Summary of 2022 Hypoxia Based on the Chesapeake Bay Environmental Forecast System

Presented by

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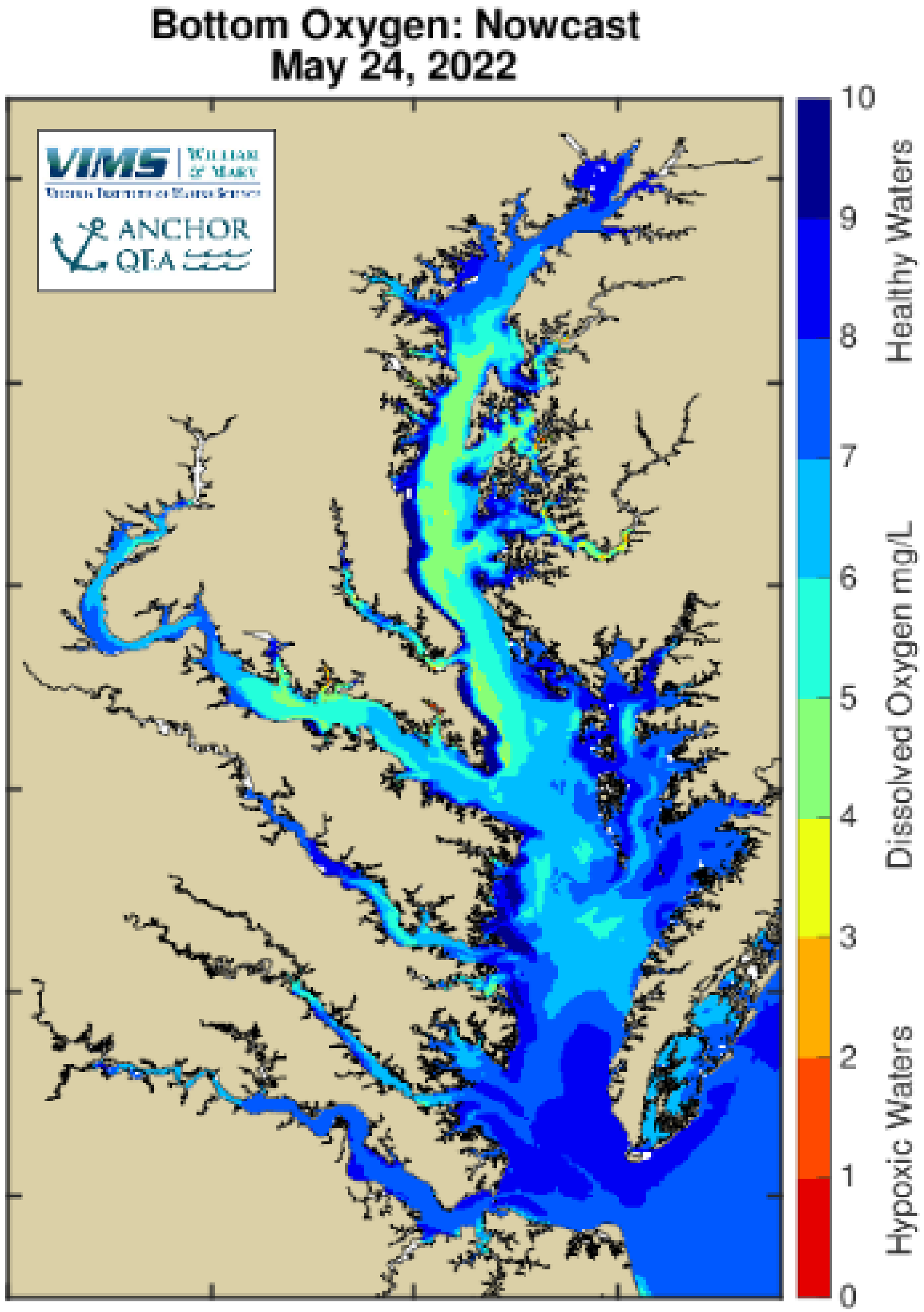
November 17, 2022



Chesapeake Bay 2022 Hypoxic Volume

- Seasonal forecast in June was for summer 2022 hypoxic volume (dissolved oxygen < 2 mg/L) to be 13% lower than the long-term average
  - Below average hypoxia because of below average nutrient inputs[1]
- Amount of hypoxia is also influenced by environmental and weather conditions during summer
  - Wind speed
  - Wind direction
  - Air and water temperature

