Hypoxia Forecasts: 2019 Chesapeake Bay Hypoxic Volume Report

Presented by

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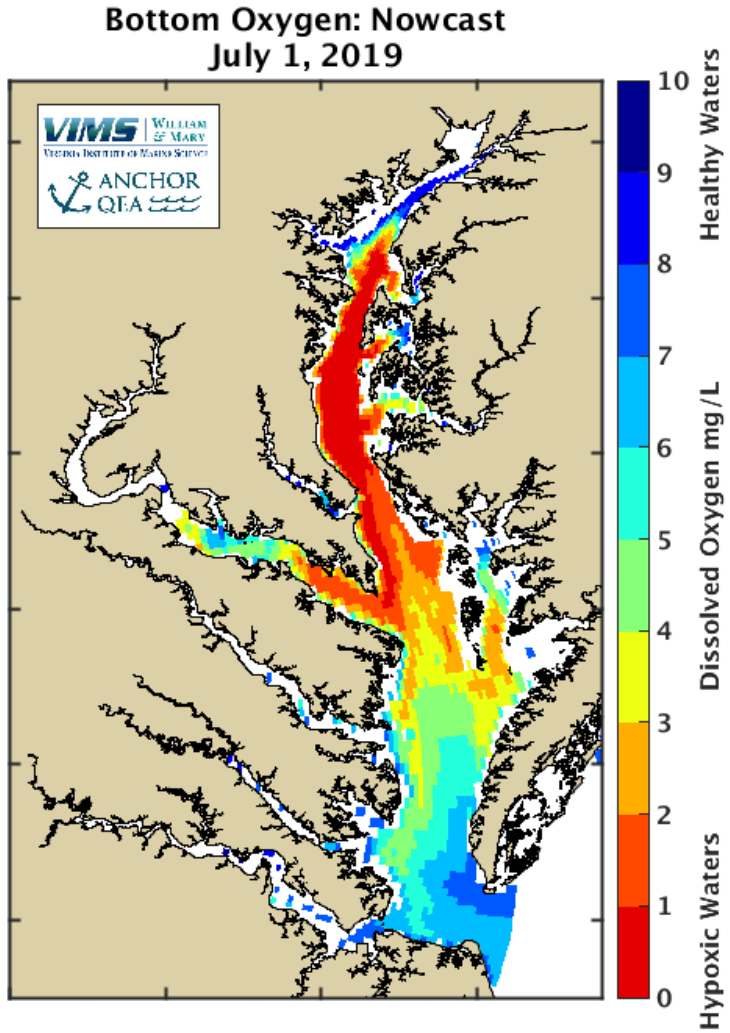
Chesapeake Bay 2019 Hypoxic Volume

- Seasonal forecast in June was for summer 2019 hypoxic volume (dissolved oxygen < 2 mg/L) to be the 4th largest in the past 20 years[1]
  - Relatively severe hypoxia forecast because of high freshwater discharge
- Amount of hypoxia is also influenced by environmental and weather conditions during the summer
  - Wind speed
  - Wind direction
  - Air and water temperature

1) 2019 springtime forecast: http://scavia.seas.umich.edu/wp-content/uploads/2019/06/2019-Chesapeake-Bay-forecast.pdf

Motivation for Real-Time Hypoxia 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

