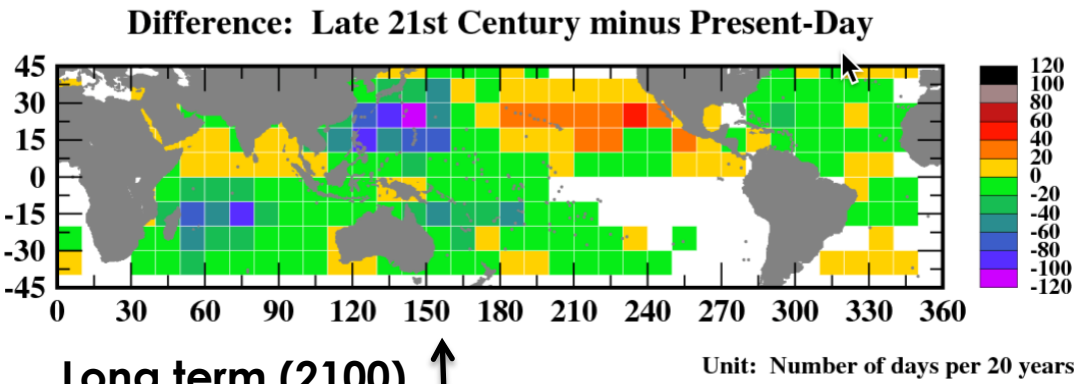
Short-term Hypoxia Forecasts for the Chesapeake Bay

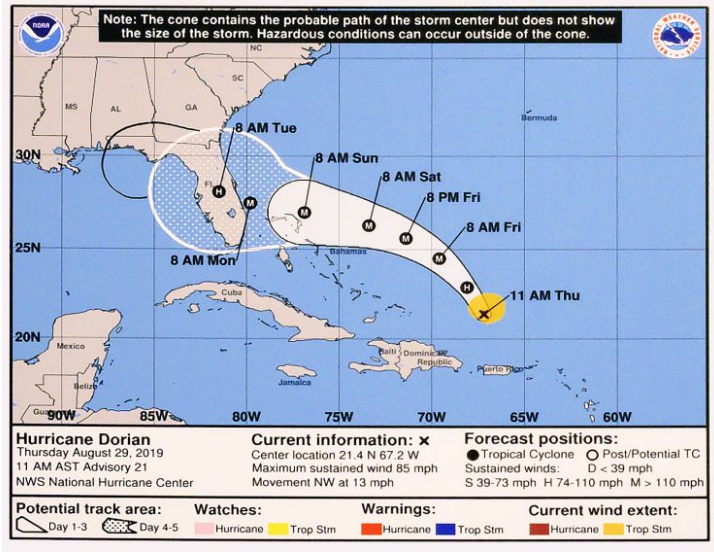
Marjorie Friedrichs[1], Aaron Bever[2]
[1]Virginia Institute of Marine Science
[2]Anchor QEA

Background on Forecasting

Hurricane Example:

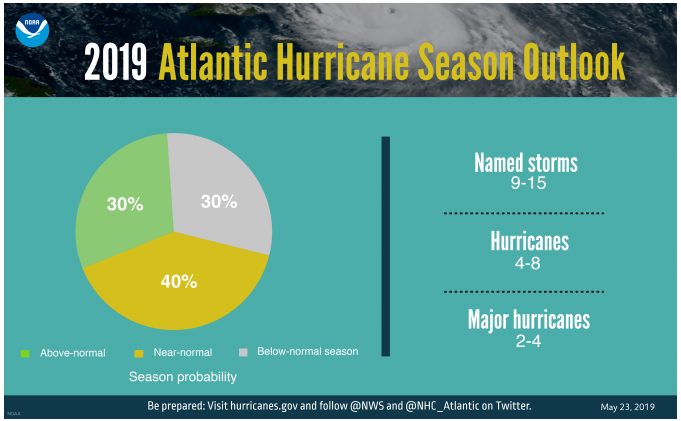


Long term (2100) forecasts/projections



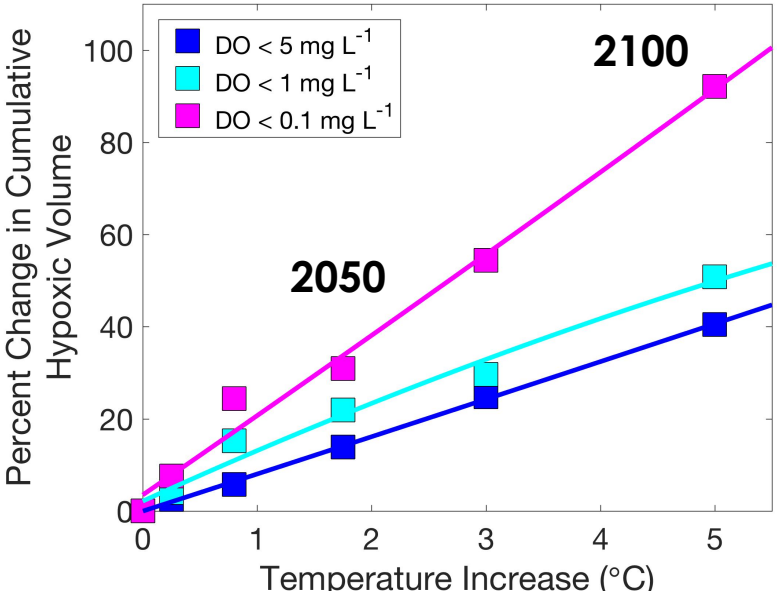
Short term forecasts

Seasonal forecasts



Chesapeake Bay Forecasting

Long term (2100) hypoxia forecasts/projections



Irby et al., BG (2018)
Hinson et al.; Ni et al.

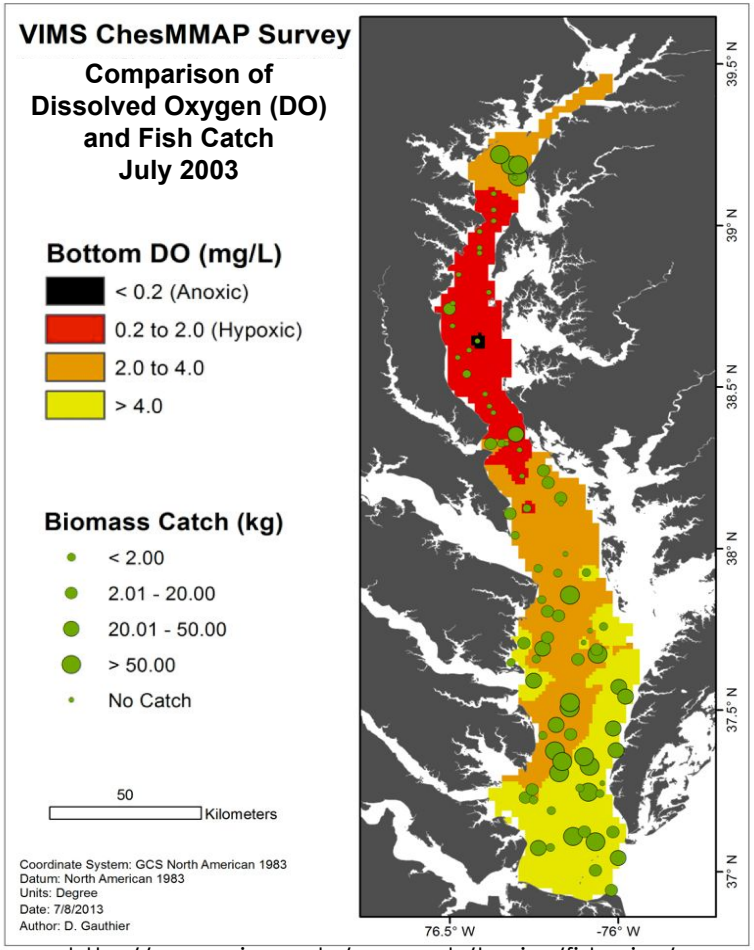
Seasonal hypoxia forecasts

Chesapeake Bay Hypoxic Volume Forecasts

Donald Scavia, Isabella Bertani, Colleen Long, and Yu-Chen Wang
University of Michigan
June 7, 2019

The 2019 Forecast **- Given the average January-May 2019 total nitrogen load of 309,403 kg/day, this summer's hypoxia volume forecast is 8.9 km^3, the 4th largest in the past 20 years.**

Motivation – Why focus on short-term forecasts?