1 2022 springtime forecast: http://scavia.seas.umich.edu/wp-content/uploads/2022/06/2022-Chesapeake-Bay-forecast.pdf

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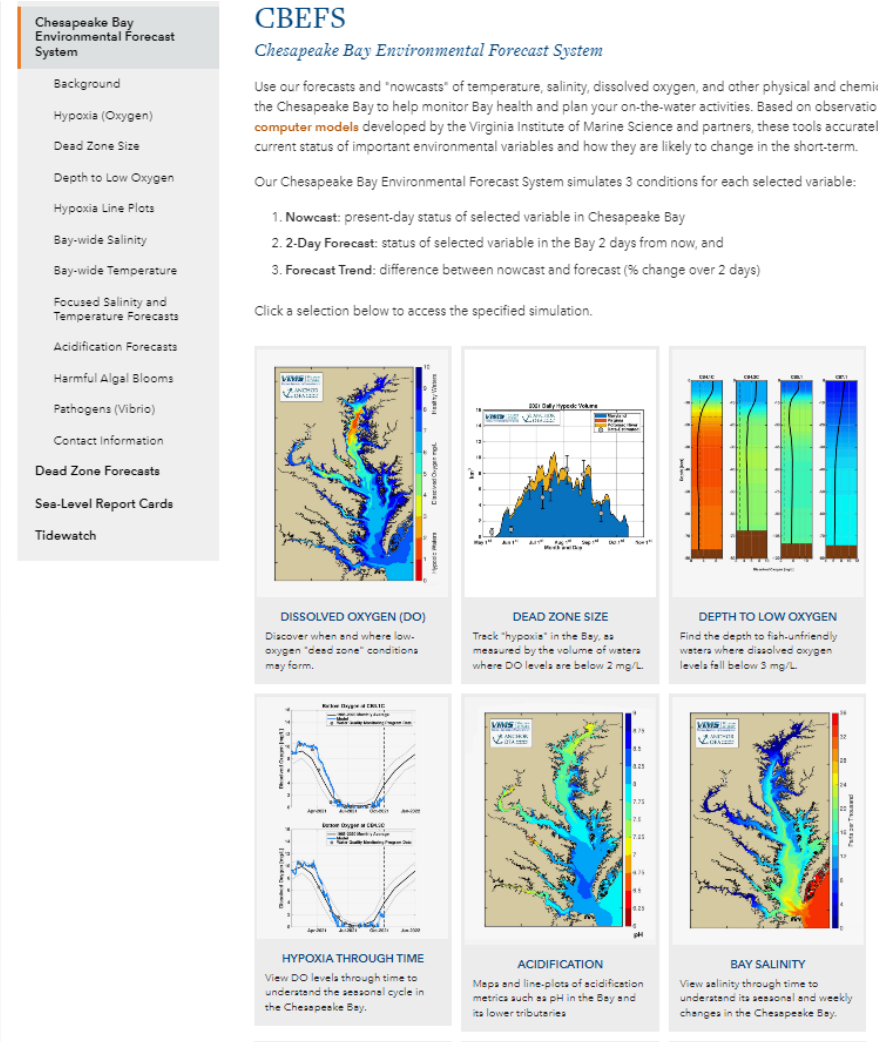
Real-Time Environmental Forecast Setup (CBEFS)

- 3-D hydrodynamic and biogeochemical model
- Performs 1-day Nowcast and 2-day forecast nightly
- Results displayed on the internet
  - www.vims.edu/cbefs
  - https://oceansmap.maracoos.org/chesapeake-bay/
- Real-time model-data hypoxic volume comparison made available online as cruise data becomes available



Real-Time Environmental Forecast Model (CBEFS)

www.vims.edu/cbefs

Atmospheric Forcing

Estuarine Model (ChesROMS)

