2024 Western Lake Erie Harmful Algal Bloom (HAB) Forecast And Measured Size

Donald Scavia, Yu-Chen Wang, Daniel Obenour

June 28, 2024

Forecast summary: A Harmful Algal Bloom of 4.06 Cyanobacteria Index (CI), about 19,488 metric tons (MT) is predicted for the western basin of Lake Erie in 2024, with a 95% predictive interval of 3.15 – 6.21 CI, about 15,120 – 29,808 MT. This forecast is significantly lower than the 2002-2023 average (5.05 CI), and about one-quarter of the 2015 maximum. This forecast is a contribution to NOAA's ensemble bloom prediction.

The model is an adaptation of the one described in 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 2024, we modified the model, calibrating it to the 2002-2023 average CI. Re-calibrated models using loads up to July can explain 89% of the interannual variability. The spring bioavailable phosphorus loads and bloom forecasts compared to observed historical blooms are shown below:
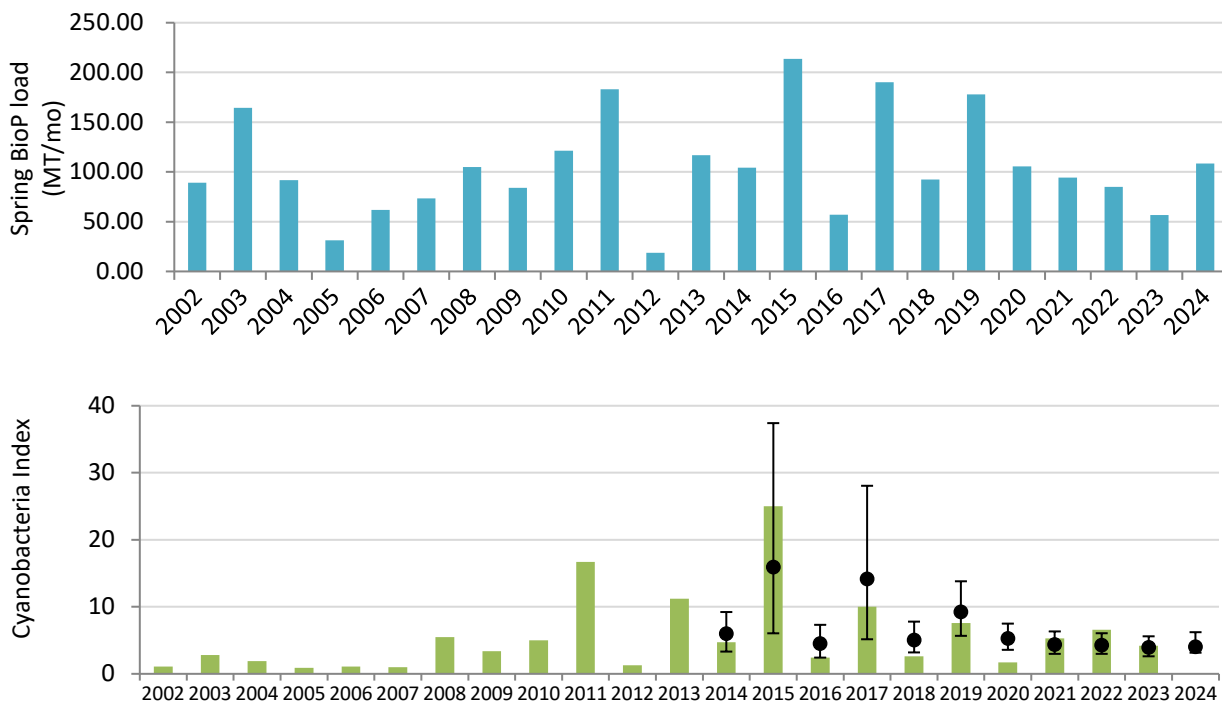

Spring phosphorus loads (top) and mean bloom observations with forecasts (bottom). Error bars represent 95% predictive intervals.

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 to the average CI. The CI index is based on processing satellite image spectra specific for cyanobacteria (Stumpf et al. 2016). The model is calibrated only to the average CI in Western Lake Erie from 2002 to 2023.