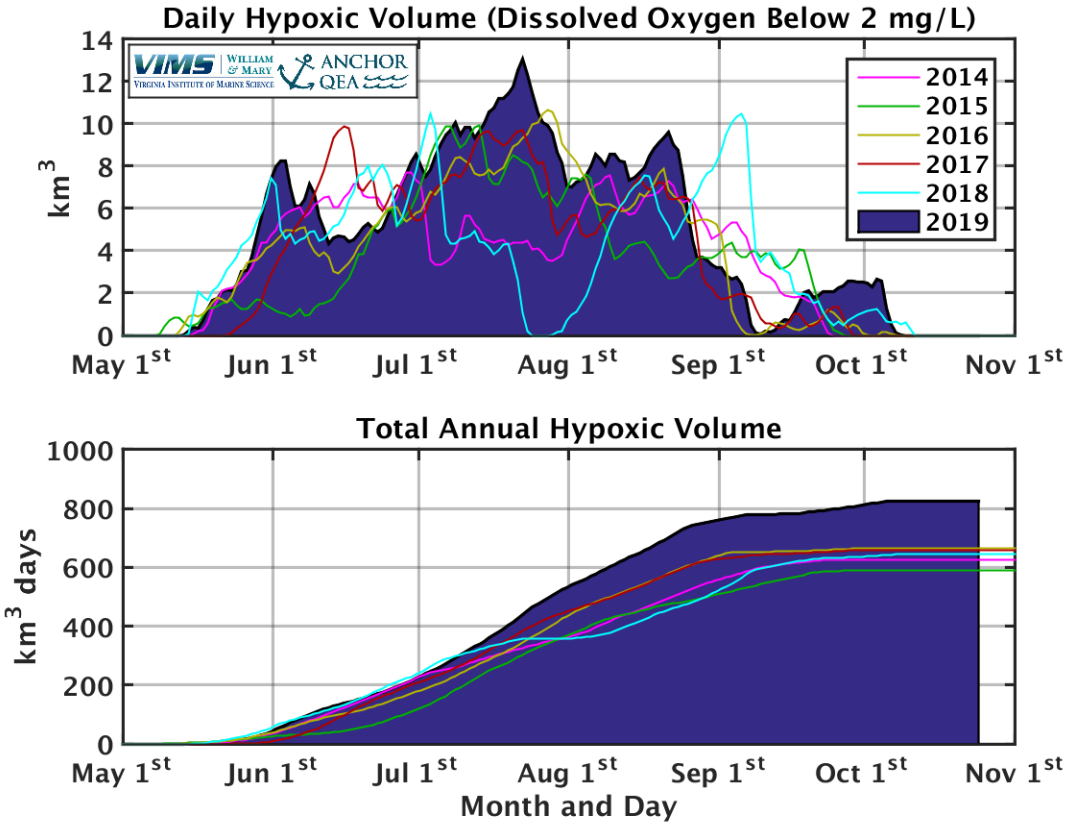


Real-Time Hypoxia Forecast Setup

- 3-D ChesROMS hydrodynamic model
- Average of two dissolved oxygen (DO) modules
  - Estuarine Carbon Biogeochemistry Model (ECB)
  - Simple Respiration Model (SRM)
- Performs 1-day nowcast and 2-day forecast nightly
- Results displayed on the internet
  - www.vims.edu/hypoxia
- Real-time model-data hypoxic volume comparison as cruise data becomes available

Real-Time Hypoxic Volume

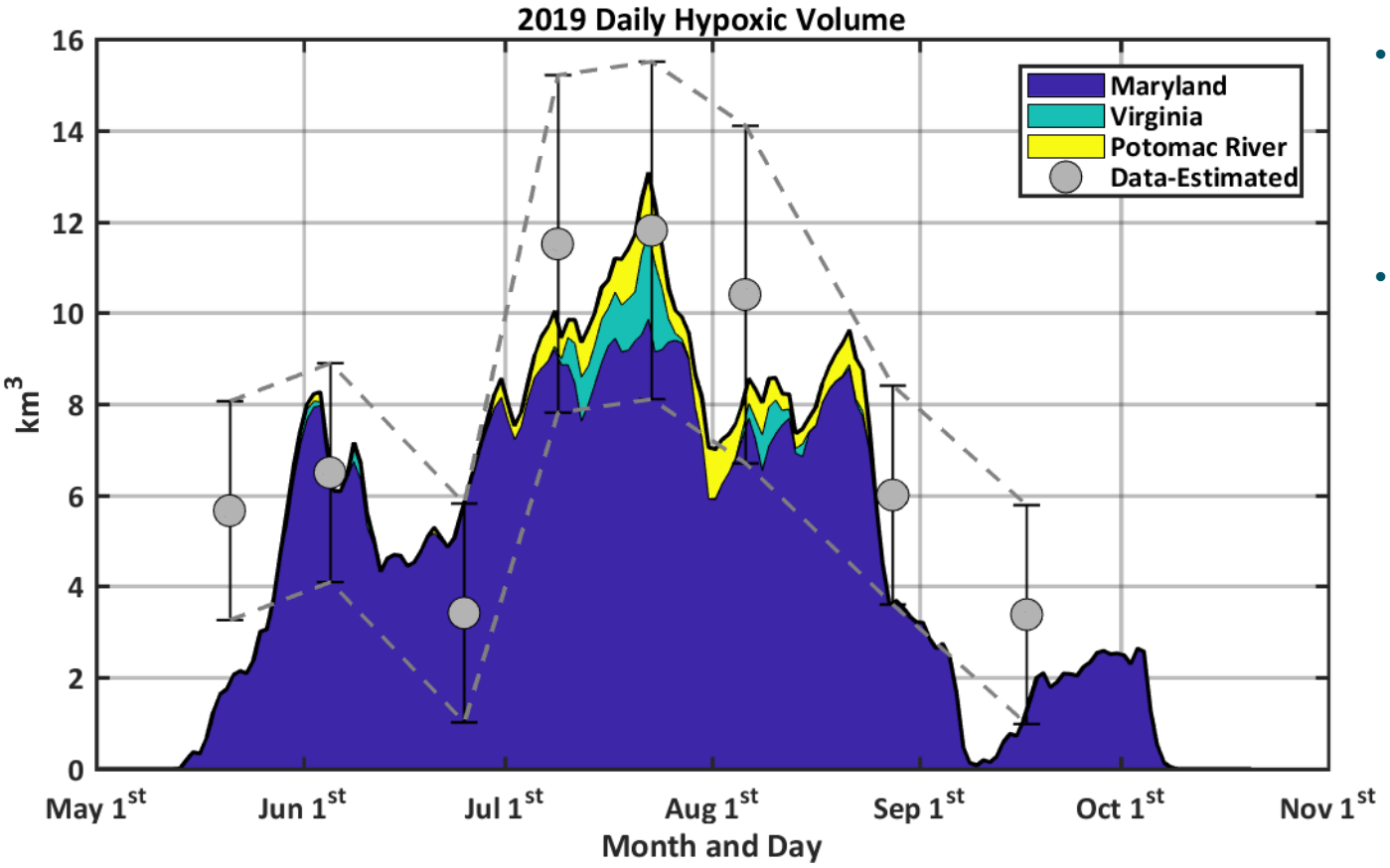
- Hypoxic volume continually estimated throughout the summer