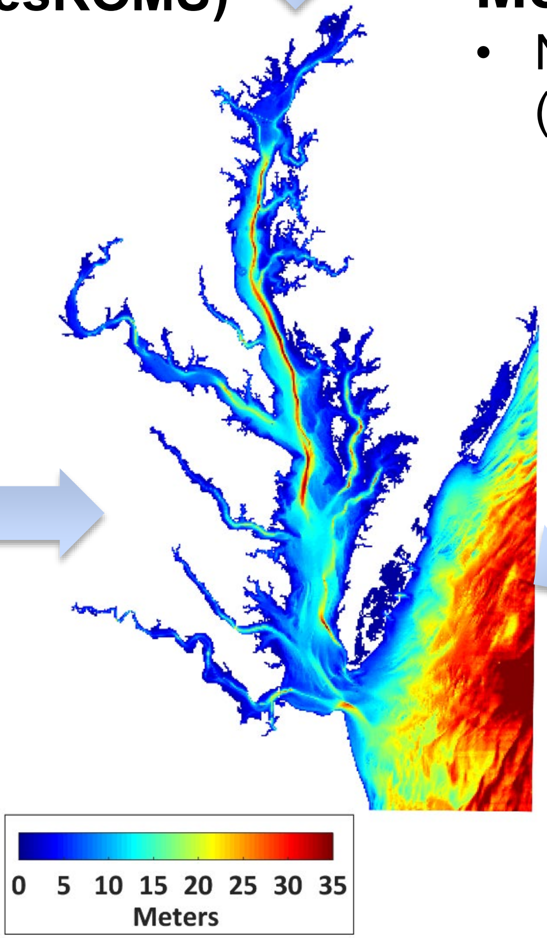
- ~600m x 600m
- 20 vertical levels

Meteorology

- North American Mesoscale (NAM) model

Dissolved Oxygen

- Full biogeochemical module (ECB)



Riverine Inputs

Coastal Fluxes

Terrestrial Inputs

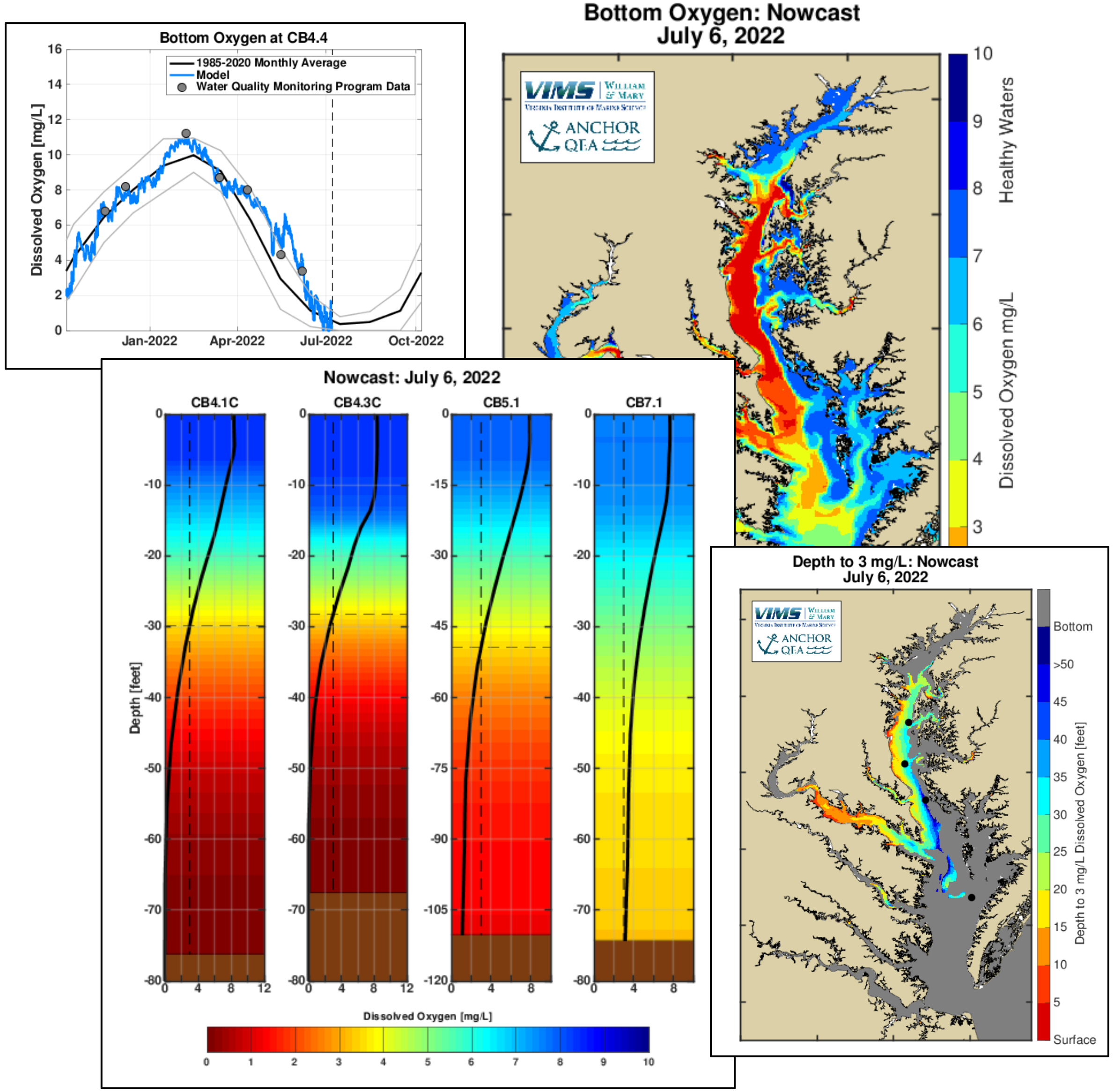
- Freshwater from USGS scaled to P6-Watershed model
- Nutrients from Climatology

