Challenge
• Mercury (Hg) and monomethylmercury (MMHg) availability change over time during lab studies of methylation and demethylation which affects model structure and estimated values of reaction rate constants. No model-experiment approach to date has explicitly addressed these questions.

Approach and Results
• Using time-resolved measurements of filter passing Hg and MMHg during methylation/demethylation assays, a multisite kinetic sorption model, and re-analyses of previous assays, we show that competing kinetic sorption reactions can lead to time-varying availability and apparent non-first-order kinetics in Hg methylation and MMHg demethylation.

Significance and Impact
• Neglecting competing kinetic processes confounds analyses of methylation/demethylation assays, resulting in rate constant estimates that are systematically biased low. Our new model overcomes those limitations.