Seasonal forecasts of Chesapeake Bay hypoxia

Modeling Workgroup Quarterly Review
01/11/23

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Chesapeake Bay hypoxia forecasting model

Driver:

Jan-May average Susquehanna TN load

Calibration target:

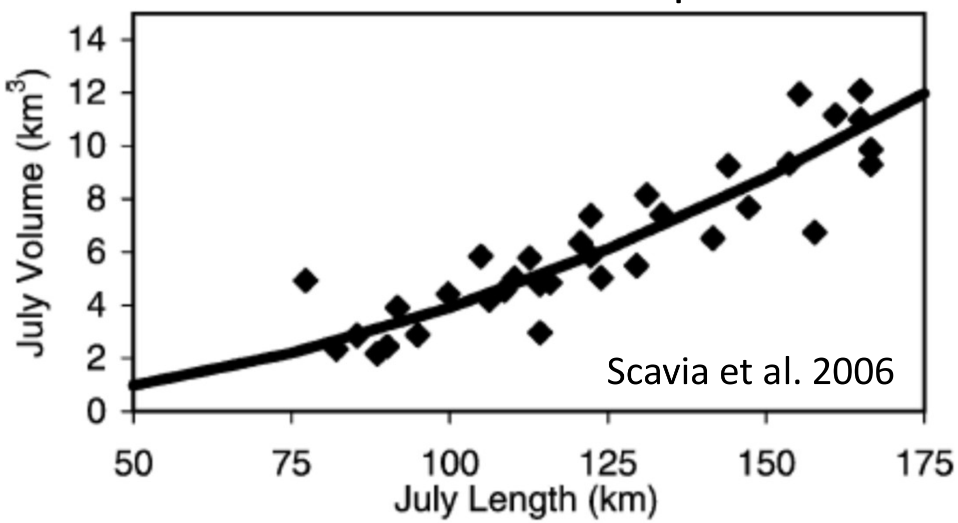
Mean July hypoxic volume (HV) ([DO] < 2 mg/L)

Model output:

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

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

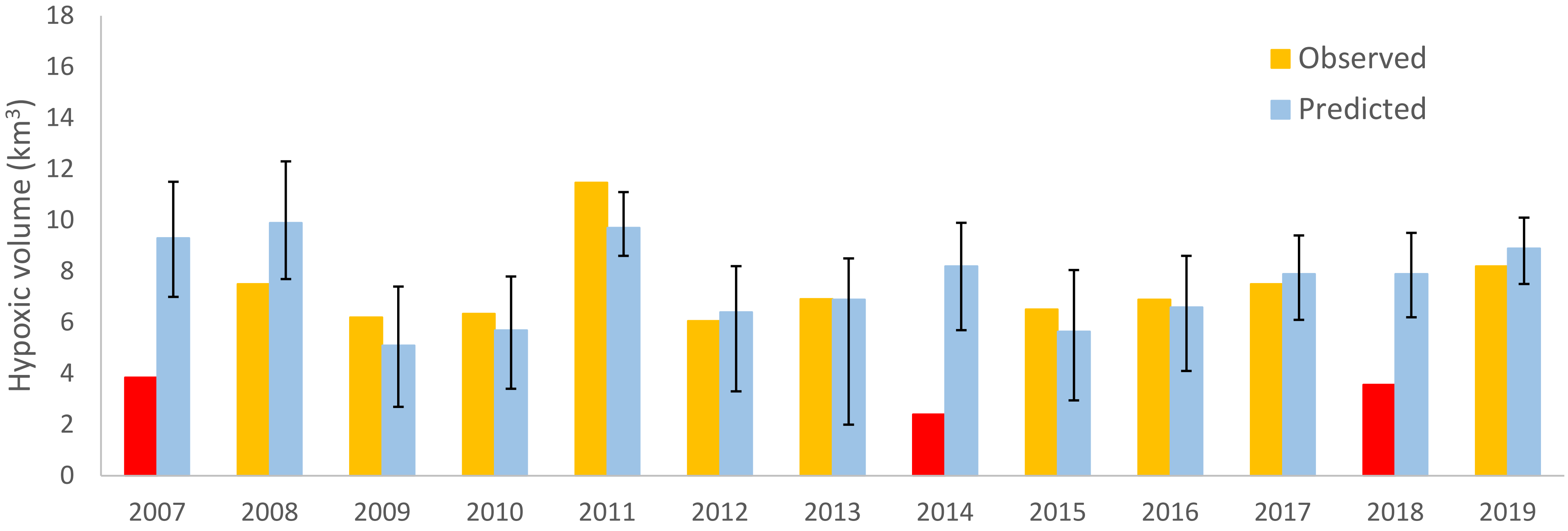
V-L relationship



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

Chesapeake Bay hypoxia forecasting model

Forecasting track record for Jul HV



Calibration exercises

1. HV metrics:
Average Summer (km^3), Total Annual (km^3 * days)

2. HV estimates
3 sets of interpolated estimates: **Murphy** et al., 2011, **Bever** et al.. 2013 and **Zhou** et al., 2014

3. Load sources:
Sus, Pot, Sus+Pot, Sus+Pot+PS, All 9 RIM rivers, All 9 RIM rivers + PS

4. Load time frames:
Oct-May (all possible combinations)
Oct-Jun (all possible combinations)

Updated model version

Driver:

Jan-May average
~~Susquehanna TN load~~
All 9 RIM rivers + PS TN load

Calibration target:

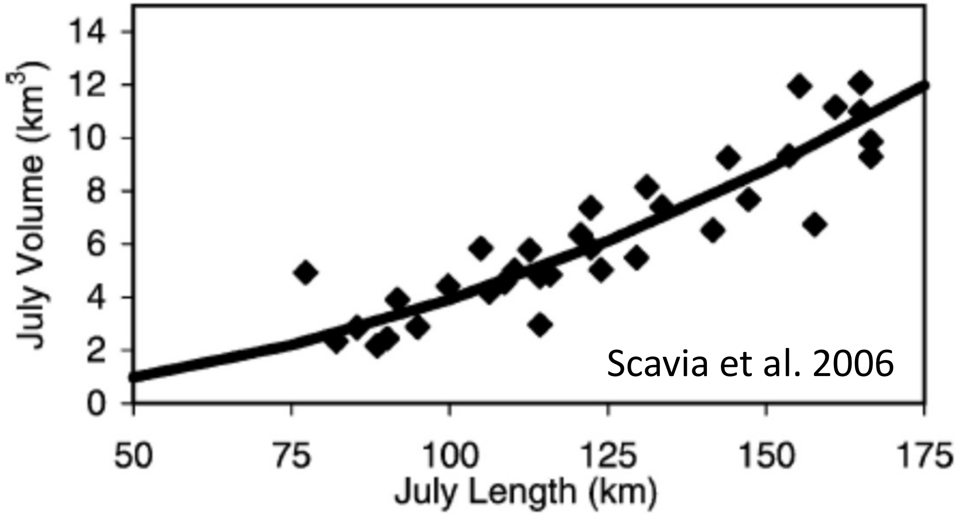
~~Mean July hypoxic volume (HV)~~
Total Annual HV
([DO] < 2 mg/L)

Model output:

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

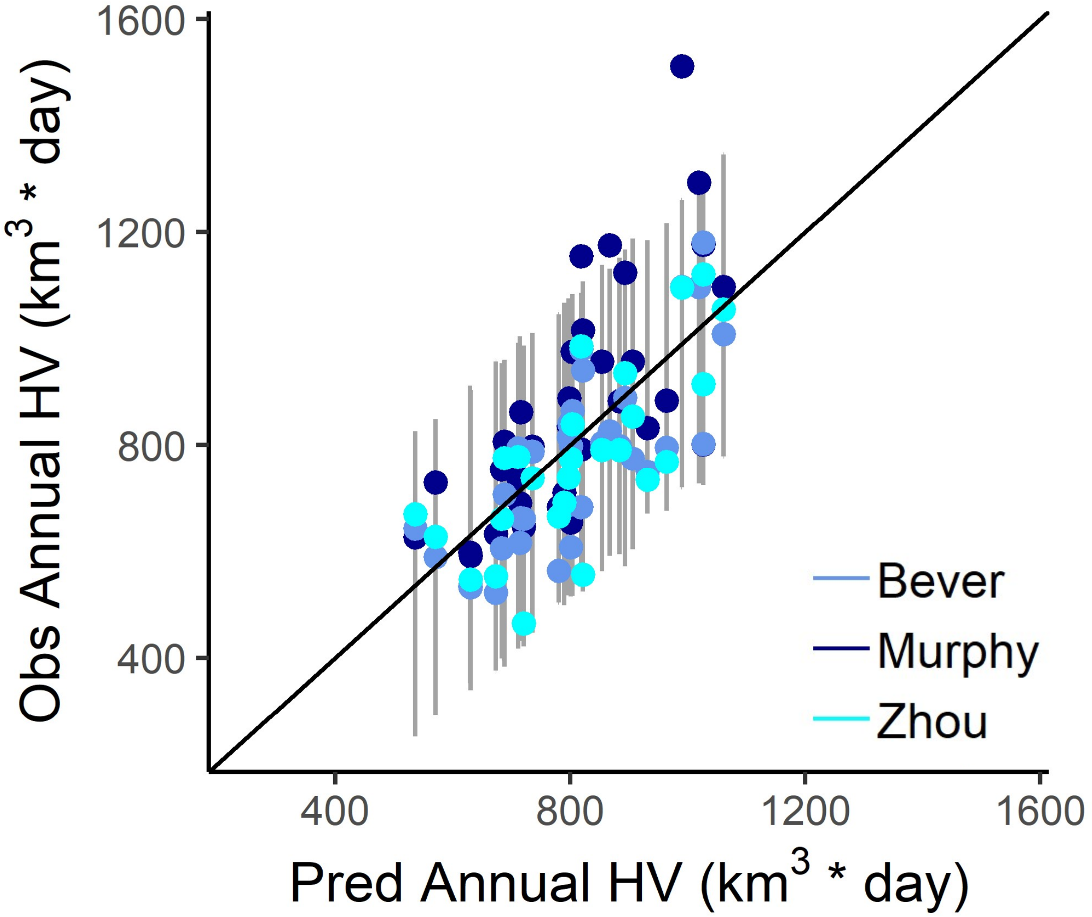
Hypoxic length = sum of all segments with [DO] < 2 mg/L