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

2019 Hypoxic Volume Model-Data Comparison

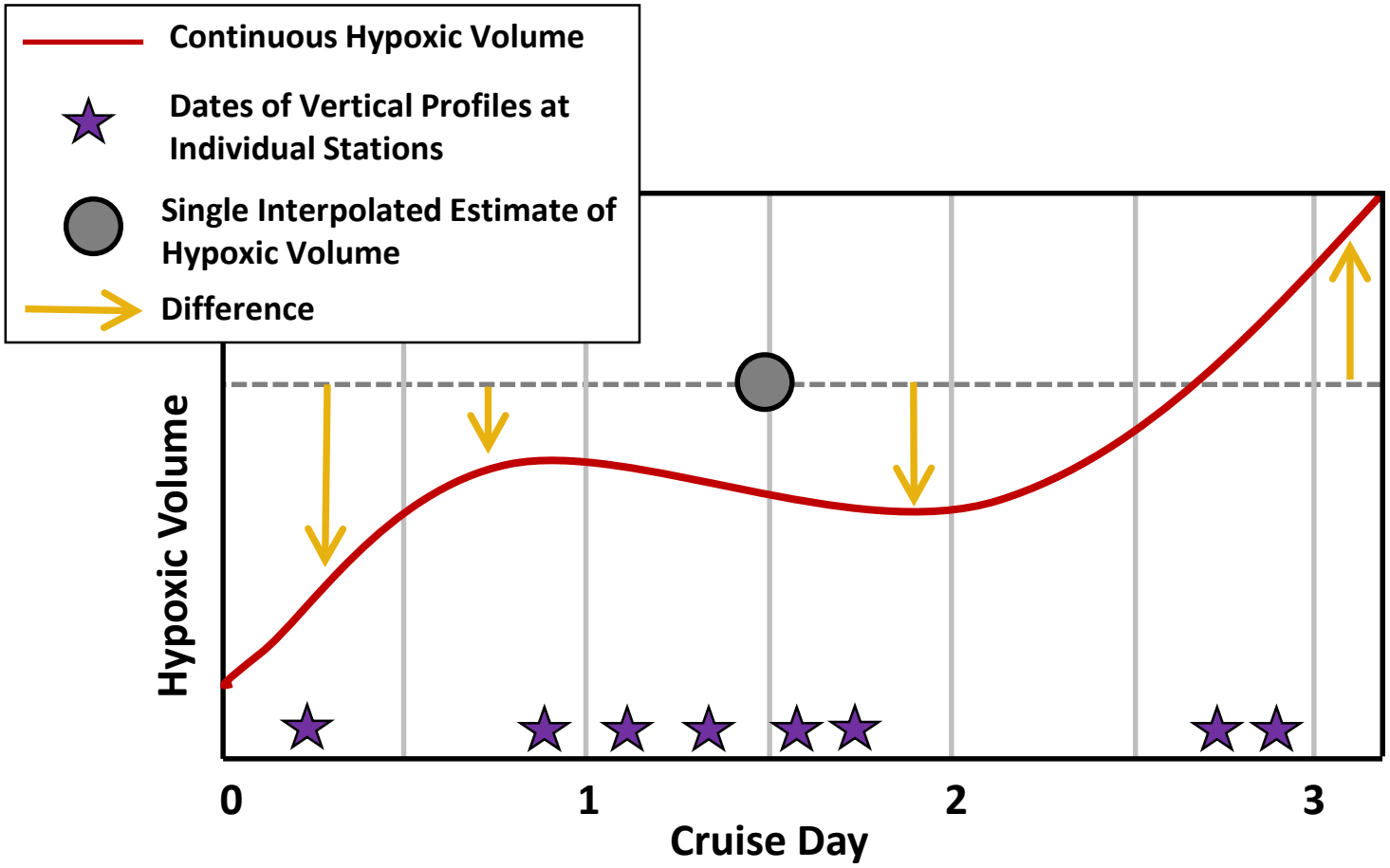
- Model matched seasonal pattern and magnitude of data-based interpolated hypoxic volume well



- Error bars based on analysis of model results spanning 1985 to 2018
- ± two standard deviations of estimated uncertainty in individual interpolated hypoxic volumes