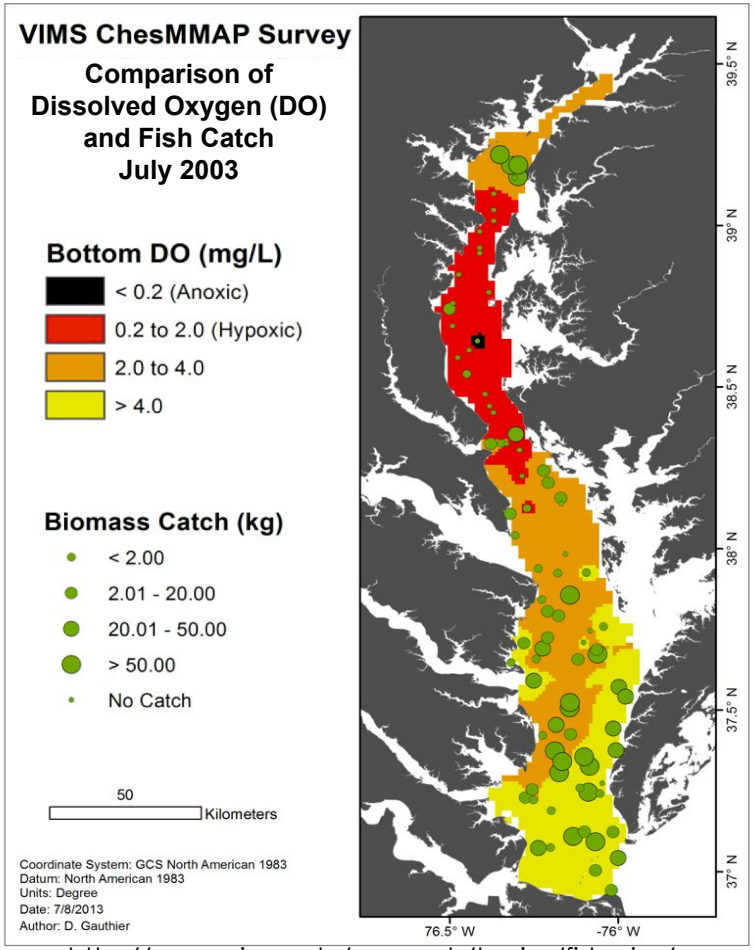


http://www.vims.edu/research/topics/fisheries/

Hypoxia 2-3 day forecasts:

- Poor habitat and low fish catches where DO < 3 mg/L
- Stakeholders include recreational and commercial fishermen, as well as charter boat captains

Motivation – Why focus on short-term forecasts?



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Acidification forecasts:

- Working with hatchery operators
- Early warning system for poor water quality
  - Delay spawning
  - Avoid supplying spawning tanks with Bay intake water
- Collaborating with aquaculture industry through VIMS SAIAC
  - Feedback on information provided and visualization

Chesapeake Bay Environmental Forecast System (CBEFS)

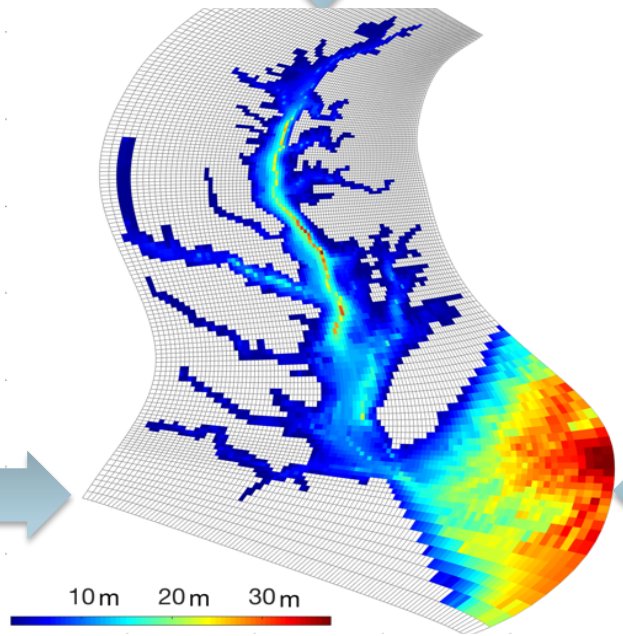
Atmospheric forcing

Estuarine model

- ~1km x 1km
- 20 layers
- Tides

NOAA atm. forcing

- Winds
- Solar radiation
- Temperature
- Precipitation



Riverine inputs

Terrestrial Inputs from USGS data

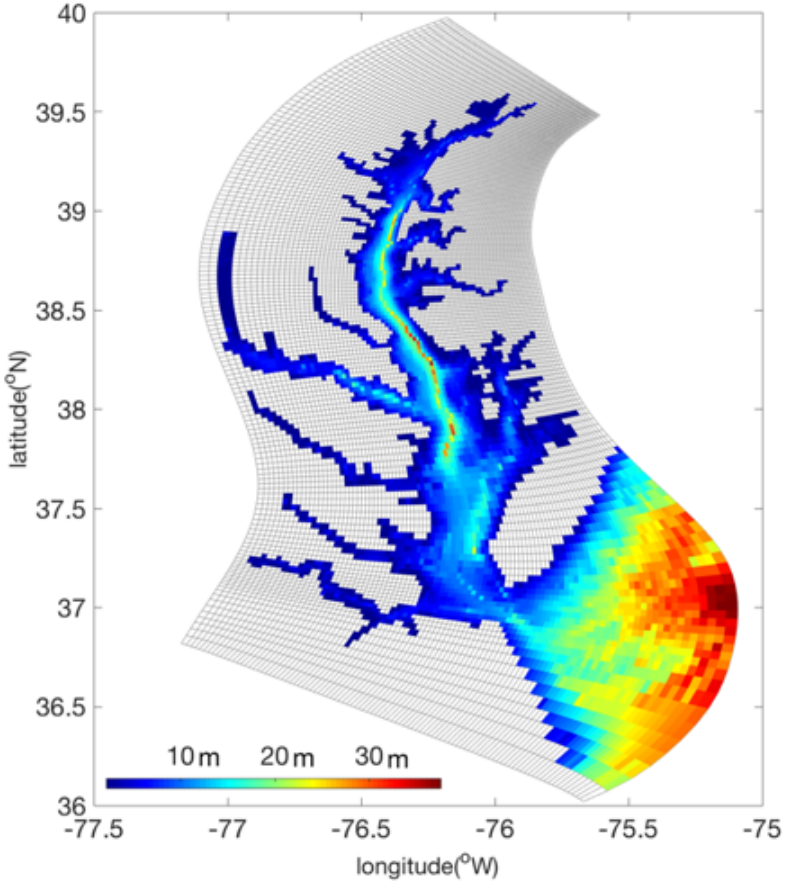
Coastal fluxes

Climatological NOAA data

***Ches*ROMS**

Feng et al., 2015, Da et al., 2018

Chesapeake Bay Environmental Forecast System (CBEFS)



Take average of two hypoxia models in ChesROMS:

