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# The Surfer Health Study: Microbial Water Quality Measurements Supporting a Combined Wet Weather Surfer Epidemiology and QMRA Study in San Diego, CA

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## Abstract

Fecal indicator bacteria (FIB), e.g. *Enterococcus*, are commonly used to measure marine recreational beach water quality. Epidemiological studies performed at beaches with known human fecal contamination have shown that FIB are reliable predictors of swimming related illness; and current water quality standards are based on these relationships. In contrast, the correlation of illness rates with FIB counts or direct measurement of pathogens at California marine beaches impacted by storm water has not been extensively studied. Furthermore, quantitative measurement of pathogens along with FIB can enable estimation of dose and exposure necessary for a site-specific predictive modeling of health outcomes via Quantitative Microbial Risk Assessment (QMRA). We measured microbial water quality at two storm water impacted beaches with large surfer populations during a combined wet weather surfer epidemiology and QMRA study in the winter of 2014 in San Diego, CA. Surf zone water samples were collected daily from Ocean Beach and Tourmaline Surfing Park during January 2014-March 2014 and December 2014-March 2015. Storm water was collected from the main discharges at the study beaches: the San Diego River at Ocean Beach and Tourmaline Creek at Tourmaline Surfing Park during storm events in February 2014 and December 2014-March 2015. Microbial water quality was determined by quantifying FIB (total and fecal coliforms, *Enterococcus*) through standard cultivation techniques, F+ and somatic coliphage through standard cultivation techniques, human-specific and general FIB markers through digital QPCR (e.g. HF183, *Enterococcus* QPCR), and pathogenic bacteria (*Salmonella* invA, *Campylobacter* VS1), viruses (human Adenovirus, human Norovirus, and Enterovirus), and protists (*Cryptosporidium* COWP, *Giardia* β-giardin) through digital QPCR in storm water and beach water samples. Environmental measurements including water temperature, salinity, surf height, tide, current, wind speed, wind direction, and discharge flow were measured during daily and storm event sampling. There was a strong positive correlation between FIB and precipitation, and a positive correlation between FIB and tide, particularly during spring tide events. However water samples above the single sample *Enterococcus* limit (104 CFU/ml) had only a weak correlation with an increase in illness rates from wet weather ocean exposure measured in the epidemiology study. F+ and somatic coliphage numbers did not correlate with tide, and were not consistently detected at the beaches; but coliphage numbers did correlate with precipitation and discharge flow. Although pathogen measurements did not perfectly co-vary with FIB measurements, quantification of pathogenic bacteria and viruses using digital QPCR allowed for estimation of pathogen load in the storm water and surfer exposure in the surf zone. This study demonstrates the power of combining sensitive molecular measurement of microbial water quality, QMRA predictive modeling, and empirical illness rates to characterize public health risk at previously uncharacterized sites or environmental conditions.