

Decadal and Shorter Period Variability of Surf Zone Water Quality at Huntington Beach, California

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The concentration of fecal indicator bacteria in the surf zone at Huntington Beach, CA, varies over time scales that span at least 7 orders of magnitude, from minutes to decades. Sources of this variability include historical changes in the treatment and disposal of wastewater and dry weather runoff, El Niño events, seasonal variations in rainfall, spring-neap tidal cycles, sunlight-induced mortality of bacteria, and nearshore mixing. On average, total coliform concentrations have decreased over the past 43 years, although point sources of shoreline contamination (storm drains, river outlets, and submarine outfalls) continue to cause transiently poor water quality. These transient point sources typically persist for 5–8 yr and are modulated by the phase of the moon, reflecting the influence of tides on the sourcing and transport of pollutants in the coastal ocean. Indicator bacteria are very sensitive to sunlight; therefore, the time of day when samples are collected can influence the outcome of water quality testing. These results demonstrate that coastal water quality is forced by a complex combination of local and external processes and raise questions about the efficacy of existing marine bathing water monitoring and reporting programs.

Introduction

Huntington Beach made national news in the summer of 1999 when a large section of beach, at one point encompassing 20 km, was closed to the public. Over 1 million people visit this stretch of beach in a typical summer; therefore, the closures impacted the local economy and contributed to public concern that surf water quality in California is getting progressively worse (1). Nationally, the number of beach advisories and closures nearly doubled from 1999 to 2000,

primarily due to changes in the state and local regulations governing surf monitoring and reporting (2). In this study, we utilize a 43-yr-long time series of monitoring data and several short-term high-frequency sampling studies to characterize the decadal and shorter period variability of surf water quality at Huntington Beach. These data shed light on how (i) physical and biological phenomena modulate the impact of coastal pollution on surf water quality, (ii) water quality at this site has evolved over time and in response to infrastructure improvements, and (iii) monitoring and reporting of coastal water quality and identification of specific sources of coastal pollution can be improved.

Methods

Historical Data: Regulatory Bacteriological Monitoring. Marine bathing water regulations in California, and throughout most of the world, are based on the concentration of coliform and/or enterococci bacteria in the surf zone where bather contact is most likely to occur. Since June 1958, the Orange County Sanitation District (OCS D) and the Orange County Health Care Agency have measured total coliform (TC) concentrations at a minimum of six surf zone stations in Huntington Beach (Figure 1). The sampling and laboratory methodologies employed in this monitoring effort have remained static, but the number of sites sampled and the sampling frequency at each site have changed over time. Prior to 1998, surf zone water was assayed for TC only. Briefly, 100 mL of ocean water is collected from an incoming wave at ankle depth in a sterile container, put on ice, and returned to the laboratory within 6 h where 1.0 mL, 0.1, and 0.01 mL are analyzed according to standard method (SM) 9221B. Beginning in July 1998, the analyses were expanded to include assays for fecal coliform (FC) and enterococci (ENT). Analyses for FC are conducted on 1.0 mL, 0.1 mL, and 0.01 mL of surf zone water using SM 9221E; 10–50 mL of sample is assayed for ENT using EPA Method 1600. From 1958 to 1970, water samples were collected daily from five locations within the beach boundaries: stations 0, 3N, 6N, 9N, 12N, and 15N (Figure 1). In 1970, stations 21N and 27N were incorporated into the monitoring program, and the sampling frequency was decreased to 3–5 times per week. During 1981 and 1982, samples were collected only once per week.

Historical Data: Rainfall. Local rainfall data is archived on the Orange County Public Facilities and Resource Department Web site (3). We utilized data recorded at the Huntington Beach fire station from 1958 through 1999. Because the fire station rainfall gauge was not maintained after 1999, we utilized data recorded at nearby Costa Mesa Water District for 2000 and 2001. Dates and strengths of El Niño events were retrieved from the National Atmospheric and Oceanic Organization Web site (4).

Historical Data: Analysis. All of the TC and rainfall data collected in a given year were divided into a winter period (January–February–March, JFM) and a summer period (June–July–August, JJA). We then calculated the geometric means and 95% confidence intervals for TC during JFM and JJA using data collected at all sites in the study area. The total amount of rainfall recorded during JJA and JFM of each year was also computed.

The summertime pollution signal was divided into four periods of time (events) based on the presence of unique TC sources that impaired beach water quality for multiple years. During each of the events, water quality in the entire surf zone, or at a subset of surf zone stations, was analyzed for

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