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Tidal Forcing of Enterococci at Marine Recreational Beaches at Fortnightly and Semidiurnal Frequencies

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ABSTRACT

Marine beach water quality is typically monitored in early morning once a week without respect to tidal condition. To assess the effect of tide on this public health warning system, we analyzed enterococci (ENT) data from 60 southern California marine beaches with differing geomorphology, orientation, and proximity to runoff sources. ENT concentrations during spring tides were significantly higher ($p < 0.1$) than those during neap tides at 50 of the beaches, and at the majority of these, water samples were also more than twice as likely to be out of compliance with the ENT single-sample standard during spring tides compared to neap tides. When tide range (spring/neap) and tide stage (ebb/flood) conditions were considered together, spring-ebb tides yielded the highest ENT concentrations and the greatest chance of exceeding the single-sample standard at the majority of beaches. The proximity to a terrestrial runoff source, the slope of the runoff source, the slope of the beach, and the orientation of the beach had minimal influence on the tidal modulation of ENT concentrations. The presence of spring and spring-ebb tide signals at such a great percentage of beaches suggests that tide should be considered in the design and interpretation of beach monitoring program data. It also suggests that ENT delivered by tidally forced sources other than terrestrial surficial runoff are widespread. Possibilities include ENT-laden groundwater (saline and fresh) from the beach aquifer as well as ENT-enriched sands, decaying wrack, and bird feces near the high water line.

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