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# Boulders as bellwethers: studying the effects of storm waves on boulder deposits can improve our understanding of coastal storm wave forces

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As sea level rises, so does the threat to coastlines, populations, and infrastructure. Rocky coasts are especially understudied, in part because of difficulties in modeling wave-energy attenuation in such environments. But recent studies show they are surprisingly sensitive to high-energy events, and need to be better integrated into coastal management and environmental response planning. Predicting the forces likely to act on infrastructure requires understanding extreme wave behavior in the coastal zone.

Surprisingly, we lack data on how big coastal waves can get and exactly how much work they can do, as illustrated by debates about whether storm waves can move coastal boulders weighing 100s of tonnes. Some use hydrodynamic equations to argue that only tsunami can exert the required forces, but others contend that existing equations are not fully descriptive, and cite evidence for boulders moving during storms. Because there is no consensus about how big waves can be at the coast, and the masses they can move, it has not been possible to fully model or predict effects of storm waves on coasts.

Work in progress will change that situation. Using a baseline dataset documenting >1000 boulders in western Ireland that moved during the 2013-2014 storms—including nineteen in the range 50-500t—our research group is working toward a unified model, integrating field, numerical, and experimental methods, directly linking waves of known magnitude to specific physical work.

First, we are working with the Marine Institute to produce three-dimensional terrestrial-to-marine topography for the Aran Islands. This allows us to link boulders (and their movements) to coastal geometry and offshore geomorphology. Second, numerical modeling of non-linear wave dynamics over variable bathymetry shows how waves are amplified in the coastal zone. Spectra generated by these codes will be tied to measured bathymetry so that results can be ground-truthed. Third, wave-tank experiments link fieldwork and numerical models, showing in a scaled environment—constructed to model the Aran Islands—relationships between wave amplification, pressures generated, and boulder masses moved. The result will be a quantified, multivariable model combining wave forces, geomorphology, and work done onshore (represented by boulder movements).

Our analysis will be valuable for considering storm effects on walls, roads, and other coastal infrastructure. The numerical models of wave power, grounded in physical reality, will provide robust estimates of dynamics in the shallow offshore environment. This will enhance our understanding of rocky coasts, and will inform coastal engineers, civil planners, and groups developing renewable marine energy installations.