# Application of continuous monitoring oxygen data: the Chesapeake Bay Environmental Forecasting System (CBEFS)

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*Anchor QEA*

www.vims.edu/cbefs

Chesapeake Bay Program

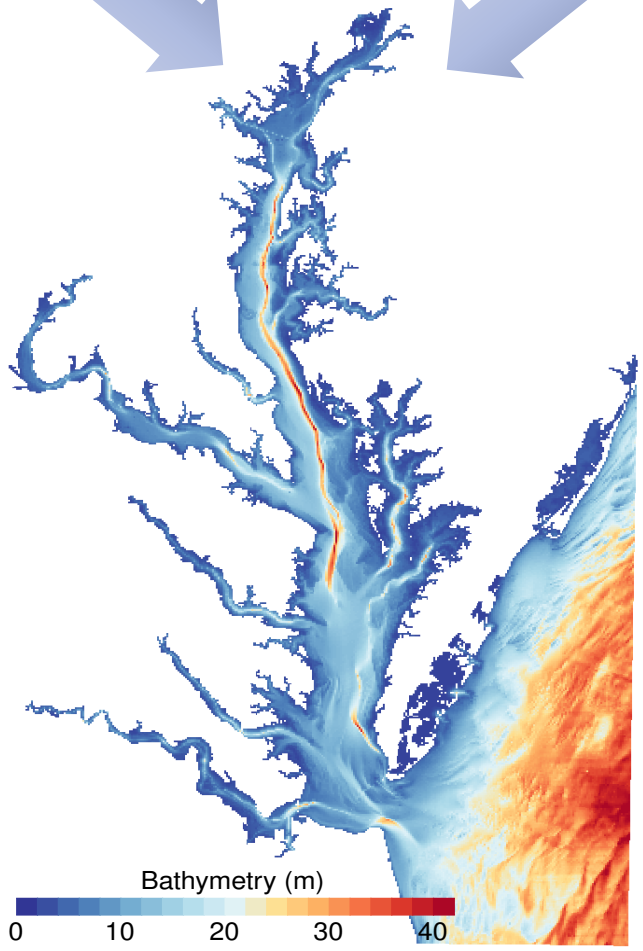
Science. Restoration. Partnership.

# CBEFS: Chesapeake Bay Environmental Forecast System

## Atmospheric inputs

Reanalysis Products
- Winds
- Solar radiation
- Temperature
- Precipitation

***Estuarine model***
***ChesROMS-ECB***
- 600m x 600m grid
- 20 depth levels
- Tides, circulation
- Nutrients, plankton
  $O_2$, pH, sediment




*Bever et al., Env Model. & Software, 2021*

## Terrestrial inputs

USGS gauge data;
Phase 6+real-time discharge+AI model

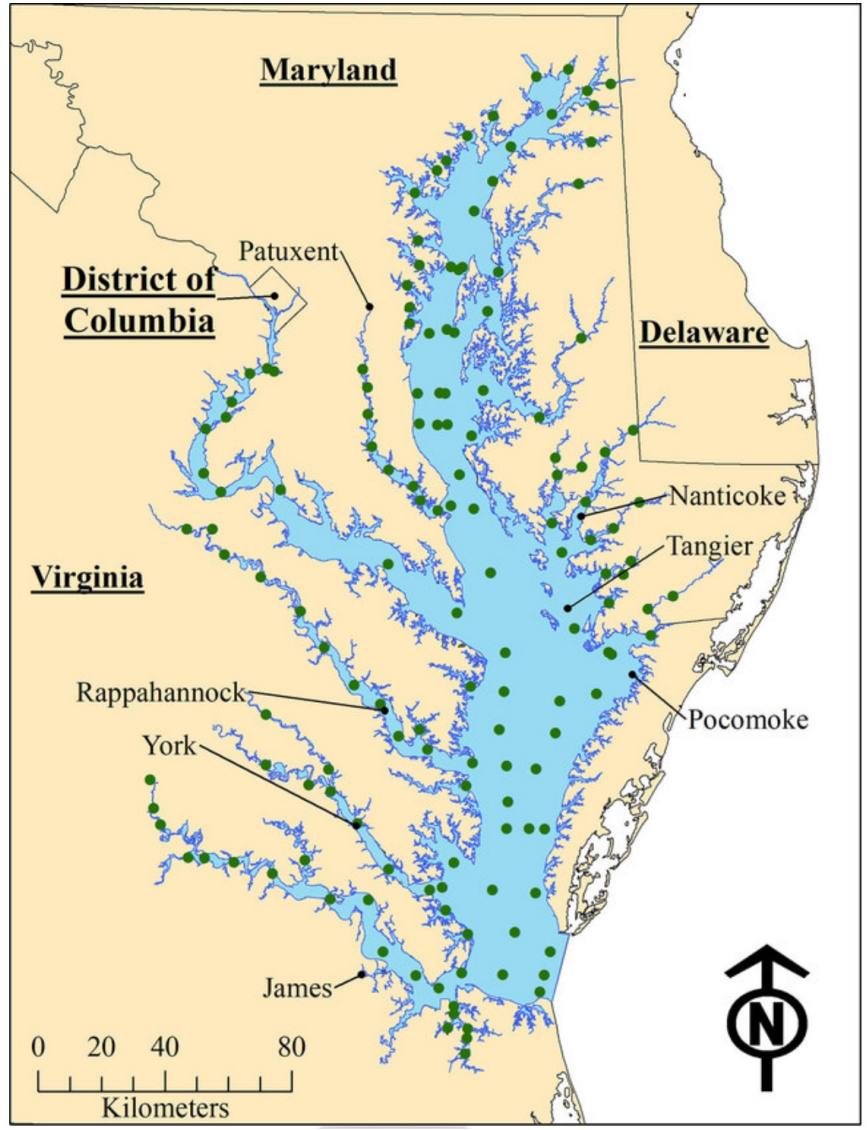
## Coastal inputs

In situ data, NOAA climatology & coastal ROMS model

# Data are critical for model development!

**Evaluated and CBP WQ Monitoring data (~37 yrs of data; ~17 cruises/yr)**

- Temperature
- Salinity
- Oxygen
- pH
- Nutrients
- Chlorophyll




From: Davis et al., 2019

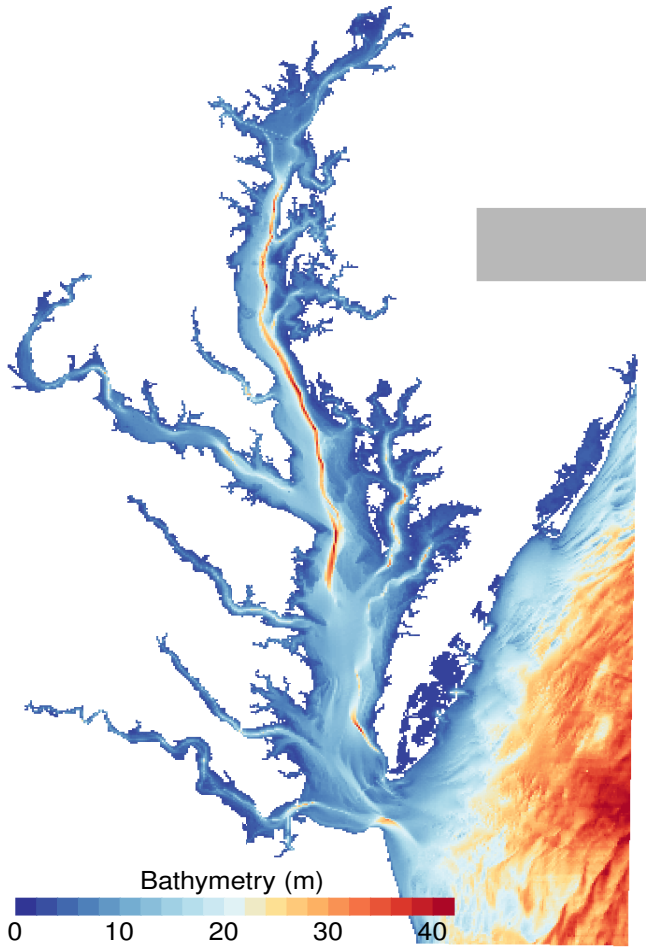
→ And now, continuous vertical profile data!

# CBEFS: Chesapeake Bay Environmental Forecast System

**Atmospheric inputs**

**Terrestrial inputs**

**Coastal inputs**




**Evaluate** model performance with observational water quality data

## Real-time model forecast setup:

- Nowcast and 2-day forecast automatically produced nightly
- Forecasts displayed on the VIMS website

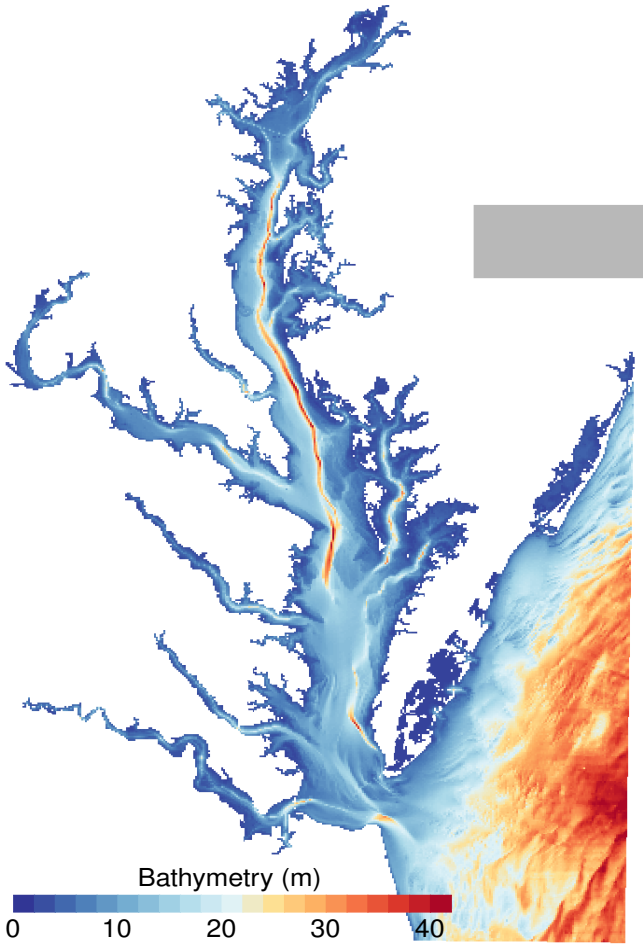
**www.vims.edu/cbefs**

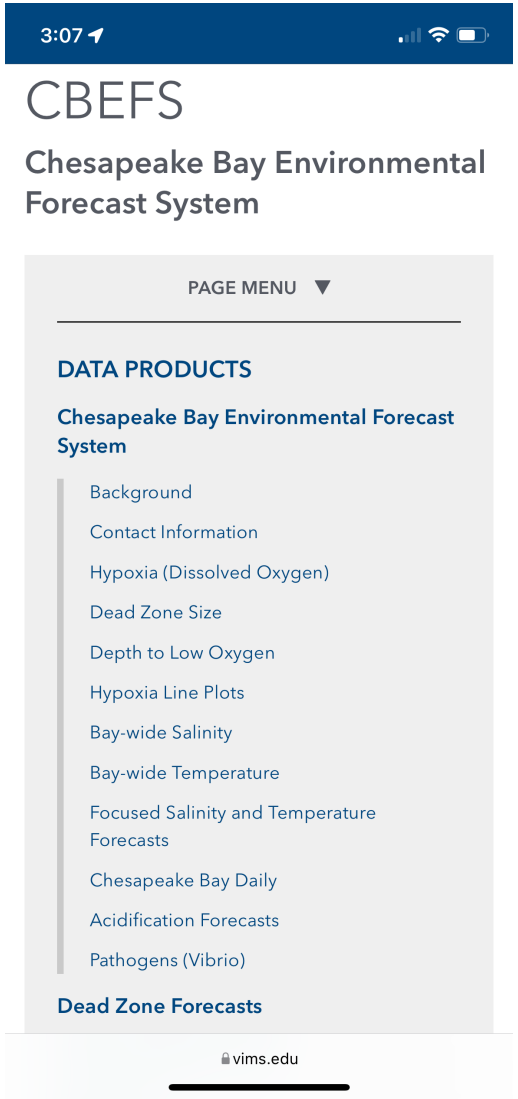
# CBEFS: Chesapeake Bay Environmental Forecast System

**Atmospheric inputs**

**Terrestrial inputs**

**Coastal inputs**




**Evaluate** model performance with observational water quality data

**www.vims.edu/cbefs**

# CBEFS: Chesapeake Bay Environmental Forecast System


**Chesapeake Bay Environmental Forecast System**

- Background
- Contact Information
- Hypoxia (Dissolved Oxygen)
- Dead Zone Size
- Depth to Low Oxygen
- Hypoxia Line Plots
- Bay-wide Salinity
- Bay-wide Temperature
- Focused Salinity and Temperature Forecasts
- Chesapeake Bay Daily
- Acidification Forecasts
- Pathogens (Vibrio)

**Dead Zone Forecasts**

**Sea-Level Report Cards**

**Tidewatch**


## CBEFS

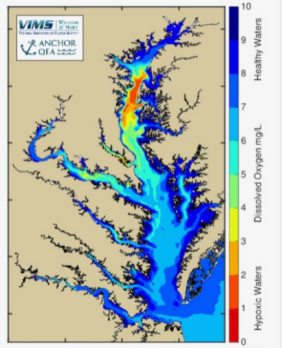
### Chesapeake Bay Environmental Forecast System

Use our forecasts and "nowcasts" of temperature, salinity, dissolved oxygen, and other physical and chemical factors within the Chesapeake Bay to help monitor Bay health and plan your on-the-water activities. Based on observations and **computer models** developed by the Virginia Institute of Marine Science and partners, these tools accurately predict the current status of important environmental variables and how they are likely to change in the short-term.

