2022 Western Lake Erie Harmful Algal Bloom (HAB) Forecast And Measured Size

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Forecast summary: A Harmful Algal Bloom of 22,940 metric tons (MT) is predicted for the western basin of Lake Erie in 2023, with a 95% predictive interval of 8,307 – 47,550 MT. This forecast is significantly lower than the 2002-2022 average (31,441 MT), and about one-quarter of the 2015 maximum. This forecast is a contribution to NOAA's ensemble bloom prediction.

This year's forecast is based on a new model (Scavia et al. 2023) that includes estimates of the impact of internal phosphorus recycling by including the bioavailable phosphorus load from previous years, similar to that used by Ho and Michalak (2015). This linear, segmented model predicts HAB extent as a function of the load with slopes before and after a model-estimated change point. The model, calibrated with three independent estimates of the 2002-2020 HAB observations and loading of bioavailable phosphorus, explained 77% and 85% of the interannual variability when using loads through June or July, respectively. It also explained 69% of the interannual variability in a leave-one-out cross validation, and 75% of the variability in blind forecasts. In 2023, we re-calibrated the model using the 2002-2022 HAB observations. Re-calibrated models using June or July can explain 74% and 82% of the interannual variability, respectively. The spring bioavailable phosphorus loads and bloom forecasts compared to observed historical blooms are shown below:
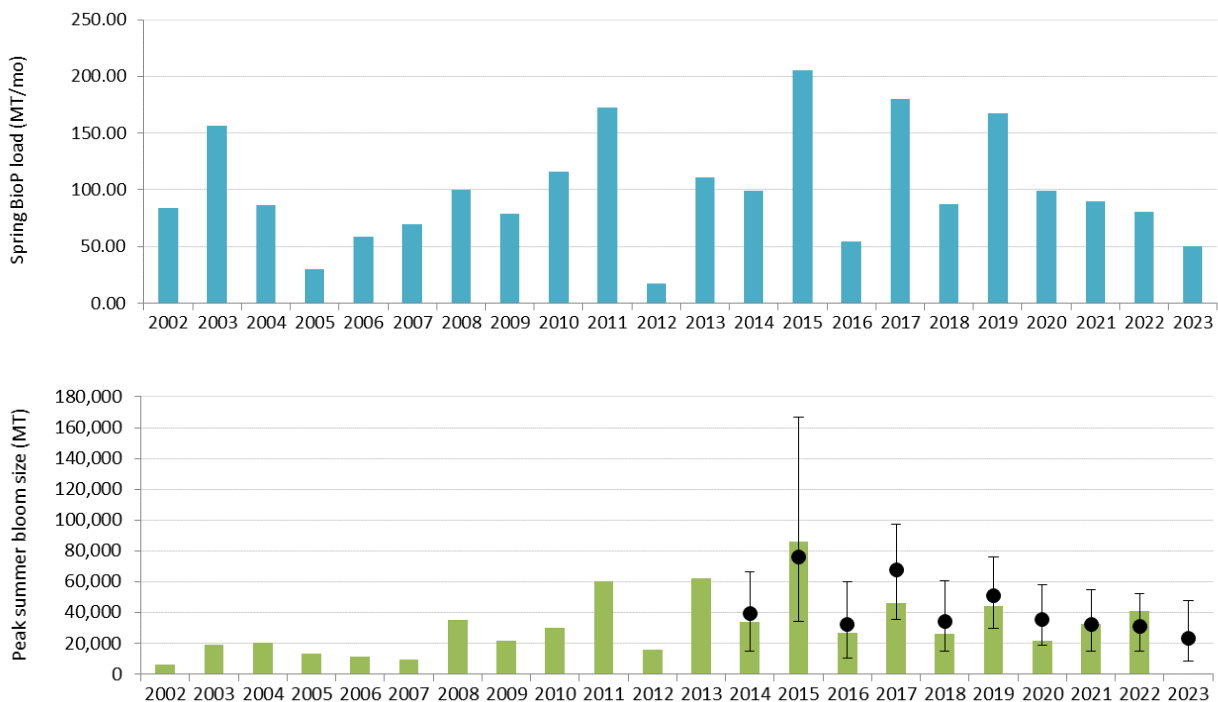
Spring phosphorus loads (top) and mean bloom observations with forecasts (bottom). Error bars represent 95% predictive intervals.

Phosphorus loads: Daily TP and DRP loads were downloaded from Heidelberg University's National Center for Water Quality Research (https://ncwqr.org/monitoring/data/), and aggregated to monthly loads. Bioavailable P was estimated as DRP plus a fraction of particulate P (TP-DRP), where the faction was determined during model calibration.

HAB extent estimates: The HAB model was calibrated using three sets of HAB estimates for 2002-2022. HAB extent as dry weight biomass was derived from two satellite-derived estimates (Stumpf et al. 2016; Manning et al. 2019) and a geostatistical estimate based on *in situ* observations (Fang et al. 2019). The Stumpf cyanobacteria index is based on processing satellite image spectra specific for cyanobacteria, whereas the Manning biomass estimates are based on chlorophyll-specific spectra (Sayers et al. 2016) that give similar results for relatively high chlorophyll concentrations. Both are constrained to near-surface observations. The Fang estimates are based on *in situ* chlorophyll observations, which are relatively sparse, but provide full water-column estimates. Stumpf estimates are for the full lake, whereas the other two estimates only determine bloom size within the western basin. So, the Stumpf estimates were clipped to the western basin as described by Fang et al. (2019).
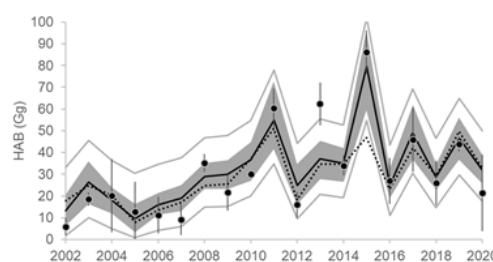

Figure 1. Calibrated HAB model. Mean and standard deviation of observations (boxes), prediction (solid line) with 95% credible intervals for parameter error (shade) and parameter error plus prediction error (grey line). Dotted line is prediction for the model calibrated with loads through June.

HAB model calibration:. Calibration was based on Bayesian inference using a Markov Chain Monte Carlo (MCMC) sampling algorithm implemented within WinBUGS interfaced with the R package, R2WinBUGS (Lunn et al., 2000; R Core Team, 2015; Sturtz et al., 2005). Detailed information on the MCMC algorithm settings, chain convergence evaluation, and parameter prior distributions can be found in Obenour et al. (2014) and Bertani et al. (2016). A new response curve was developed for the revised model based on parameter estimates and model-specific spring loads.

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