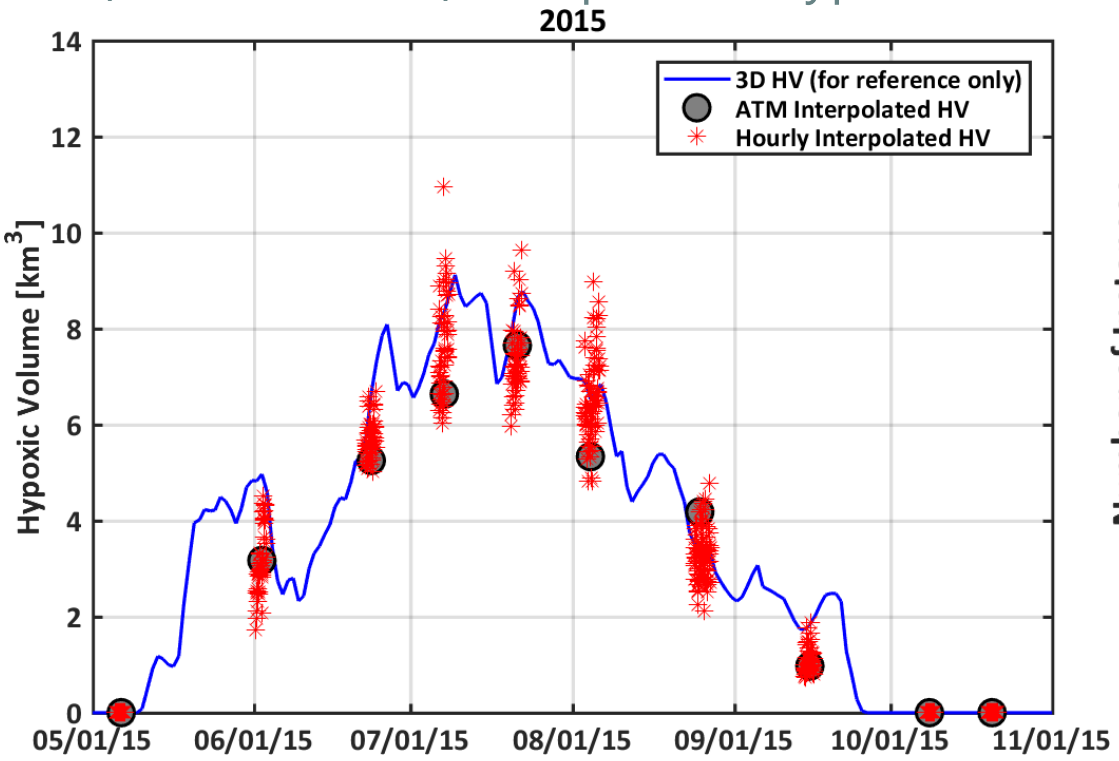
Data-Based Hypoxic Volume Uncertainty

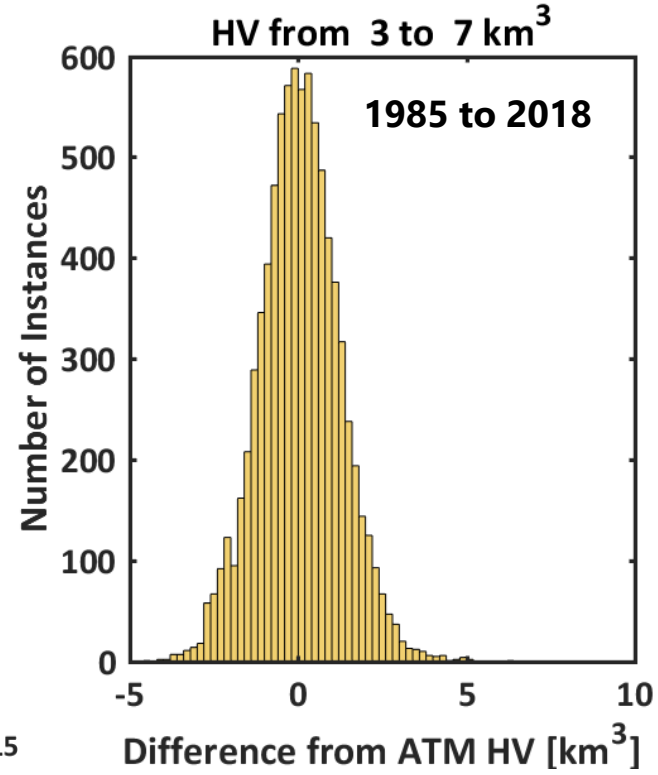
- Uncertainty estimated using the variability in interpolated hypoxic volumes over the duration of cruise-based sampling



Data-Based Hypoxic Volume Uncertainty

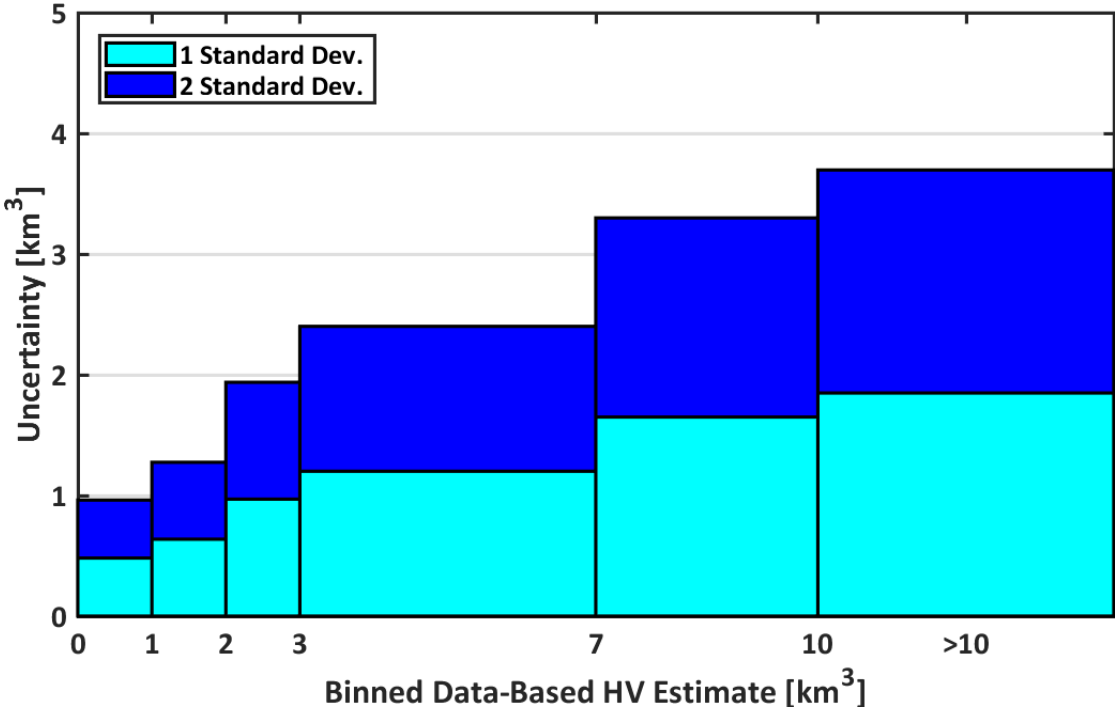
- Used model results from 1985 to 2018 to develop distributions of difference from interpolated Absolute Time Match (ATM) hypoxic volume at dates/times of data collection and individual hourly (instantaneous) interpolated hypoxic volumes