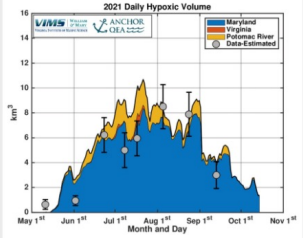
Our Chesapeake Bay Environmental Forecast System simulates 3 conditions for each selected variable:

1. **Nowcast**: present-day status of selected variable in Chesapeake Bay
2. **2-Day Forecast**: status of selected variable in the Bay 2 days from now, and
3. **Forecast Trend**: difference between nowcast and forecast (% change over 2 days)

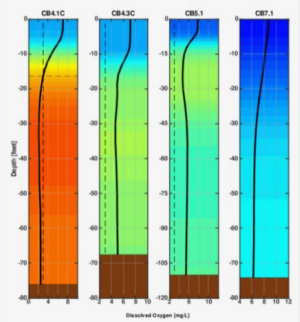
Click a selection below to access the specified simulation.




DISSOLVED OXYGEN (DO)
Discover when and where low-oxygen "dead zone" conditions may form.



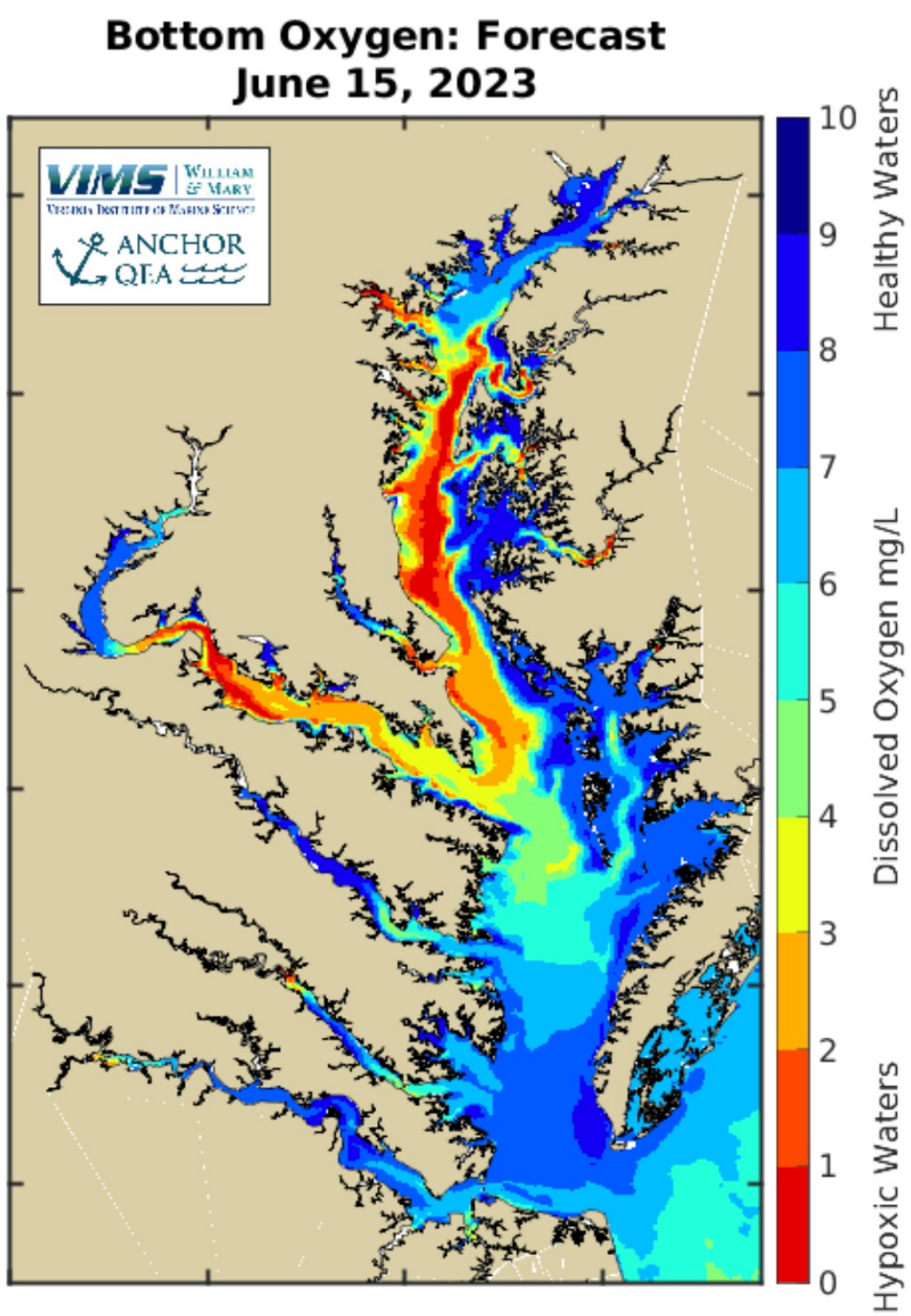

DEAD ZONE SIZE
Track "hypoxia" in the Bay, as measured by the volume of waters where DO levels are below 2 mg/L.




DEPTH TO LOW OXYGEN
Find the depth to fish-unfriendly waters where dissolved oxygen levels fall below 3 mg/L.

- Temperature
- Salinity
- Hypoxia/Dead Zone size
- Acidification metrics
- Bacteria (Vibrio)
- Harmful Algal Blooms (HABs)

**www.vims.edu/cbefs**



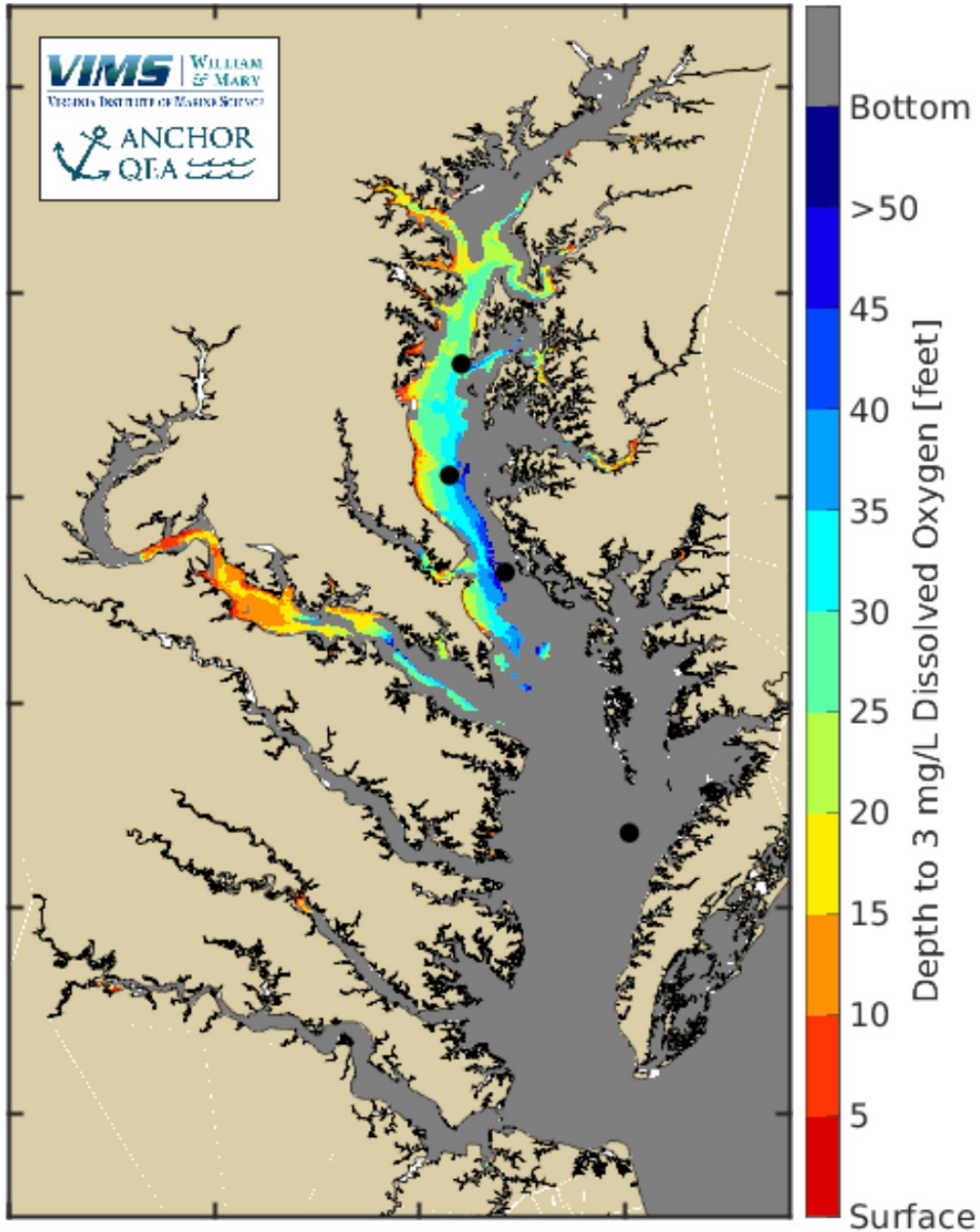

**screenshot of forecast for today**

**Blues → High bottom oxygen**
= Good bottom water
= Bottom fish and crabs

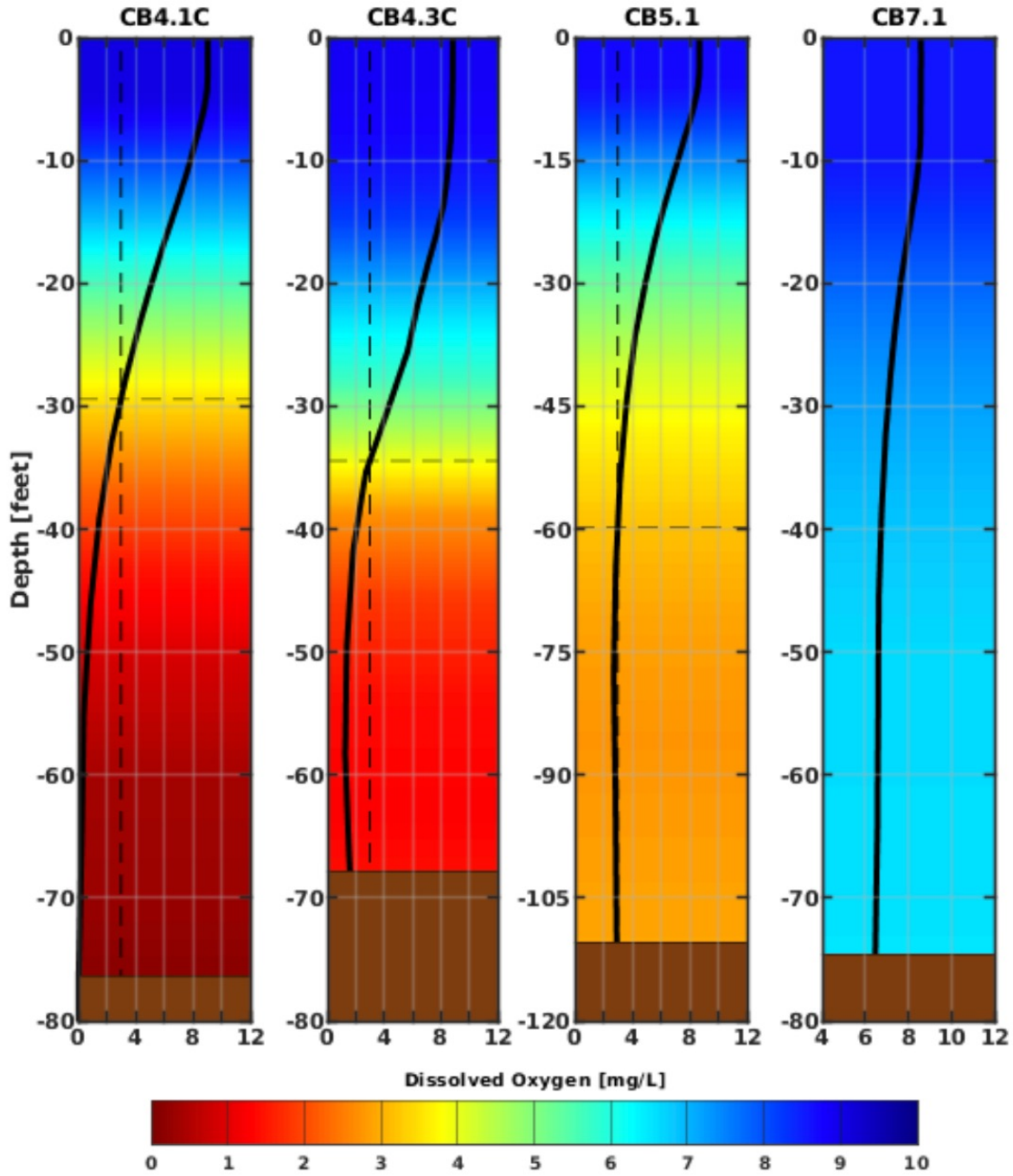
**Yellow/green → Moderately low oxygen**
= Poor bottom water
= Fewer bottom fish and crabs

