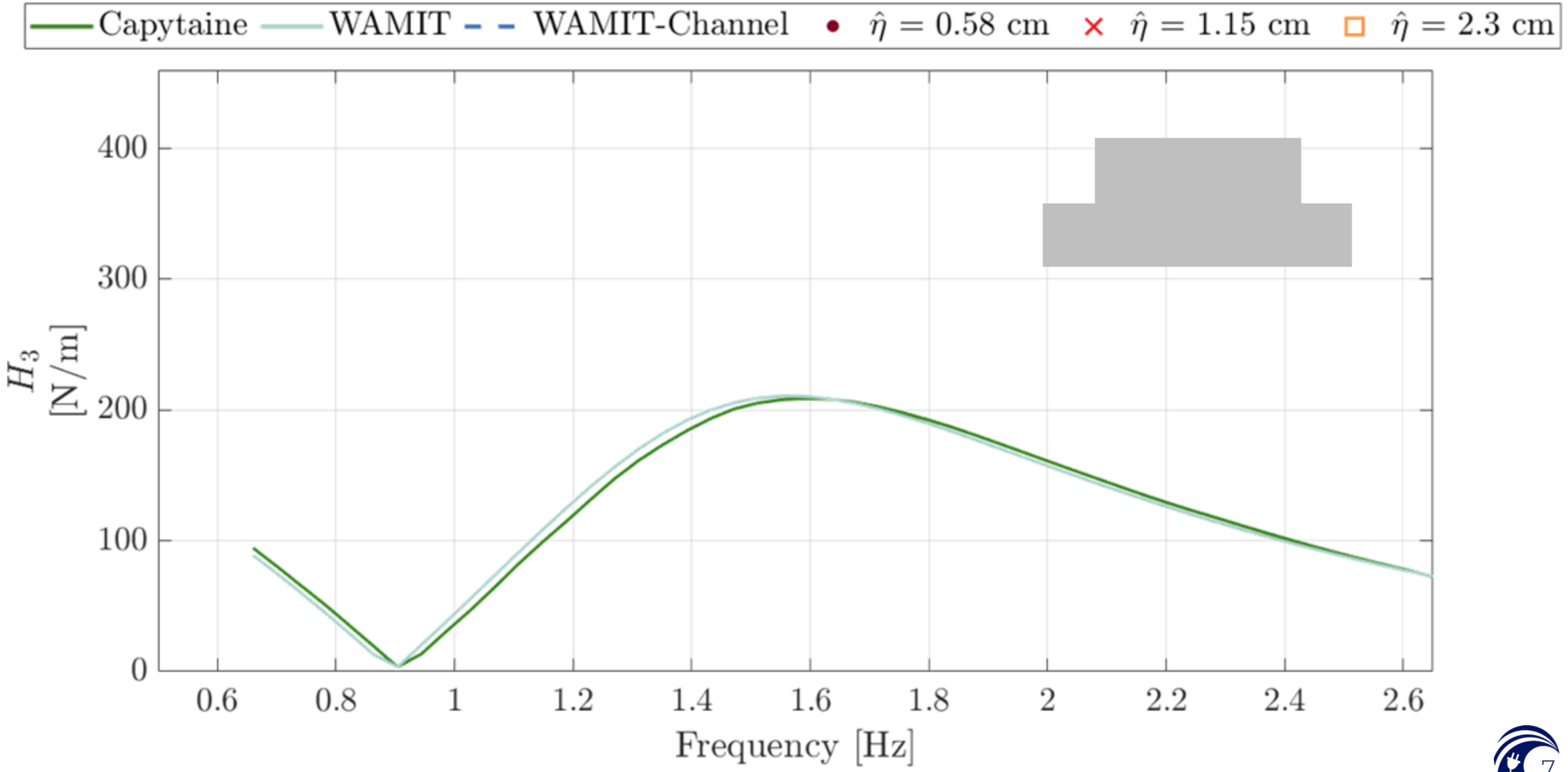
$$H_3(\omega, \hat{\eta}) = \frac{\widehat{F_R}}{\hat{\eta}}$$