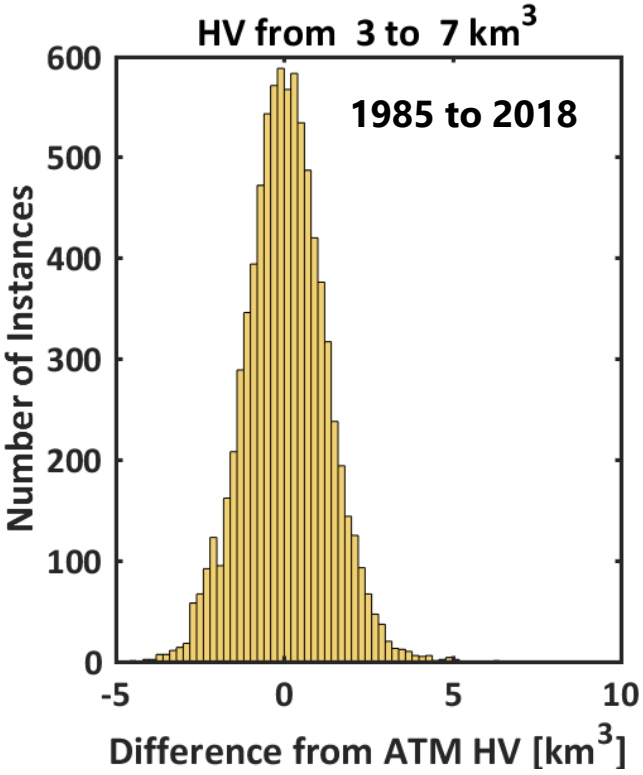




Data-Based Hypoxic Volume Uncertainty

- Standard deviation in distribution used to estimate uncertainty in interpolated hypoxic volumes from non-synoptic sampling





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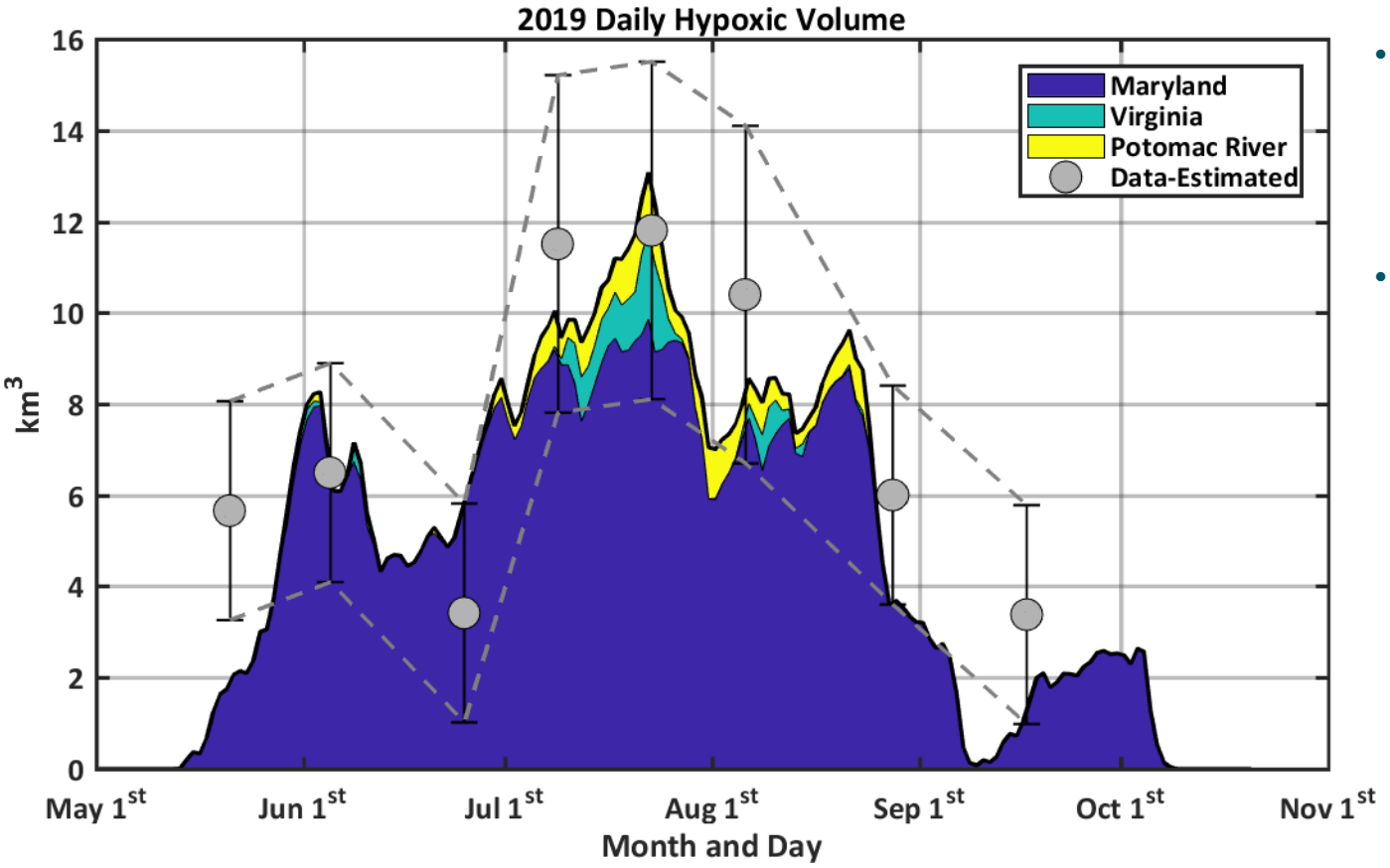