Open Boundary Inputs

- Tides
- Non-tidal water levels
- Climatological data

Motivation for Real-Time Dissolved Oxygen Forecasts

- Recreational and commercial stakeholders can use forecasts to plan their use of the Bay
- Severity of hypoxia can be tracked in real-time throughout the summer
- Hypoxia at the end of the year can be compared to historical conditions and the recent past



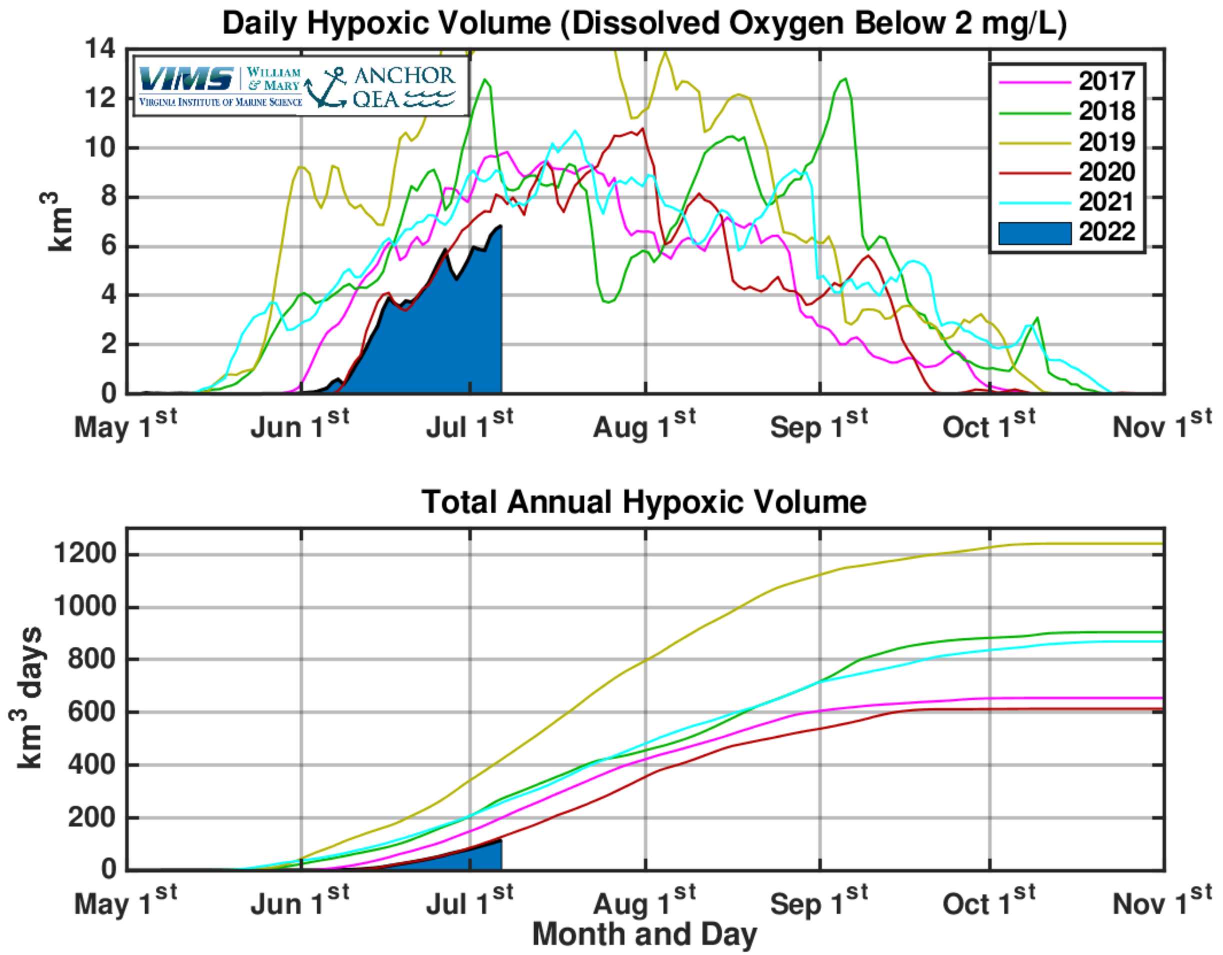
Comparing 2022 Hypoxia to the Past

Maximum Daily Hypoxic Volume (km^3)	Hypoxic Duration (days)	Total Annual Hypoxic Volume (km^3 days)	Summer Average Hypoxic Volume (km^3)

- 2022 yearly hypoxia metrics compared to historical (1985 to 2021) values and recent past (2017 to 2021)