Amplitude of measured force

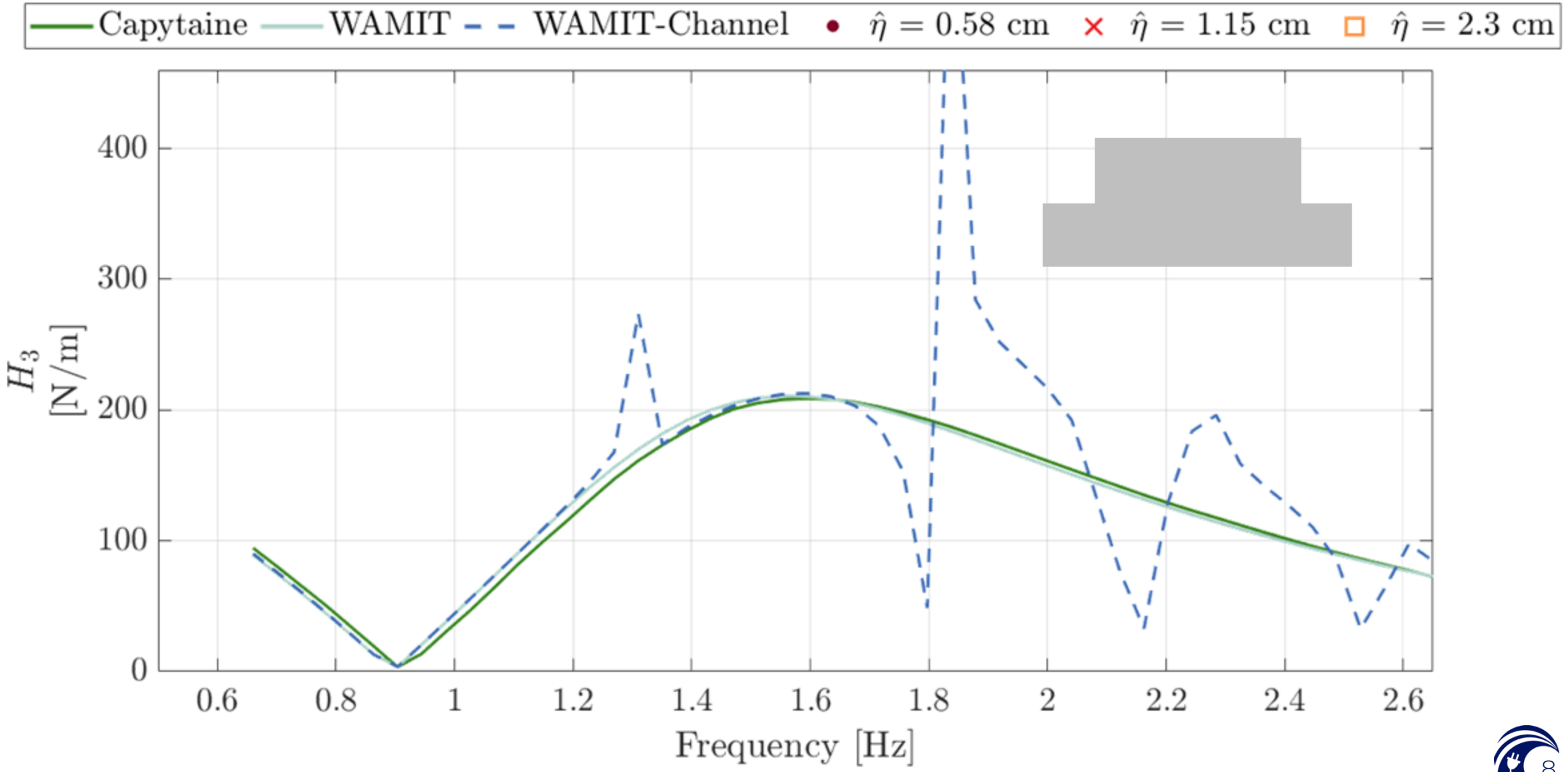
Wave Excitation Coefficients



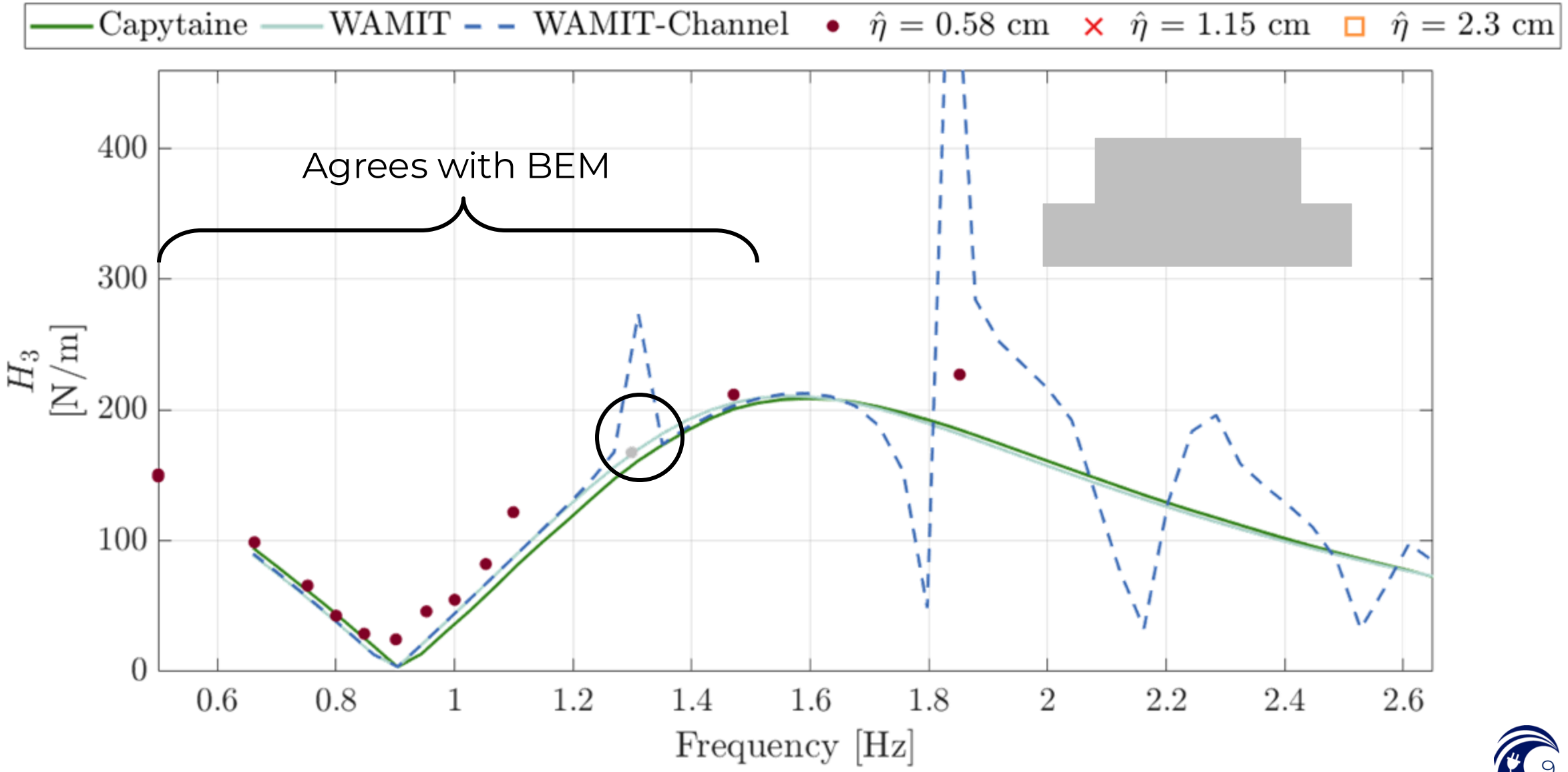
