USING REAL TIME OBSERVING DATA FOR PUBLIC HEALTH PROTECTION IN OCEAN WATERS

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INTRODUCTION

Historically, ocean water quality surveillance tools for the protection of public health have been hindered by the time lag between sample collection and availability of results (24 hours or more). This delay, coupled with the high temporal and spatial variability of bacterial levels in ocean waters, significantly reduces the accuracy of any water contact warnings based upon bacterial monitoring results (Boehm *et al.* 2002). This test method limitation leaves the health official/ beach manager with a difficult decision. He or she can make decisions based upon yesterday's sample results (that may no longer be relevant), or permanently close the beach to ensure the protection of public health. While the first option may sound unacceptable, the consequence of the latter, negative impact on the local economy due to on-going beach closures, can be equally unwelcome. This dilemma highlights the need for new and innovative technology that can measure conditions associated with contamination and provide that information in real time.

BACKGROUND

Sewage contaminated runoff in the Tijuana River has been a major public health issue in the Tijuana River Valley and adjacent ocean beaches for decades. Following rainfall in the bi-national watershed, river flows will enter the United States, Tijuana Estuary, and Pacific Ocean. Once the estuary plume enters ocean waters, ocean dynamics can transport it north onto Imperial Beach (Kim *et al*. 2004, Largier *et al.* 2004). Monitoring data for fecal indicator bacteria (FIB) demonstrate a strong relationship between water quality in the river, the estuary mouth, and ocean shoreline at the south end of Imperial Beach, located approximately one mile north of the estuary mouth (Figure 1). Research has also correlated Hepatitis A virus and enteroviruses with high FIB levels in ocean waters at the estuary mouth and Imperial Beach (Gersberg *et al*. 2006).

The County of San Diego, Department of Environmental Health (DEH) issues preemptive water contact closures for Imperial Beach during episodes of northward moving ocean currents when estuary flows are suspected to be impacting the Imperial Beach shoreline. Although most closures occur during the winter and spring rainy season, contamination of beaches north of the estuary are not limited to wet weather (within 72 hours of rain) because river flows can exceed the capacity of the river diversion system for weeks after rain. Since closure decisions cannot be tied to an easily observable event such as rainfall alone, it is essential to know exactly when episodic northward flows occur to provide accurate beach closure information.

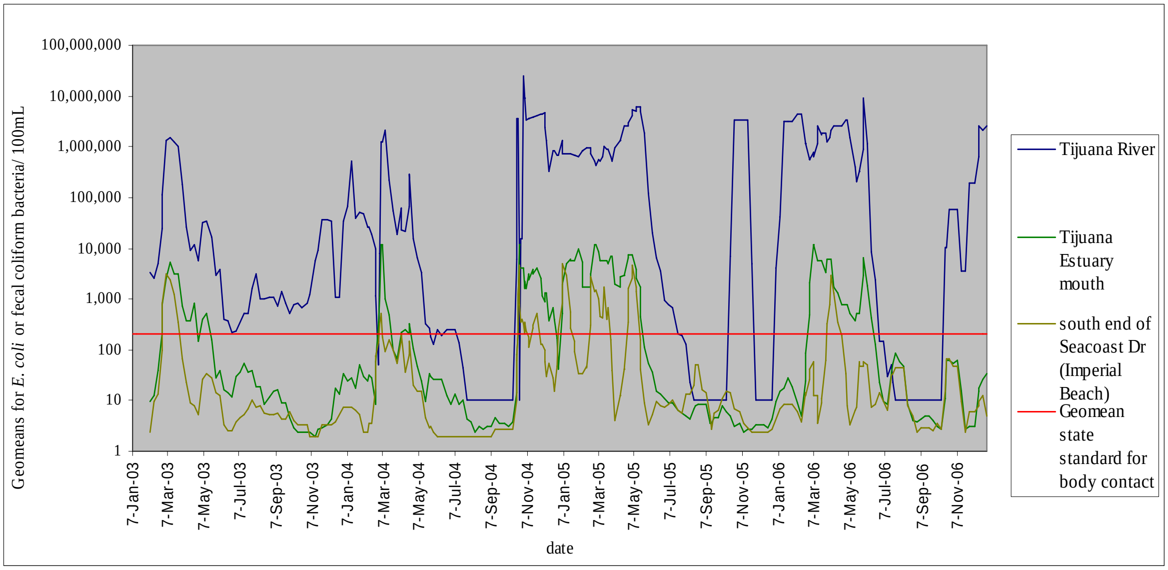

Figure 1. Geomeans for E. coli or fecal coliform in river, estuary, and Imperial Beach

Lacking any other means to make accurate beach closure decisions, DEH came to reply upon field observations (primarily from city lifeguards) for detecting northward moving currents, or other indications of contamination (odors, visual confirmation of a plume, or discolored ocean water). Thus, beach closures largely became a subjective judgment of the person reporting conditions to DEH without any validation of those observations available at the time of closure decisions. DEH needed a real time measurement to ensure the accuracy of those decisions and prevent the erosion of the water contact warnings' credibility.

