

Using DNA technology to protect beachgoers from fecal contamination

DNA-based methods provide faster, more insightful information about when it's safe vs. risky to enter the water

For decades, the public health community has tested beach water for fecal contamination using established bacterial culturing methods. But advances in DNA technology are paving the way for faster, more insightful ways to assess water quality and warn beachgoers when it's potentially unsafe to enter. In 2022, San Diego County became the first coastal community in the nation to end reliance on bacterial culturing in favor of a DNA-based method.

Key advantages of DNA technology

The traditional way to test beach water for fecal contamination is via cell culturing, where bacteria cells from a water sample are grown in a laboratory overnight and then analyzed. DNA-based methods, by contrast, focus on analyzing the bacteria cells' DNA.

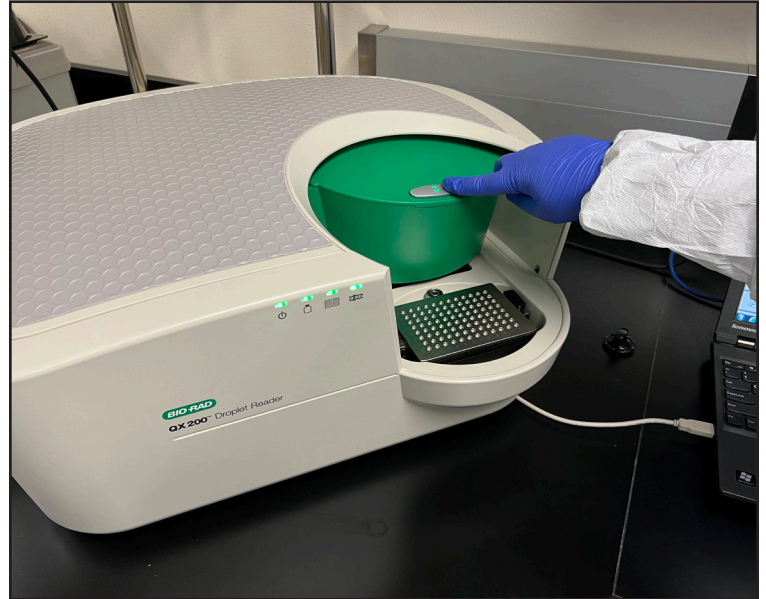
» **Faster:** Whereas cell culturing typically takes 24-72 hours after beach water samples reach a laboratory, DNA methods can provide same-day results. Speed is of the essence when it comes to protecting the health of beachgoers, especially following unexpected, transient sewage spills. Public health agencies need to close beaches and/or post warning signs as soon as a potential risk to human health has been confirmed – and then reopen beaches and/or rescind advisories as soon as the risk has passed.

» **More insightful:** Cell culturing cannot determine if fecal contamination originated in the gut of a human or another animal, such as a bird or dog. By contrast, DNA methods can make this distinction. These additional insights help the environmental management community prioritize remediating sources that represent the greatest threat to public health. (It is primarily human feces that sickens swimmers and surfers.)

DNA methods agree with culturing methods

For DNA methods to be approved as a replacement for culturing methods, the two methods must produce results that lead public health agencies to take consistently similar actions to close beaches and/or post warning signs. Scientists have conducted extensive side-by-side testing of the two types of methods across Southern California. The testing found about 90% agreement in the beach closure and notification decisions that public health agencies make based on the two methods.

When decision-making differs for a beach, scientists have multiple ways to probe why and determine which set of results is the more appropriate predictor of illness risk.



A ddPCR instrument on a laboratory benchtop uses DNA technology to test water for fecal contamination.

DNA methods are ready for prime time

Scientists have spent the past two decades working to adapt and transition DNA technology for routine use in beach water-quality testing across Southern California:

- » **Evaluated side by side:** DNA methods have been evaluated side by side with traditional culture methods to show that results are consistently equivalent.
- » **Predictive of health risk:** Epidemiology studies have confirmed that DNA methods are more reliable as a predictor of illness risks for beachgoers who enter contaminated water.
- » **Standardized:** DNA methods have been standardized and published in peer-reviewed scientific literature.
- » **EPA-approved:** In 2012, the U.S. Environmental Protection Agency approved use of an initial DNA-based method for testing beach water quality.
- » **Adopted by end users:** About 10 environmental monitoring agencies across Southern California have been trained in DNA methods and demonstrated proficiency during quality-control exercises.
- » **Accreditation-eligible:** Laboratories can be accredited to perform DNA methods through California's Environmental Laboratory Accreditation Program.

Enterococcus bacteria as an indicator of fecal contamination

When beach water quality is tested – either via culturing or DNA methods – the goal is to determine if a type of bacteria known as *Enterococcus* exceeds State standards. *Enterococcus* is a reliable, proven indicator of the presence of untreated feces, although most *Enterococcus* bacteria are not pathogens. The reason *Enterococcus* is measured instead of pathogens is that many pathogens, especially viruses, are comparatively difficult to measure. While DNA-based technology is increasingly making it feasible to measure pathogens directly, *Enterococcus* remains an established indicator of fecal contamination with a robust body of science built around it.


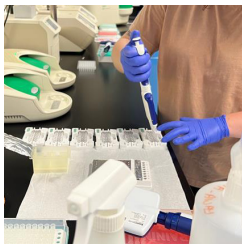


Photo credit: County of San Diego

A County of San Diego field crew collects beach water samples in the surf zone.

Cell culturing vs. DNA methods

During the beachgoing season, public health agencies across California are required under a 1997 law known as California Assembly Bill 411 to test beaches at least weekly for fecal contamination. Public health agencies have two basic ways to do this routine testing:

	 Cell culturing methods	 DNA methods
Method overview	Bacteria grown overnight in laboratory, then counted by hand	Bacterial DNA isolated and quantified using lab instrument
Development timeline	Developed more than a century ago, with newest version released in the 1990s	Developed two decades ago, with newest version of this technology released about 10 years ago
State of method	Approved by EPA in 1976 after decades of use	Approved by EPA in 2012 as an alternative to culturing
Setup required	~\$7K initial capital investment for most popular method	~\$100K capital investment for newest method; 2 weeks to retrain existing lab staff (no additional staff required)
Length of time to get results	20-78 hours total <ul style="list-style-type: none">• 2-6 hours to prep samples in lab• 18-72 hours incubation	4-9 hours total <ul style="list-style-type: none">• 2-6 hours to prep samples in lab• 2-3 hours instrument runtime
Cost per sample	~\$55 to process each sample	~\$100* to process each sample (includes consumables + labor)
Human fecal sources distinguishable?	No	Yes; DNA-based option to distinguish human sources from other animal sources

*Note: Because DNA methods produce same-day results, transitioning to a more powerful DNA method can increase public demand for daily beach testing, which has the potential to drive up program costs if culture-based testing is only being done weekly.

qPCR vs. ddPCR

qPCR (quantitative polymerase chain reaction) and **ddPCR** (droplet digital PCR) are two established DNA-based methods for fecal contamination testing. ddPCR is an easier-to-use successor technology to qPCR, although the basic underlying scientific approach is the same for both. Costs and time also are about the same for both.

State of method adoption

Since 2010, about 10 Southern California agencies have invested in qPCR to complement culturing during routine fecal contamination testing. In 2022, San Diego County became the first coastal community in the nation to replace its culturing methods with ddPCR.

More reading

Text of California [AB 411](#) and [SB 1395](#)

[Southern California demonstration project: qPCR vs. culture methods](#)

[San Diego County ddPCR beach testing portal](#)