V-L relationship

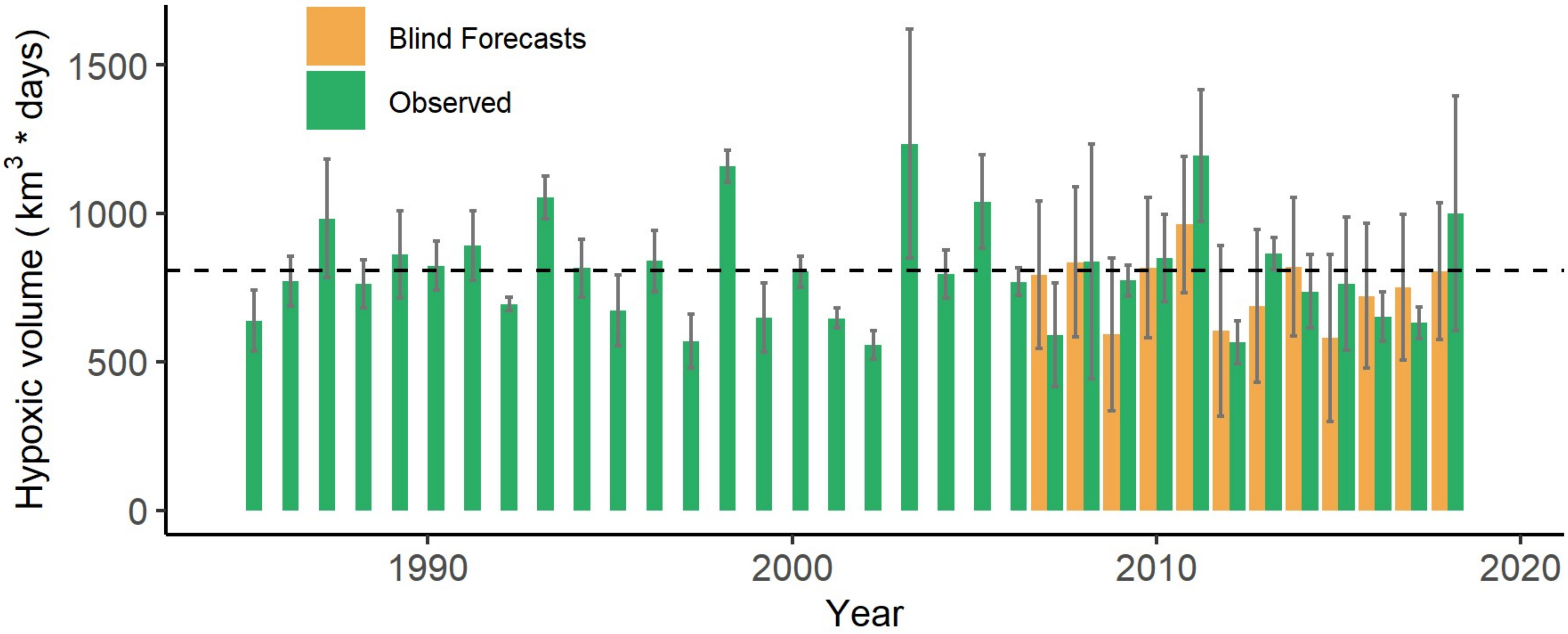


Hypoxic length → **hypoxic volume** through