Seasonal forecasts of Chesapeake Bay hypoxia

Modeling Workgroup Quarterly Review
06/20/23

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Updated model version

Driver:

Jan-May 9 RIM rivers + PS TN load

Calibration target:

Total Annual HV

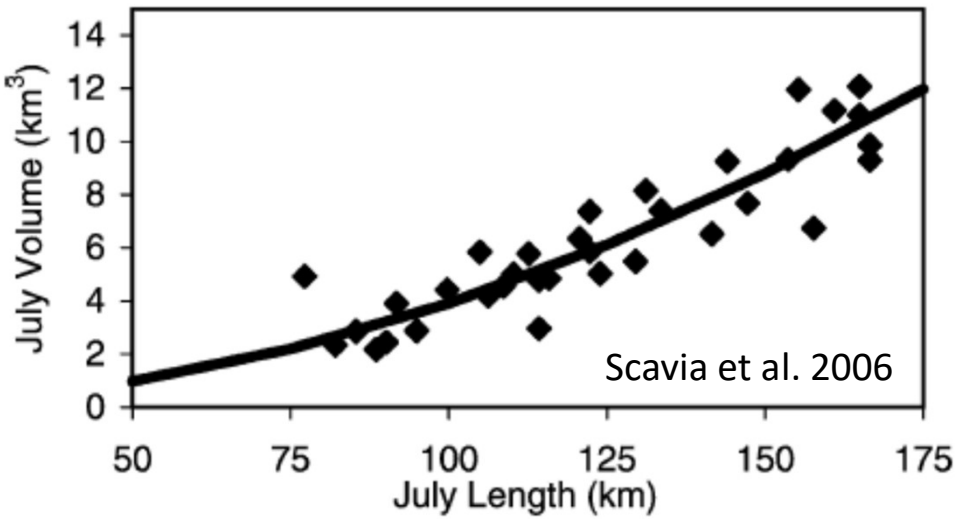
([DO] < 2 mg/L)

Model output:

Average subpycnocline [DO] as a function of distance from TN source

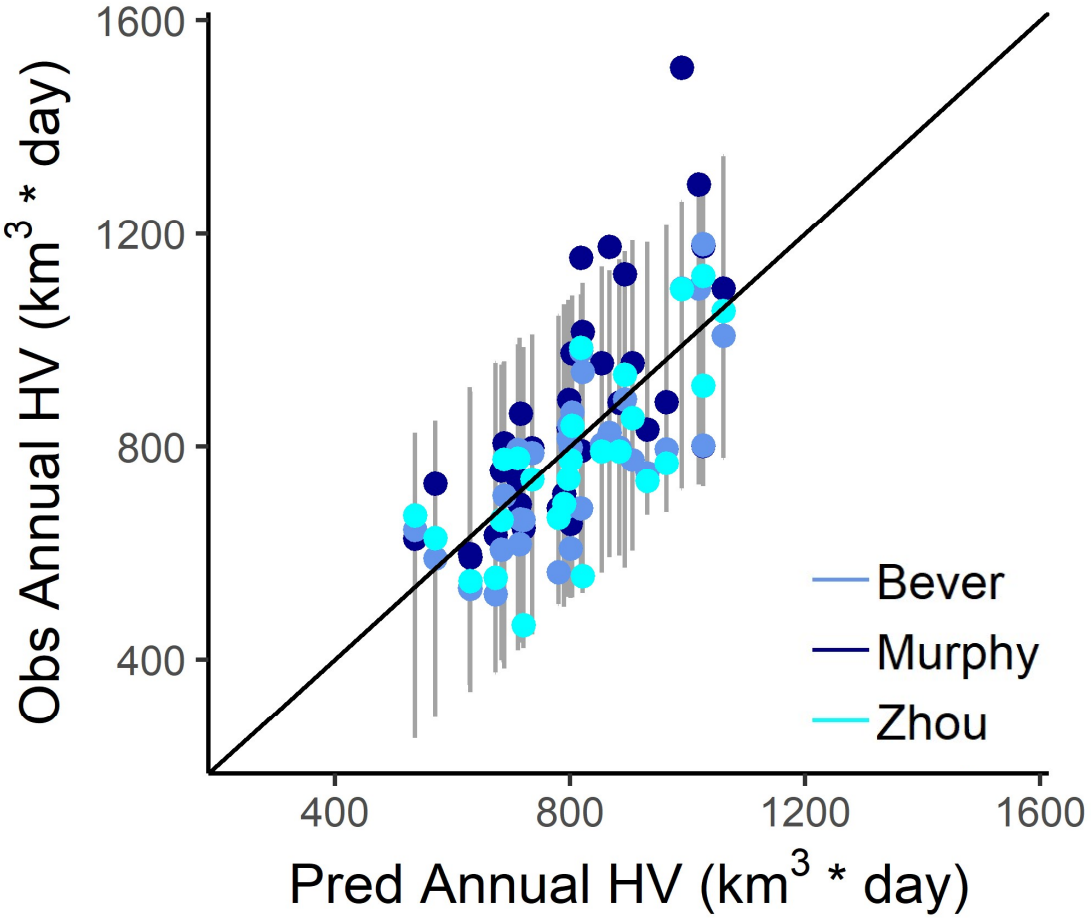
Hypoxic length = sum of all segments with [DO] < 2 mg/L