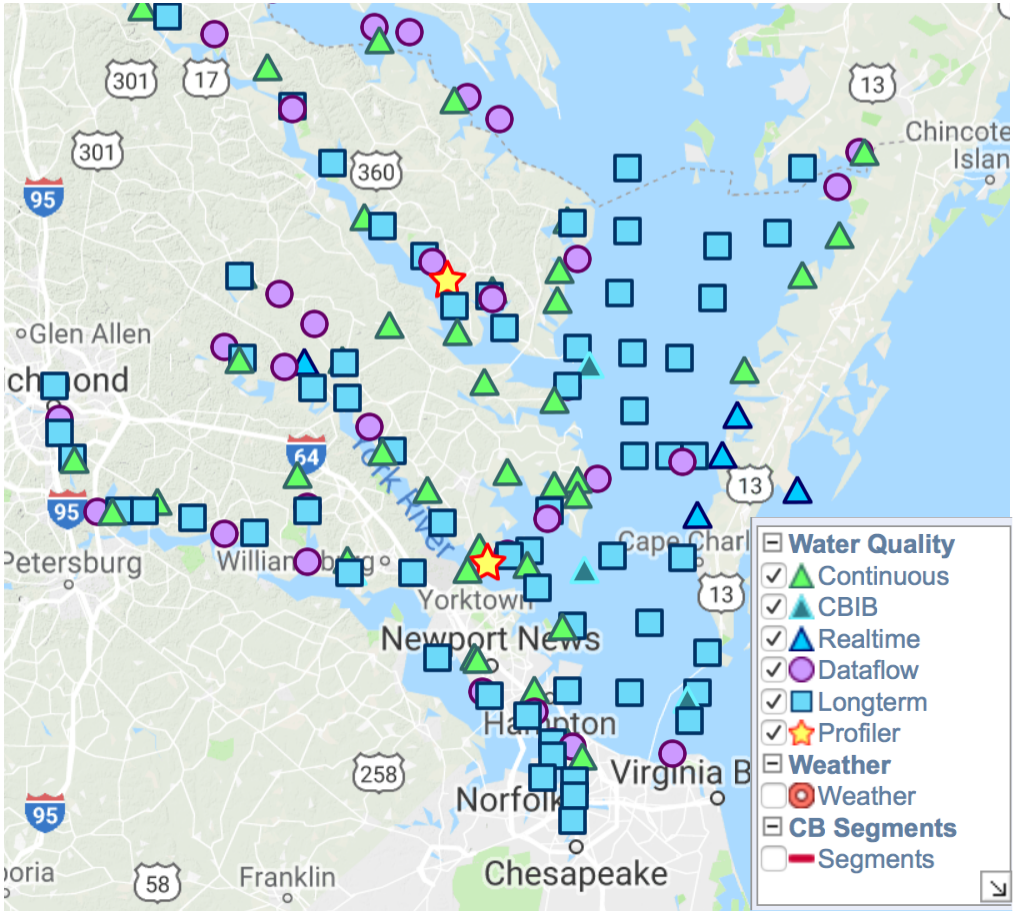
- Simple Respiration Model (SRM, Scully et al. 2013)
- Estuarine Carbon Biogeochemistry model (ECB, Feng et al. 2015)

Model comparisons (Irby et al. 2016) showed these models perform as well as the CBP's Chesapeake Bay model, but average of multiple models performs best

Available Chesapeake Bay data

Evaluated and calibrated extensively with 30+ years of Chesapeake Bay data (~17 cruises/year):

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

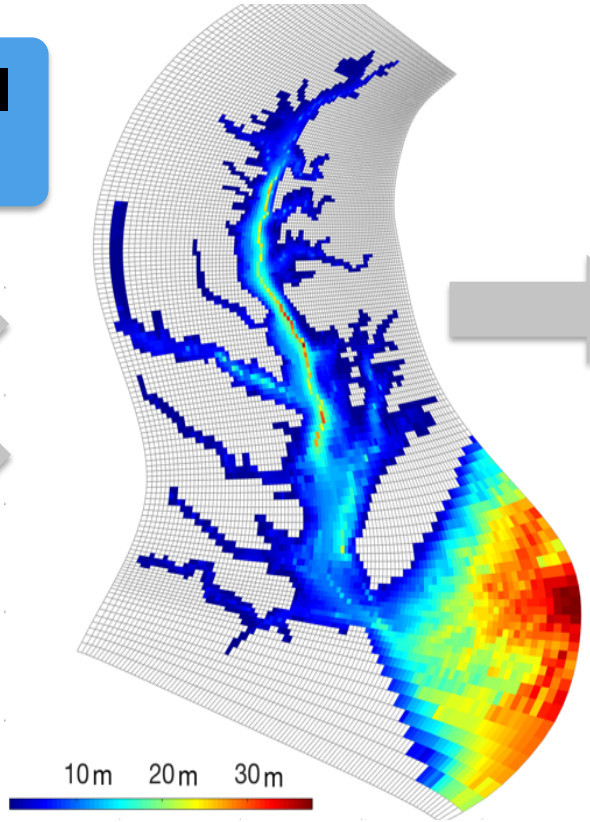


Chesapeake Bay Environmental Forecast System (CBEFS)

Atmospheric forcing

Riverine inputs

Coastal fluxes



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/hypoxia

- Collaboration with IOOS Regional Association (MARACOOS)

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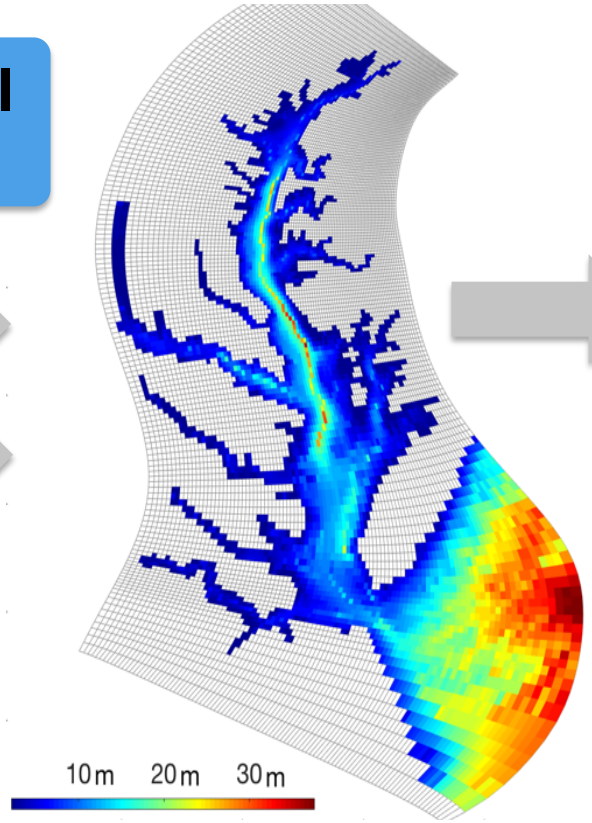

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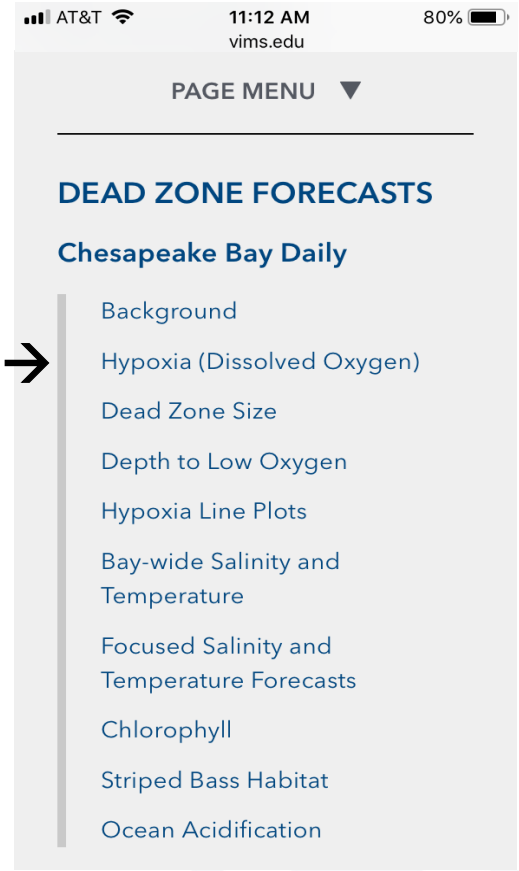
Click here →