- Historical values are based on statistics from biogeochemical model simulations
  - Combination of long hindcast simulation and forecast-like simulations of the recent past

Real-Time Hypoxic Volume

- Hypoxic Volume continually estimated throughout the summer
- Visual comparison to recent past (last 5 years)
  - How is this summer going so far?
  - Any notable events (e.g., Hurricane Ida in 2021)?



Dead Zone Size Forecasts: https://www.vims.edu/research/topics/dead_zones/forecasts/cbay/hypoxic-volume/index.php

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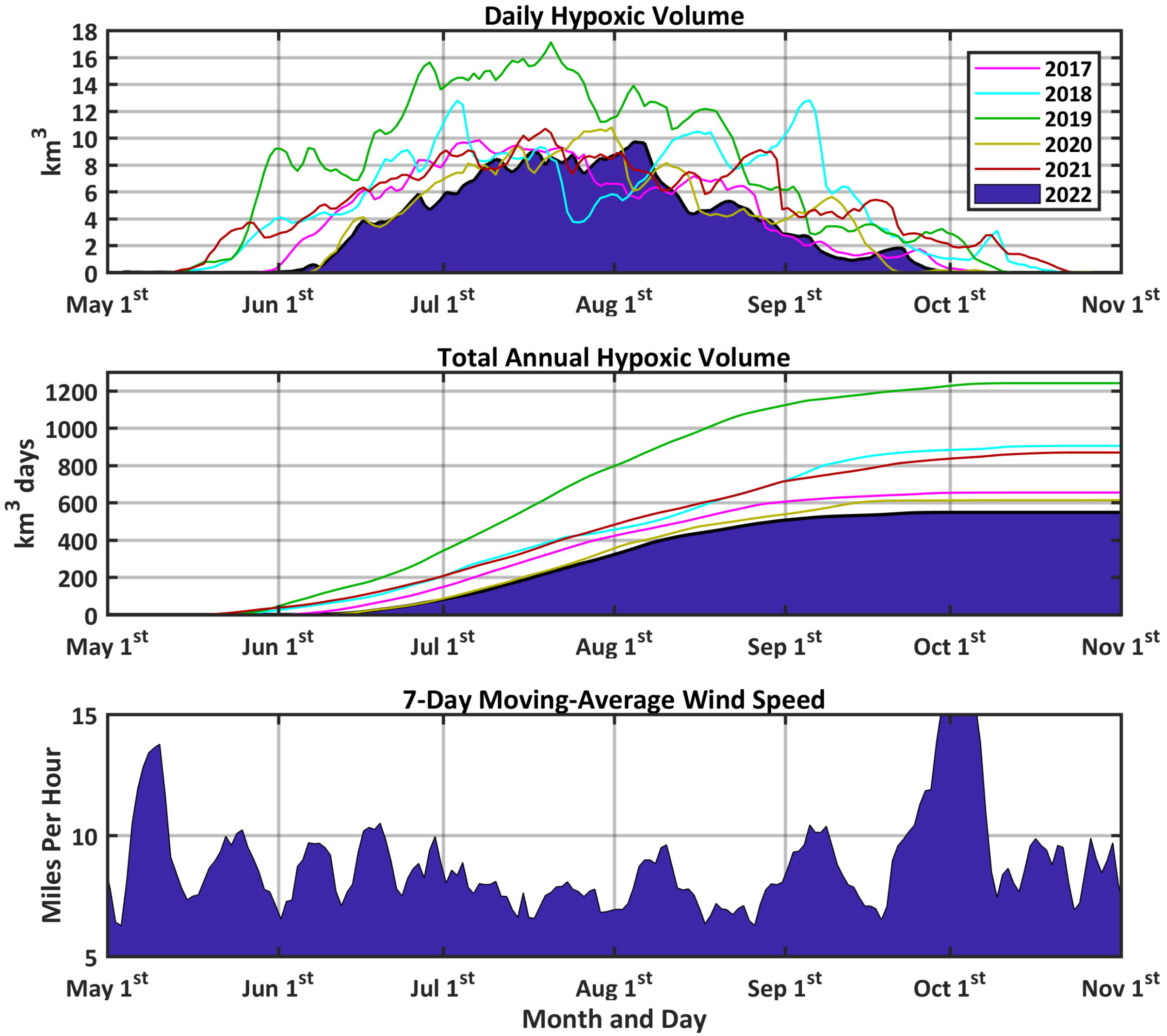
Chesapeake Bay 2022 Hypoxia Summary