empirical V-L relationship

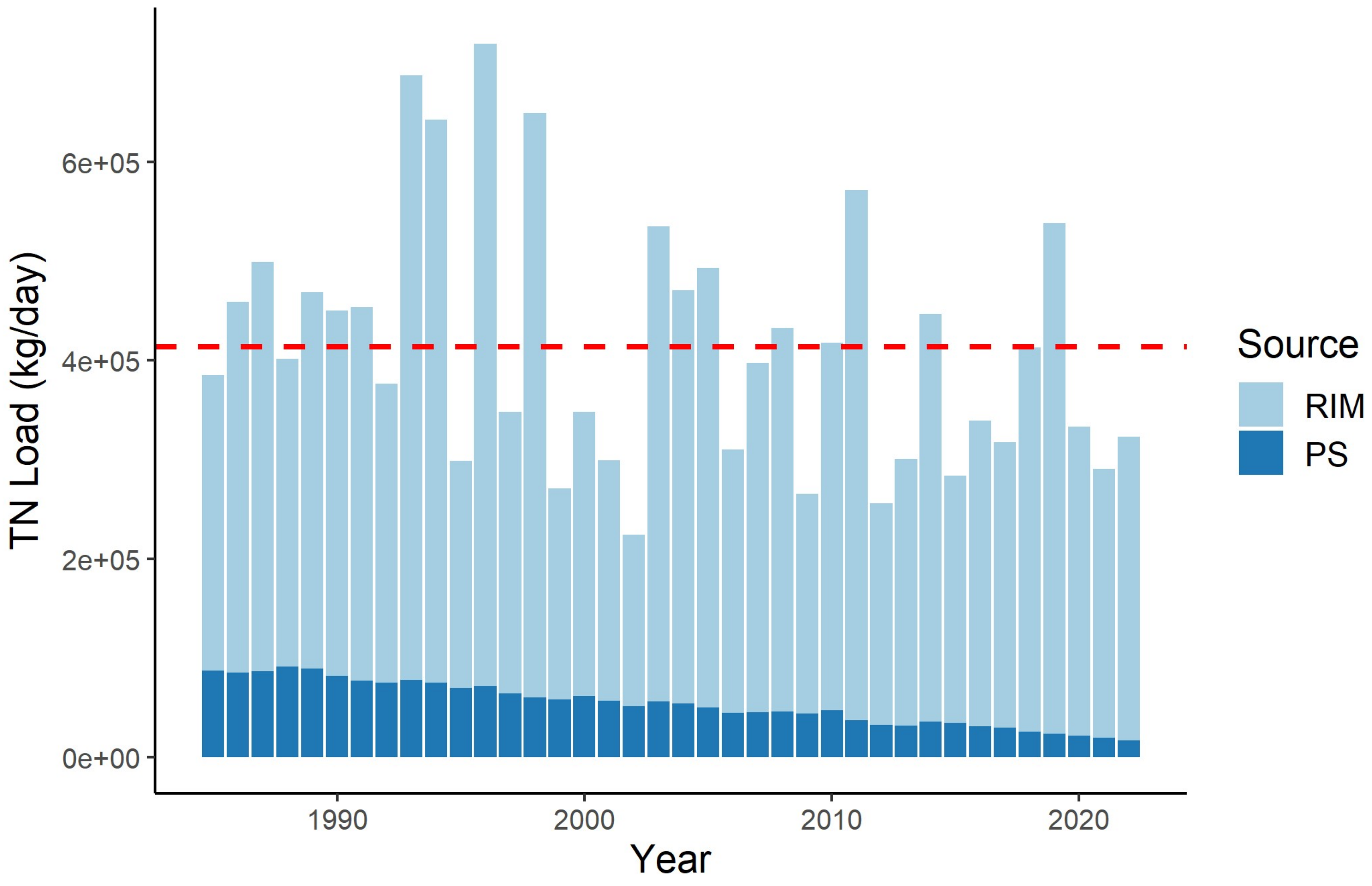
Predicted vs. observed Total Annual HV