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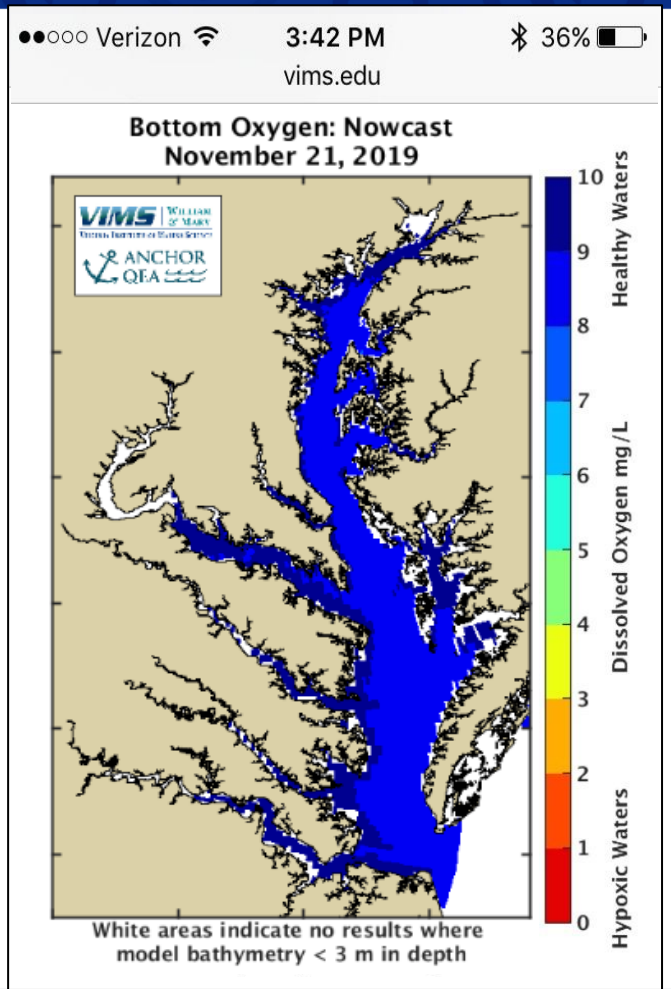

iPhone screenshot of Today's *Nowcast*

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/orange → Very low bottom oxygen
= Bad bottom water
= No bottom fish or crabs

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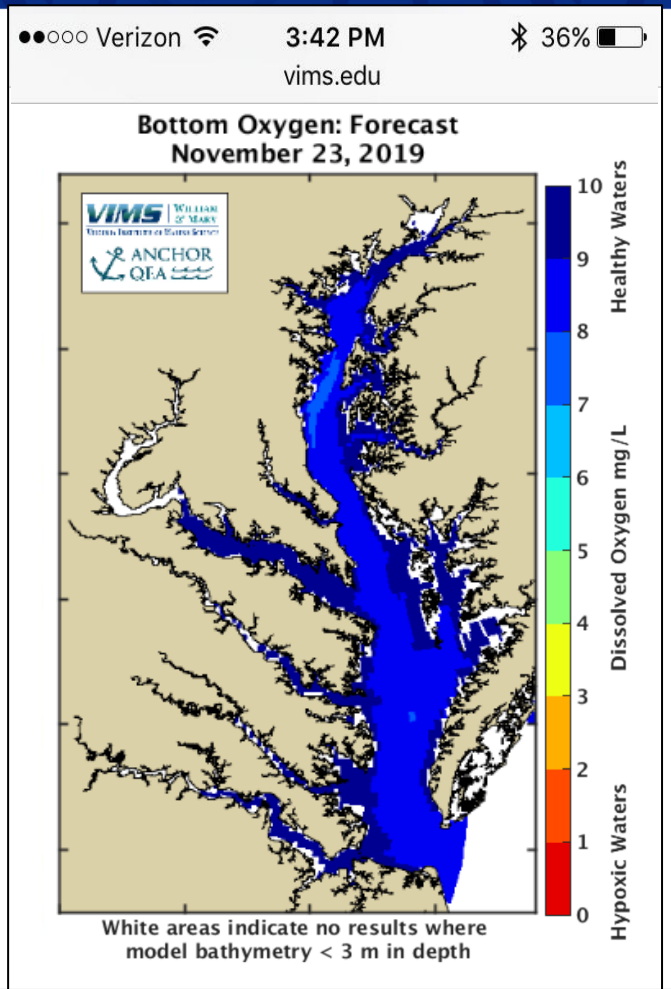

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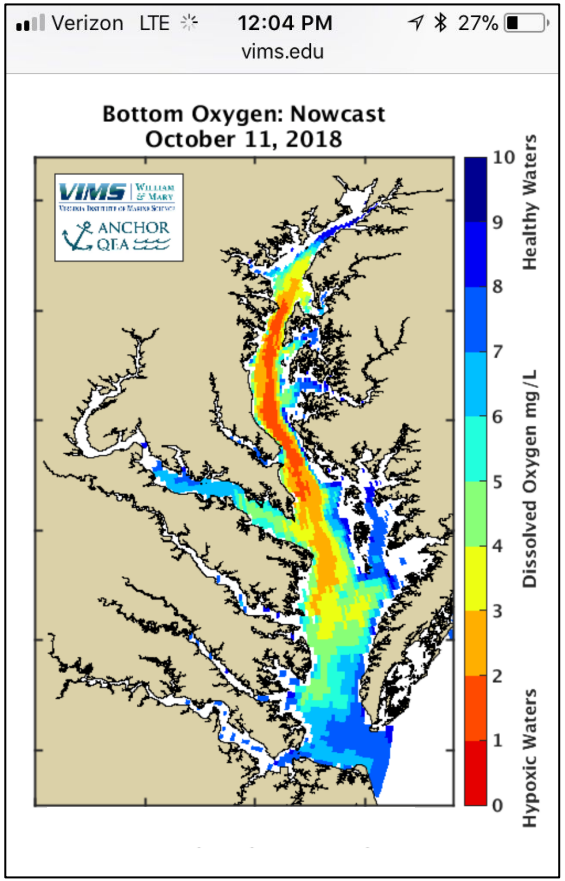
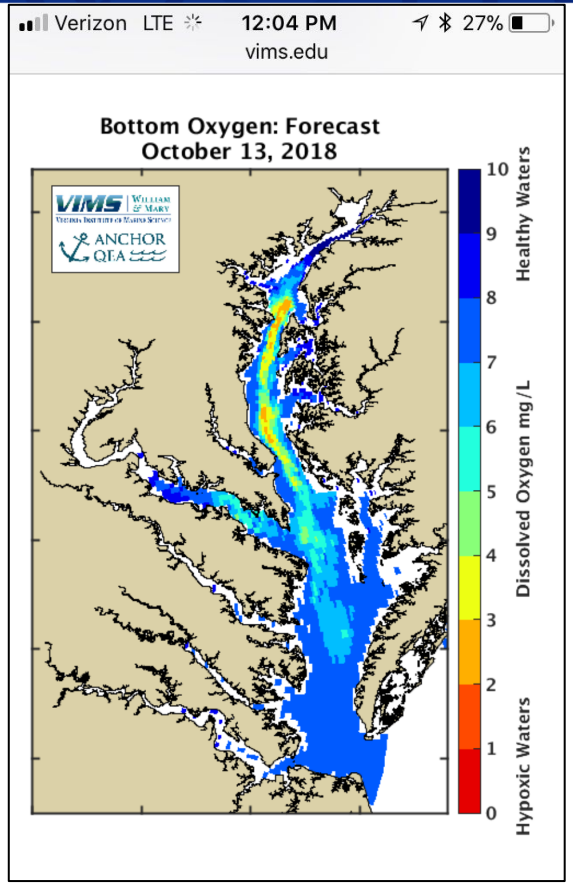


Before "Michael"



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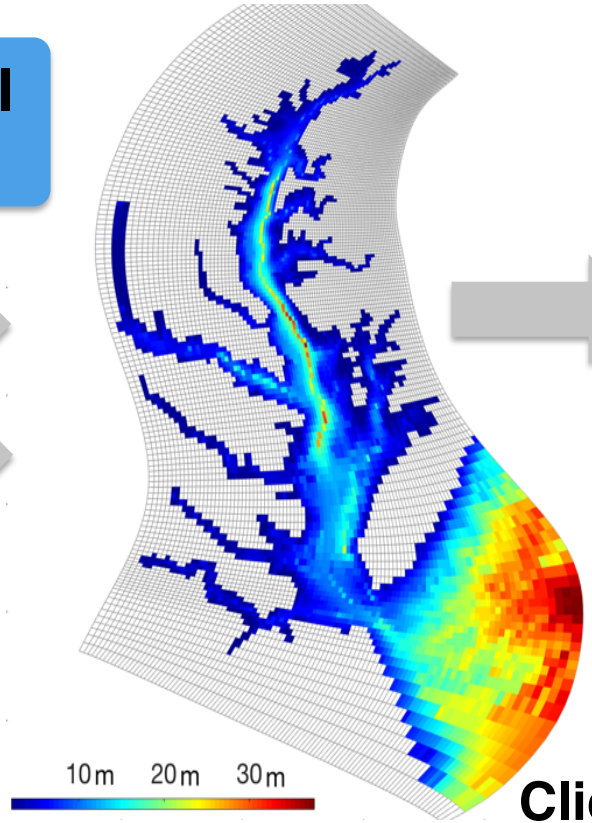

