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Nonlocal formulations, inverse problems, and conservation laws for water waves

We consider a nonlocal formulation of the water-wave problem for a free surface with an irrotational flow and show how the problem can be reduced to a single equation for the interface. The formulation is also extended to include constant vorticity and interfacial flows of different density fluids. We show how this formulation can be used to address various inverse problems related to water waves, and systematically derive Olver's conservation in terms of boundary variables. This framework easily lends itself to computing the related conservation laws for various asymptotic models and multiple scales.