

The Sequential Probability Ratio Test: An efficient alternative to exact binomial testing for Clean Water Act 303(d) evaluation

Connie Chen¹, Matthew O. Gribble², Jay Bartroff³, Steven M. Bay⁴, Larry Goldstein³

¹*Department of Statistics, Carnegie Mellon University, Pittsburgh, PA*

²*Department of Environmental Health, Emory University Rollins School of Public Health, Atlanta, GA*

³*Department of Mathematics, University of Southern California, Los Angeles, CA*

⁴*Southern California Coastal Water Research Project, Costa Mesa, CA*

ABSTRACT

The United States' Clean Water Act stipulates in section 303(d) that states must identify impaired water bodies for which total maximum daily loads (TMDLs) of pollution inputs into water bodies are developed. Decision-making procedures about how to list, or delist, water bodies as impaired, or not, per Clean Water Act 303(d) differ across states. In states such as California, whether or not a particular monitoring sample suggests that water quality is impaired can be regarded as a binary outcome variable, and California's current regulatory framework invokes a version of the exact binomial test to consolidate evidence across samples and assess whether the overall water body complies with the Clean Water Act. Here, we contrast the performance of California's exact binomial test with one potential alternative, the Sequential Probability Ratio Test (SPRT). The SPRT uses a sequential testing framework, testing samples as they become available and evaluating evidence as it emerges, rather than measuring all the samples and calculating a test statistic at the end of the data collection process. Through simulations and theoretical derivations, we demonstrate that the SPRT on average requires fewer samples to be measured to have comparable Type I and Type II error rates as the current fixed-sample binomial test. Policymakers might consider efficient alternatives such as SPRT to current procedure.

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