- Error bars based on analysis of model results spanning 1985 to 2018
- ± two standard deviations of estimated uncertainty in individual interpolated hypoxic volumes

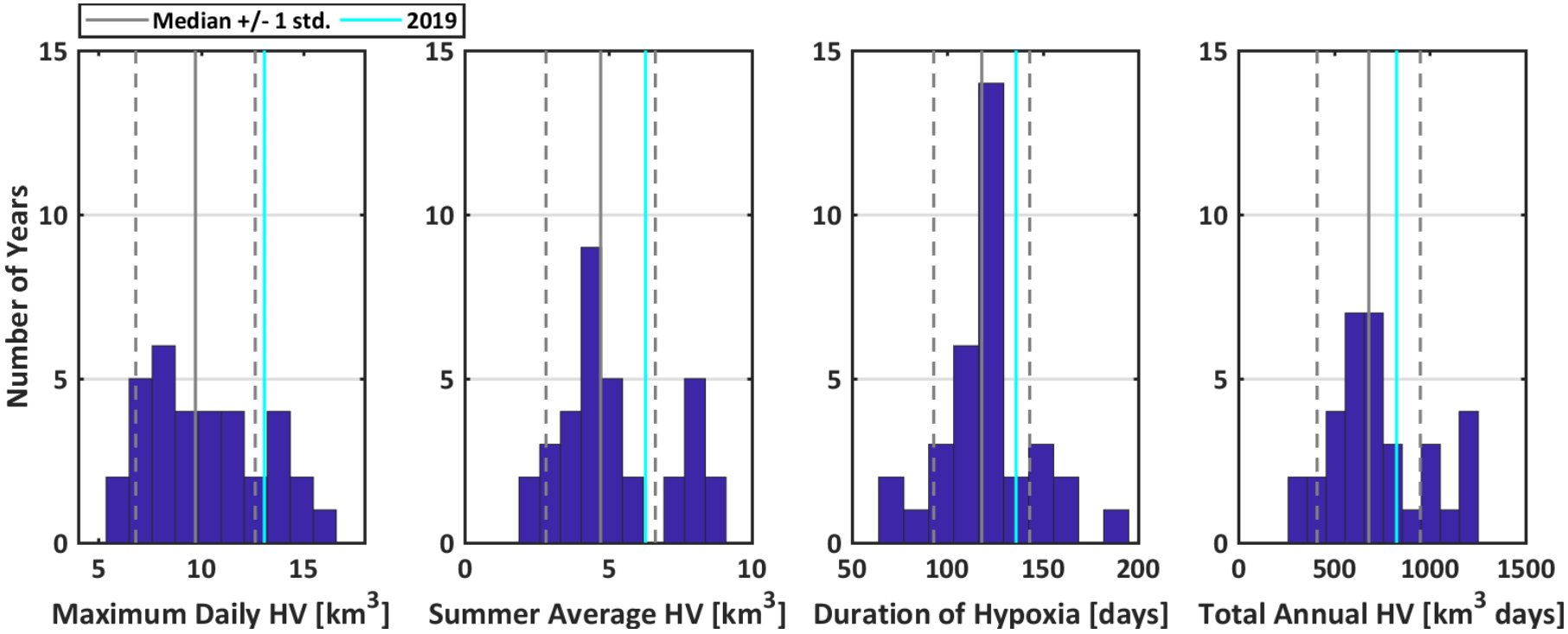
2019 Chesapeake Bay Hypoxic Volume Report

- 2019 yearly hypoxia metrics compared to historical (1985 to 2018) values and the recent past (2014 to 2018)
- Historical values are based on statistics from a 34-year biogeochemical hindcast simulation
  - 34-year simulation necessitates differences between historical and forecast model inputs
- Recent past values are based on the forecast model
  - Completely consistent with forecast model

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

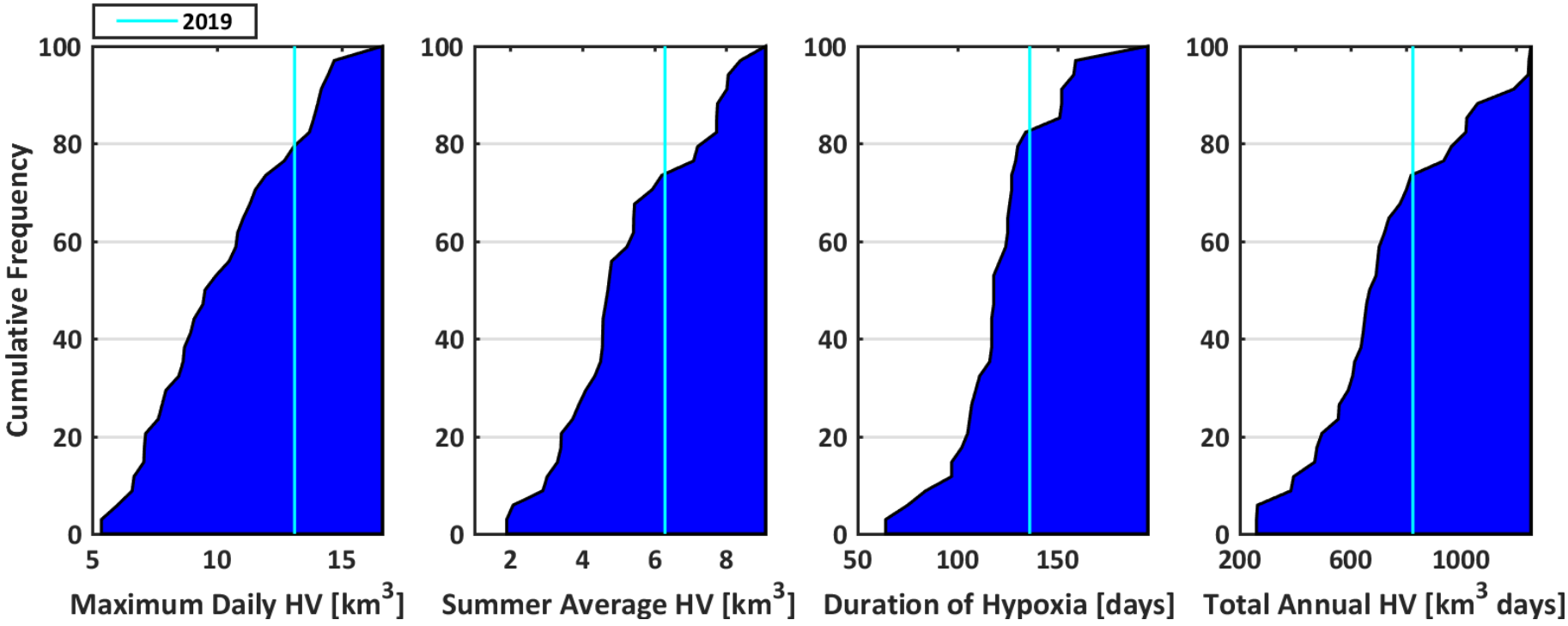
2019 Chesapeake Bay Hypoxic Volume Report