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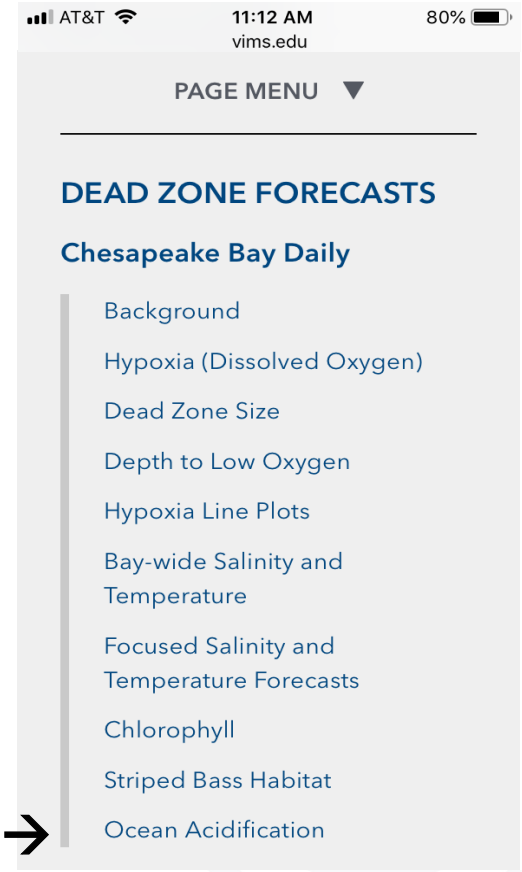
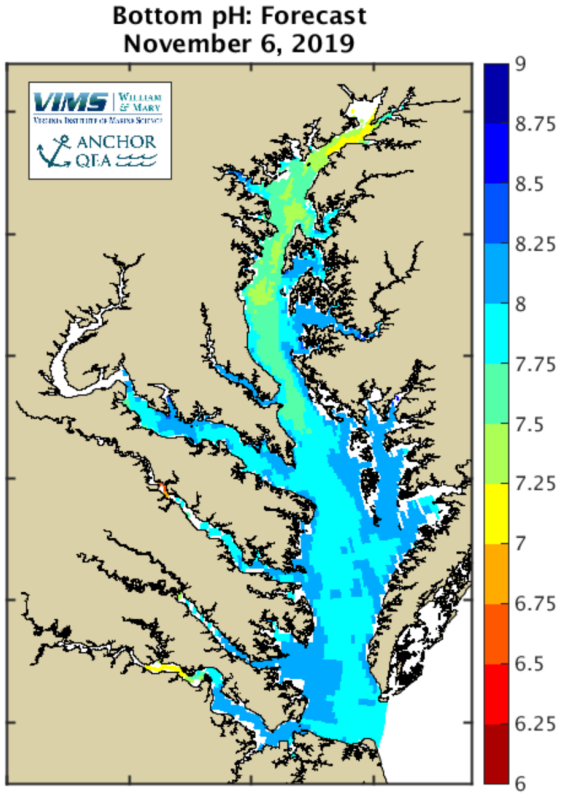
www.vims.edu/hypoxia



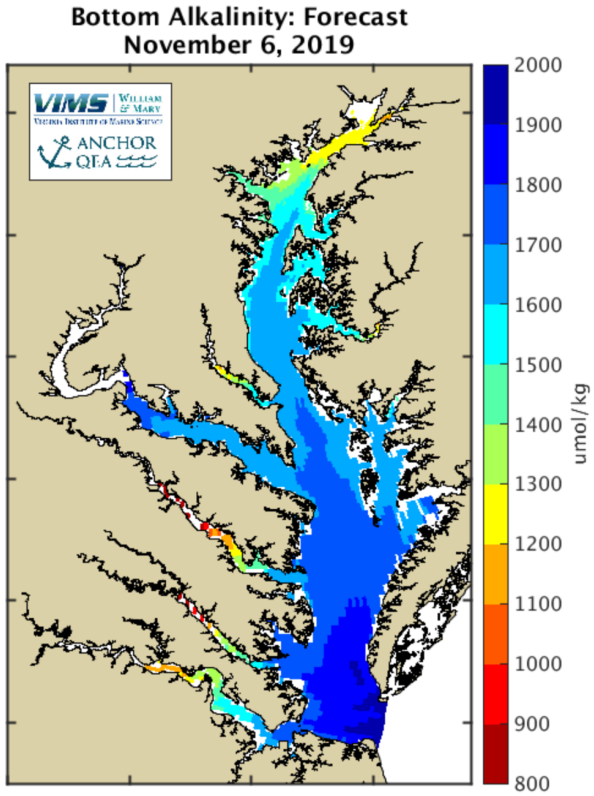
Click here →

Chesapeake Bay Environmental Forecast System (CBEFS)

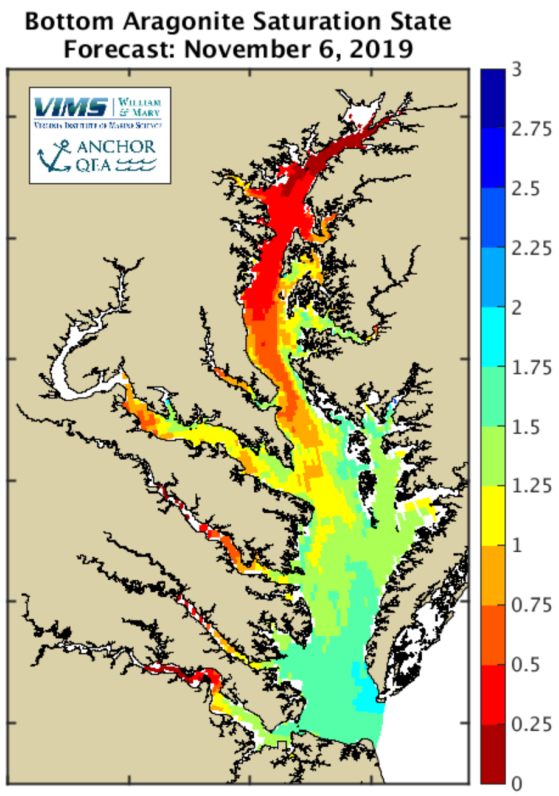
Bottom pH Forecast



Bottom TAlk Forecast



Bottom Ω Forecast



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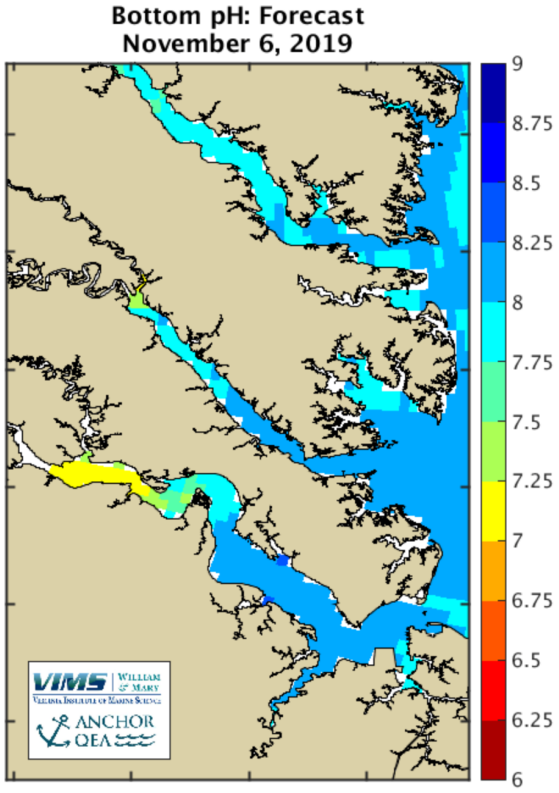