V-L relationship

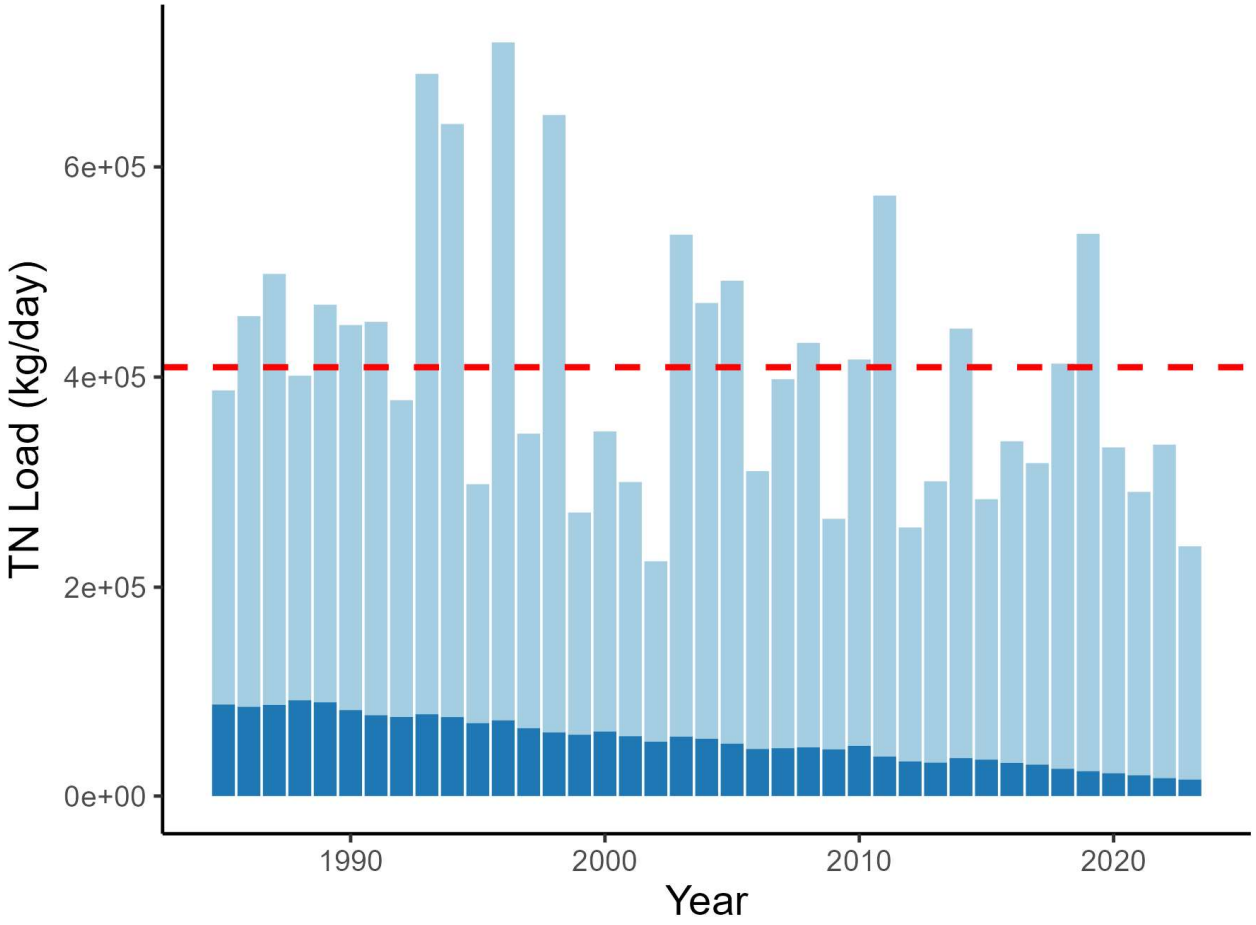


Hypoxic length → **hypoxic volume** through empirical V-L relationship

Predicted vs. observed Total Annual HV