ALTERNATE TECHNOLOGY SOLUTION

In 2002, DEH provided $112,000 in funding to the Scripps Institution of Oceanography (SIO) to collect and analyze bacterial levels in beach water samples in order to validate the San Diego Coastal Ocean Observing System (SDCOOS) as a tool for real time beach water quality monitoring. The study effort focused on the historical analysis of FIB data in comparison to ocean currents, rainfall amounts, and flows from the Tijuana Estuary. It also collected FIB samples to be correlated with high frequency radar measurements of alongshore currents measured one kilometer offshore from the Tijuana Estuary mouth. The surface current mapping array in this region consists of three compact antennas located at the Coronado Islands, tip of Point Loma, and Border Field State Park. FIB data was also correlated with surf zone currents measured by a current meter attached to the Imperial Beach pier.

RESULTS

SDCOOS has placed on one web site (http://sdcoos.org/ibpier/) most of the information tools DEH uses in determining when Tijuana Estuary flows are moving northward. In addition to real time measurements of ocean currents, the page contains real time data on swell and wind direction, as well as flow rates in the Tijuana River. Early in the program, information on ocean currents was presented in the form of two – one dimensional graphs of north-south and east-west currents. These graphical products

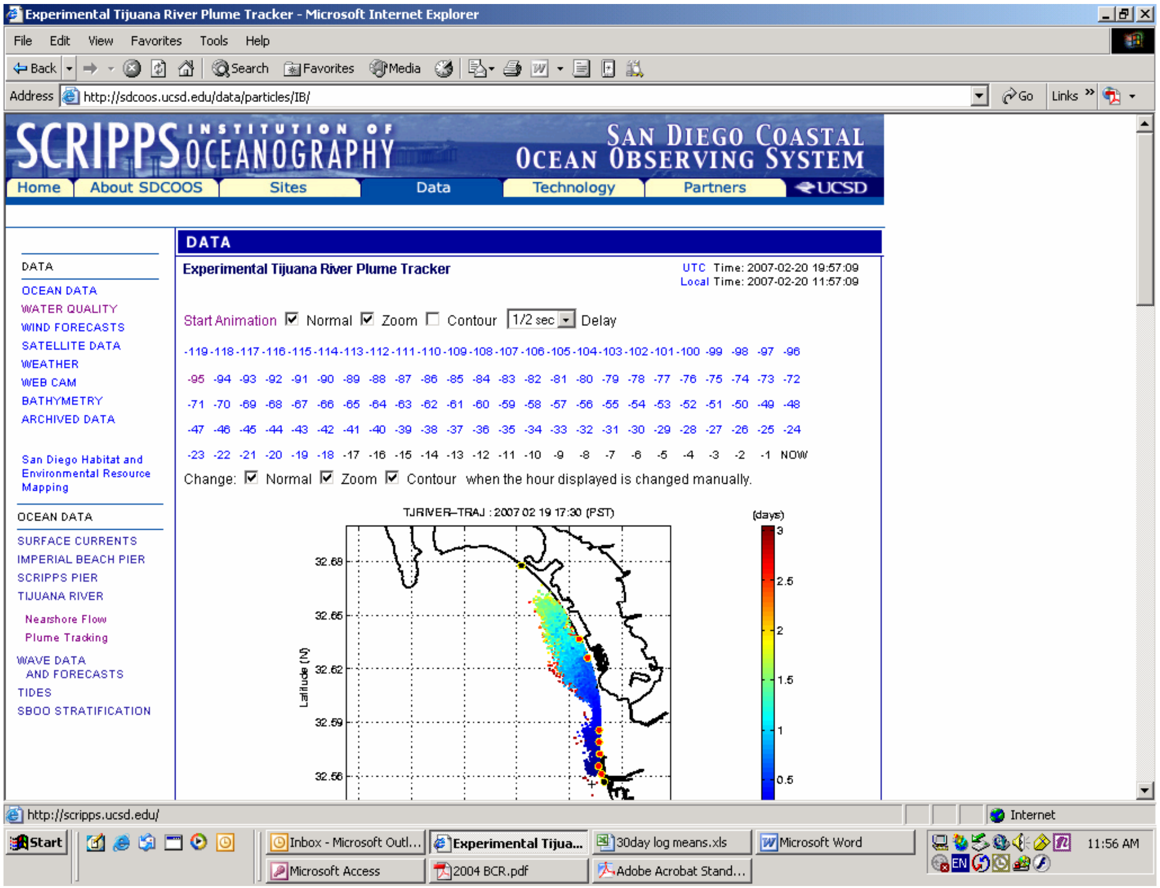

Figure 2. Real time model of the Tijuana Estuary plume movement

were updated in late 2005 by a two dimensional trajectory estimate of the Tijuana Estuary plume movement computed from the time series of surface current maps (Figure 2). This was the first application of this technology for public health protection in ocean waters. The SDCOOS web site explains the development of the "plume tracker" model:

> "This display shows the results of a lagrangrian particle tracking algorithm applied to hourly surface currents. The plot indicates the tracking of water from the mouth of the Tijuana River within the domain observed by SDCOOS. On an hourly basis, 100 particles are released at the rivermouth and tracked for a 3 day period to provide a better estimate of where the Tijuana River plume may be impacting the coast. New positions within the region are updated hourly and the color of the particle represents the age of the particle since it was released."

A limited test of the plume tracker's accuracy was conducted using water quality/ FIB samples from February through April of 2004 (Figure 3). Results show an overall accuracy rate for the model between 57 and 80 percent with some water quality sampling locations showing better agreement than others. The accuracy of SDCOOS in measuring ocean current direction can also be gleaned by comparing that data to field observations. Field observations most often agree with SDCOOS data during rain events with strong south winds (south to north) and northward moving currents. Agreement is lower during dry weather conditions when suspected contamination and ocean dynamics causing northward movement are more subtle.

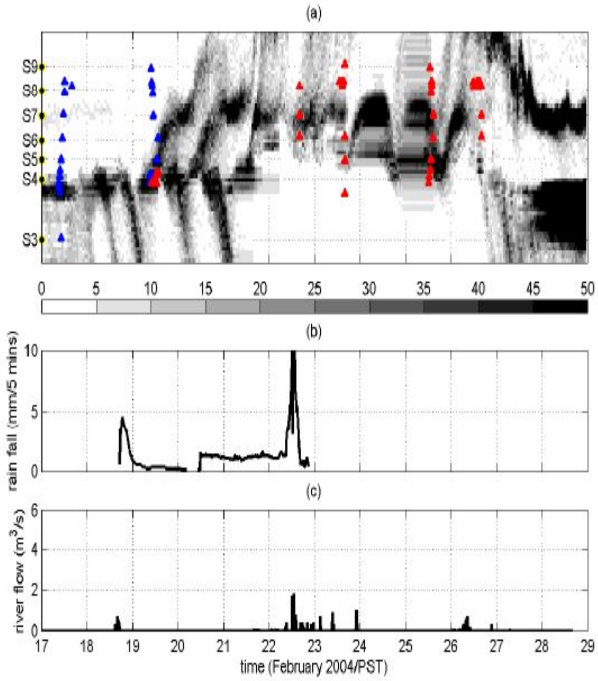

Figure 3: (a) Concentration of particles along sampling stations. (b) Rainfall. (c) Tijuana River flow rate entering the U.S. [1m^3/sec = 23 million gallons/ day]

Between 2004 and 2006, DEH regularly examined SDCOOS data in the context of the most recent water quality/ FIB data, field observations, and river flow rates, and summarized this in e-mails to the Imperial Beach Lifeguards and SIO staff. These e-mails highlighted the times of agreement and disagreement between field observations and measured or modeled ocean current direction on SDCOOS. This facilitated an on-going dialogue between all three parties that has identified surf zone currents (closer to the shoreline) and river flow rates as additional inputs needed to improve the accuracy of the estimated plume position and its relevance to high levels of FIB on the coastline.

MANAGEMENT IMPLICATIONS

The SDCOOS web page and plume tracker model have greatly enhanced the presentation of, and DEH's ability to use, information relevant to beach closure decisions. While the SDCOOS web page and plume tracker do not replace the need for human input, these tools can serve to validate closure decisions made by DEH, and act as an early warning of northward moving currents before they are detected by field observations. Overall, the pilot application of this technology to beach water quality has been successful in providing greater confidence in beach closure decisions during times of suspected contamination of Imperial Beach.

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Southward flow at the Tijuana Estuary mouth following rain. The estuary plume is affecting the Tijuana Slough National Wildlife Refuge shoreline, Border Field State Park, and Playas De Tijuana in Baja California, Mexico. Residential housing in Imperial Beach (the south end of Seacoast Drive) is visible at the bottom of the image. Photo courtesy of Ocean Imaging, Inc. www.oceani.com