**Red → Very low bottom oxygen**
= Bad bottom water
= No bottom fish or crabs

# Depth to 3 mg/L: Nowcast
# June 13, 2023

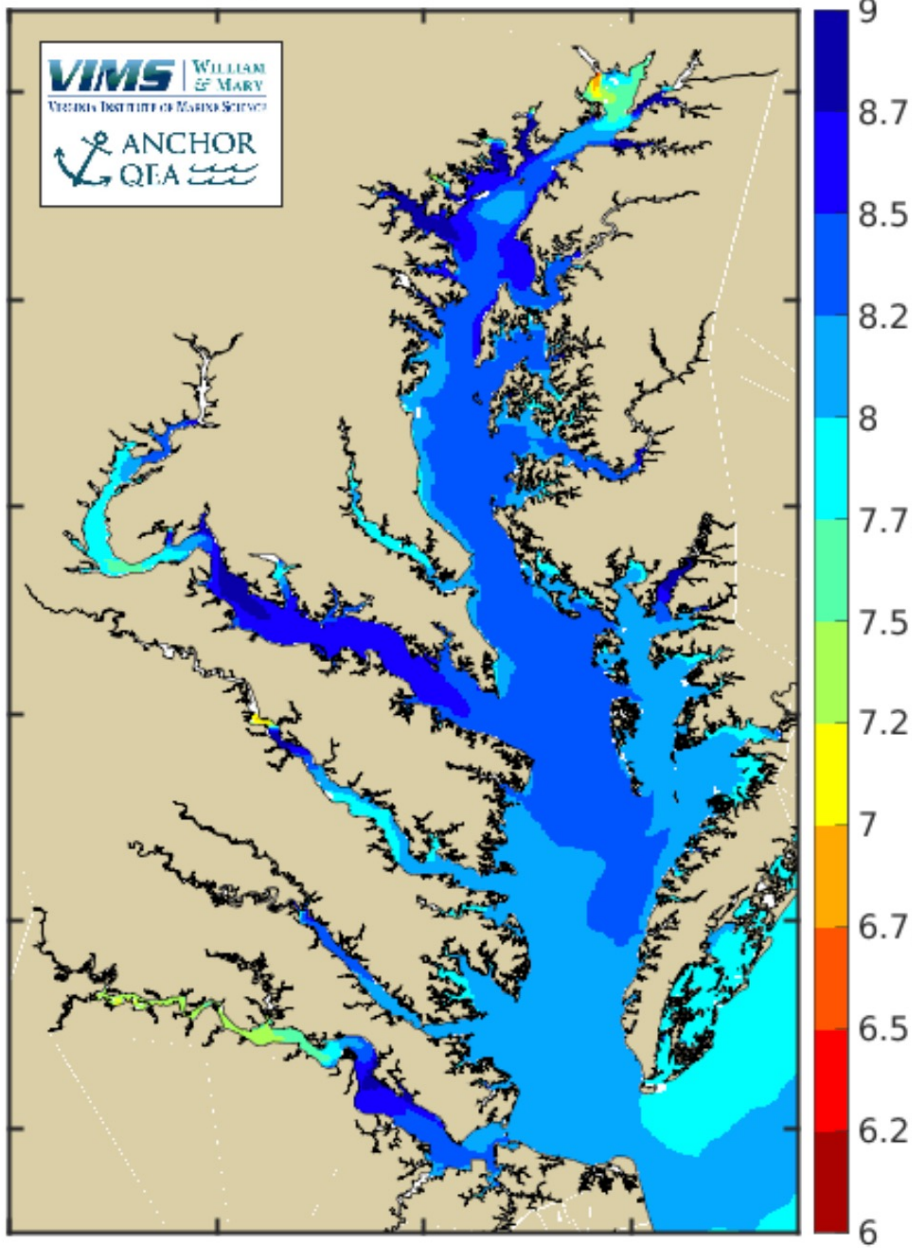



## Nowcast: June 13, 2023

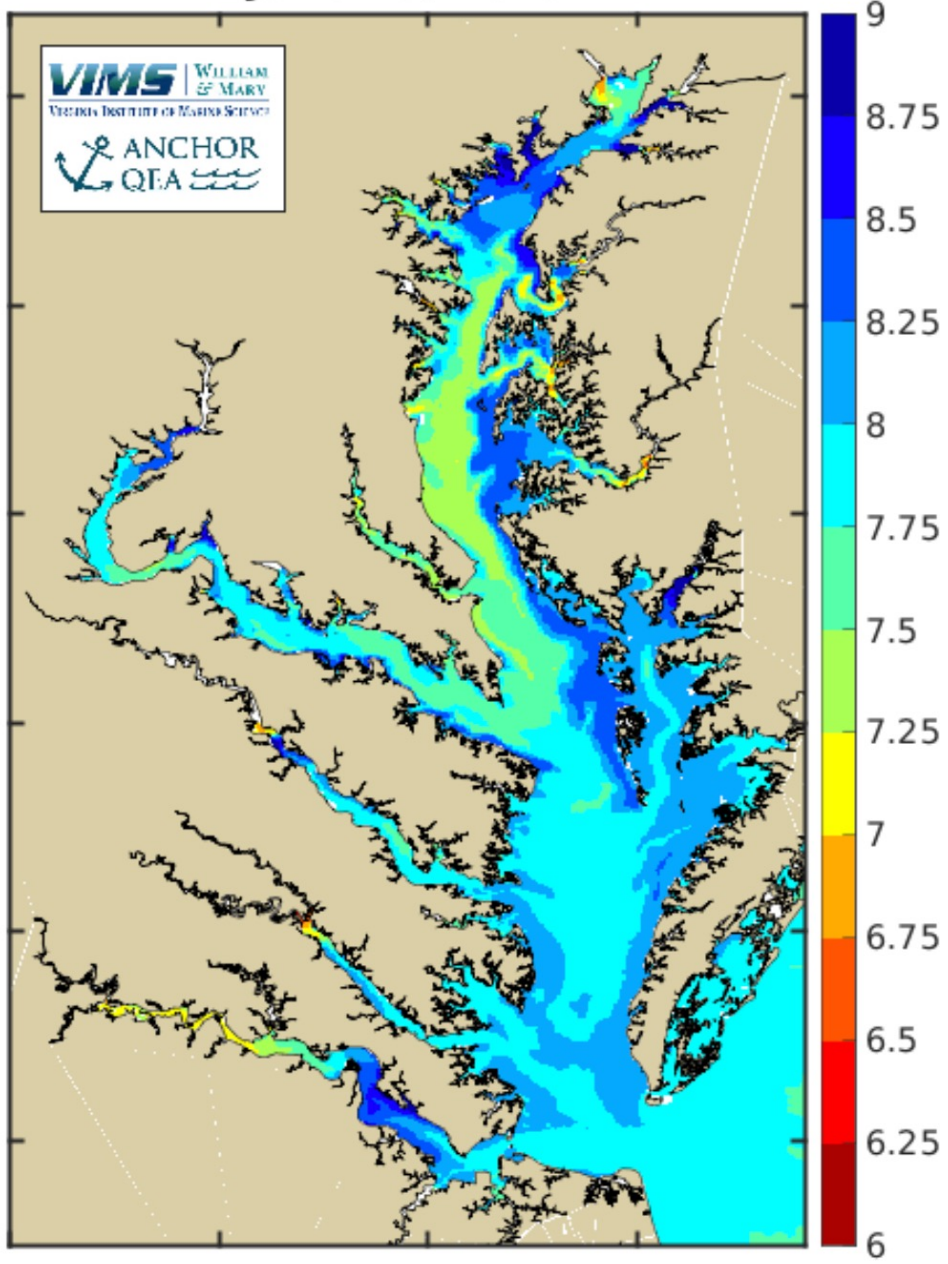


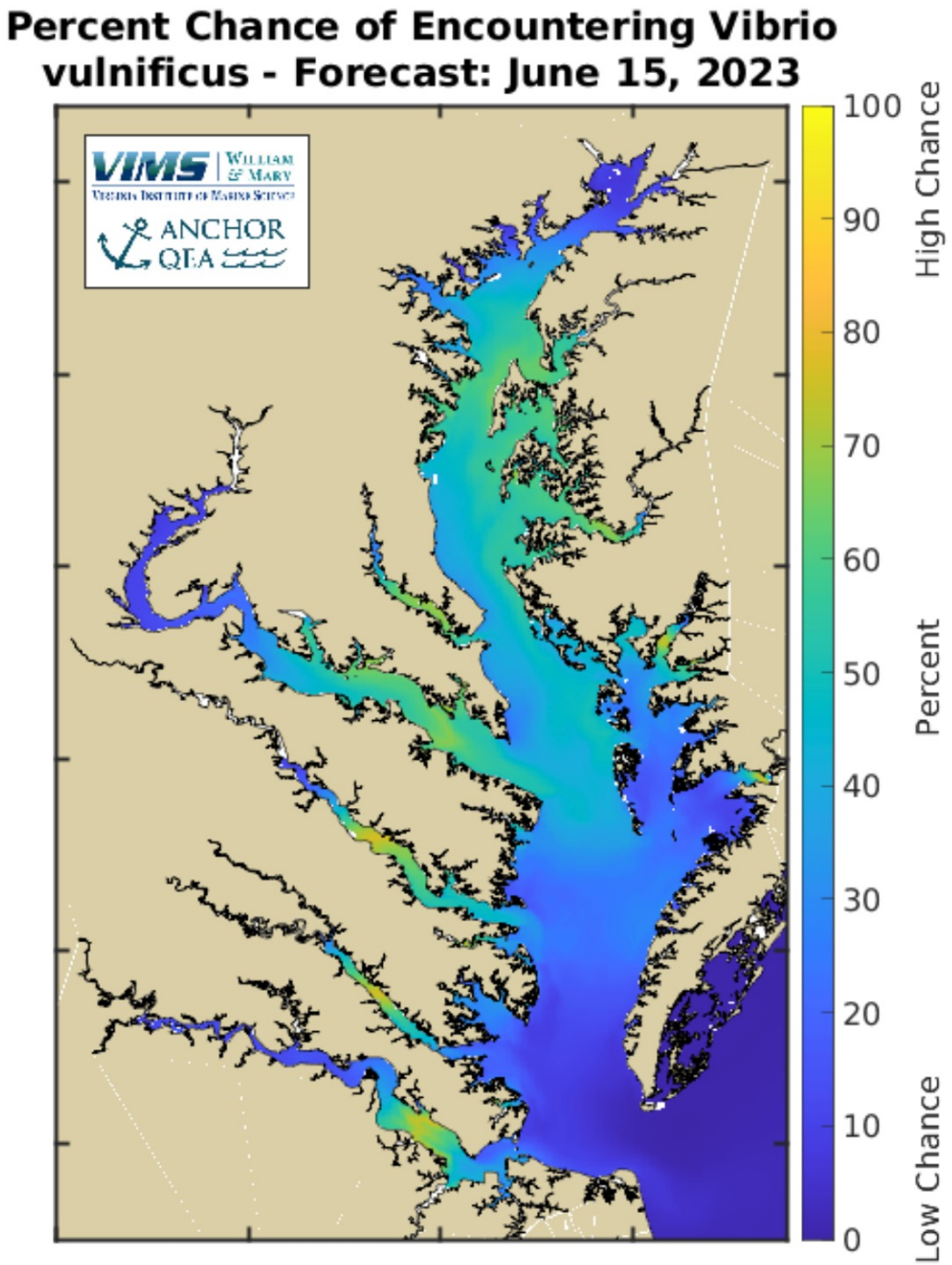
**pH**

## Surface pH: Forecast
## June 15, 2023

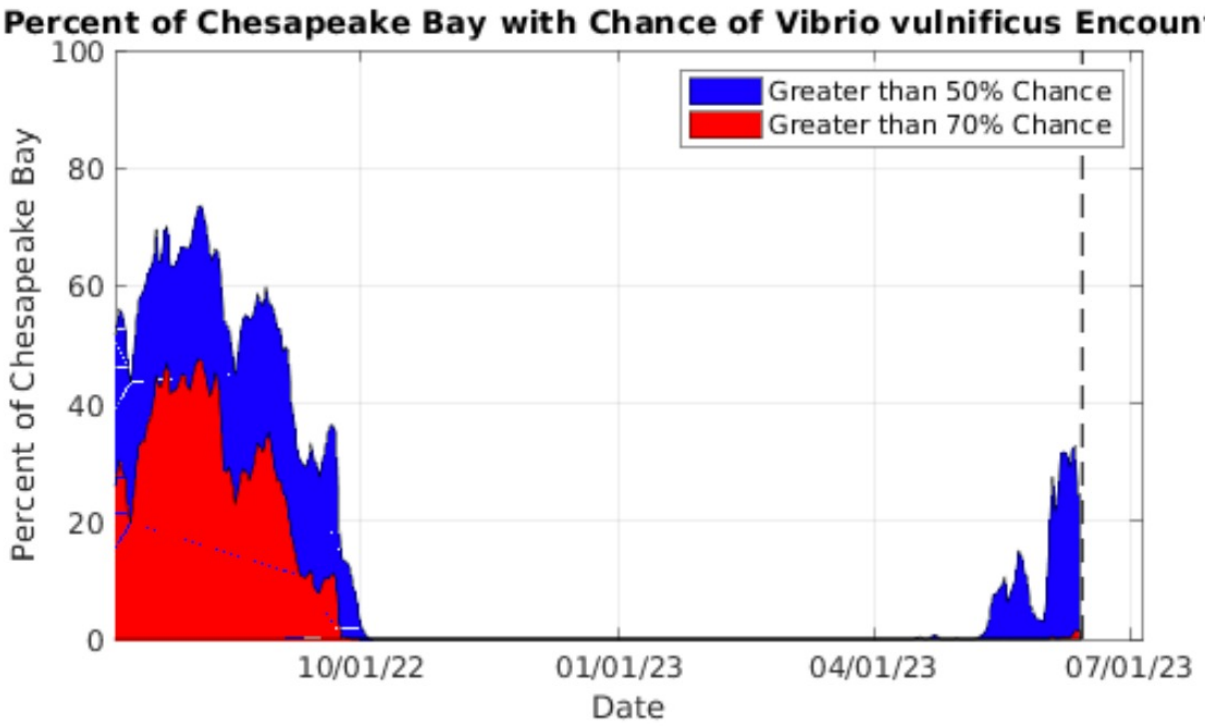


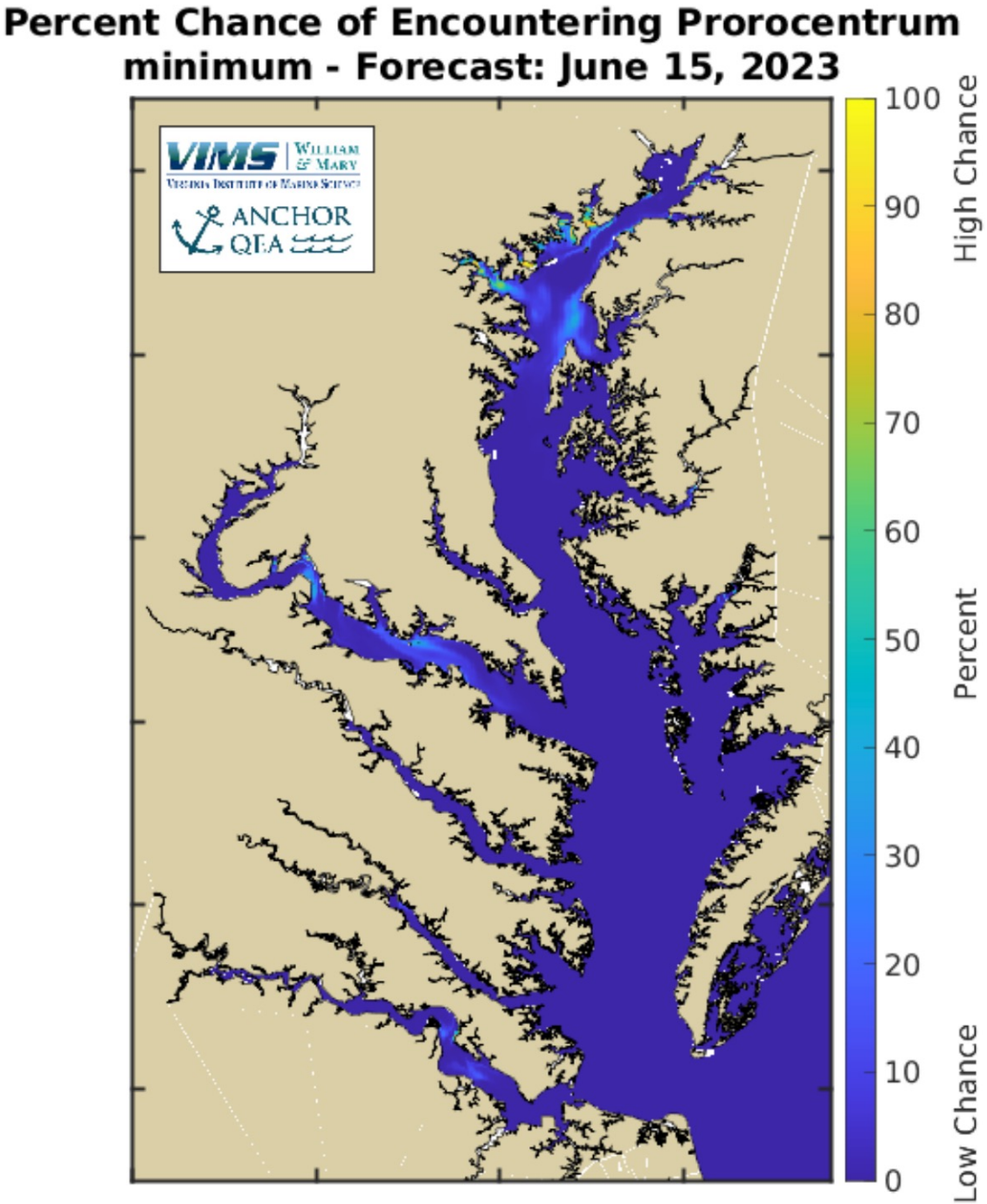

## Bottom pH: Forecast
## June 15, 2023



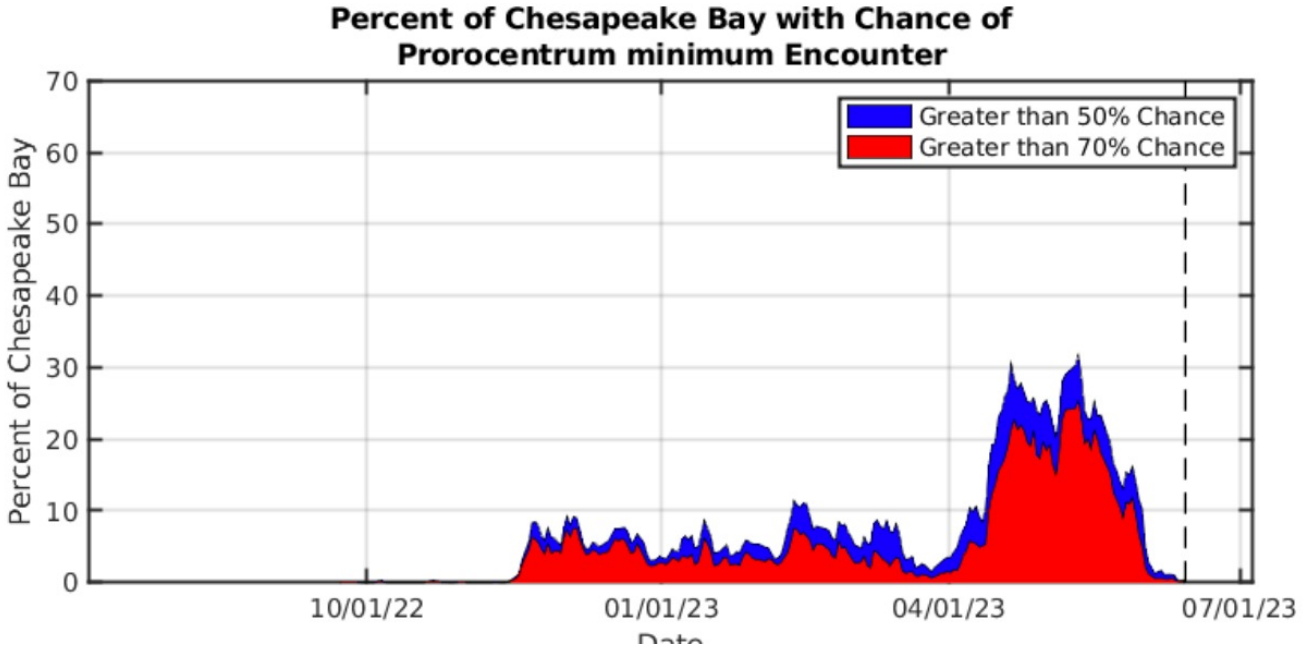



# Vibrio forecast






# HAB forecast



# VIMS 2022 Dead Zone Report Card

VIMS | William & Mary
Virginia Institute of Marine Science

Anchor QEA

## 2022 Chesapeake Bay Dead Zone Report
## November 2022

### Hypoxia Background

The "Dead Zone" of the Chesapeake Bay refers to a volume of deep water that is characterized by oxygen concentrations less than 2 mg/L, which is too low for aquatic organisms such as fish and blue crabs to thrive. The Chesapeake Bay experiences such "hypoxic" conditions every year, with the severity varying from year to year, depending on nutrient and freshwater inputs, wind, and temperature. Multiple metrics are used to relate the severity of hypoxia between different years:

- ***Maximum Daily Hypoxic Volume*** ($km^3$): The greatest volume of Chesapeake Bay water experiencing hypoxic conditions on any day of the year[1]
- ***Duration of Hypoxia*** (days): The number of days in a given year between the first and last day of hypoxic conditions exceeding 2 $km^3$ in volume
- ***Total Annual Hypoxic Volume*** ($km^3$ days): The total amount of hypoxia in the Bay for a given year, calculated by summing the hypoxic volume on each day

# VIMS 2022 Dead Zone Report Card

VIMS | William & Mary
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ANCHOR QEA

