Warning: Beach closures may not be valid

Rain, tides and sunlight can affect water samples, scholar finds

BY MARK SHWARTZ

Nothing will ruin a day at the beach like a sign in the sand that reads, "Warning: Contaminated Water. Unsafe for Swimming or Contact."

According to the Natural Resources Defense Council, there were more than 13,000 closures and advisories at ocean and freshwater beaches in the United States in 2001 -- the vast majority prompted by lab tests showing elevated levels of fecal bacteria in the water.

But a recent study in the journal *Environmental Science & Technology* (ES&T) is raising questions about the reliability of water monitoring programs now in use at most U.S. beaches. The study also has uncovered a surprisingly strong correlation between beach pollution and the forces of nature -- including rainfall, sunlight and the gravitational pull of the moon.

Alexandria Boehm, the Clare Boothe Luce Assistant Professor of Civil and Environmental Engineering, collects a sample of ocean water at Capitola Beach to be tested for bacterial contamination. Photo: L.A. Cicero

"There are many factors that can influence the..."
concentration of bacteria in a sample of water," said Alexandria B. Boehm, the Clare Boothe Luce Assistant Professor of Civil and Environmental Engineering at Stanford and lead author of the ES&T study. After conducting extensive field studies of Southern California beaches, Boehm is extending her research to the sandy shores of Northern California not far from the Stanford campus.

"A lot of water sampling is done once a day, but there usually is a one- to four-day delay between the time a sample is taken and testing results are known," she explained. "In our study, we found that a lot of pollution events last just one day or one hour, so the problem is likely to have passed by the time a warning sign is posted."

The result, Boehm said, is that people may be barred from swimming at beaches that are actually clean, while contaminated beaches may be inadvertently kept open, exposing swimmers, snorkelers and surfers to a wide range of illnesses -- some producing mild symptoms (such as chills, fevers and upset stomachs) and some that are potentially lethal (including hepatitis and meningitis). Beach closures also can have a serious economic impact on restaurants, shops and other local businesses.

"Decisions to post or close a beach should not be based on the concentration of indicator bacteria in a single grab sample," Boehm noted. "It's not that the single sample standard doesn't protect people, it also overprotects them and says the beaches are dirty when they're not."

**Surfing and science**

An avid surfer, Boehm traces her interest in coastal ecology to her childhood in Hawaii. "I love being in the ocean," she said. "I grew up in Oahu, so I grew up swimming, surfing, playing in the water and diving."

After graduating from high school, Boehm moved to Southern California, where she earned an undergraduate degree at Caltech and a doctorate in environmental engineering at the University of California-Irvine. Much of her free time was spent at nearby Huntington Beach, one of Orange County's most popular surfing spots. In the summer of 1999, while Boehm was completing her doctoral thesis, Huntington Beach was thrown...
into the national spotlight when Orange County officials shut down several miles of beachfront after tests revealed high concentrations of fecal bacteria.

"The public was outraged and demanded that someone be blamed for the dirty water," Boehm recalled, "but to this day, no one has determined the source of the contamination."

More than a million people visit Huntington Beach in a typical summer, so the local economy was devastated by the closure, which lasted more than two months. When she joined the UC-Irvine faculty in 2000, Boehm decided it was a perfect time to conduct an in-depth study of the water quality at Huntington Beach.

"One of my favorite spots to surf was right at the mouth of the Santa Ana River, where bacteria concentrations are typically high," Boehm said. "It was kind of nice just being in the place where I was spending so much time studying and doing research."

With the help of the sanitation district and other local agencies, Boehm and her colleagues analyzed more than 100,000 water samples that had been collected at 17 monitoring stations along the beach since 1958.

"We found that water quality at Huntington Beach today is no worse than it was in the '80s," she noted. "In fact, it's actually getting better."

The study showed that pollution levels dramatically declined following the construction of a 4.5-mile-long sewage outfall pipe in 1971. Many of the beach closures that have occurred since than can be attributed to tougher state water quality standards, Boehm said.

