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The effects of bioturbation on the initiation of motion of intertidal sands

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ABSTRACT

The results of laboratory flume experiments on initiation of sediment motion in natural marine sediments (fine sand) are reported. Sediment cores were taken from an intertidal region during all seasons of the year over a four-year period. Critical shear stresses for initial grain motion were determined for bed conditions corresponding to: (1) the natural field state at low tide when the cores were taken, (2) abiotic conditions (control) for comparison with critical stresses predicted using Shields' curve. Also, critical erosion velocities were determined over extensively biogenically reworked natural field cores for simulated flood tide conditions. Values of critical shear stress estimated for the control cores agree well with predictions from Shields' curve. In the field state, critical shear stresses vary with time of the year, being nearly equal to Shields' predicted values in the winter. Critical shear stresses in the fall are nearly twice those predicted by Shields' curve. The higher critical shear stress values in the fall are attributed to biologically induced adhesion of sediment. Extensive biogenic reworking lowered critical erosion velocities below that measured in the field cores. The critical velocities were never lower than those of the control cores or the values predicted by Shields' curve assuming smooth turbulent flow. Our study quantifies, for the first time, the net effect of biological processes on the stability of natural fine sands. We suggest that Shields' initiation of motion criterion be used as a standard to define net biological stabilization or destabilization of the sediment water interface.

1. Introduction

Determining sediment stability at the seabed under given hydrodynamic conditions is one of the basic problems in the study of marine sediment transport. Estimates of the critical shear stress for initiation of grain motion are necessary in various sediment transport relationships, e.g., Yalin (1963), as well as in the determination of boundary roughness associated with intense near-bed sediment transport (c.f., Smith and McLean, 1977; Grant and Madsen, 1982). To determine initial sediment motion, sediment transport workers depend on empirical laboratory criteria. The most widely accepted criterion is that of Shields (1936) (hereafter referred to as

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