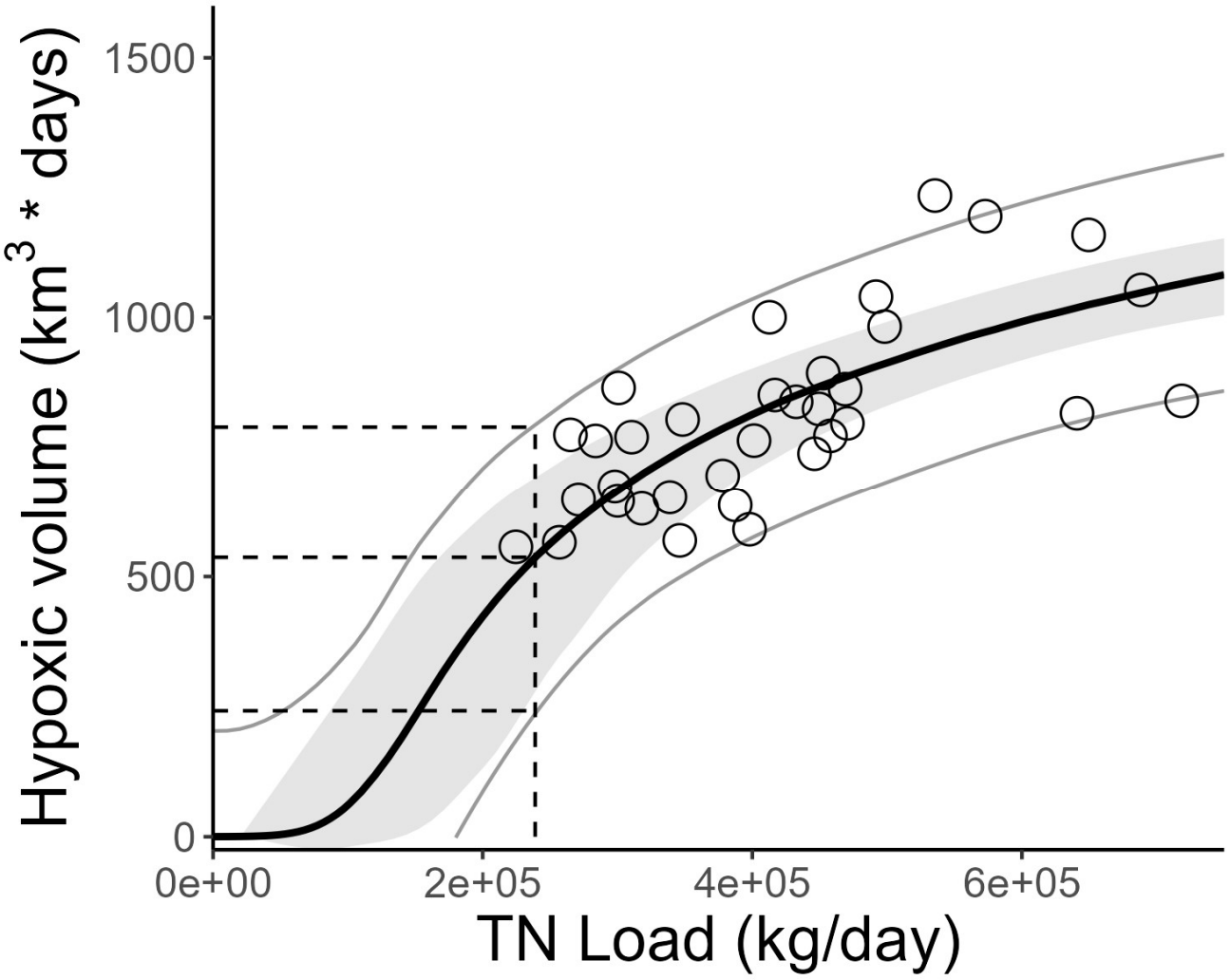
1985-2023 Jan-May TN load



This year's Jan-May TN load is 40% lower than long-term average, largely driven by relatively dry conditions