"We're becoming more conservative about what is safe and what is not safe," she added. "I think that the rash of beach closures that have been occurring recently here and throughout the United States are because of changes in the way that people monitor and the fact that regulations have become more strict."

**Rain, tides and sunlight**

Nature also plays an important role in determining beach quality. The *ES&T* study
revealed that, on average, bacterial levels at Huntington Beach were three times higher in the rainy months of January, February and March than during the dry summer months of June, July and August when beach use is at its peak. The apparent cause of this seasonal disparity is sewer system failures and stormwater runoff that occur during heavy winter rains.

More surprising was the discovery of a direct relationship between beach contamination and the lunar cycle. Tides on Earth are determined by the gravitational pull of the moon, and the range between high and low tides is greatest during full and new moons. At the other extreme, tidal range is minimal during neap tides, which occur in the first and third quarters of the moon.

"In our study, we found that, at certain locations, water quality was worse during full and new moons than during neap tides," Boehm explained. "I'm currently trying to see if there is some oceanographic pattern that can account for it. Perhaps polluted ground water is pumped into the surf zone during full and new moons when the tide range is bigger."

In their study, Boehm and her co-workers analyzed data collected during two intensive sampling surveys at Huntington Beach. In one survey, water samples were collected every hour for two consecutive weeks. In the other survey, researchers spent a night at the beach collecting samples every 10 minutes.

"One of the things we found during these short-term studies was that water quality varies over the course of the day," she said. "That's because sunlight influences the concentration of bacteria in the water, so if someone goes out and collects a sample in the morning, bacteria levels will be much higher than if they collect the sample at noon or at 2 p.m."

Because fecal bacteria are so sensitive to sunlight, Boehm recommended that authorities consider the time of day a sample of water is taken when assessing human health risk. "Right now, there's no time-of-day associated with the standards set in place by the government," she observed.

In the ES&T study, Boehm and her colleagues also suggested replacing single sample monitoring
with a more reliable method known as geometric mean sampling. "The geometric mean standard is much better because it integrates water quality from the last 30 days into the measure of how clean the water is," she said, adding that it gives authorities a more accurate standard for making decisions about beach postings and closures.

**Northern California**

This past summer, Boehm left UC-Irvine and moved 500 miles north to join the Civil and Environmental Engineering Department at Stanford. Upon her arrival, she received a Clare Boothe Luce Professorship -- an award given by the Henry Luce Foundation to promote the advancement of young American women in the sciences, engineering and mathematics.

Included in the endowment is a two-year stipend that will allow Boehm to extend her research to the beaches of Northern California, including Santa Cruz County -- a popular surfing and sunbathing spot located on Monterey Bay about 50 miles southwest of Stanford. Like Huntington Beach, Santa Cruz beaches are popular but have suffered many closures and advisories in recent years.

"I want to see if I find any of the same results in Santa Cruz that I found at Huntington Beach," Boehm said. "I want to see if there are the same seasonal patterns in the water quality, and if there is variability during the day."

She also plans to continue her research on lunar patterns to see if they can be used as a regulatory tool to predict pollution events. "If you know that water quality is worse during full and new moons, then maybe you should just shut the beach during that time instead of continually monitoring it," she explained.

"The best thing you can do to make beaches cleaner is to be aware of what's going on in your community and tell the officials in your county that you are concerned about beach water quality. Also, don't put things down the storm drain that you wouldn't want to swim in."

Although ocean water at Santa Cruz is much cooler than at Huntington Beach or Hawaii, Boehm predicts that it won't be long before she dons her wetsuit and rides the wild surf: "I'd like
to get out and do field work with my students, including undergraduates. It sounds like fun -- camping on the beach, surfing and sampling water!"

Other co-authors of the ES&T study were Stanley B. Grant and Joon H. Kim of UC-Irvine; Samuel L. Mowbray and Charles D. McGee of the Orange County Sanitation District (OCSD); and Catherine D. Clark, Denise M. Foley and Daniel E. Wellman of Chapman University. The study was supported by the National Water Research Institute, OCSD, the Santa Ana Regional Water Quality Control Board and five Southern California cities including Huntington Beach.