Chesapeake Bay 2022 Hypoxic Volume Summary

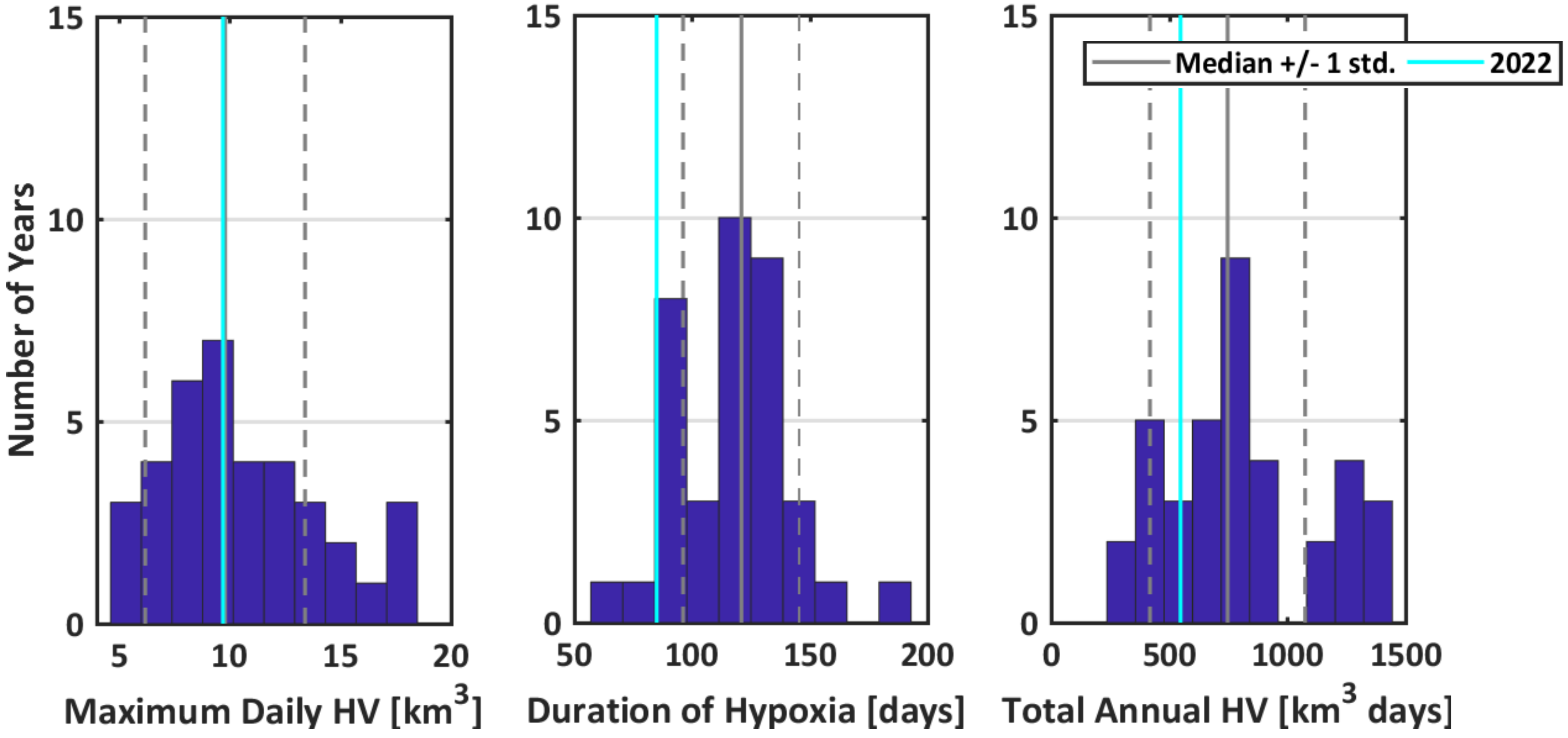
- Model-based estimates of 2022 hypoxia show better than average hypoxia conditions