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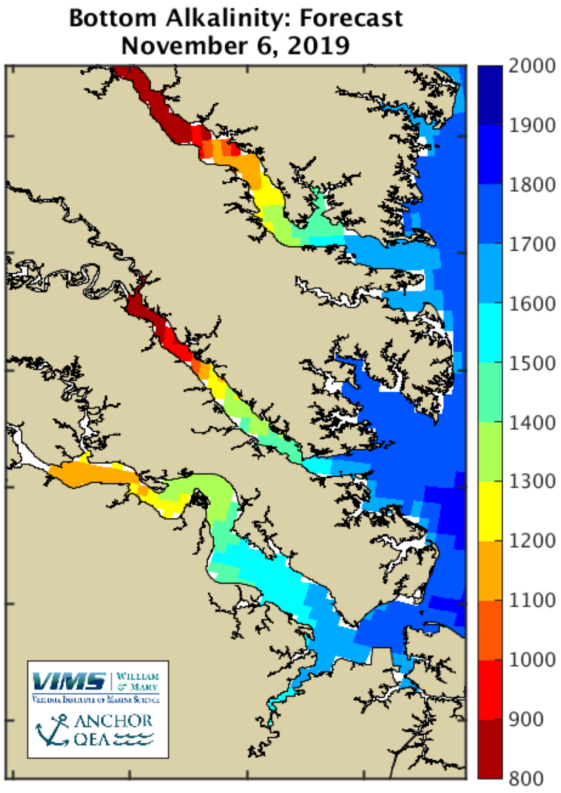

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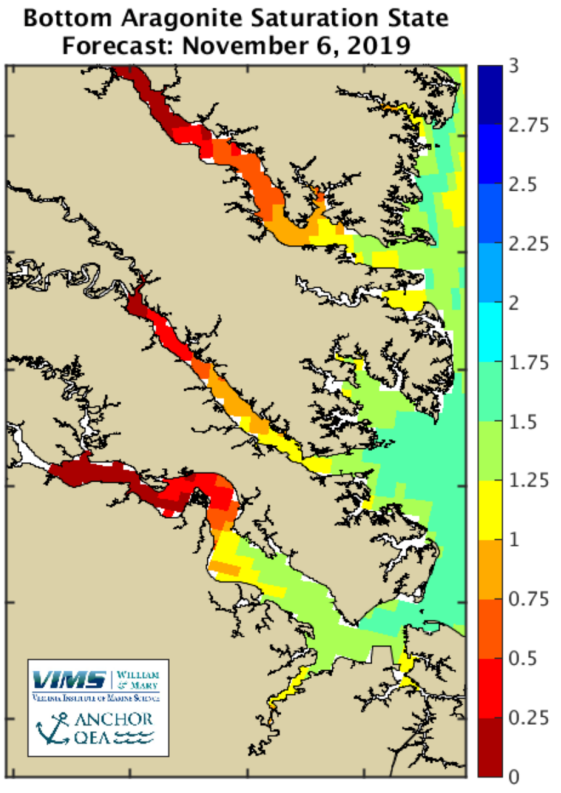

Feedback from Stakeholders:

- Include ocean side of eastern shore
- Include food availability and quality (HABs)
- Show climatological information
- Display depth where 3 mg/L occurs
- Higher resolution in specific areas of interest

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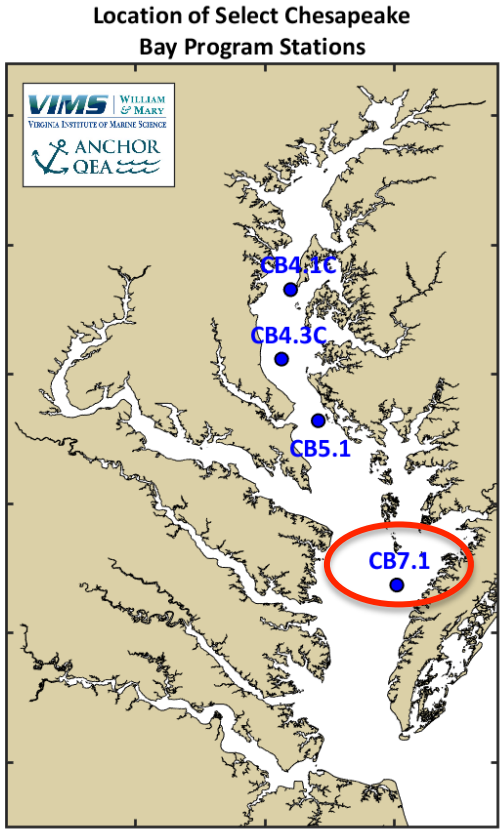
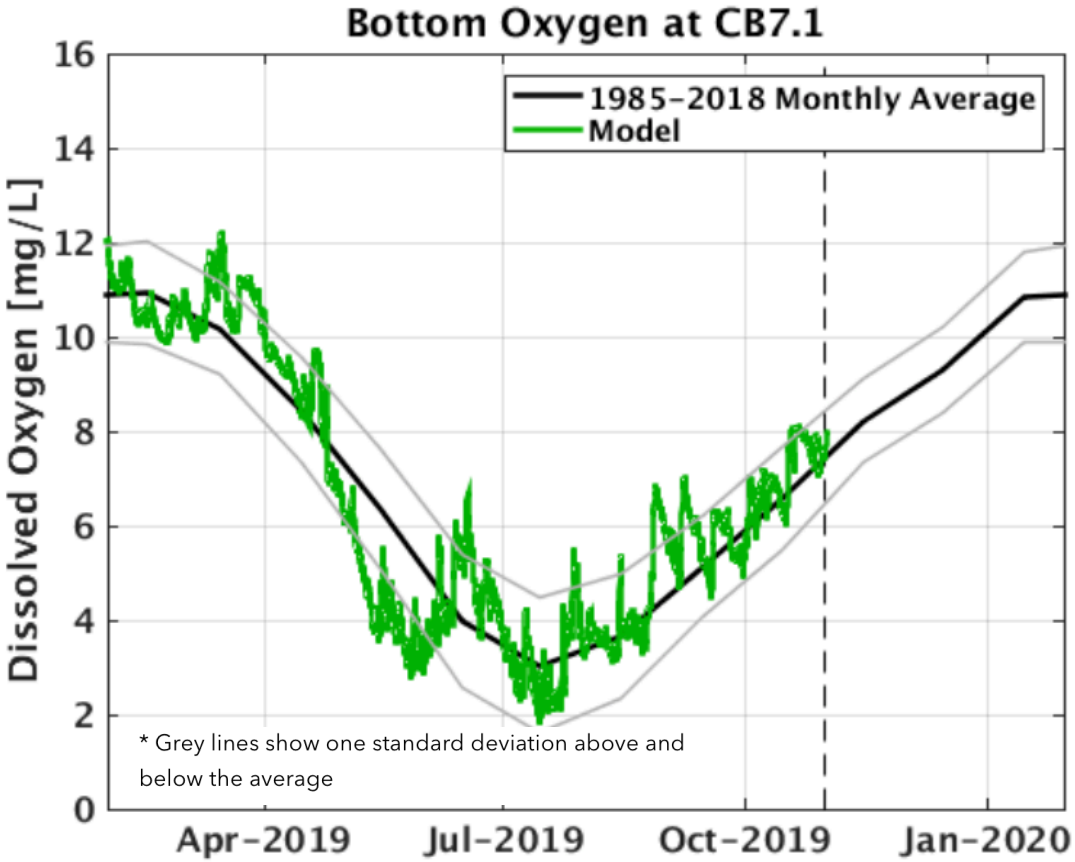
Updates in response to stakeholder feedback





http://www.vims.edu/hypoxia → hypoxia line plot link

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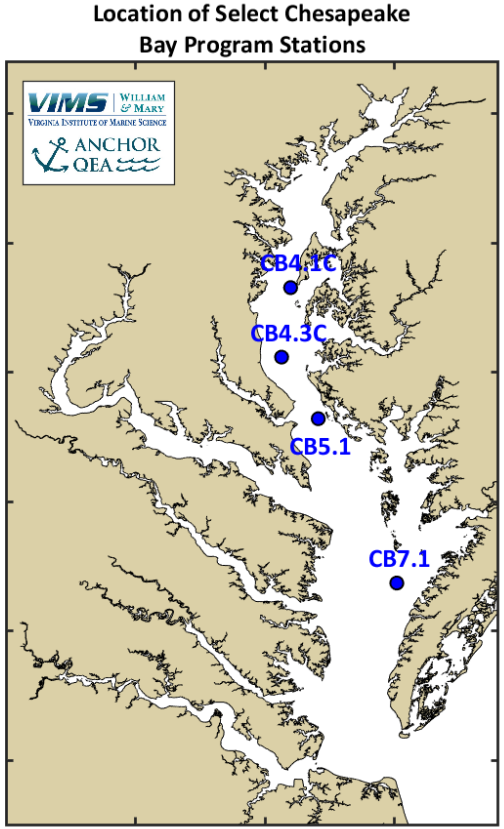

