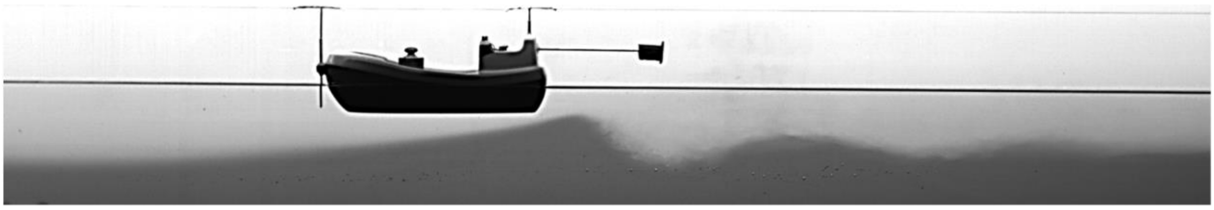
Internal breaking wave:
from the dead water effect to complex structures.

Johan Fourdrinoy[a], Julien Dambrine[b], Madalina Petcu[b], Morgan Pierre[b], and Germain Rousseaux[a]

[a]Institut Pprime, CNRS, Université de Poitiers, Institut supérieur de l'aéronautique et de l'espace–École nationale supérieure de mécanique et d'aérotechnique (ISAE-ENSMA), 86073 Poitiers Cedex 9, France;
[b]Laboratoire de Mathématiques et Applications, Université de Poitiers–CNRS, 86073 Poitiers Cedex 9, France;



A movement of a ship in a density stratified environment generates different internal waves systems. These waves cause boat's slowdowns, known as dead-water. In wide channel experiments, the boat' speed oscillates when passing a dispersive undulating depression. With strong lateral confinement (narrow channel), the amplitude of the waves increases, and the boat can even come to a stop. When the waves' cambers become too high, breaking-waves appear at the stern.

The study of this phenomenon has led us to revisit an old experiment of Scott Russell. The Scottish engineer studied the formation and propagation of dispersive waves when an object is removed from a laterally confined open channel with a shallow layer of water. The "vacuum" created by the mass removal generates a linear dispersive free surface deformation with a front of negative polarity followed by a wave train. If we extend this configuration to a two-layers stratification, we can observe a linear dispersive wave with negative polarity à la Scott Russell, propagating along the interface.

During an initial disturbance of high amplitude many other structures appear. The wave front will first break, generating a mixing zone. Within this area, baroclinic modes can appear as a wave response to vertical displacements. Finally, if the amplitude of the initial impulse is even stronger, a hydraulic response appears. Indeed, a BOLUS, or breaking wave 2-mode, (an ovoid coherent mass of recirculating mixed fluids immerged in a surrounding medium/a of different density/ies) propagating along a pycnocline. These different hydraulic or wave structures have been observed experimentally by a subpixel detection method allowing spatiotemporal monitoring of structures of very low amplitudes.