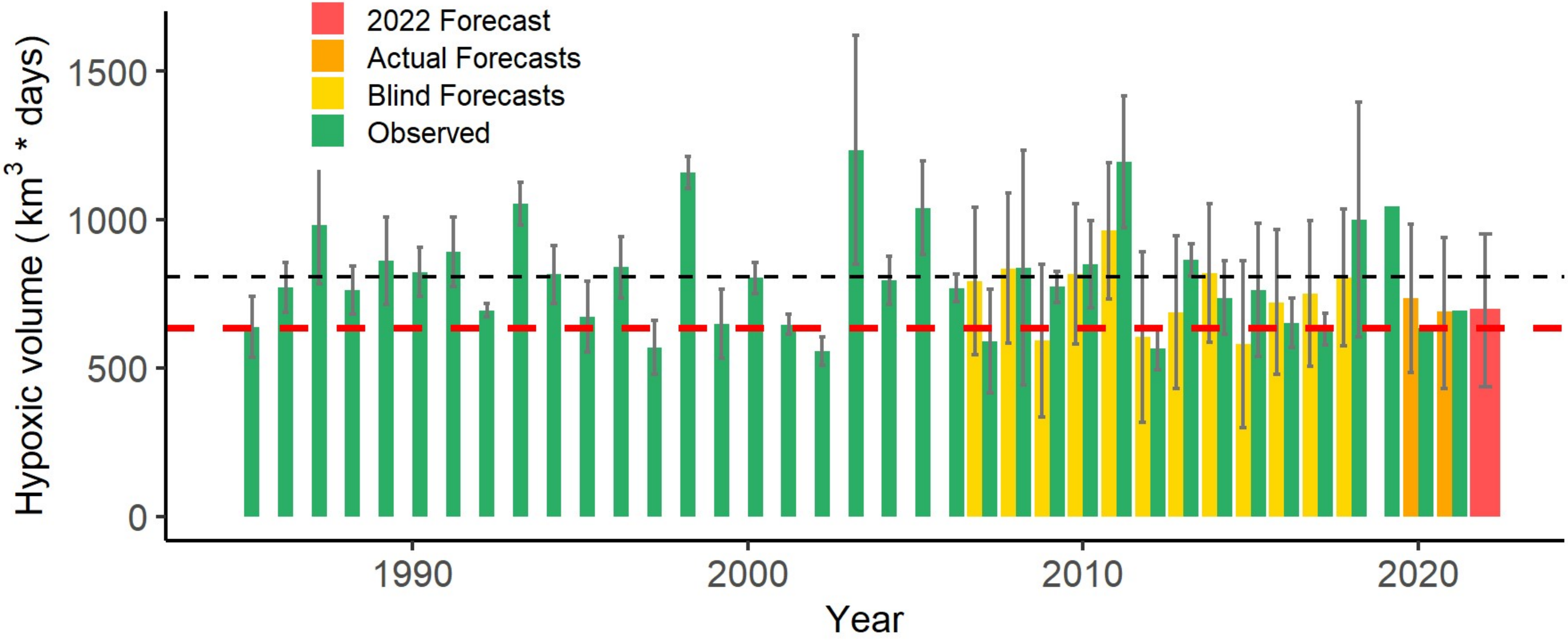
Creating a model track record – blind forecasts