Wave Excitation Coefficients



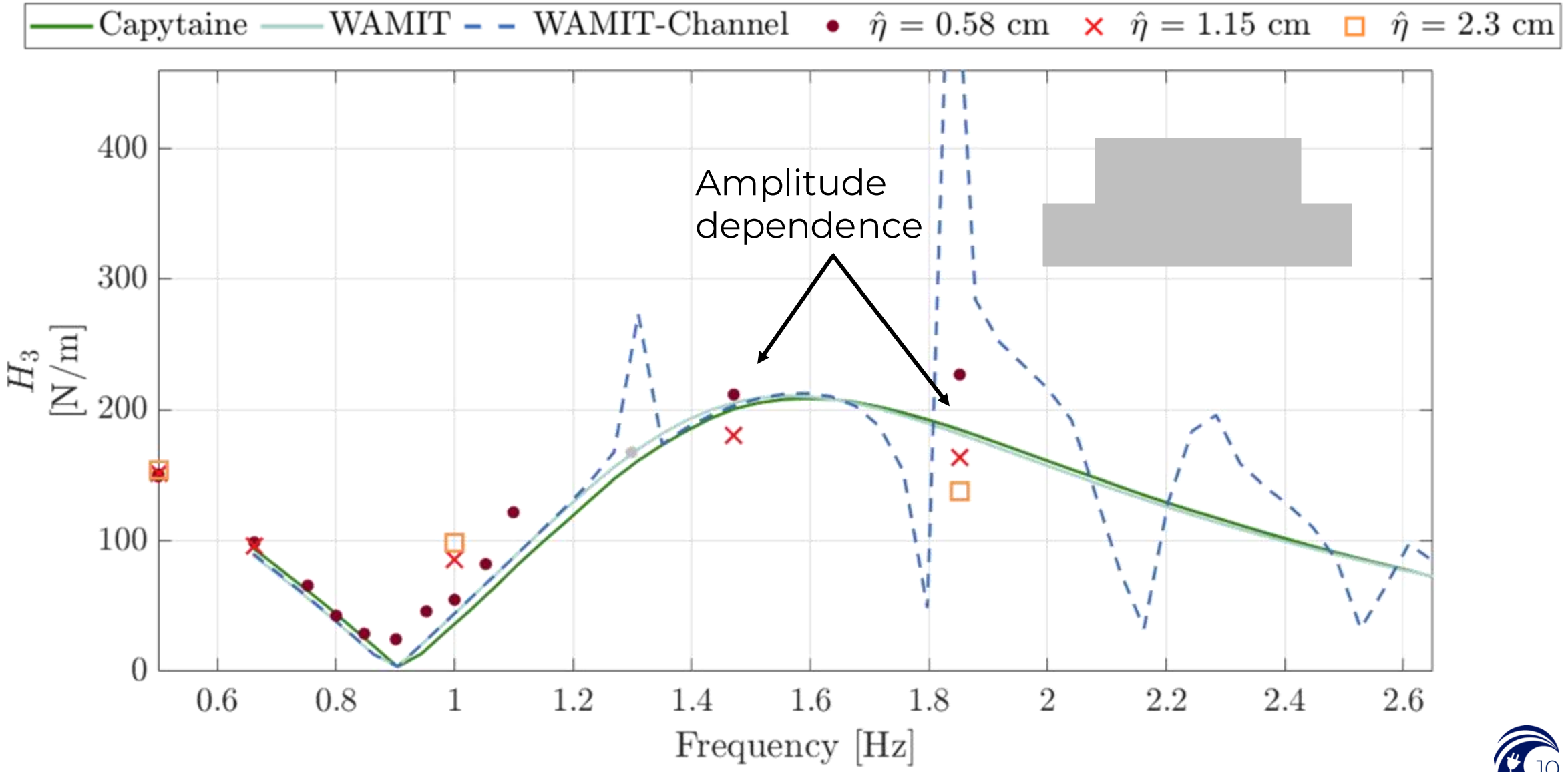
Wave Excitation Coefficients



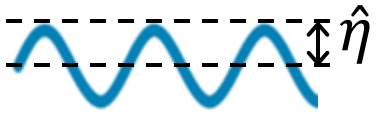