## 2022 Chesapeake Bay Dead Zone Report
## November 2022

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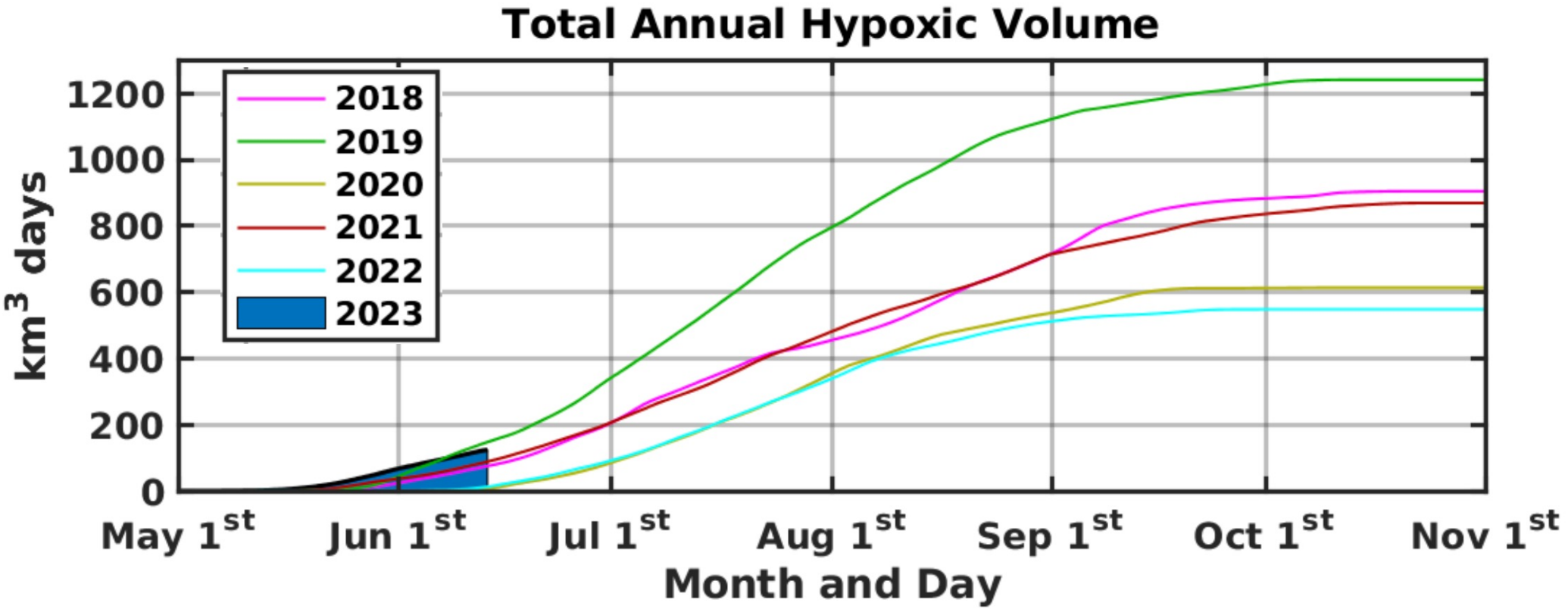
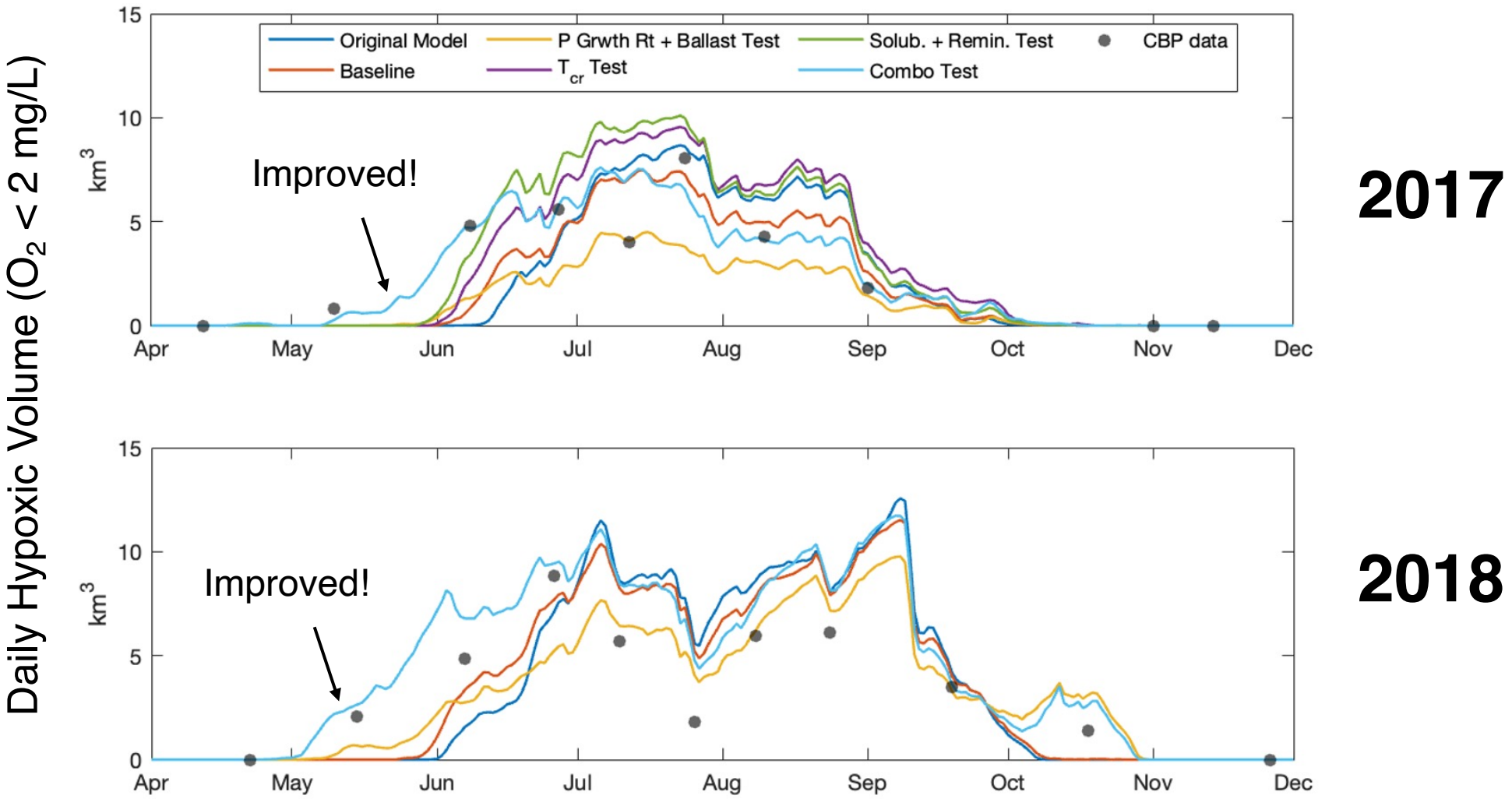
**In 2022:**