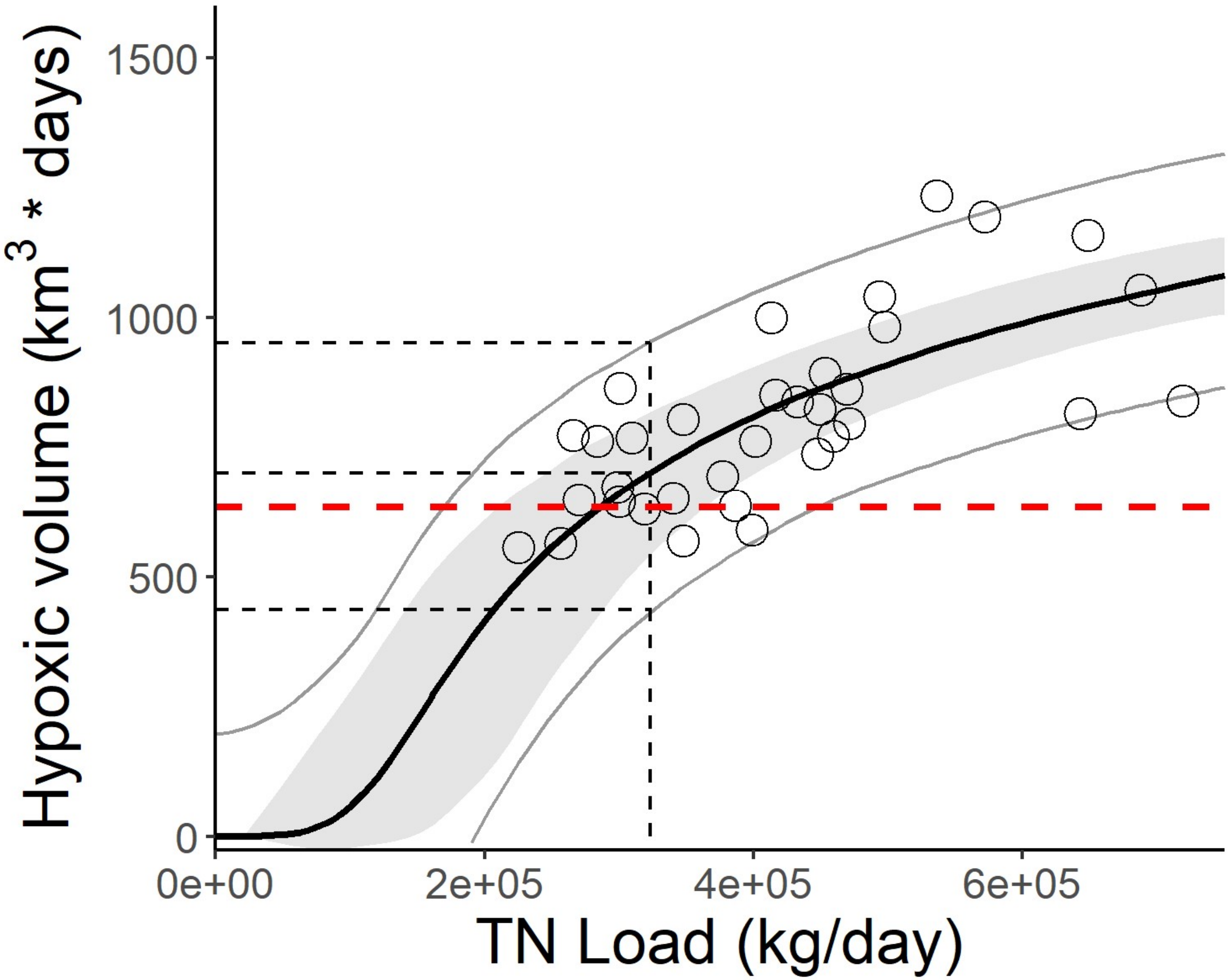
1985-2022 Jan-May TN load



2020-2022 Forecasts



2022 Forecast



CBP Press Release (2022)

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Chesapeake Bay Program
Science. Restoration. Partnership.

Chesapeake Bay "dead zone" predicted to be 13% lower than average

Low oxygen conditions also expected to start later in the season

Media Release | 06-28-22

Annapolis, MD—Researchers from the Chesapeake Bay Program, the University of Maryland Center for Environmental Science, University of Michigan and U.S. Geological Survey announced today that they are predicting this summer's dead zone to be smaller than the long-term average taken between 1985 and 2021. This is due to the below average amount of water entering the Bay from the watershed's tributaries this past spring, as well as decreased nutrient and sediment pollution from jurisdictions within the watershed.

End-of-summer assessment (2022)