- Development of historical yearly metrics
- Median ± one standard deviation considered "normal"



2019 Chesapeake Bay Hypoxic Volume Report

- 2019 maximum daily hypoxic volume > 80% of historical years
- 2019 summer average hypoxic volume > 74% of historical years
- 2019 duration of hypoxia > 83% of historical years
- 2019 total annual hypoxic volume > 74% of historical years



2019 Chesapeake Bay Hypoxic Volume Report

- High end of normal yearly metrics compared to historical conditions

Year	Maximum Daily Hypoxic Volume (km^3)	Average Summer Hypoxic Volume (km^3)	Hypoxic Duration (days)	Total Annual Hypoxic Volume (km^3 days)
Historical*	**6.8 to 12.6**	**2.8 to 6.6**	**93 to 143**	**411 to 951**
2014	7.7	4.9	115	625
2015	9.9	4.6	98	588
2016	10.7	5.1	101	664
2017	9.9	5.3	92	657
2018	10.4	4.8	123	645
2019	**13.1**	**6.3**	**136**	**826**

*Historical values are the median ± 1 standard deviation from 1985 to 2018
Within ± 1 standard deviation considered relatively "normal"

2019 Chesapeake Bay Hypoxic Volume Report

- High end of normal yearly metrics compared to historical conditions
- More severe hypoxia in 2019 than in the recent past

Year	Maximum Daily Hypoxic Volume (km^3)	Average Summer Hypoxic Volume (km^3)	Hypoxic Duration (days)	Total Annual Hypoxic Volume (km^3 days)
Historical*	6.8 to 12.6	2.8 to 6.6	93 to 143	411 to 951
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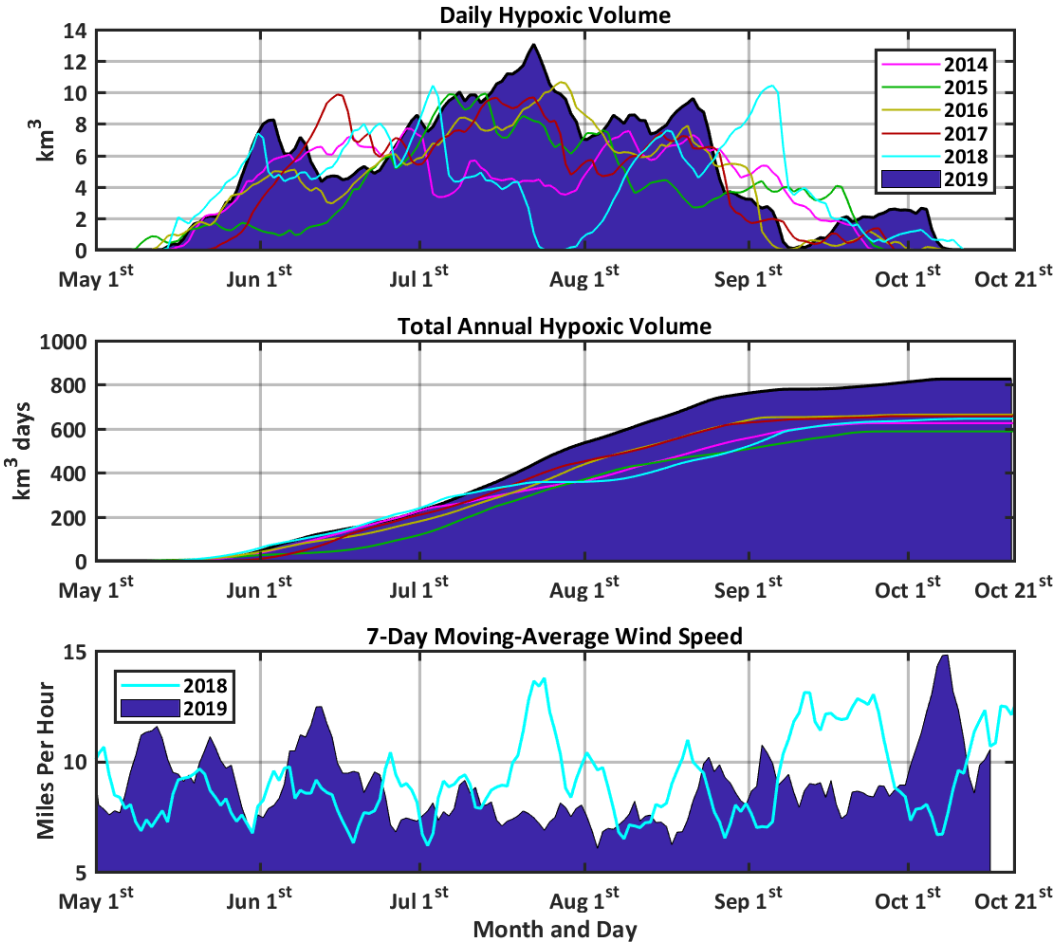
Estimates are based on complex computer models that continue to be improved; therefore, past estimates may be updated as improvements are made to the model formulations

