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Water wave packets propagating over variable depth

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Water wave packets are often described by the usual nonlinear Schrodinger equation, for which a wave packet can only exist in deep water, more precisely when $kh > 1.363$ where k is the wavenumber and h is the depth. However, near the critical depth when $kh = 1.363$ it is necessary to develop a higher-order nonlinear Schrodinger equation with variable coefficients to describe how a water wave packet will deform as it propagates shoreward from deep to shallow water. Using a combination of asymptotic analysis and numerical simulations we find that in the framework of this higher-order nonlinear Schrodinger equation, the wave packet can penetrate into shallow water $kh < 1.363$ or not even reach $kh = 1.363$, depending on the sign of the initial value in deep water of a certain parameter of the wave packet which measures its speed.