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.
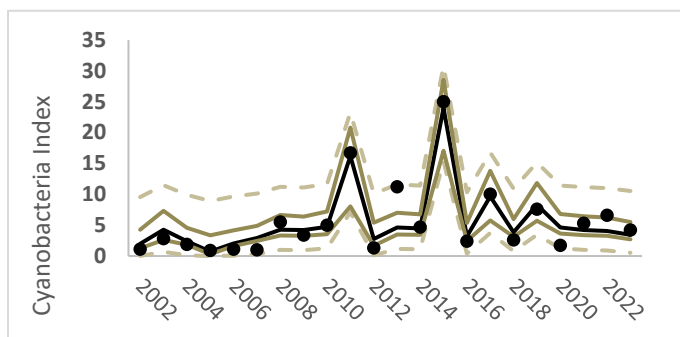
Calibrated HAB Model. The black dots are the average CI. The black line indicates the prediction. The solid lines around the prediction are the 95% credible interval of CI for the parameter error, while the dashed lines are the 95% prediction interval.

References

Bertani, I., D. R. Obenour, C. E. Steger, C. A. Stow, A. D. Gronewold, and D. Scavia (2016), Probabilistically assessing the role of nutrient loading in harmful algal bloom formation in western Lake Erie. *J. Great Lakes Res.*, 42(6), 1184-1192.

Bridgeman, T. B., J. D. Chaffin, and J. E. Filbrun (2013), A novel method for tracking western Lake Erie *Microcystis* blooms, 2002–2011. *J. Great Lakes Res.*, 39(1), 83-89.

Fang, S., D.D. Giudice, D. Scavia, C.E. Binding, T. B. Bridgeman, J. D. Chaffin, M. A. Evans, J. Guinness, T. H. Johengen, D. R. Obenour. A Space-time geostatistical model for probabilistic estimation of harmful algal bloom biomass and areal extent. Science of the Total Environment https://doi.org/10.1016/j.scitotenv.2019.133776

Ho, J.C., Michalak, A.M., 2015. Challenges in tracking harmful algal blooms: a synthesis of evidence from Lake Erie. J. Great Lakes Res. 41, 317–325.

Lunn, D.J., Thomas, A., Best, N., Spiegelhalter, D., 2000. WinBUGS—a Bayesian modelling framework: concepts, structure, and extensibility. Stat. Comput. 10, 325–337.

Manning, N.F., Y.C. Wang, C. M. Long, I. Bertani, M. J. Sayers, K. R. Bosse, R. A. Shuchman, D. Scavia. 2019 Extending the Forecast Model: Predicting Harmful Algal Blooms at Multiple Spatial Scales. J. Great Lakes Res. 45:587–595 https://doi.org/10.1016/j.jglr.2019.03.004

Obenour, D. R., A. D. Gronewold, C. A. Stow, and D. Scavia,(2014), Using a Bayesian hierarchical model to improve Lake Erie cyanobacteria bloom forecasts. *Water Resour. Res.*, 50(10), 7847-7860.

R Core Team, 2015. R: A Language and Environment for Statistical Computing

Sayers, M., Fahnenstiel, G.L., Shuchman, R.A., Whitley, M., 2016. Cyanobacteria blooms in three eutrophic basins of the Great Lakes: a comparative analysis using satellite remote sensing. Int. J. Remote Sens. 37, 4148–4171.

Scavia, D., Y-C. Wang, D.R. Obenour. 2023 Advancing Freshwater Ecological Forecasts: Harmful Algal Blooms in Lake Erie. Sci. Total Environ. https://doi.org/10.1016/j.scitotenv.2022.158959

Scavia, D., Y-C Wang, D. R. Obenour, A. Apostel, S. J. Basile, M. M. Kalcic, C. J. Kirchhoff, L. Miralha, R. L. Muenich, A.L. Steiner. 2021 Quantifying uncertainty cascading from climate, watershed, and lake models in harmful algal bloom predictions. Sci. Total Environ. https://doi-org.proxy.lib.umich.edu/10.1016/j.scitotenv.2020.143487.

Stumpf, R. P., T. T. Wynne, D. B. Baker, and G. L. Fahnenstiel (2012), Interannual variability of cyanobacterial blooms in Lake Erie, *PLOS ONE*, 7, e42444.

Sturtz, S., Ligges, U., Gelman, A., 2005. R2WinBUGS: a package for running WinBUGS from R. J. Stat. Softw. 12, 1–16