Preview – Forecast to be officially released later this week

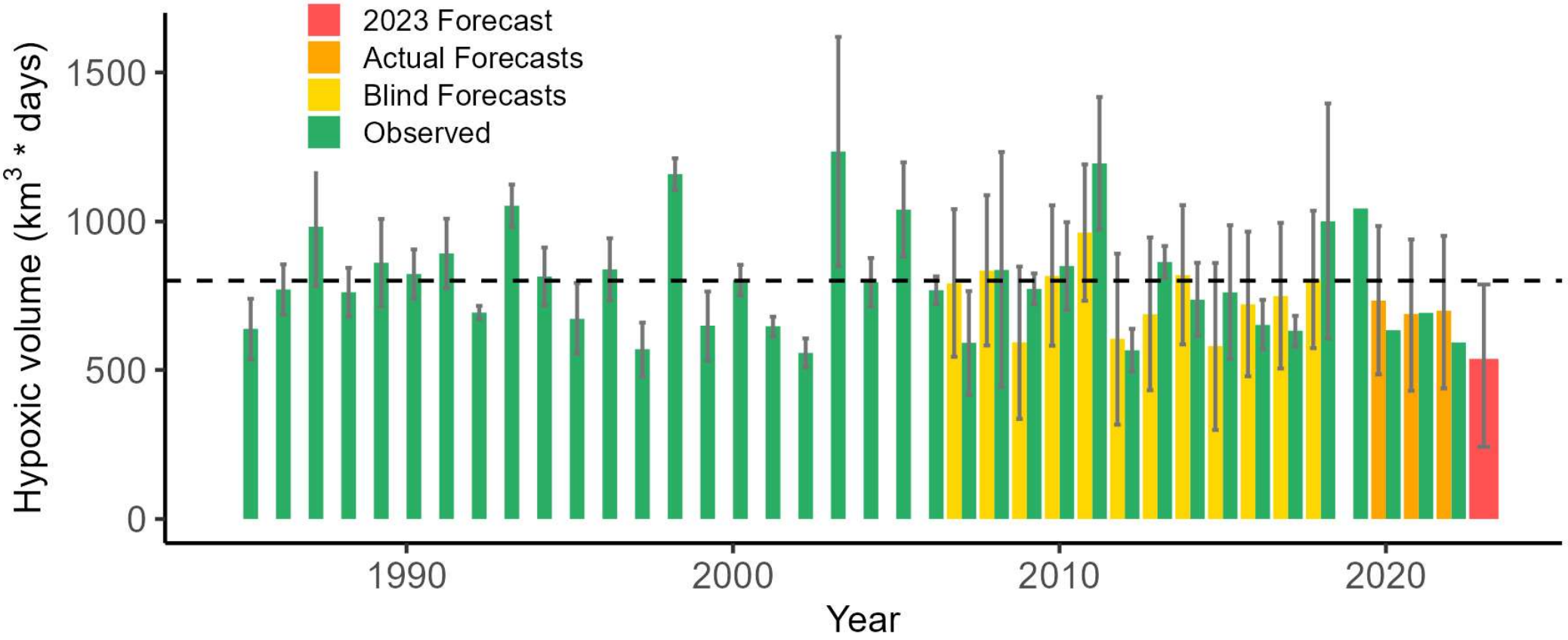
2023 Forecast



This year's forecasted HV is 30% lower than long-term average

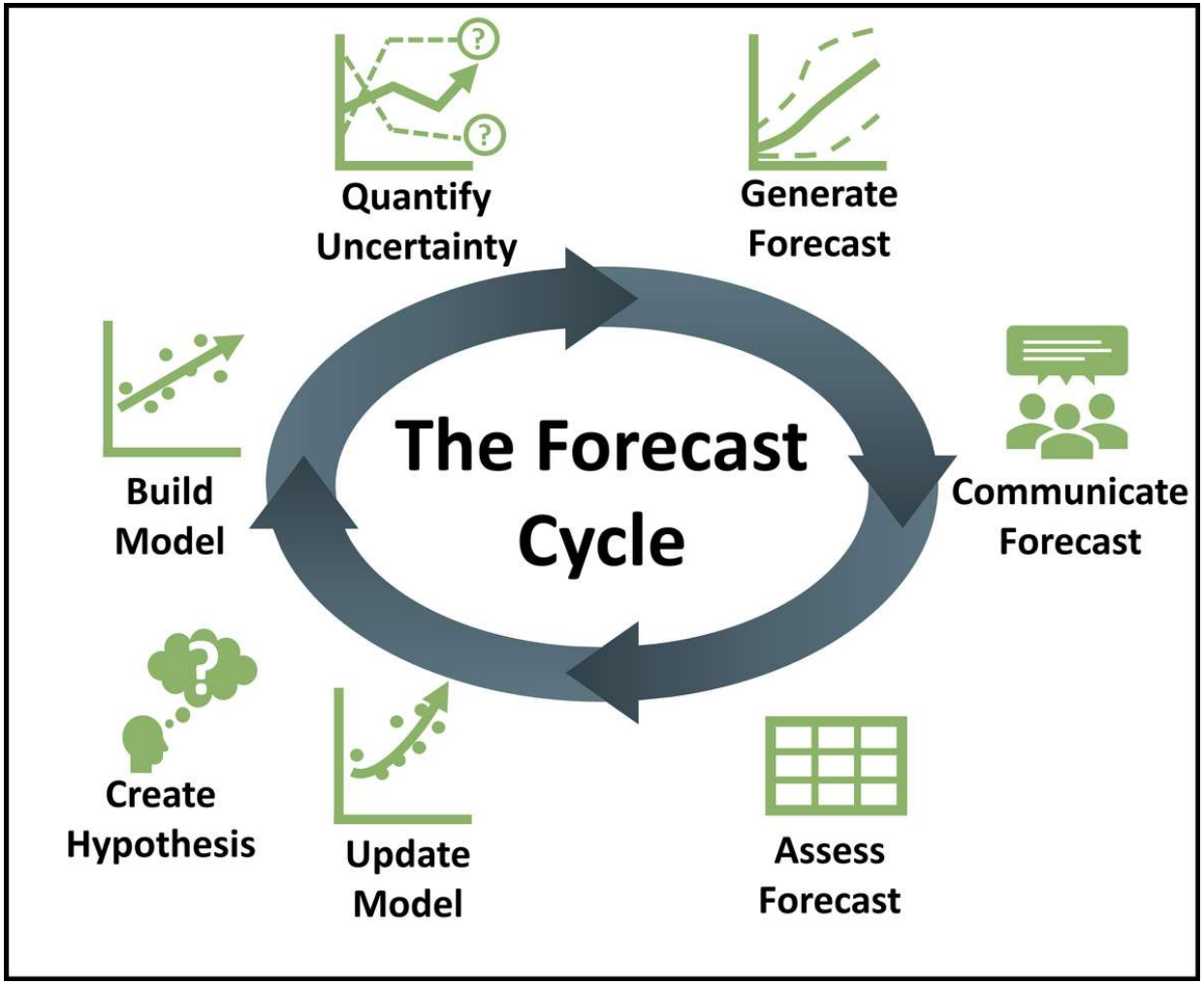
Preview – Forecast to be officially released later this week