- **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**

# 2023 Dead Zone Size

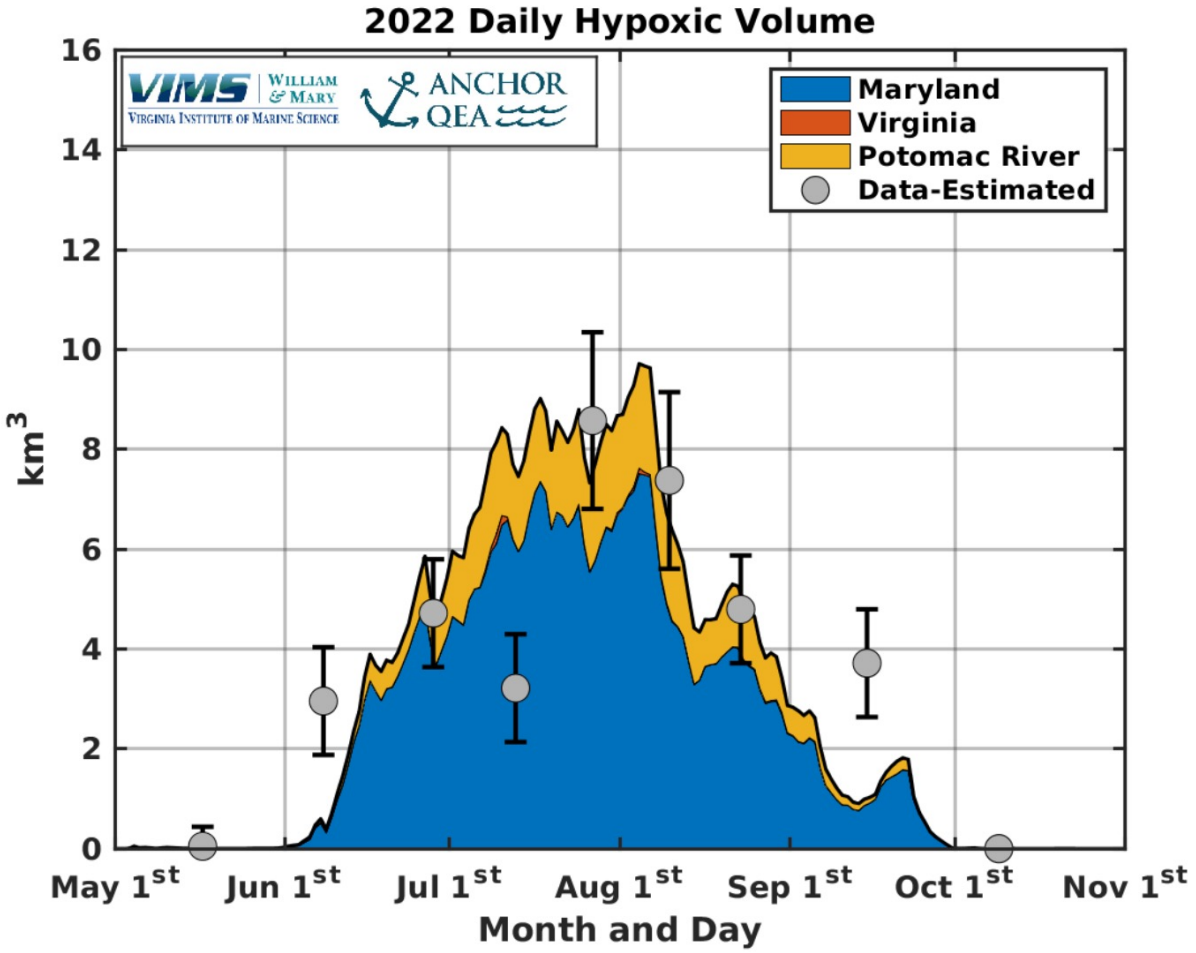


# How do we use available data?
# 1. Off season model improvements

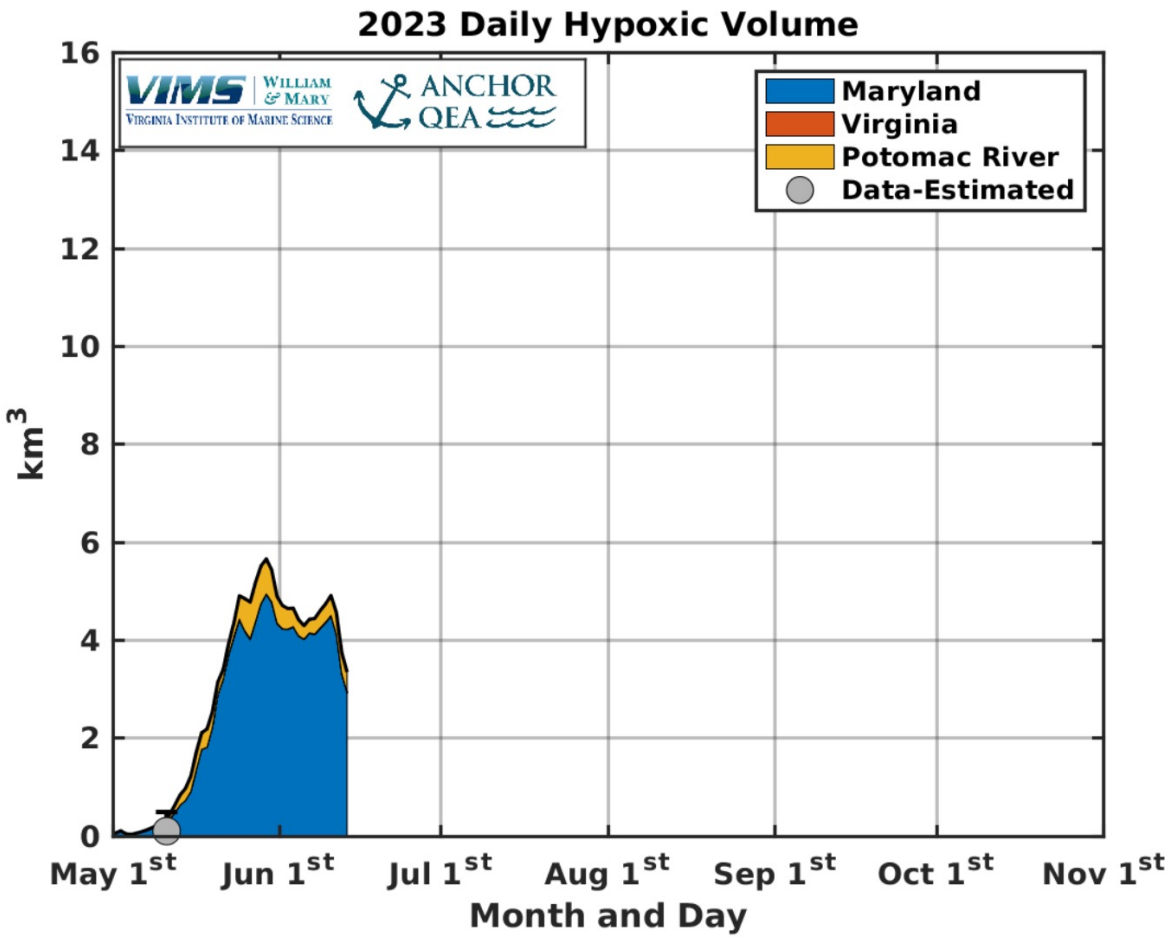


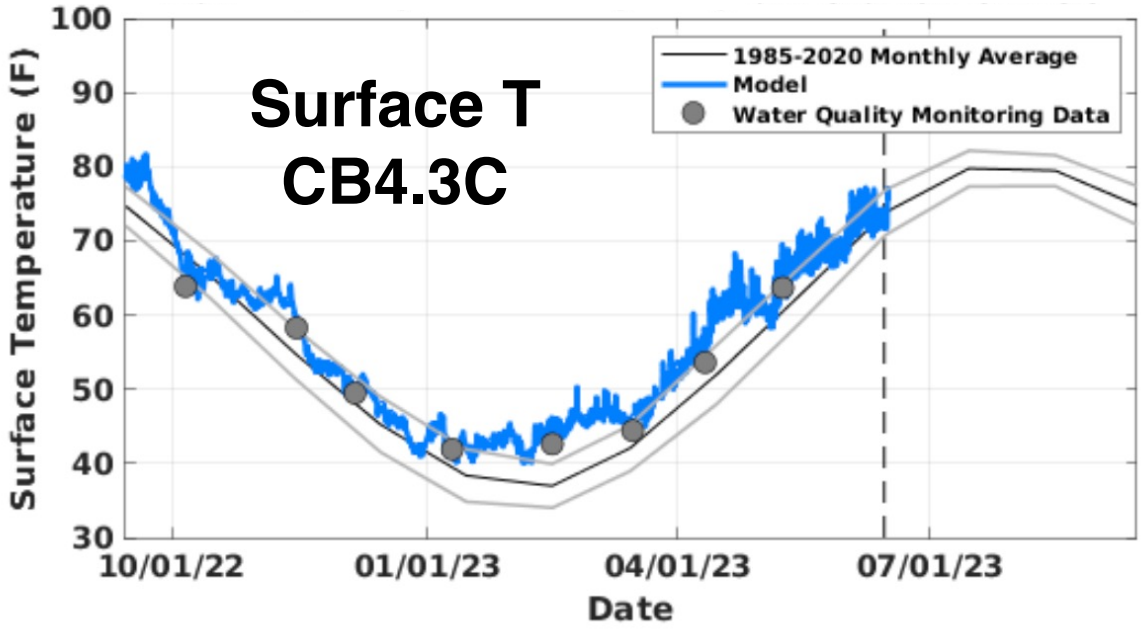
# How do we use available data?
# 2. Model evaluation