Wave Excitation Coefficients

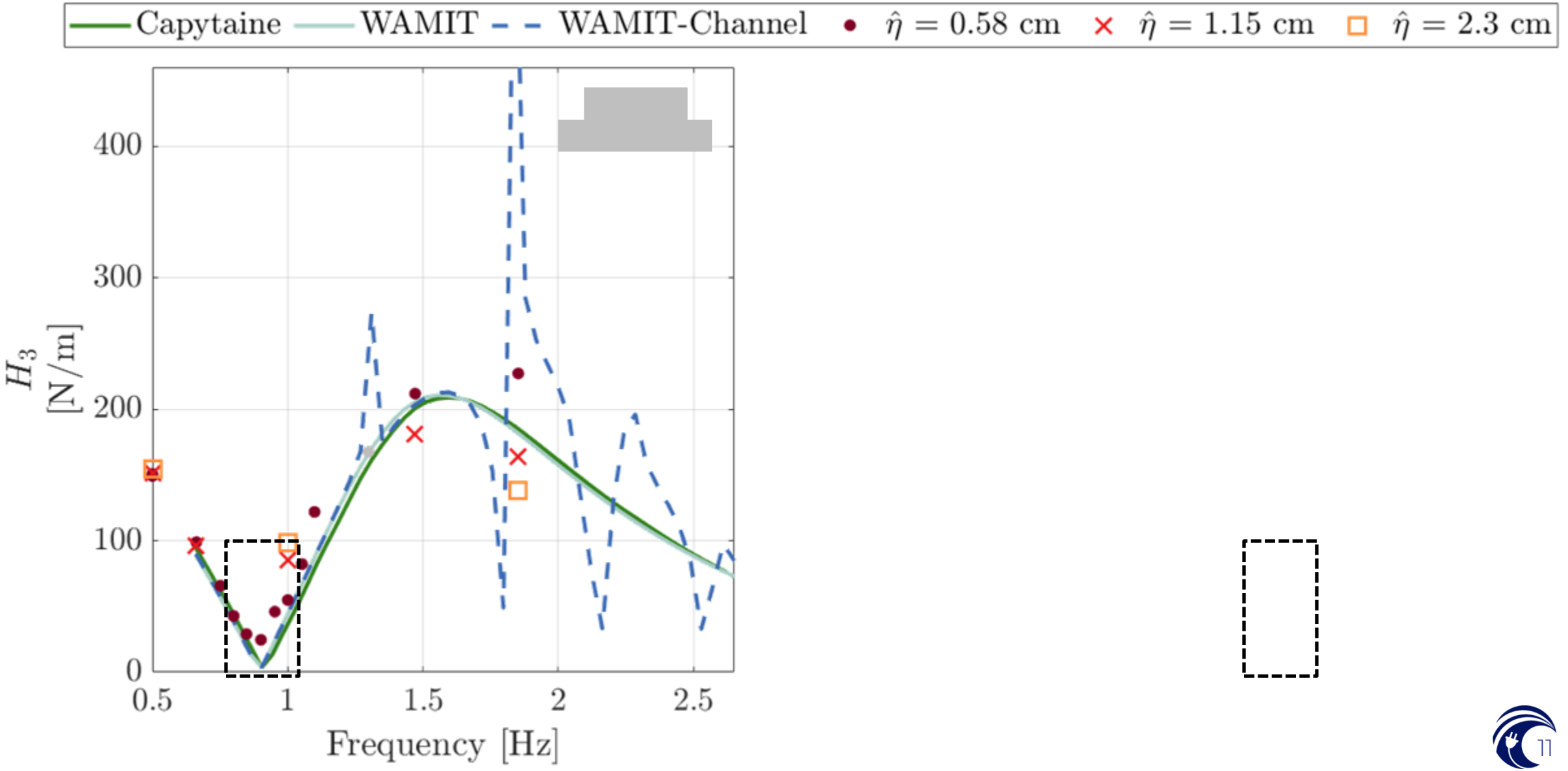


Wave Excitation Coefficients



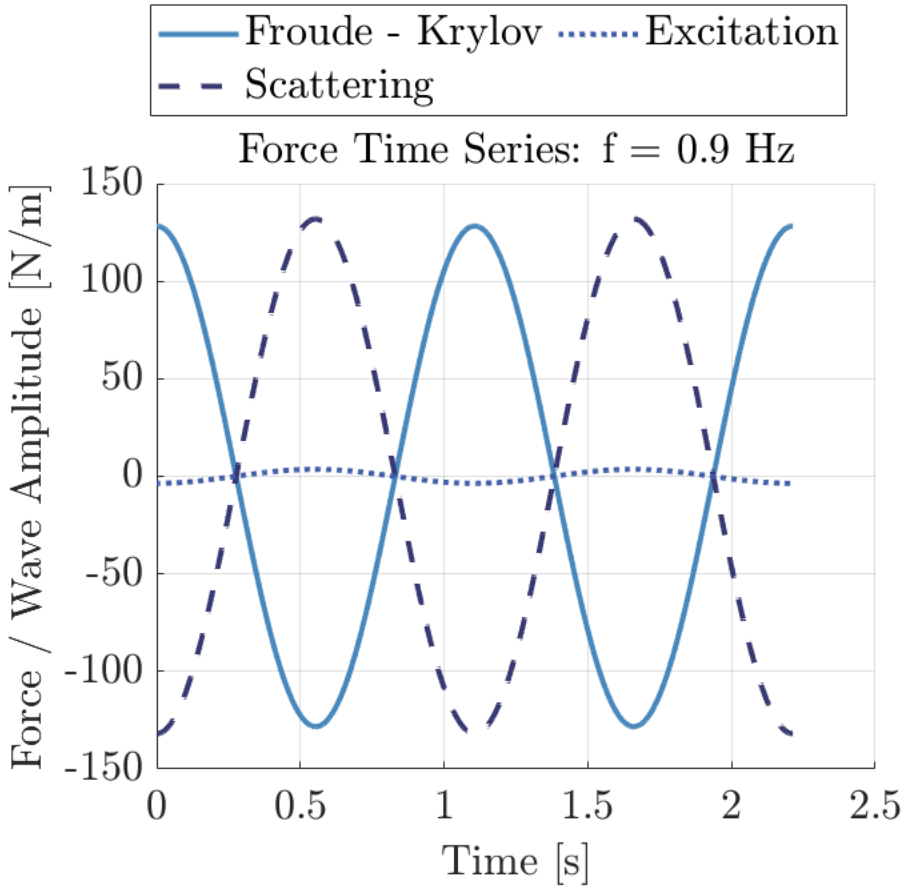