In 2022:

- **Maximum daily hypoxic volume was near average, less than 54% of historical years**
- **Duration of hypoxia was less than most (95% of) historical years**
- **Total annual hypoxic volume was less than many (76% of) historical years**

Chesapeake Bay 2022 Hypoxic Volume Summary

- Duration of hypoxia was lower than the historically normal range
- Maximum daily and total annual hypoxic volume were within normal ranges



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Chesapeake Bay 2022 Hypoxic Volume Summary

- Duration of hypoxia and total annual HV less than expected normal range

Year	Hypoxic Duration (days)	Total Annual Hypoxic Volume (km^3 days)	Maximum Daily Hypoxic Volume (km^3)
Historical*	96 to 146	418 to 1,075	6.2 to 13.4
2017	96	655	9.8 (12%)
2018	137	905	12.8 (16%)
2019	131	1,241	17.1 (21%)
2020	95	614	10.8 (13%)
2021	141	869	10.7 (13%)
2022	85	548	9.7 (12%)

Percentages are the percent of the Bay experiencing hypoxic conditions

*Estimates are based on complex computer models that continue to be improved; therefore, past estimates may be updated as improvements are made to the model formulations.
Historical values within the ranges listed can be considered relatively normal based on the 1985 to 2021 values.

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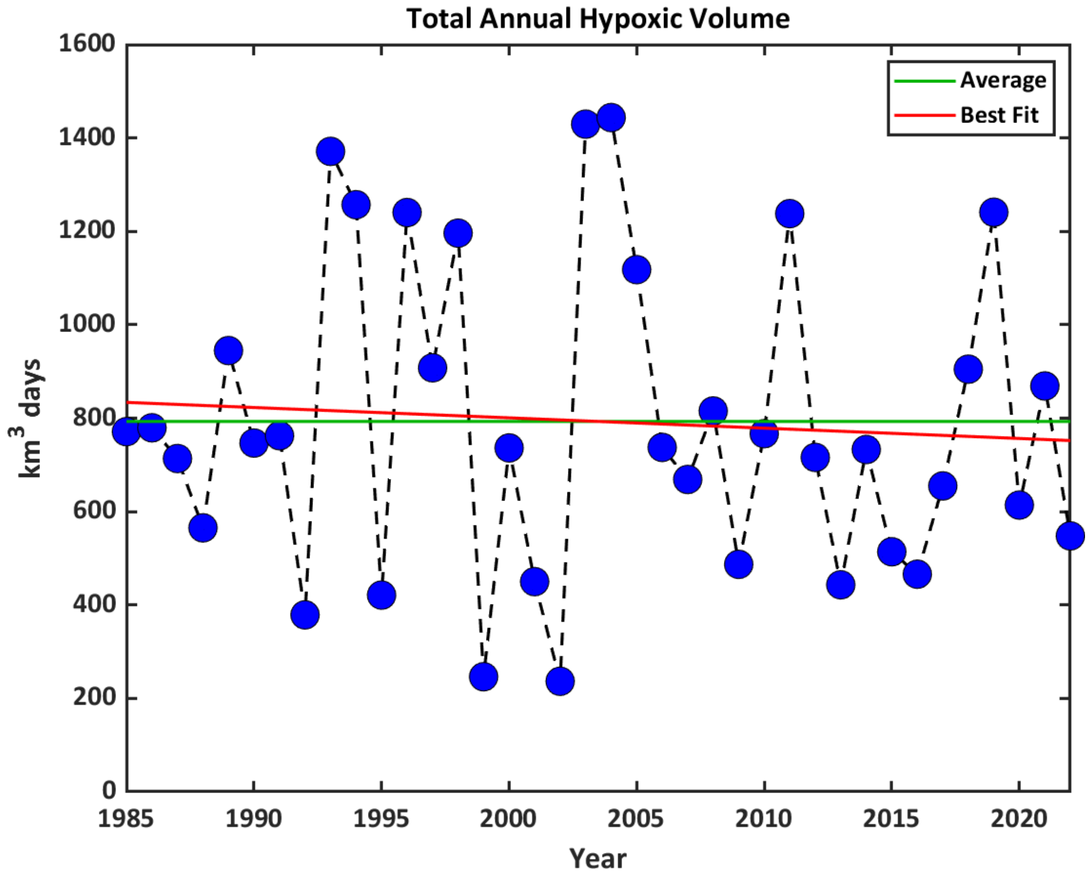
Chesapeake Bay 2022 Hypoxic Volume Summary

