Biological implications of surf-zone flow complexity

Gaylord, Brian

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ABSTRACT: Wave action imposes potentially large hydrodynamic forces on intertidal plants and animals, and can act as a primary agent of disturbance. It has also been proposed that rapid water accelerations produced by breaking waves might constrain the sizes to which intertidal organisms can grow. However, despite the proven ecological importance of surf-zone flows, few actual measurements of forces imposed on plants or animals by waves in nature have been conducted. In this study, real-time wave forces acting on individuals of the rockweed *Pelvetia compressa* and a sea urchin *Strongylocentrotus purpuratus* are recorded in the field. These measured forces are compared with values predicted from theory using laboratory-determined shape factors (i.e., drag and added mass coefficients) and simultaneous flow measurements conducted adjacent to the deployed samples. Results demonstrate that models predicting large contributions of force due to water's acceleration are likely inaccurate, most probably because such models fail to account for the small spatial scales of surf-zone accelerations. This likely eliminates any capacity for intertidal hydrodynamic accelerational forces to limit size, contrary to previous conjectures. Data also suggest that wave-induced forces predicted from simple fluid dynamic expressions can, but sometimes do not, reflect ac-curately the forces applied. Together these findings imply that although traditional hydrodynamic theory may indeed provide a valuable tool for predicting forces imposed on immersed surf-zone organisms, such approaches must be used with caution. Finally, the field recordings suggest that sharp, transient forces arising from the impingement of waves directly on non-submerged organisms may in general impose the most severe loadings experienced by intertidal plants and animals, a possibility that to date has received little attention. The precise consequences of such brief forces depend on the level of flexibility or rigidity of an organism's construction.

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