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Chesapeake Bay Program
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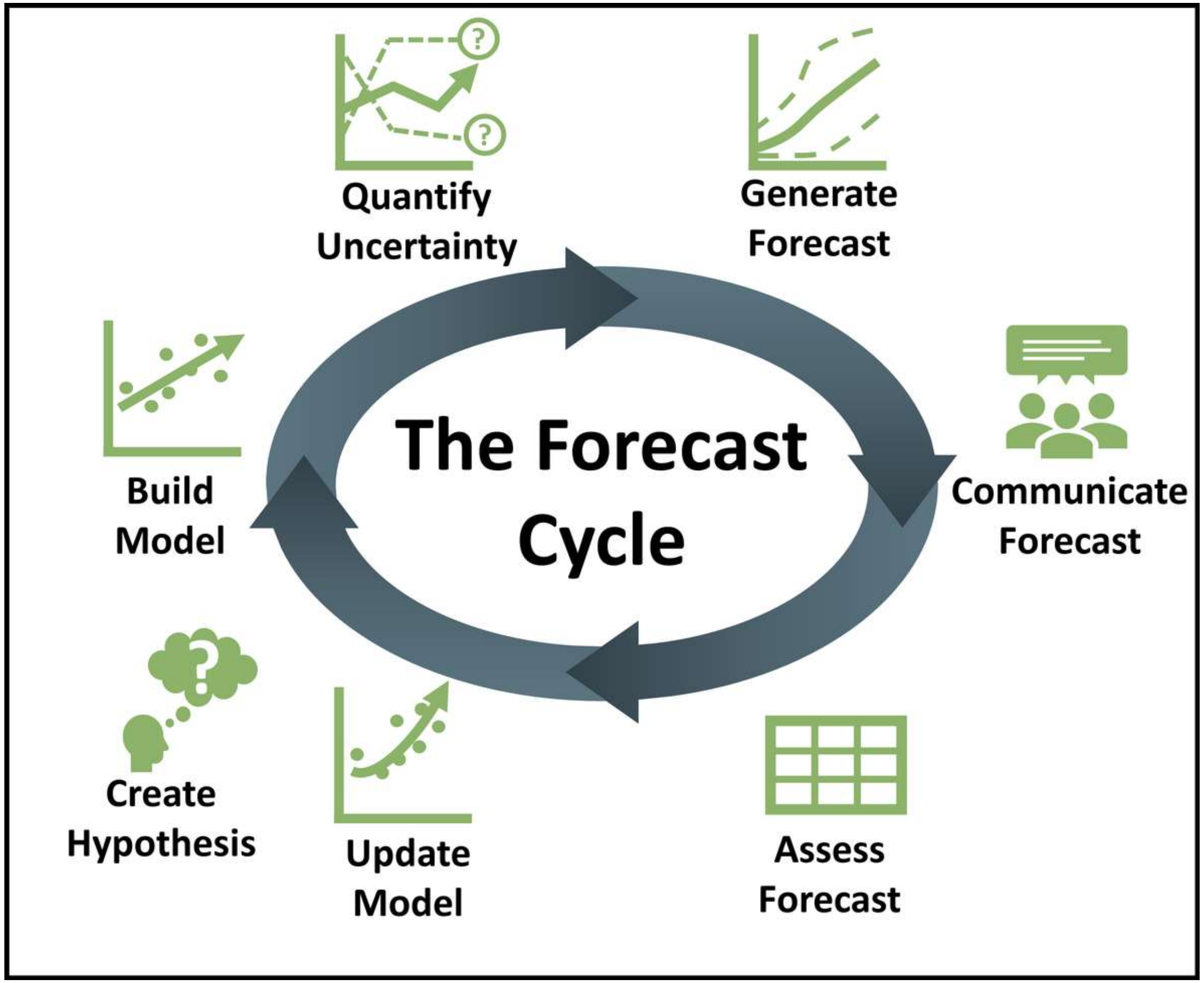
Chesapeake Bay sees smaller than average dead zone in 2022

Duration shortened by cool temperatures, strong winds

Annapolis, MD—Today, Chesapeake Bay Program partners released information on the state of the 2022 Chesapeake Bay dead zone. Experts from both the Maryland Department of Natural Resources and Virginia Institute of Marine Science concurred that hypoxic conditions in the Chesapeake Bay were better than average in 2022.

Ecological forecasting best practices



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

Draft ideas for further model refinements

<u>Small effort</u>

- Allow tributary loads to enter the model at different locations along the longitudinal segment representing the Bay to represent their actual location along the Bay mainstem

- Test the empirical hypoxic length-volume relationship with most recent hypoxic length and volume data and update it if necessary. Regression coefficients can also be estimated as part of the overall Bayesian calibration so as to account for uncertainty in the length-volume relationship as part of overall model prediction uncertainty

- Include atmospheric deposition load on water

Draft ideas for further model refinements

Intermediate effort

- 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

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

- Test the inclusion of a term that accounts for the potential effect of cumulative loads from previous years to represent internal N storage and recycling

Ideas for further model refinements

Larger effort

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

- Test the inclusion of a term that accounts for long-term changes in temperature (or other climate-related variables?) in the model

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