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Computational Simulation of a Moored Floating Aquaculture Cage

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ABSTRACT

The aquaculture sector is trying to adopt offshore cages for fish farming to meet the growing demand for fish, which cannot be satisfied by inland aquaculture installations. In open water aquaculture, the renovation of oxygen is normally ensured by the oceanic currents, but the cages are more exposed in terms of severe weather events. Computational models are very useful to comprehend the stability and structural integrity of these cages due to the currents and wave loads. The different components of a gravity aquaculture cage (floaters, sinker tube, netting panels, mooring system) are all interconnected, so that the simulation of the whole system requires a complex method of co-simulation. In this study, we propose a solver to simulate the motion of a moored aquaculture cage in regular waves. The simulations are carried with OpenFOAM, an opensource CFD toolkit used extensively for fluid dynamics simulations. Mi et a. (2024) recently developed a coupled solver based on OpenFOAM for the hydrodynamics, MoorDyn for the mooring, and EndoBeams for the structural dynamics of the floating collar. They use an Immersed Boundary Method to solve for the Fluid Structure Interaction problem, and Morrison's equations for approximating the hydrodynamic forces induced by the netting panels. They validate each part of the problem separately (net resistance, mooring of a simpler floating object, deformation of the collar), but they do not provide a validation of the fully coupled solver. In the present study, we aim at validating a simpler coupled solver (using only OpenFOAM and MoorDyn) that does not account for the floating collar deformation. For that purpose, we use the experimental results of Liu et al. (2023), who measured the mooring cable tensions and motion of a cage scaled model submitted to waves in a flume tank. The cage features a rigid floating collar, whose diameter is slightly smaller than the width of the tank. This contributes to restrict its motion in terms of sway, yaw and roll, and allows the use of only two mooring cables in the incident wave direction. In our solver, we introduce a porous surface model (Karumathil and González, 2023) to account for the netting resistance, and compute the hydrodynamic forces from CFD instead of Morrison's equations. The heave, surge and pitch motion of the cage along with the mooring forces predicted by our solver are compared to the experimental results for two wave amplitudes and two wave periods. The next step will be to increase the complexity of the multi-component coupling, including the structural deformation of the collar.

References

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