Wave Excitation Coefficients





Cancellation Frequency

$$H_3(\omega, \hat{\eta})\eta = F_{excitation}$$



Time Domain Reconstructions

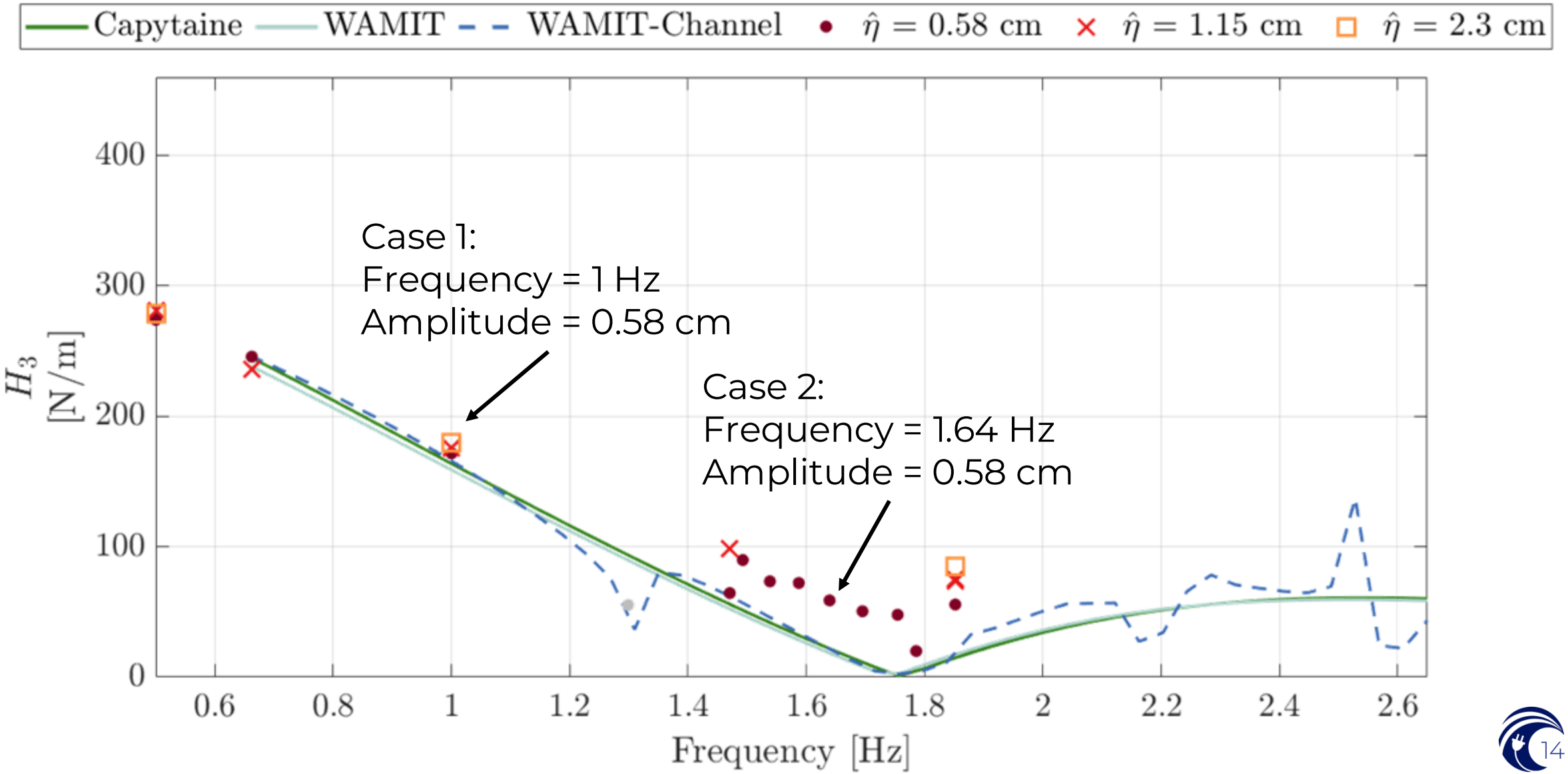
$$H_3(\omega, \hat{\eta}\,)\eta = F_{excitation} = H_3\hat{\eta}cos(\omega t + \phi_{ex})$$