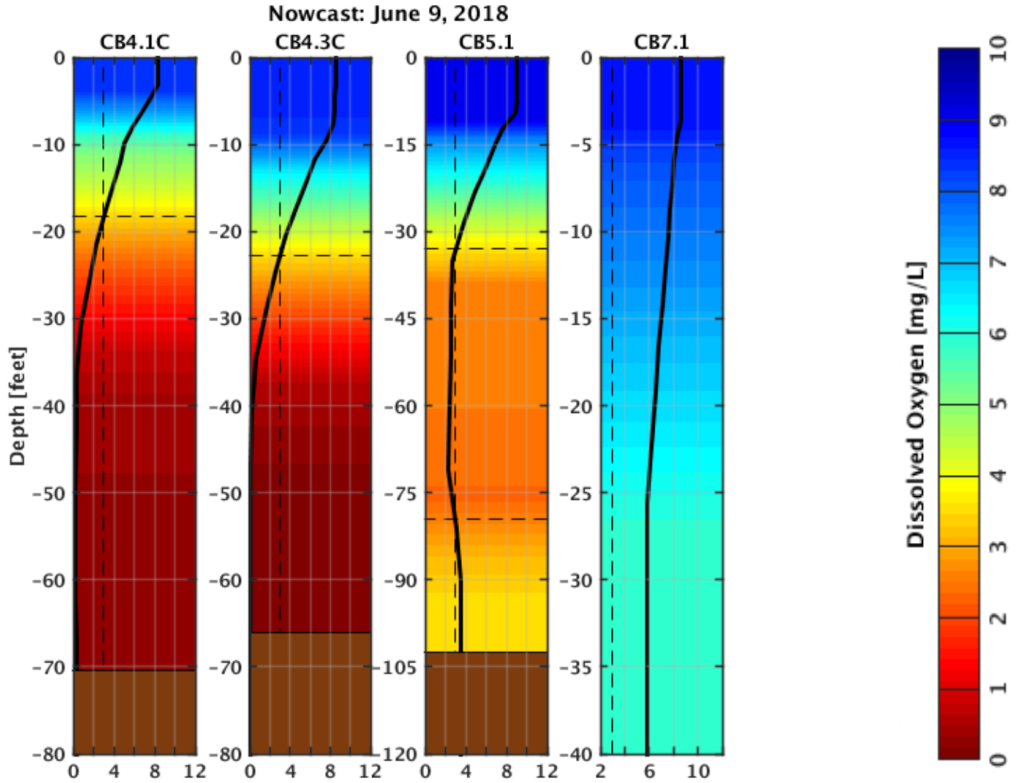

http://www.vims.edu/hypoxia → depth to low oxygen link

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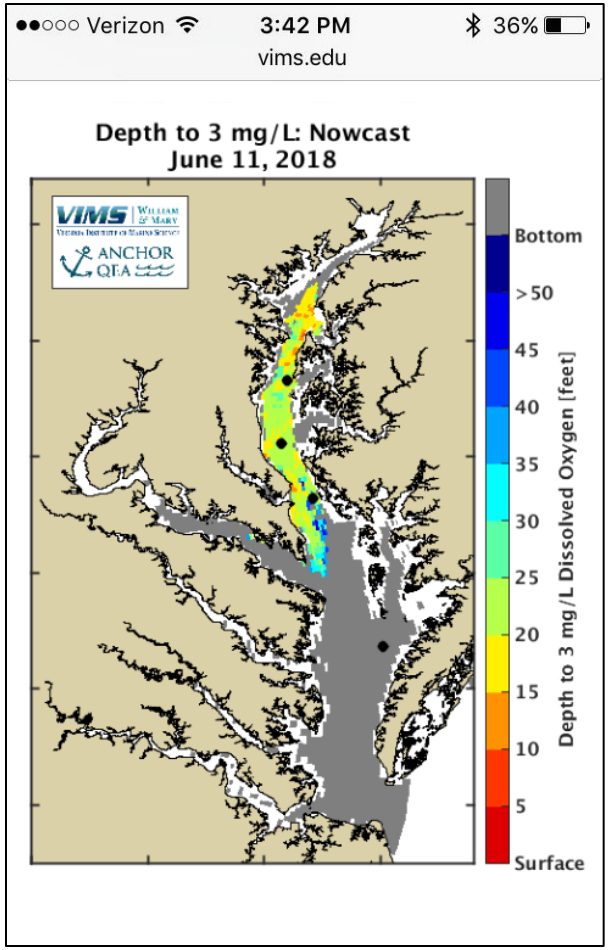
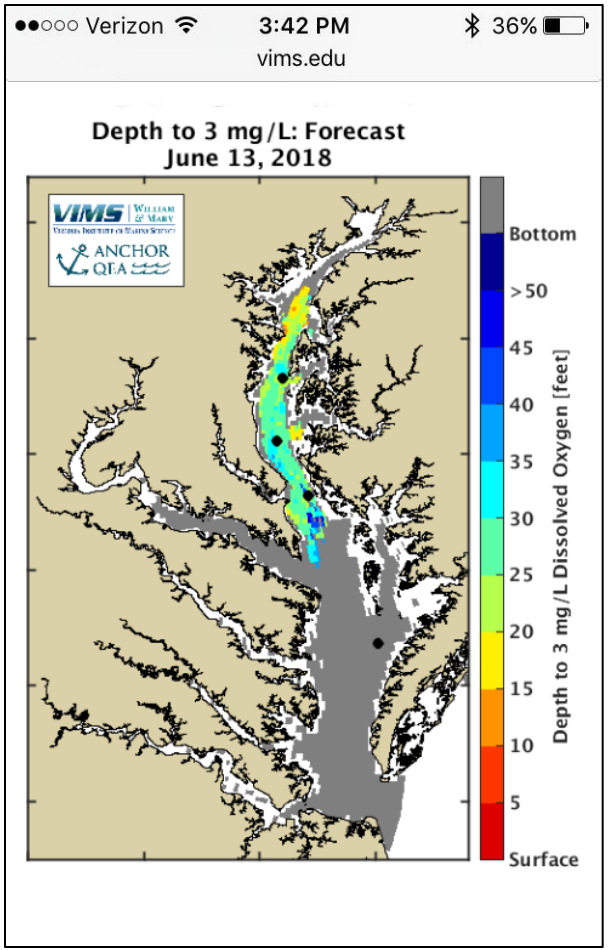




