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Solar and Tidal Modulations of Fecal Indicator Bacteria in Coastal Waters at Huntington Beach, California

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Abstract The coastal waters at many beaches in California and the United States are afflicted with fecal pollution, which poses a health risk for people exposed to the water through recreational activities such as swimming, surfing, and diving. Identifying sources of pollution is complicated by oceanographic transport/mixing processes and the nonconservative behavior of microorganisms exposed to sunlight and hostile marine conditions. This article investigates the variation of fecal indicator bacteria (FIB) concentrations in the surf zone and the adjacent coastal marsh by applying autocorrelation and cross-correlation analyses that illustrate solar and tidal modulations. A steady state bioreactor model was developed to explain solar inactivation in the surf zone, whereas a dynamic model was applied to explain tidally influenced disturbances in the coastal marsh. These models applied to intensive monitoring datasets on FIB and environmental variables have provided insights into the biologic and physical processes controlling coastal water quality, specifically the influence of sunlight and tides on bacterial levels.

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Introduction

Coastal waters are susceptible to contamination involving numerous types of microbial pathogens such as viruses, bacteria, and parasites (Dufour 1977; Dutka and others 1974; Geldreich 1978; Pourcher and others 1991), and thus serve as a vehicle for transmitting disease (e.g., a skin or gastrointestinal disease) to people either contacting or ingesting the water (Toranzos and McFeters 1997). Marine bathing water quality regulations in the United States require that the concentrations of fecal indicator bacteria (FIB) in the surf zone be monitored as an indicator of fecal pollution, which causes frequent beach advisories and poses a threat to the public health. However, current approaches for solving the problem of fecal pollution in the surf zone are hampered by an incomplete understanding of the magnitude of the dominant processes affecting FIB concentrations: storm/urban runoff and associated bacterial loading (Boehm and others 2003; Dwight and others 2002), inactivation by sunlight (Boehm and others 2002), and redistribution by tidal action (Boehm and Weisberg 2005).

Recently, several studies have investigated the surf zone in an attempt to explain the complex dynamics controlling the fate and transport of bacteria. These studies have identified a significant relationship between FIB concentrations and the phase of the moon (MEC 2000; Grant and others 2000), potential FIB sources and their temporal variability in the surf zone with respect to tidal phase (Grant and others 2001), various environmental factors modulating FIB con-