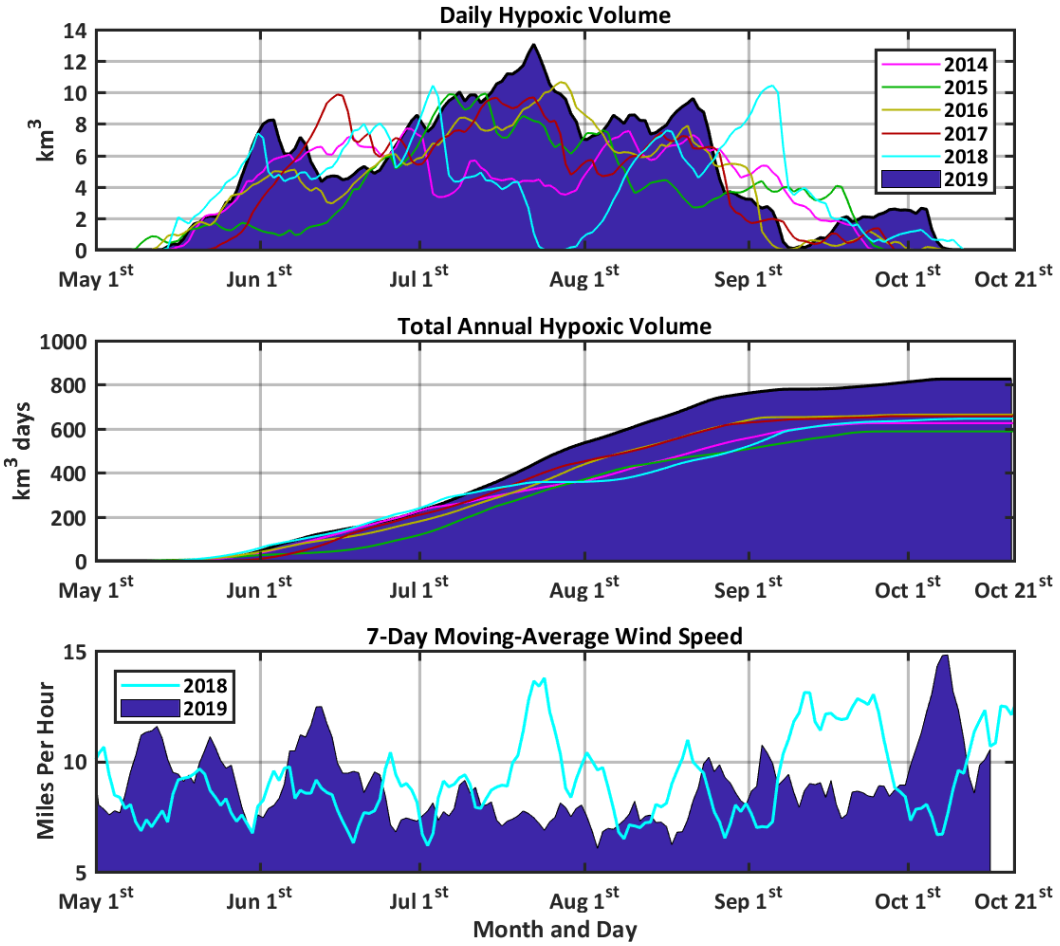
2019 Chesapeake Bay Hypoxic Volume Report

- Total hypoxia was at the high end of recent past through early July
- Light winds from late June to mid-August allowed hypoxia to expand and increase to higher than recent past



2019 Chesapeake Bay Hypoxic Volume Report

- Strong winds in July 2018 mixed the Bay and reduced hypoxia, even with high freshwater discharges
- No similar period of strong wind in summer 2019



Conclusions on 2019 Chesapeake Bay Hypoxia

- Model matched seasonal pattern and magnitude of data-based interpolated hypoxic volume well
- The total amount of hypoxia in 2019 was on the high end of normal conditions from 1985 to 2018
  - Maximum daily hypoxic volume was severe
- Light winds during the summer contributed to hypoxia in 2019 being more severe than in 2018
- Even with environmental conditions that favor severe hypoxia (high freshwater input to the Bay and light winds), the total amount of hypoxia in 2019 was within the normal range, suggesting nutrient reductions since the 1980s have helped improve water quality in the Bay

Next Steps

- Add 2019 hypoxic volume model-data comparison summary to real-time webpage
- Provide 1985 to 2018 model-estimated hypoxic volumes to Don Scavia and Isabella Bertani for use in seasonal forecasting
- Publicly release 2019 Chesapeake Bay Hypoxic Volume Report

Questions

www.vims.edu/hypoxia