2020-2023 Forecasts



Preview – Forecast to be officially released later this week

Ecological forecasting best practices



Moore, Carey, and Thomas, 2021 – https://serc.carleton.edu/eddie/teaching_materials/modules/module5.html

Exploratory analyses for model refinements

Revise model formulation to let the model "pick" the optimal loading period probabilistically

$$BOD_w = \frac{1}{\sum w_m} \times \sum_{m=1}^{8} BOD_m \times w_m$$

where 1 = October of previous year and 8 = May of current year

$$w_m = \begin{cases} 0 & \text{For m} \leq \text{Bp-1} \\ m + 1 - B_p & \text{For Bp-1} < \text{m} < \text{Bp} \\ 1 & \text{For m} \geq \text{Bp} \end{cases}$$

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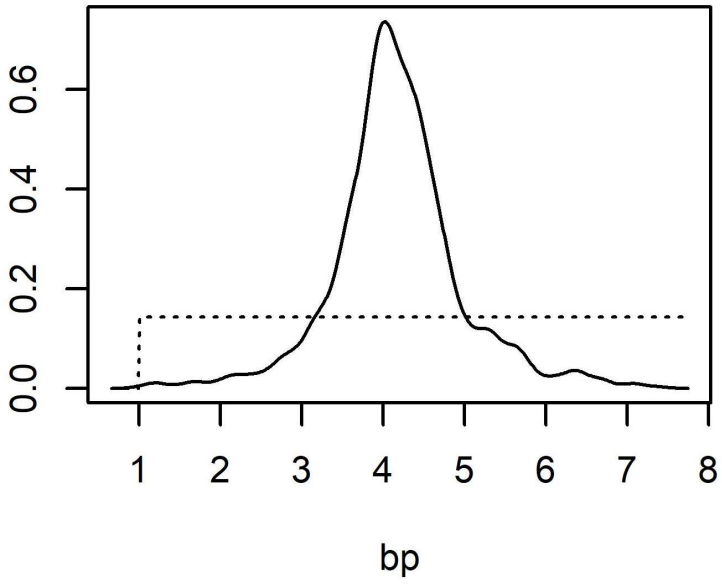
Bp: mean = 4.17; st.dev = 0.8



Exploratory analyses for model refinements

Revise model formulation to test the inclusion of a term that accounts for the potential effect of cumulative load from previous years to represent internal N storage and recycling

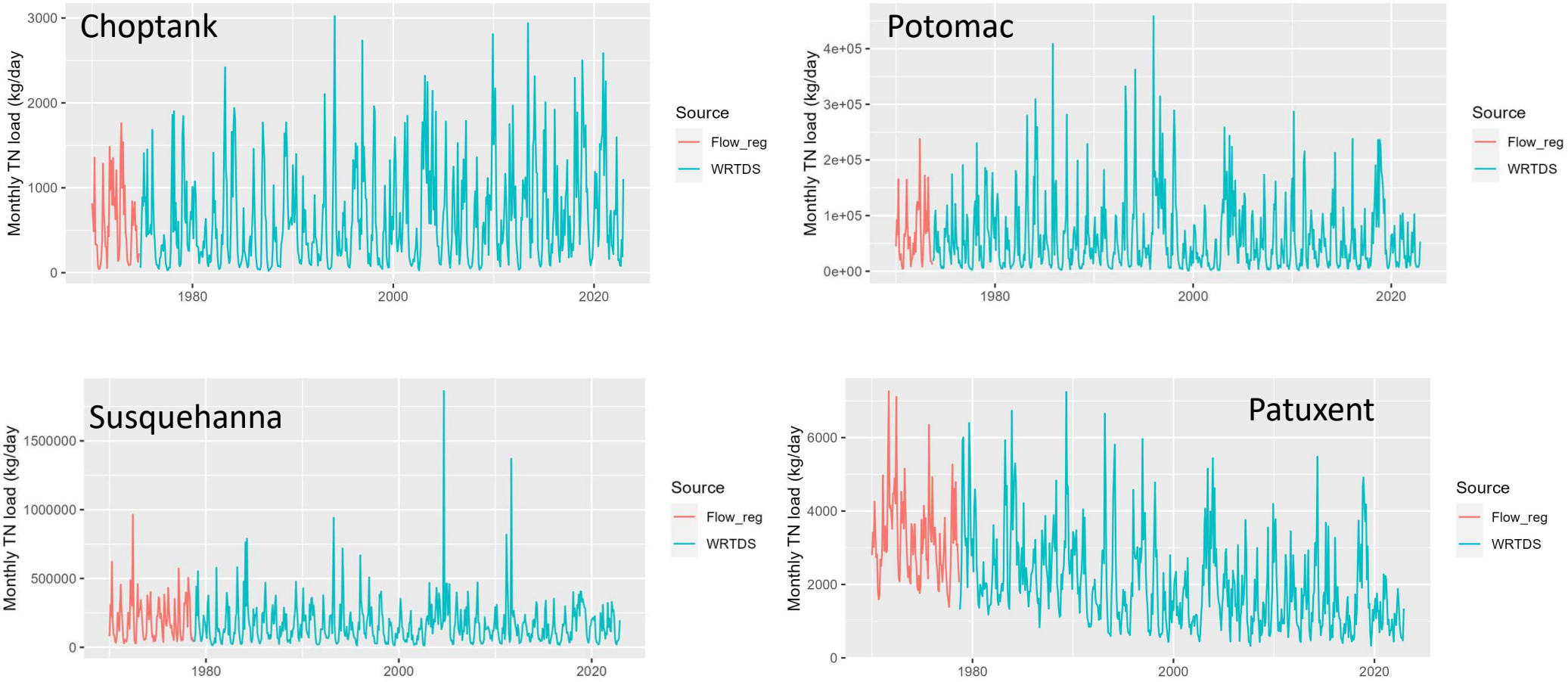
1. Estimated TN loads at RIM stations back to 1970