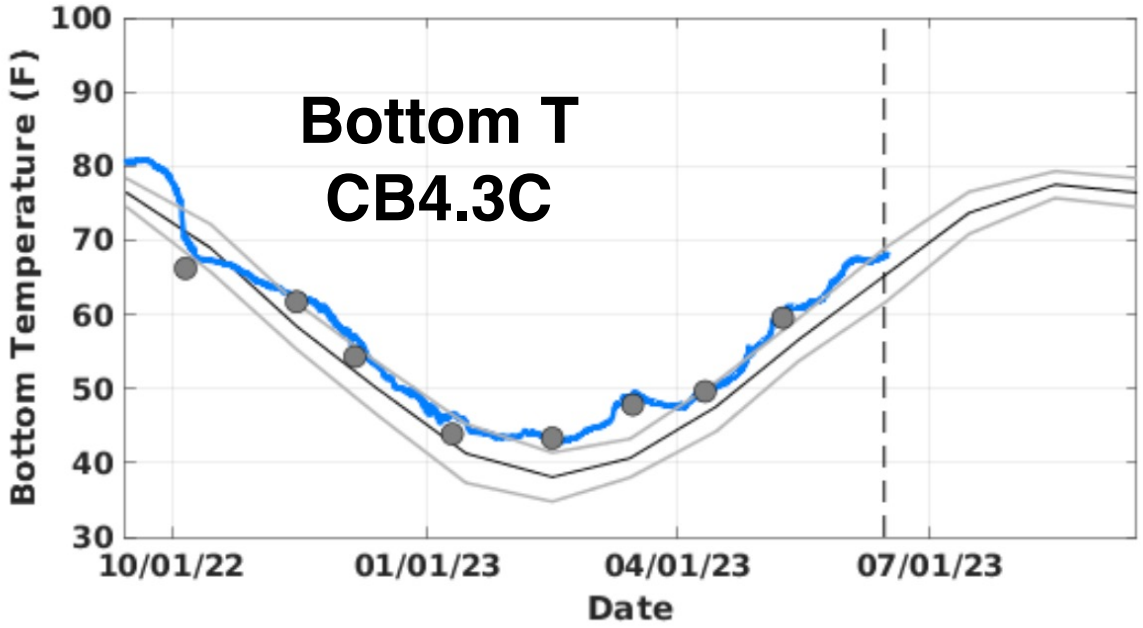
## Dead Zone 2022




## Dead Zone 2023



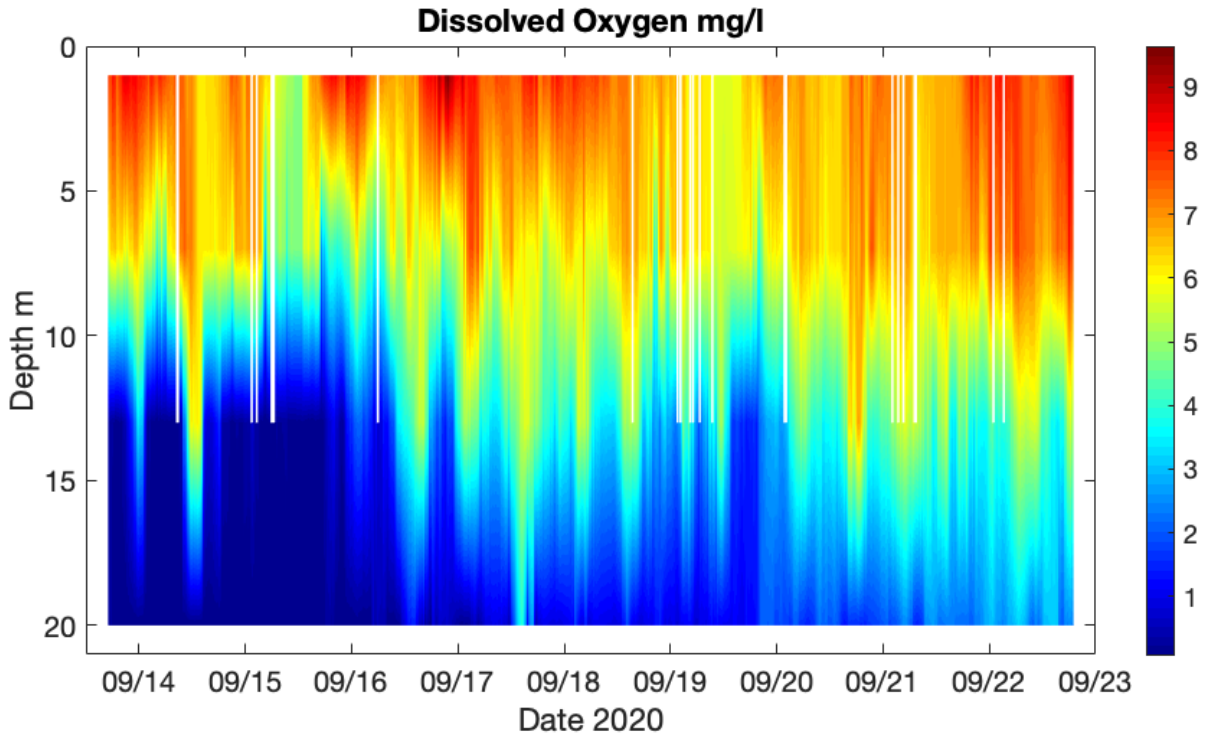


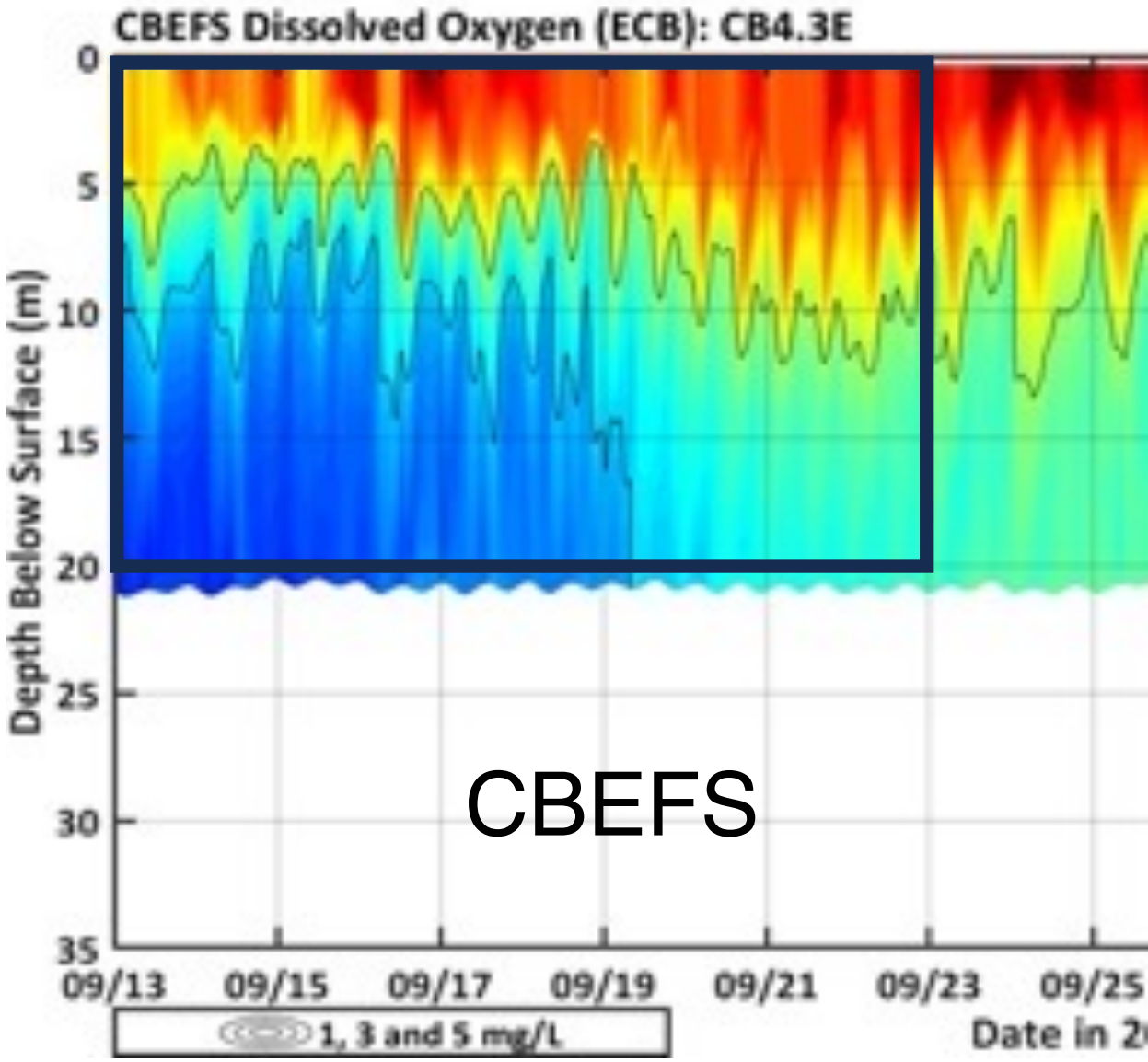

**How do we use available data?**

**3. Enhancing confidence in forecasts**

# 2021 Model-data comparison



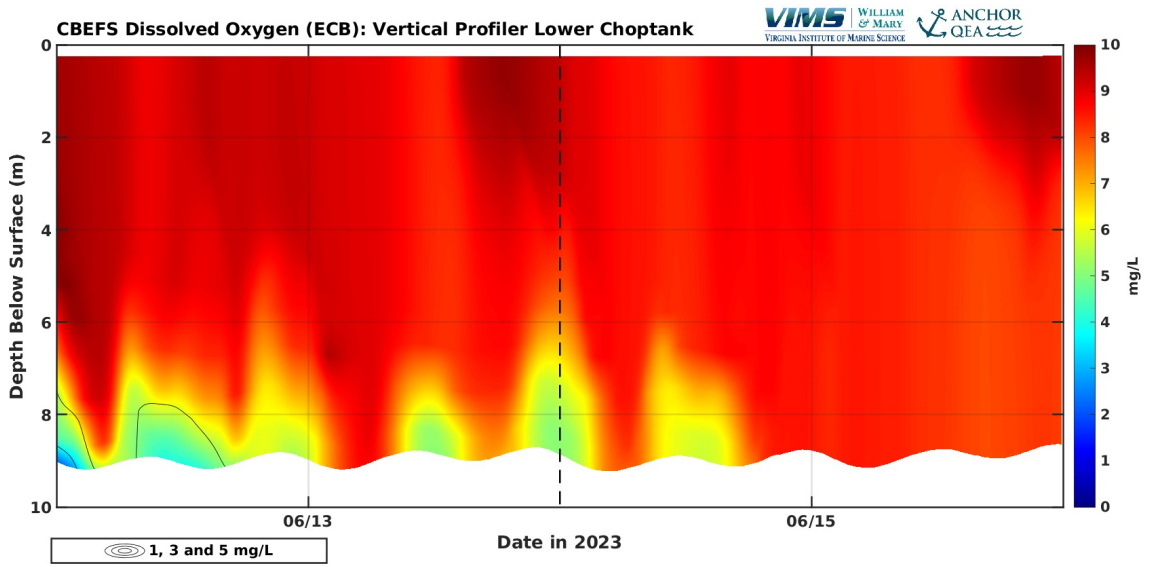

Monitoring data



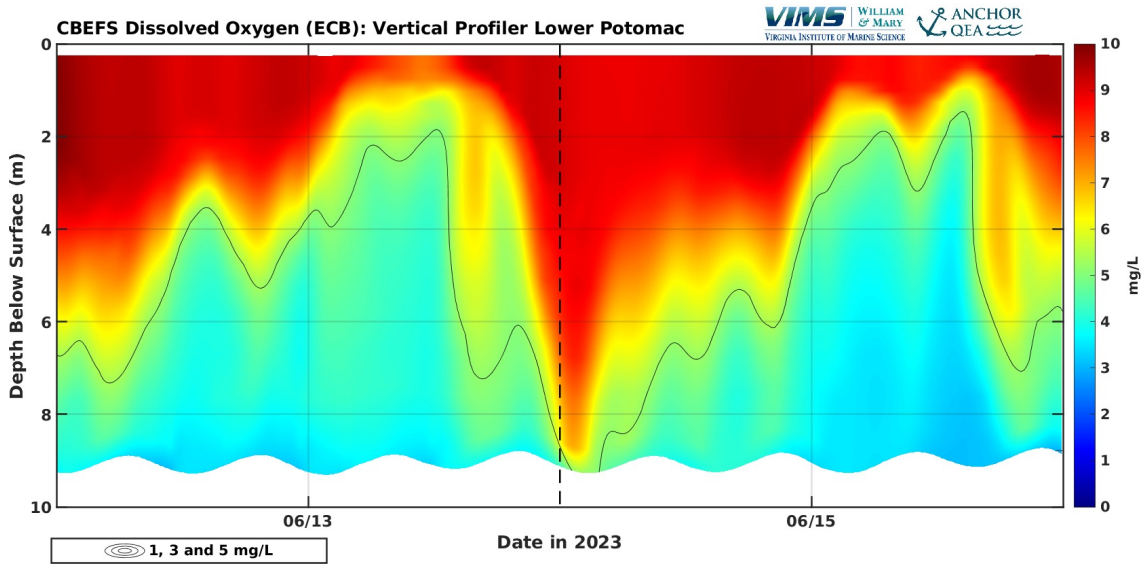

CBEFS

# CBEFS Oxygen: 2023 Monitoring Sites

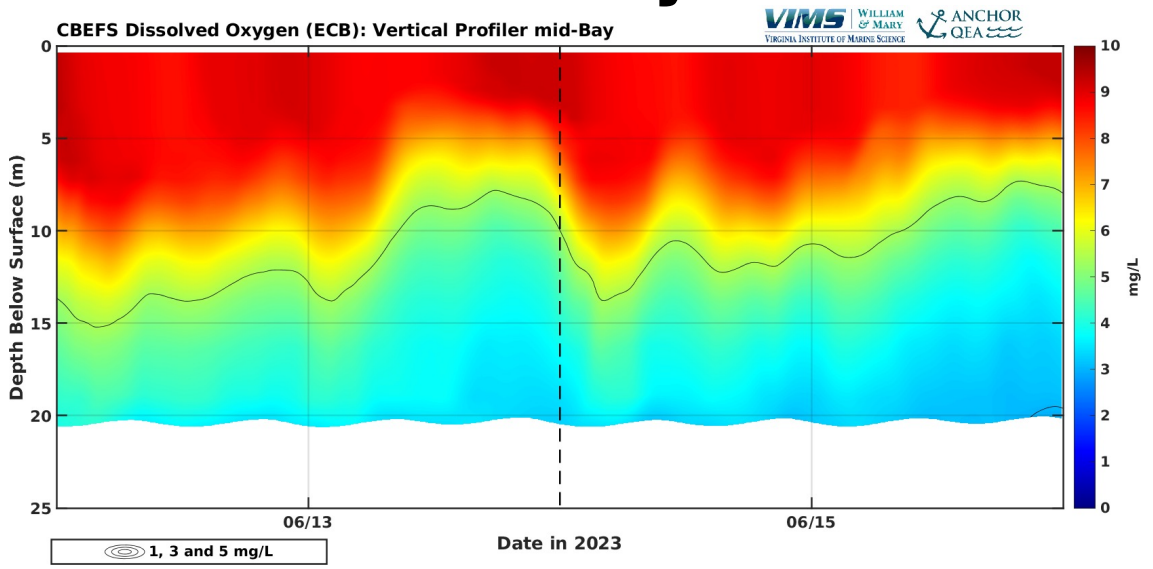
## Lower Choptank




## Lower Potomac

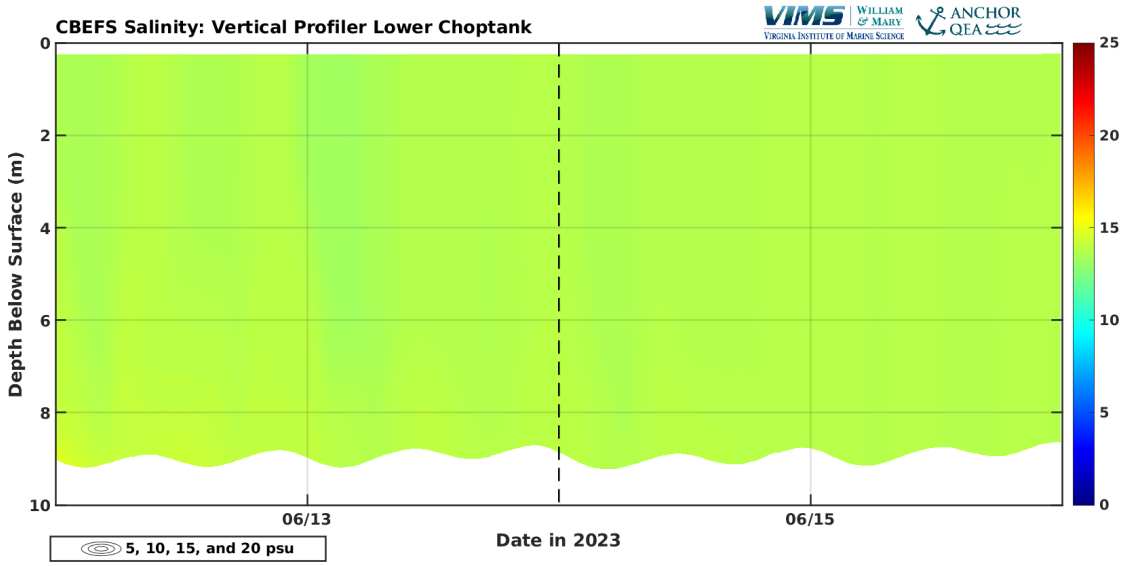



## Mid Bay

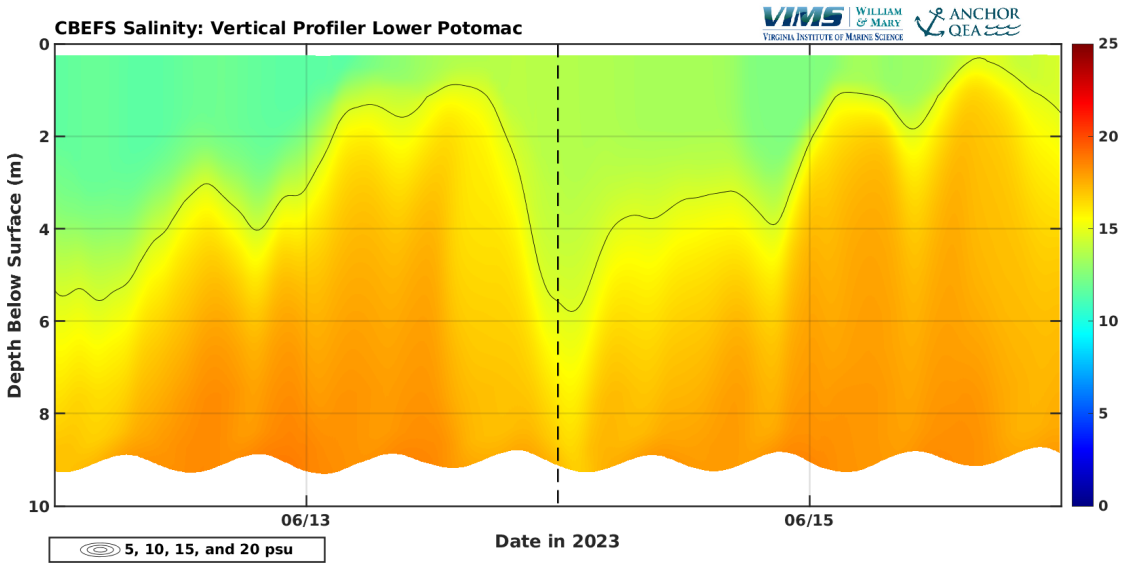


# CBEFS Salinity: 2023 Monitoring Sites

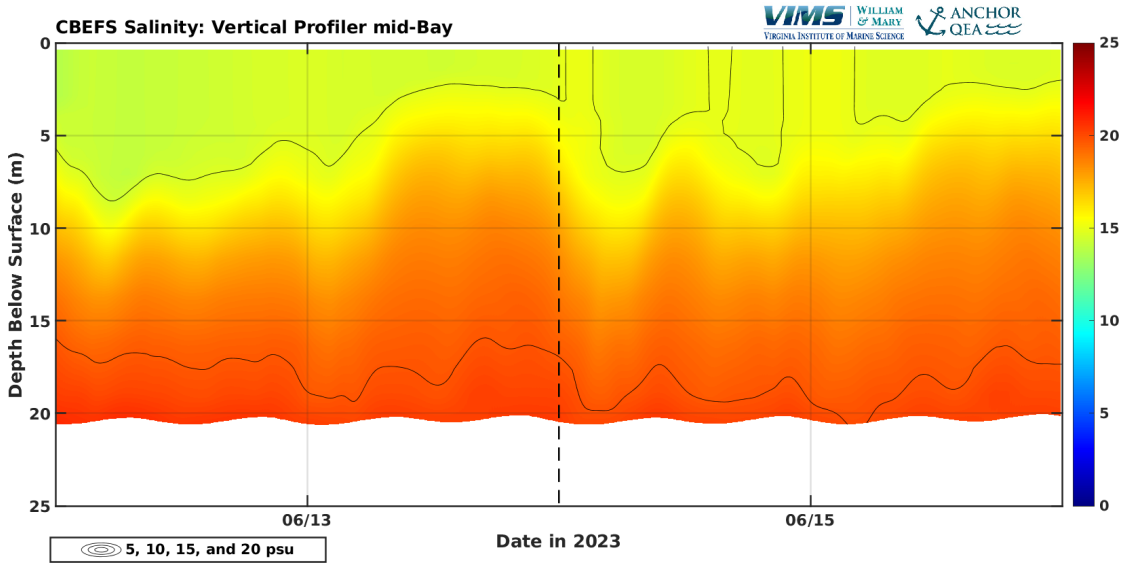
## Lower Choptank




## Lower Potomac




## Mid Bay



# Summary

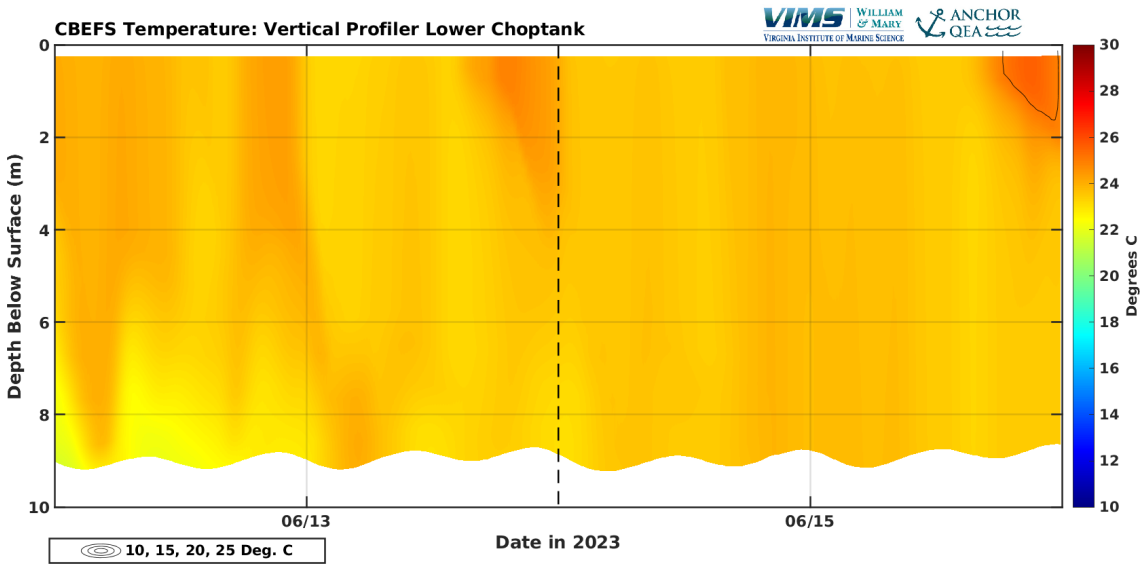
