COASTLINE SHAPES : LARGE-SCALE MORPHODYNAMICS AND RESPONSES TO CLIMATES AND HUMANS

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The flux toward shore of alongshore momentum, which drives alongshore sediment flux, varies with local coastline orientation, and with local degree of exposure to waves. Coastline shape therefore influences the alongshore patterns of alongshore sediment flux. Gradients in this flux, in turn, alter coastline shape—a morphodynamic feedback. Modeling studies show that such feedbacks lead ultimately to dynamic-equilibrium coastline shapes, including sandwaves, capes, and spits [1]; crenulate bays [2] and pocket beaches on rocky coastlines; and convex, spit-bounded coastlines. One conclusion arises in each of these studies: Coastline shape depends sensitively on the wave climate, defined as the angular distribution of wave influences on alongshore sediment transport.

Given this sensitive dependence, shifts in wave climate, as can be expected from shifts in storm statistics, will tend to alter coastline shape—involving decadal-scale changes in the location and intensity of coastal erosion zones. Such changes, likely related to changing influence from hurricane-generated waves, have been detected along undeveloped large-scale cuspate capes [3]. On a developed cape nearby, shoreline stabilization through beach nourishment has prevented an equivalent change in erosion rates. Combined observations and modelling indicate that the signal of wave climate change can be detected in the human component of the system, in the form of increased nourishment rates on one flank of the cape (Johnson et al., 2015). Finally, these recent works involved the implicit assumption that coastline response to changing forcing occurs in a quasi-equilibrium manner. However, new modeling shows that in some cases coastline responses can exhibit long-term memory and path dependence, complicating potential detection and forecasting of climate change signals in some human/coastline systems.

Because shoreline stabilization decisions, made in response to coastline changes, affect large-scale coastline change, the present and future evolution of developed coastlines results from coupled physical and human dynamics. Case studies from the Carolina and Virginia coasts, USA, provide examples.

References

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