    - using WRTDS-K for all years with TN samples
    - using station-specific load vs. flow regressions for years with no TN samples

2. Included additional load term in the model and let the model «pick» the optimal number of cumulative previous years probabilistically

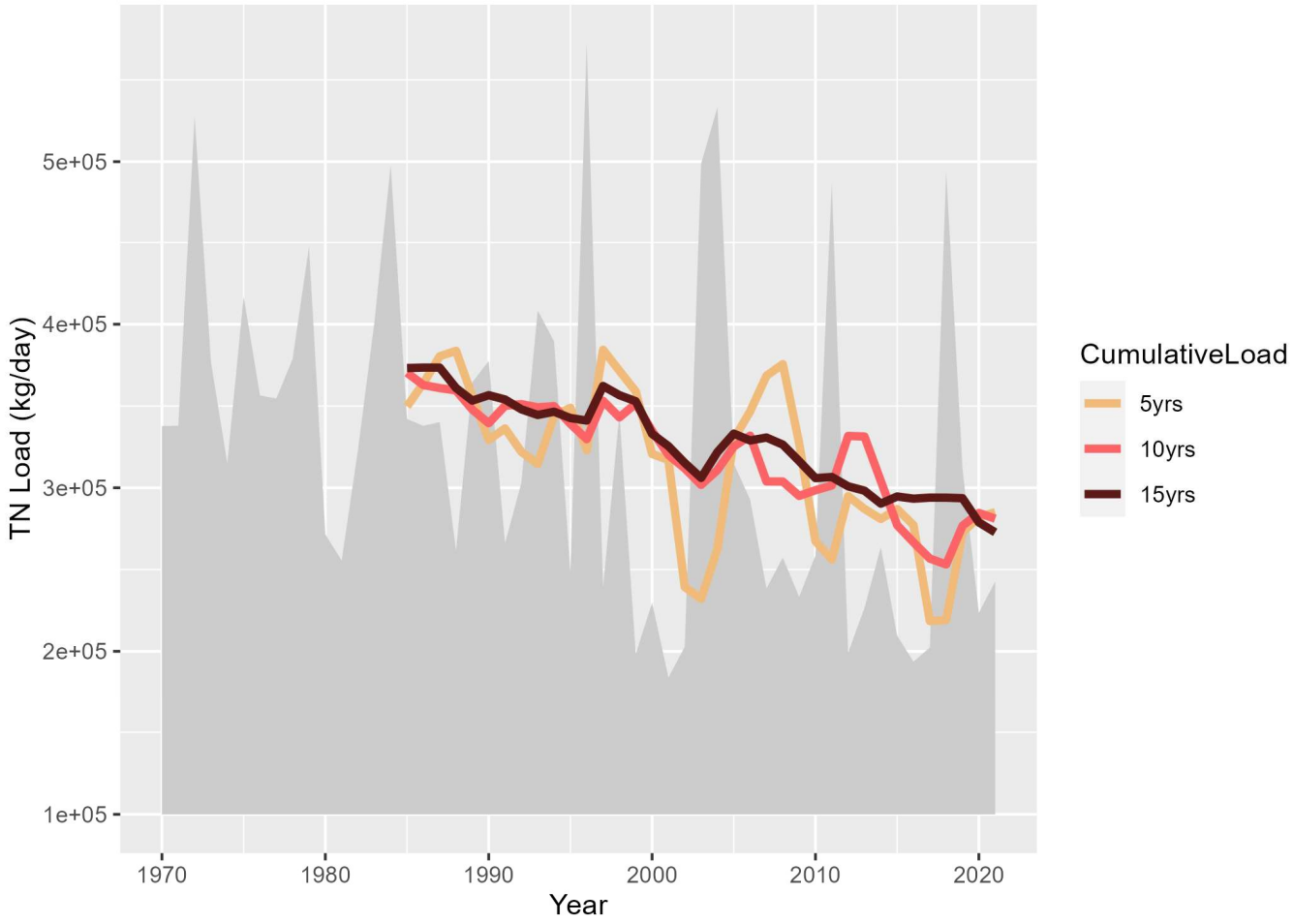
Exploratory analyses for model refinements