Compare to evaluate the accuracy of the linear assumption

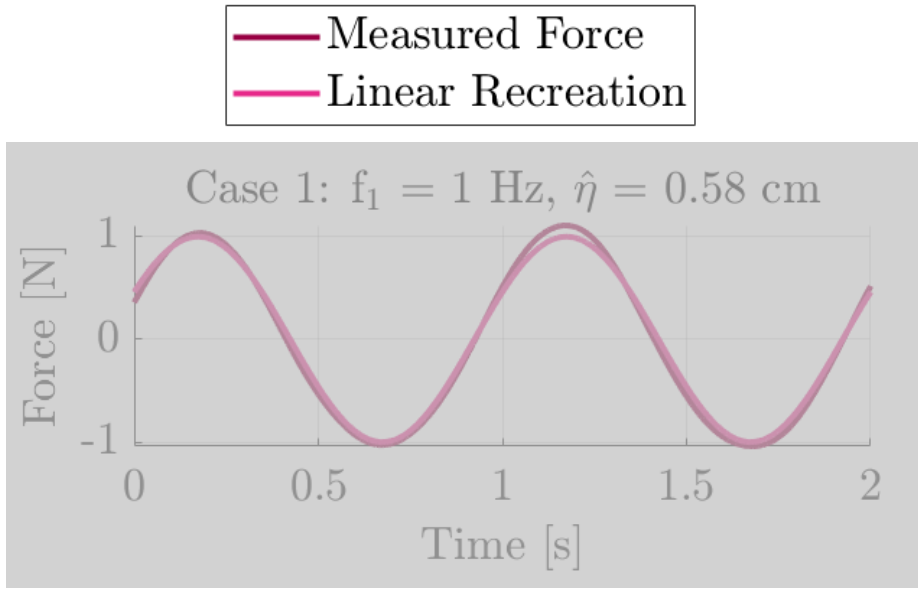
Measured force

F_R

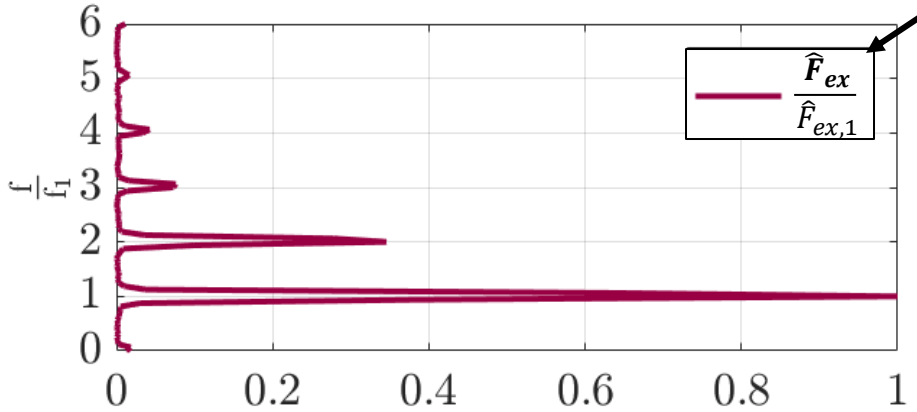
Wave Excitation Coefficient



Time Domain Reconstructions



Norm. Force Amplitude



← Norm. $\hat{\eta}$

Conclusions / Next Steps

- WAMIT and Capytaine results agree for both floats
- Experimental H_3 agree with BEM at low frequencies, and disagree at high frequencies
- Destructive interference of the Froude-Krylov force and scattering force cause nulls in H_3
- The first harmonic wave excitation signal is not fully descriptive of the measured force signal
  - This could be due to experimental artifacts

Thank You

Acknowledgements:

- Gemma Calandra
  - model manufacturing
  - Additional wave excitation experiments

Questions:

