How does stratification affect shoaling Internal Solitary Waves?

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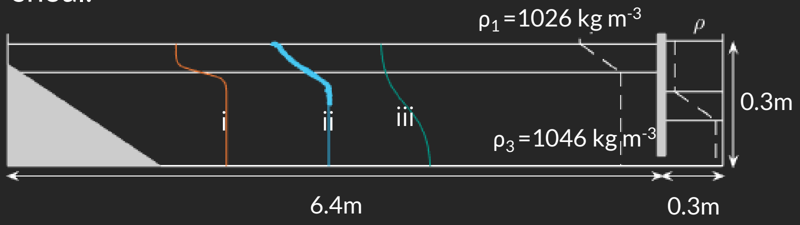
Scan/click to watch a 10 minute presentation

1) Background

Existing studies of shoaling ISWs have (e.g. [1, 2, 3]) used a "two layer" stratification with two mixed layers separated by a thin pycnocline (layer where density rapidly increases with depth). These studies categorised breaking types based on the Iribarren number (Wave vs Slope Steepness)

2) Methods

Combined use of a laboratory flume tank and the SPINS numerical model [4], setup shown below, allow us to study the behaviour of ISWs as they shoal.



Three density profiles are studied in the model, (i) the three-layer stratification (orange), which has been extensively studied in past numerical and laboratory work; (ii) the 2 layer stratification (blue), which is also employed in these laboratory experiments; (iii) a linear stratification where the density gradient extends throughout the water column (green). Wave amplitude and topographic slope are varied.

[1] Sutherland B. R, Barrett, K. J and Ivey, G. N. (2013), Shoaling internal solitary waves, *J. Geophys. Res. Oceans*, **118**, 4111-4124.

[2] Nakayama, K., Sato, T, Shimizu, K, Boegman, L (2019), Classification of internal solitary wave breaking over a slope, *Phys. Rev. Fluids* **4**, 01480

[3] Aghsaee, P., L. Boegman, K. Lamb (2010). Breaking of Internal Solitary Waves, *J. Fluid Mech.*, 659, p289-317

[3] Subich, C.J., Lamb, K. G., Stastna, M. (2013), Simulation of the Navier-Stokes equations in three dimensions with a spectral collocation method, *Int. J. Numer. Meth. Fluids*, **73**, 103-129

3) Results

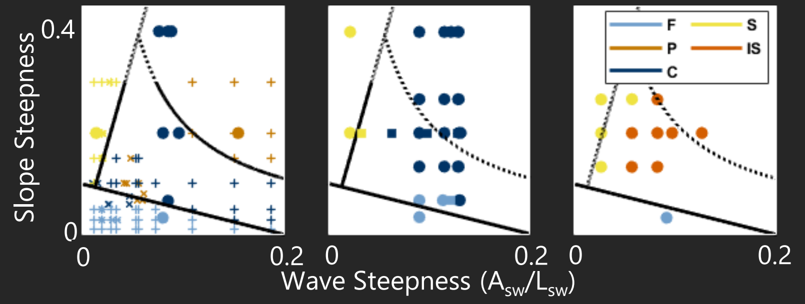
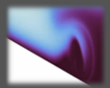


Figure showing Iribarren number based classification for each stratification, past data from [2, 3] as 'x' and '+' respectively, our simulations as filled circles. Colours show breaking type (F = Fission, S = Surging, P = Plunging, C = Collapsing, IS = Surging with unstable bolus)

For each of our key results, click or scan for a short clip from a demonstrating simulation:

Plunging dynamics seen in the 3 layer stratification are suppressed in the 2 layer and linear stratification by a density gradient in the **upper** layer



Collapsing dynamics seen in the 3 and 2 layer stratifications are suppressed in the linear stratification by a density gradient in the **lower** layer

At higher incident wave steepness, the bolus formed by surging breakers in the linear stratification can support a train of Kelvin-Helmholtz billows on their upper boundary

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