Examples of RIM TN loads going back to 1970



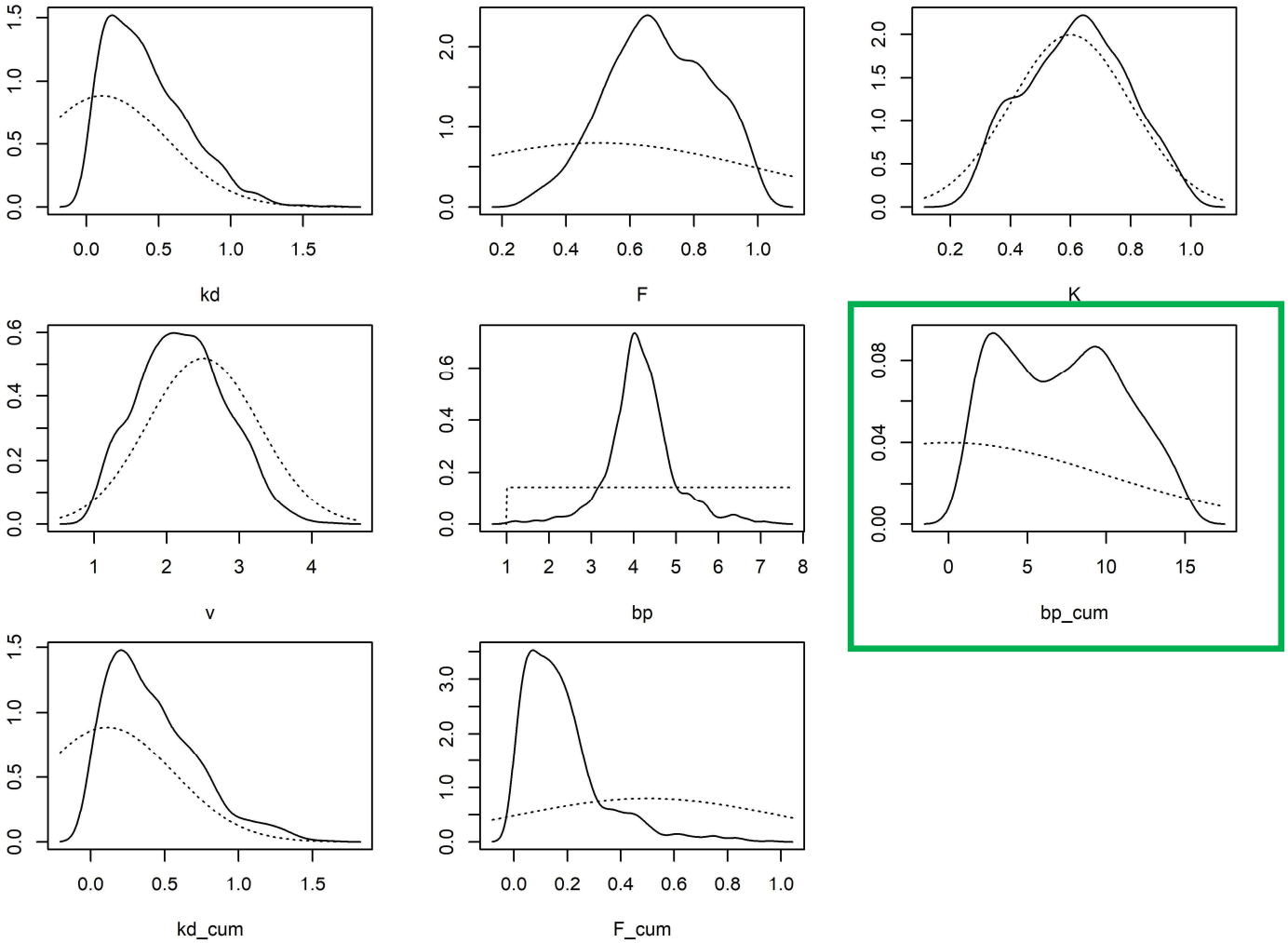
Exploratory analyses for model refinements

