Geophysical Research Abstracts, Vol. 8, 08612, 2006
SRef-ID:

Emergent interactions and self-organization in the shape evolution of enclosed water bodies

A. Ashton (1,2), R. Littlewood (1), A.B. Murray (1)

(1) Division of Earth and Ocean Sciences, Nicholas School of the Environment and Earth Sciences; Center for Nonlinear and Complex Systems, Duke University, USA (2) Now at Woods Hole Oceanographic Institute, Woods Hole, MA, USA (abmurray@duke.edu / Fax: +1 919-6845833)

Recent work has revealed a previously unappreciated instability in the large-scale, plan-view shape of sedimentary shorelines (Ashton et al., 2001; Murray and Ashton, 2004). Breaking waves drive an alongshore sediment flux, and when the waves approach from highly oblique angles, divergence of this flux along a perturbation on an otherwise straight shoreline cause perturbation growth. When local wave climates are dominated by these 'high-angle' waves, shorelines tend to become progressively bumpier over time. Numerical modeling has illuminated various modes of emergent interactions between shoreline features as they attain finite amplitude (Ashton and Murray, 2003; Murray and Ashton, 2003). These interactions stem largely from a wave shadowing effect; features such as emergent spits that protrude from the shoreline tend to shelter other parts of the shoreline from approaching waves. The resulting non-local interactions lead to the self-organization of rhythmic capes, spits, and alongshore sandwaves.

The previous work involves an initially straight, infinite-length shoreline (periodic lateral boundary conditions) affected by alongshore-uniform deep-water wave forcing—i.e. waves approaching from a distant source. Here we highlight an increased level of complexity that arises in an enclosed water body, where the characteristics of waves approaching one section of shoreline depend on the length over which the local wind is blowing—the 'fetch'. Starting with an initially rectangular basin, local fetches affecting shoreline sections depend on the location within the domain, and the direction the wind is blowing from. With an isotropic distribution of randomly varying wind directions, some shoreline segments experience wave climates dominated by high-angle

waves. As finite-amplitude features develop in these areas, they affect the fetches felt by other shoreline segments. Thus, the pattern evolution on opposite shores becomes coupled. The fetch-limitation interactions lead to new modes of emergent interactions and highly entertaining shape evolutions. If the initial water body is sufficiently elongated, merging of shoreline features extending from opposite shores will ultimately segment it into multiple water bodies.