- CBEFS provides short-term forecasts of multiple products (hypoxia, acidification, HABs)
  - Large and increasing set of end-users
  - Also used for long-term climate change and nutrient reduction scenarios (Irby et al., 2018, St-Laurent et al., 2019; Frankel et al., 2022, Hinson, et al., 2022, 2023…)

- Access to in situ data are critical:
  - Model development
  - Model improvement
  - Model evaluation
  - Increasing confidence of end-users

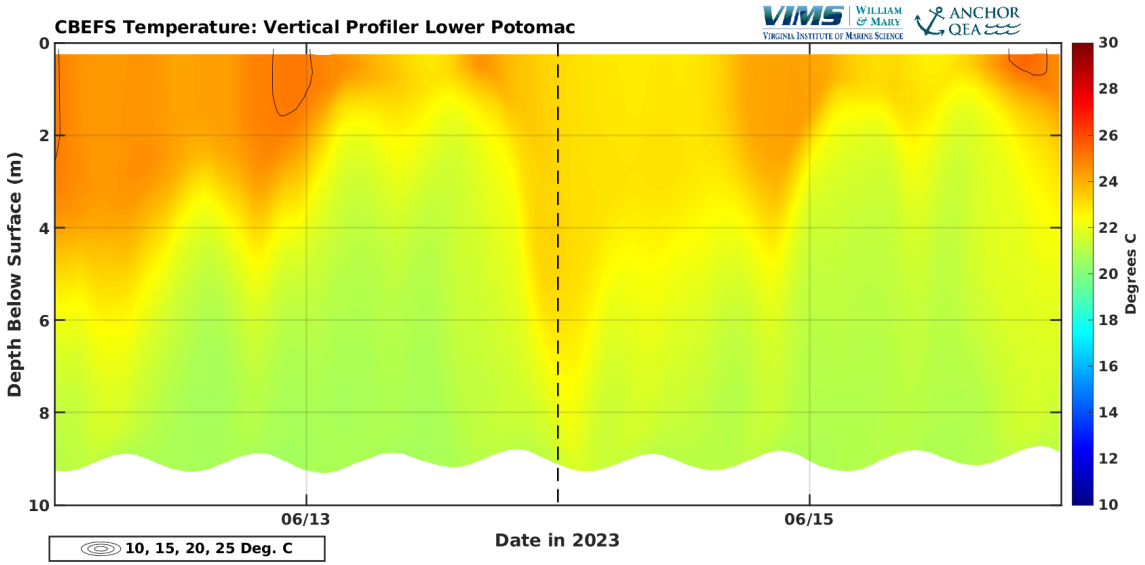
- Real-time vertical profiling data will be extremely useful in all these ways!

# CBEFS Temperature: 2023 Monitoring Sites

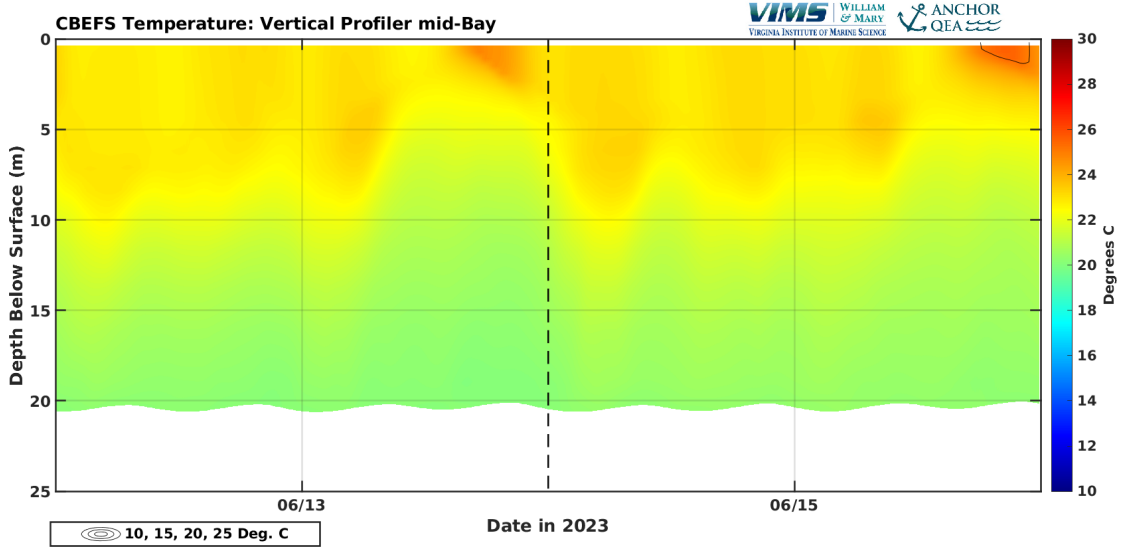
## Lower Choptank

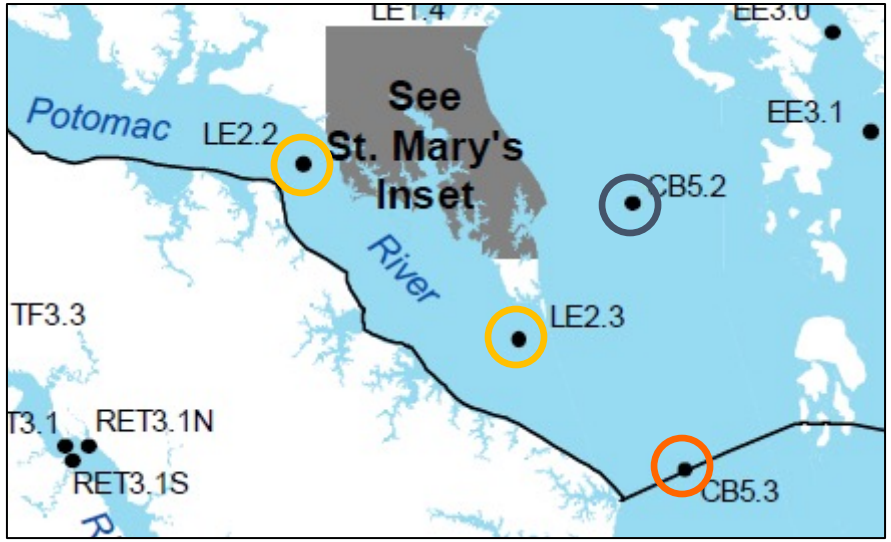
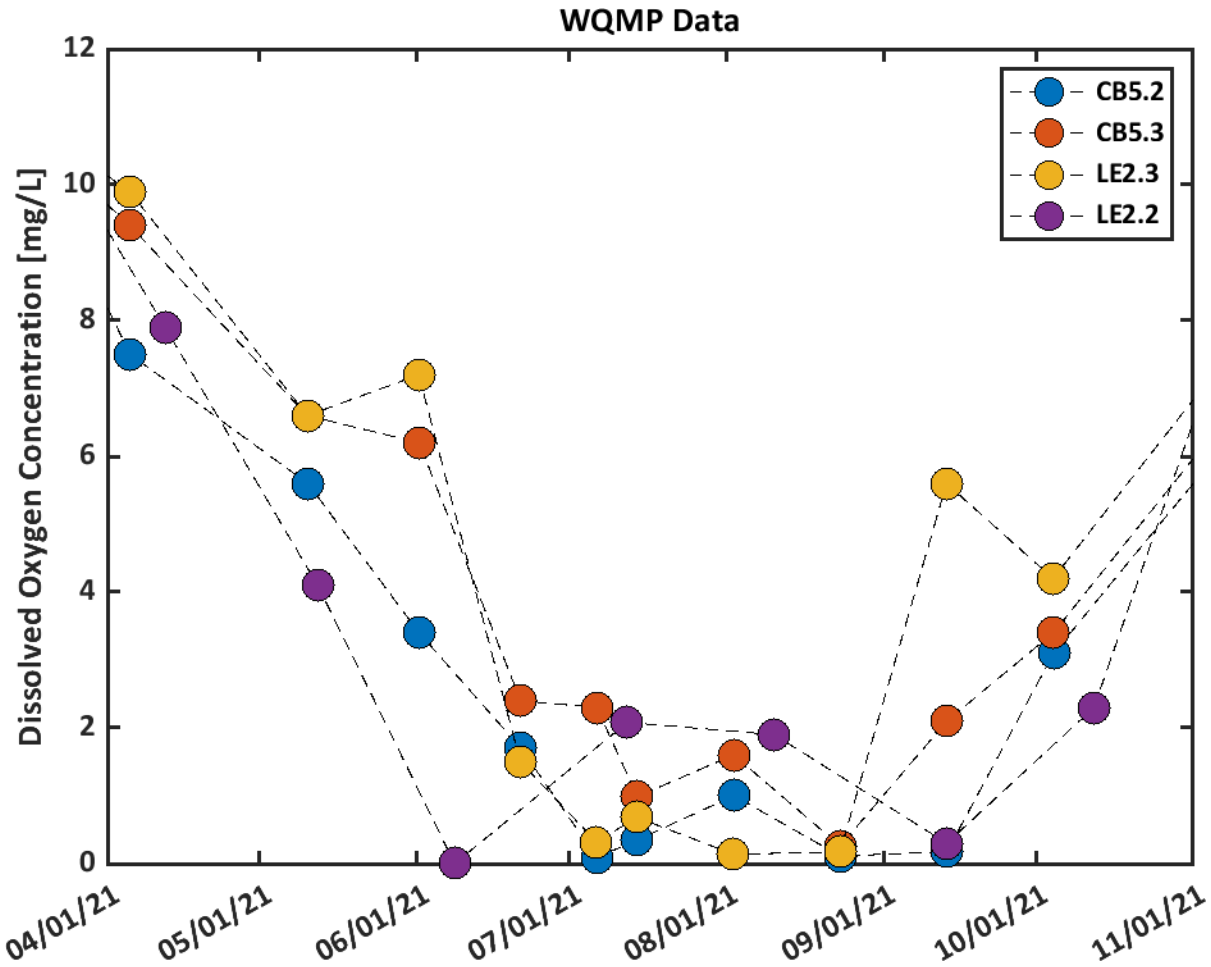



## Lower Potomac




## Mid Bay



# Dissolved Oxygen Around Lower Potomac

- Evaluate near-bottom dissolved oxygen