Development of perturbations on a buoyant coastal current

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The dynamics of a small perturbation on a coastal current in a buoyant upper layer of the ocean is investigated. The active upper layer vanishes at a certain distance away from the coast, forming a front. The perturbations are imposed on a steady basic state with no along-coast variation. Analytical solutions are derived for two special configurations of the background state: (i) constant along-shore velocity, i.e. a coastal current with triangular cross-section and (ii) a constant potential vorticity current. In both cases we find two wave modes: a slowly moving frontally trapped wave, and a coastally trapped wave that moves approximately with the internal Kelvin wave speed plus the current speed at the coast. These two wave modes are not sufficient to build up a generally shaped initial perturbation. The part of the initial perturbation not covered by the two wave modes will in case (i) split into an infinite number of higher wave modes all travelling faster than the frontal wave and in case (ii) be advected and slowly smeared out by the current. We find that for all physically relevant cases the perturbations always move in the direction of the Kelvin wave, ie., in the same direction as the coastal current, as long as the current is unidirectional.