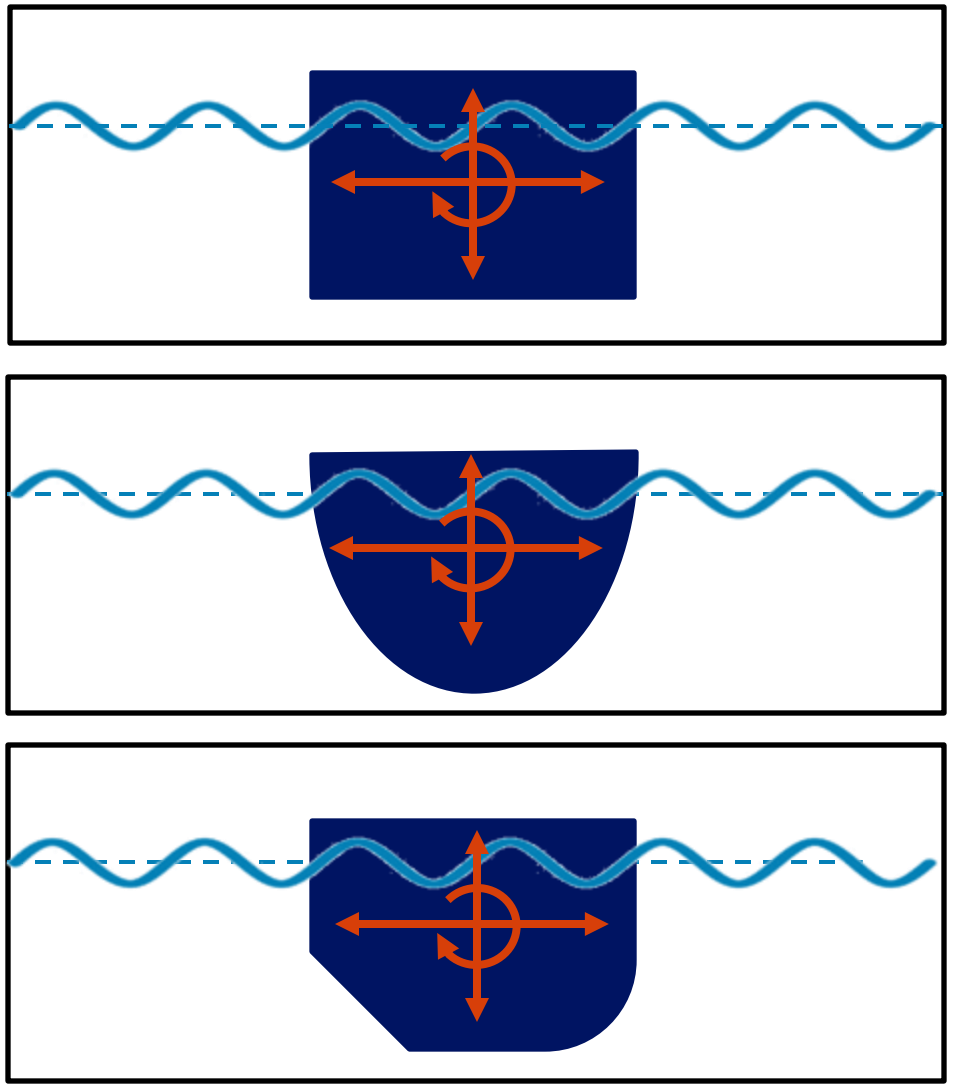
smp52@uw.edu

NAVFAC
Naval Facilities Engineering Command

PMEC

Appendix

Point-Absorber Float Hydrodynamics



- WEC float geometry is an important design driver
  - requires accurate characterization of hydrodynamic response
- Float hydrodynamics are often characterized via experiments or boundary element method simulations (BEM)

Project Goals

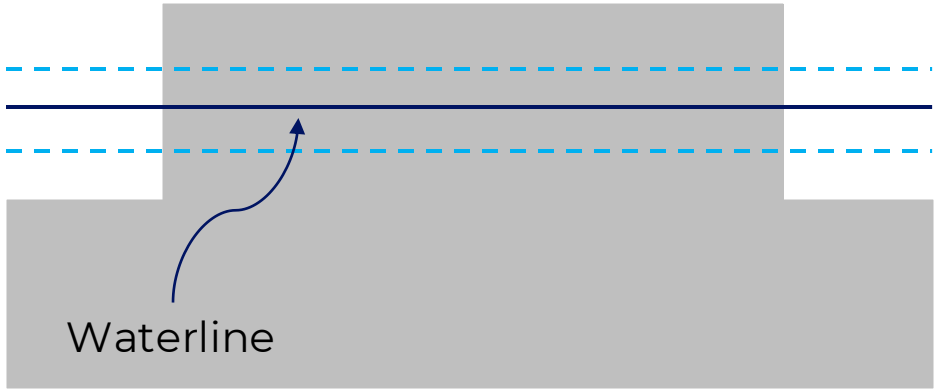
Compare hydrodynamic coefficients from experiments and Boundary-Element-Methods (BEM) across various float geometries?

This Presentation

1. Compare wave excitation results for four float geometries in heave
2. Identify the source of cancellation frequency behavior in the wave excitation force coefficient
3. Compare the measured force signals to time domain recreations using linear hydrodynamics assumptions

Geometries

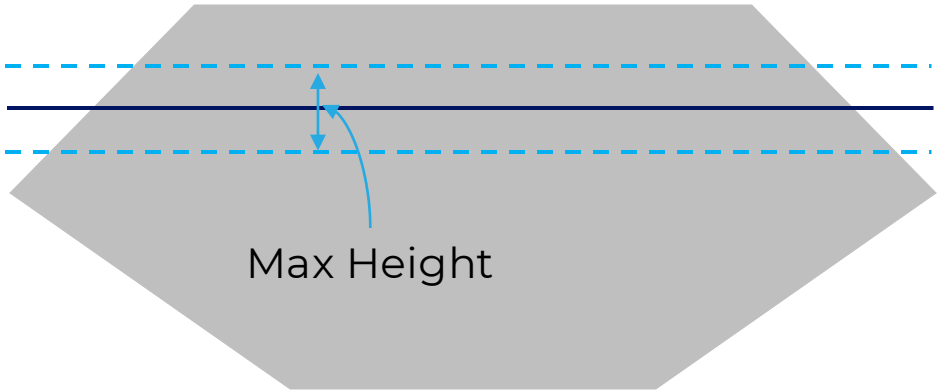
Hat



T – Shape

Ring

Diamond



WEC Hydrodynamics

PTO Force

$$(A_{33}(\omega) + M)\ddot{z} + B_{33}(\omega)\dot{z} + K_{33}z = H_3(\omega)\eta + F_a$$

Radiation Term

Heave excitation coefficient

Wave elevation

$$H_3(\omega, \hat{\eta})\eta = F_R$$ ← Measured heave force

$$H_3(\omega, \hat{\eta}) = \frac{\widehat{F_R}}{\hat{\eta}}$$

$\widehat{F_R}$ ← Amplitude of measured force

$\hat{\eta}$ ← Wave Amplitude

Cancellation Frequency

Froude – Krylov Force

Scattering or Diffraction

$$H_3(\omega, \hat{\eta}\,)\eta = F_{excitation} = F_{incident} + F_{scattering}$$

$$H_3\hat{\eta}cos(\omega t + \phi_{ex})$$

Wave Amplitude

Wave frequency

From BEM