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More than a concave-upward equilibrium profile: geological control on nearshore morphological configuration

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Recognition of the fundamental role of the geological framework in coastal morphodynamics has increased over the past two decades, with significant contributions highlighting the importance of geological control on beach and nearshore morphology and dynamics. Although it is self-evident that the evolution of coastal systems is intimately linked to the antecedent or inherited geological framework, its influence on contemporary coastal processes is poorly represented in decadal to centennial (i.e. meso-scale) conceptual and numerical models of coastal change. This is partly driven by a limited quantitative understanding of how the geological framework controls modern coastal evolution and how it relates to hydrodynamic processes and morphodynamics, as well as difficulties in transforming qualitative geophysical observations into quantitative parameters. However, the poor incorporation of geological control in contemporary coastal models is mostly the outcome of widely accepted assumptions that equilibrium concave-upward profiles are a suitable representation of the nearshore, even when only covered by a veneer of sediment, and that barriers and beaches are unrestricted piles of sediment responding exclusively to hydrodynamic forcing.

In this work, we explore a wealth of morphological, geophysical, sedimentary and hydrodynamic data to investigate the morphological configuration of nearshore profiles associated with various degrees of geological control along a broad range of coastal environments in the northern coast of Ireland. We analyse the adequacy of parametric limits for nearshore morphological evolution and compare nearshore profiles obtained from multibeam bathymetry of 15 sites with modelled equilibrium profiles based on a) uniform wave energy dissipation and b) balance of sediment transport relationships. Equilibrium profile models were applied considering the range of sediment sizes in the nearshore of each site and computed using the morphodynamics important wave conditions for nearshore sediment transport, determined by magnitude-frequency analysis.

Results reveal a general disagreement between observed and modelled nearshore equilibrium profiles, also suggesting that the active nearshore zone extends seaward, deeper than indicated by parametric depth of closure approaches. Shallow sub-bottom seismic profiles from several of the study sites further demonstrate that the underlying geological framework exerts a fundamental control, which influences nearshore morphodynamics and large-scale coastal behaviour. Different modes of geological control on nearshore configuration are identified, based on the outline of the underlying bedrock surfaces and the wave ravinement surfaces. Our work expands the reasoning that coastal systems, more often than not, deviate significantly from simplified dynamic equilibrium concepts, and reaffirms that nearshore geological control is unavoidable in the prediction of future coastal evolution.