- Relatively mild hypoxia in summer 2022
  - Matches spring seasonal forecast of better than average hypoxic conditions
  - Same finding from the water quality monitoring program
  - Much shorter duration than 2021
  - Slightly less hypoxia than 2020
  - Much lower maximum hypoxic volume than 2019
- Relatively windy and cool May delayed the onset of hypoxia in the Bay
- Demonstrates how a relatively late onset followed by a quick decline from near-average maximum summer hypoxic conditions can result in a relatively low amount of total hypoxia in the Bay.

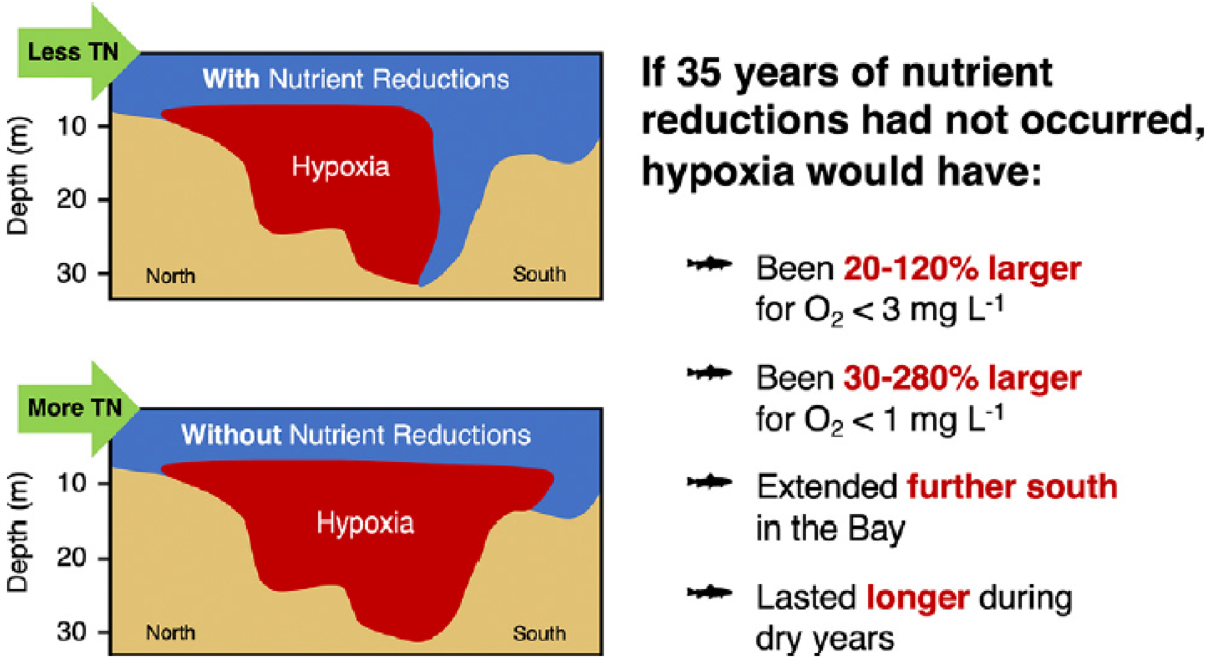
Hypoxic Volume Through Time (1985 to 2022)

- Do hypoxia metrics show a decreasing trend through time?
- No significant trend from 1985 to 2022
- Effects of nutrient reductions are confounded by interannual variability in river inflows and nutrient supply



Hypoxic Volume Through Time (1985 to 2022)

- Frankel et al. (2022) evaluated the effects of nutrient reductions after removing the effects of variation in river flow
- Nutrient reductions have decreased the duration and southern extent of hypoxia in the Bay
- From 1985 to 2019, warming has offset 6–34% of these hypoxia improvements



Source: Frankel et al. 2022. http://dx.doi.org/10.1016/j.scitotenv.2021.152722

Questions

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