Total RIM TN loads going back to 1970



Exploratory analyses for model refinements

Parameter posterior estimates

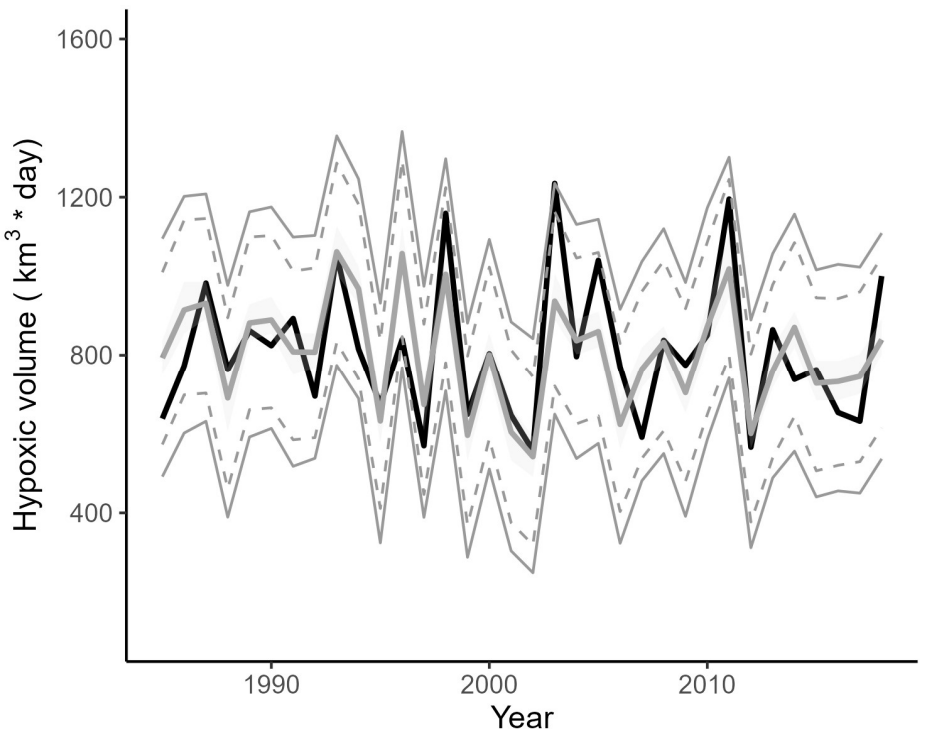


	Mean	St.Dev.
Kd	0.42	0.29
K	0.62	0.17
F	0.69	0.16
V	2.22	0.61
Bp	4.17	0.8
Bp_cum	**7.17**	**3.77**
Kd_cum	0.42	0.31
F_cum	0.18	0.15

Dotted lines: priors; Solid lines: posteriors

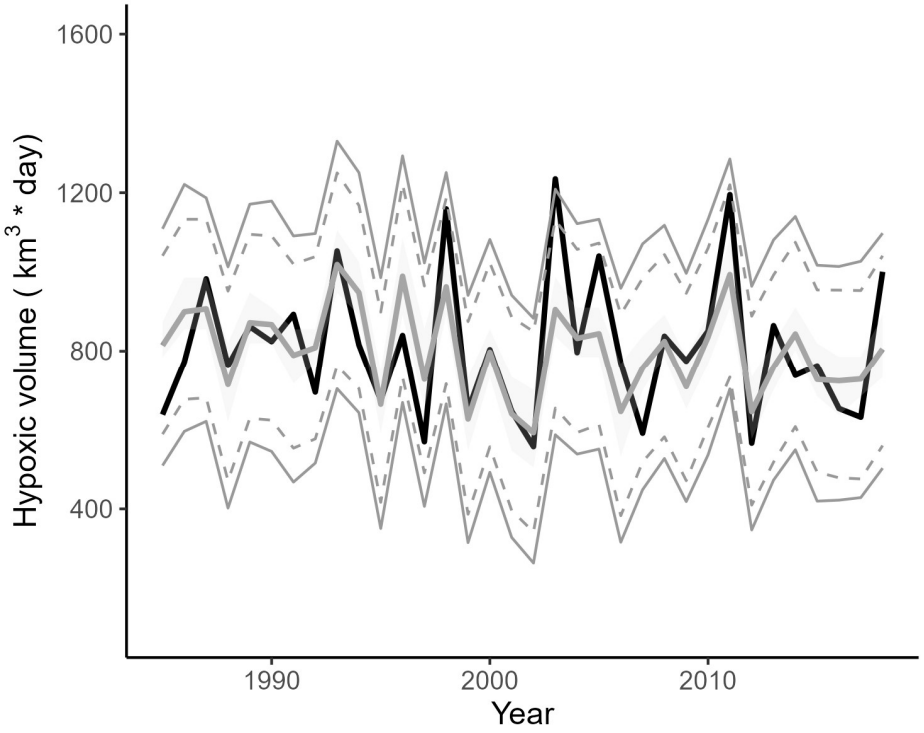
Exploratory analyses for model refinements

Original model version



R^2	0.45
RMSE	1.41
MAE	1.10

Model with cumulative load term



R^2	0.43
RMSE	1.44
MAE	1.10

Gray lines: model predictions; Black lines: Average of three sets of observations

Other ideas we are working on

- Test the inclusion of a term that accounts for long-term changes in temperature in the model

- Test the possibility that loads coming from different tributaries may have different levels of effectiveness in contributing to hypoxia by assigning different weights to different tributaries. Weights can be estimated as part of the Bayesian calibration.

- Investigate ways of including a term in the model that accounts for stratification conditions at the beginning of the season

- Define HV < 3 mg/L

Forecasting resources

USGS – Streamflow and load data

Eyes on the Bay – MD Tidal Water Quality Data

VECOS – Virginia Estuarine and Coastal Observing System

University of Michigan Forecast Page – Forecast results

VIMS – Chesapeake Bay Environmental Forecast System