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Fluid Flow and Fluid–Structure Interaction in Sustainable Offshore Infrastructure: Applications to Renewable Energy and Aquaculture

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Extended Abstract

The development of sustainable offshore infrastructure requires reliable prediction of strongly coupled interactions between waves, currents and flexible structures. This keynote presents recent advances in high-fidelity computational modelling of offshore aquaculture and renewable-energy systems, focusing on deformable nets, floating collars, moorings and wave-energy devices. Coupled CFD–structural frameworks based on OpenFOAM and Basilisk combine two-phase free-surface modelling, immersed-boundary methods, adaptive mesh refinement and multibody dynamics to predict hydrodynamic loading, structural deformation and power extraction under realistic wave and current conditions. Recent validation studies show good agreement for net deformation, mooring response and hydrodynamic loads, while wave-energy-integrated simulations demonstrate strong coupling between incident waves, structural response and absorbed power.

The presentation will also examine how cage deformation, biofouling and fish motion modify internal circulation, water exchange and dissolved-oxygen transport, with direct implications for fish welfare and system performance. Biofouling increases net resistance and alters the coupled hydrodynamic response, while collective fish motion can significantly modify local mixing within cages. These developments illustrate how advanced fluid-flow and fluid–structure interaction modelling can support safer, more efficient and sustainable offshore food and energy infrastructure.