

## Propeller and Rudder Interaction in Large-Amplitude Waves

Eric Heilshorn<sup>1,\*</sup>, Bradford G. Knight<sup>2</sup>, Kevin M. Silva<sup>3</sup> and Kevin J. Maki<sup>1</sup>

<sup>1</sup> Department of Naval Architecture and Marine Engineering,  
University of Michigan, Ann Arbor, MI USA.

<sup>2</sup> Department of Ocean Engineering, University of Rhode Island, Kingston, RI, USA.

<sup>3</sup> Naval Surface Warfare Center Carderock Division, West Bethesda, MD, USA.

\* ejheilsh@umich.edu.

### ABSTRACT

The control of ships in large amplitude seaways depends on the interaction of the ship propulsion and rudders to keep the ship on the desired course. The rudder and propeller must be designed to control the ship in conditions that pose risk of capsize. Also, the rudder and other appendages must be sized to comply with other maneuvering in waves criteria. Computational Fluid Dynamics (CFD) has made little impact towards assessment of maneuvering in waves because the number of conditions that must be considered are too numerous to afford CFD. This is primarily due to the cost of discretizing the rudder and propeller with sliding or overset meshes.

Recent work by the author team has developed a rudder propeller modeling framework that alleviates the need to discretize the control surfaces when performing simulations for ships maneuvering in waves (Knight and Maki 2024). The existing rudder propeller model is trained with double-body CFD computations of the propellers and rudders operating in the behind condition in different conditions, and the effect of waves is imposed with linear superposition. The current paper will describe work that extends the rudder and propeller model to include training in conditions that have large-amplitude waves, and to explicitly account for the wave-hull-propeller-rudder interaction. A set of focused waves from sea-state seven will be used to study the interaction between the waves and the rudder and propeller forces (see Figure 1).

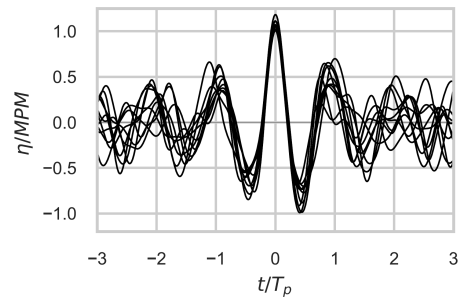


Figure 1: Ensemble of Focused Waves

### References

Bradford G. Knight and Kevin J. Maki. “Fast-running CFD calculations of the ONR Tumblehome performing maneuvers in calm water and in waves using a Gaussian process regression propeller and rudder model.” *Ocean Engineering*, 2024, vol. 303, 117671.