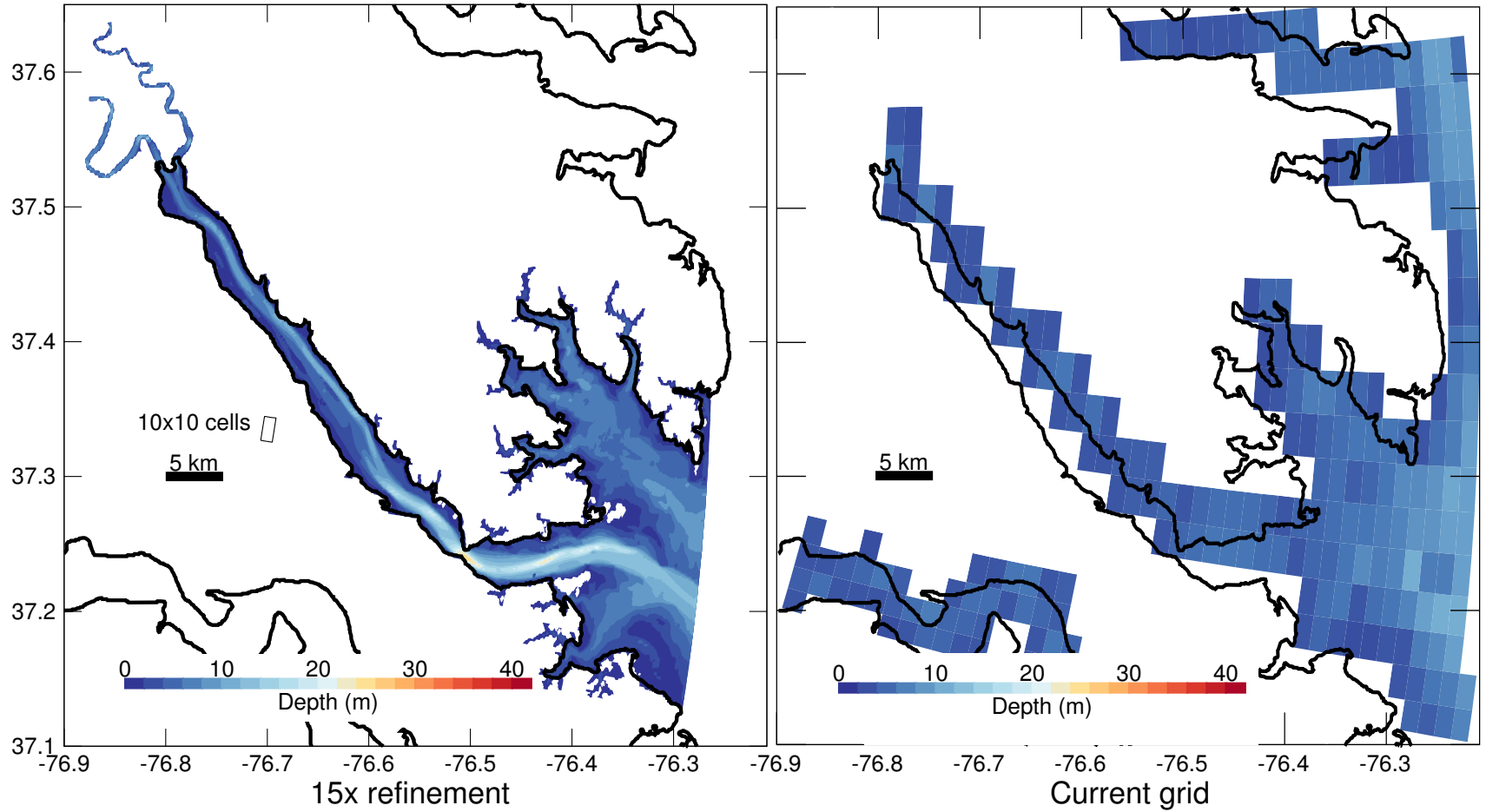
iPhone screenshots From Monday June 11

Monday (6/11)
→ should fish in upper 20-25m

Wednesday (6/13)
→ should fish in upper 30-35m

Dark grey = can fish anywhere in water column

Updates in response to stakeholder feedback



Summary

- Developed(ing!) environmental forecast system for the Chesapeake Bay (CBEFS)
- Forecasts are also posted on the vims.edu/hypoxia and the IOOS MARACOOS OceansMAP portal
- Continue to need input from stakeholders to better understand their needs and priorities
- Continual improvements in CBEFS are needed
    - As more data & computer resources become available
    - As stakeholder needs change

VIMS | William & Mary
Virginia Institute of Marine Science

Anchor QEA

2019 Chesapeake Bay Dead Zone Report

November 2019

2019 Chesapeake Bay Hypoxia Score

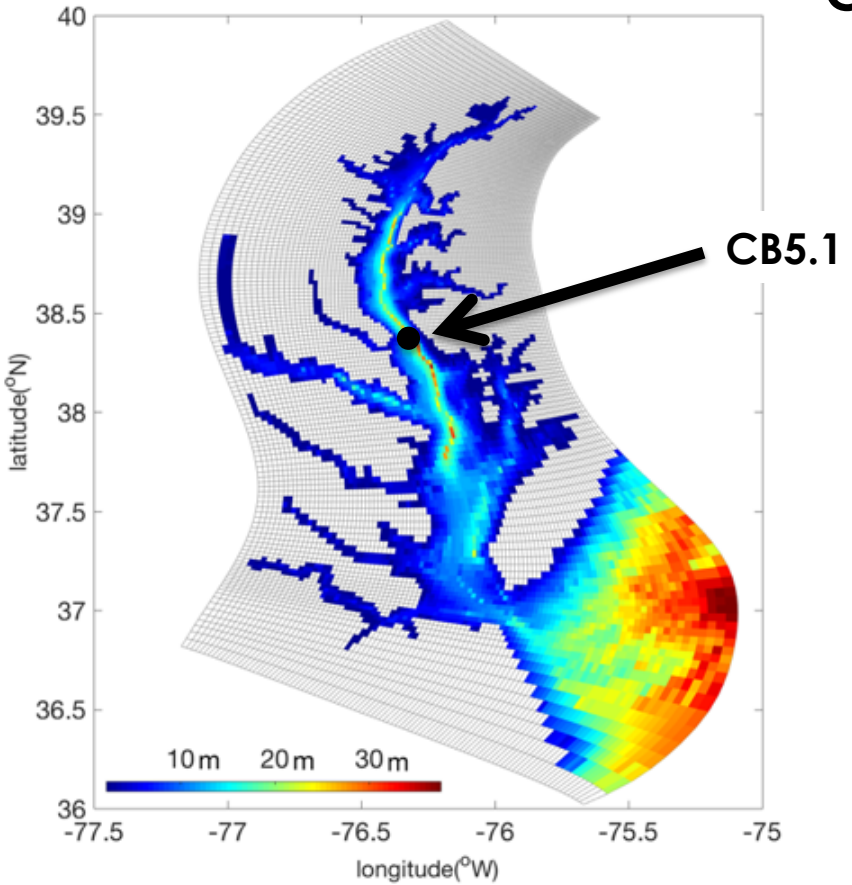
The Virginia Institute of Marine Science[b] and Anchor QEA operate a real-time three-dimensional hypoxia forecast computer model that predicts daily dissolved oxygen concentrations throughout the Bay (www.vims.edu/hypoxia). The metrics listed above were estimated for 2019 from this forecast model; for reference, the same statistics have also been generated for historical years (**1985-2018**).

In 2019:

- **Maximum daily hypoxic volume was greater than 79% of historical years**
- **Summer average hypoxic volume was greater than 74% of historical years**
- **Duration of hypoxia was greater than 82% of historical years**
- **Total annual hypoxic volume was greater than 74% of historical years**

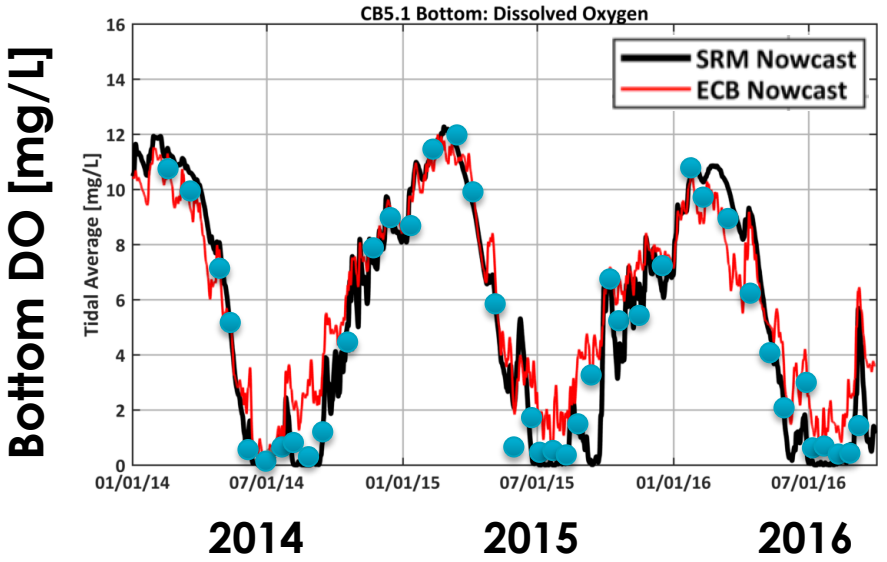
Extra Slides

Methods – Hypoxia forecast model



Comparison to CBP WQ Mon. Data:

Observed SRM ECB



- Averaging output from multiple Bay models reproduced oxygen observations best (Irby et al. 2016)