COMT
Chesapeake Bay Hypoxia Modeling

VIMS: Marjy Friedrichs (lead PI)
Carl Friedrichs (VIMS-PI)
Ike Irby (funded student)
Dave Forrest (VIMS-PI)
Aaron Bever (consultant/ Anchor QEA)

UMCES: Raleigh Hood (UMCES-PI)
Hao Wang (funded student)

WHOI: Malcolm Scully (WHOI-PI)

Other Collaborators: Jian Shen (VIMS), Wen Long (PNNL), Jeremy Testa (UMCES), Meng Xia (UMCES)

Federal Partners:

NOAA-CSDL: Lyon Lanerolle (NOAA-PI), Frank Aikman

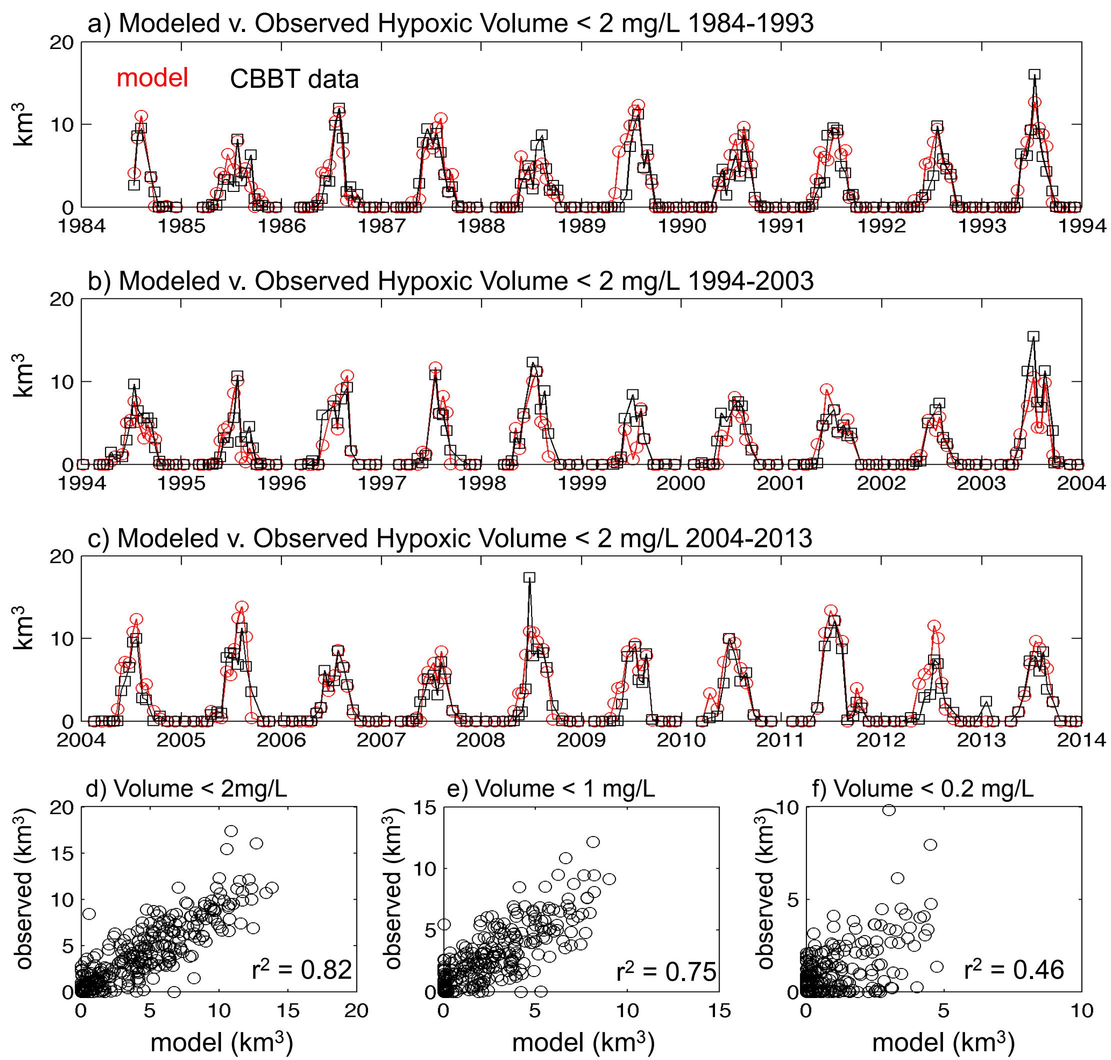
EPA-CBP: Lewis Linker, Gary Shenk

NOAA NOS/CO-OPS Transition Partner: Pat Burke

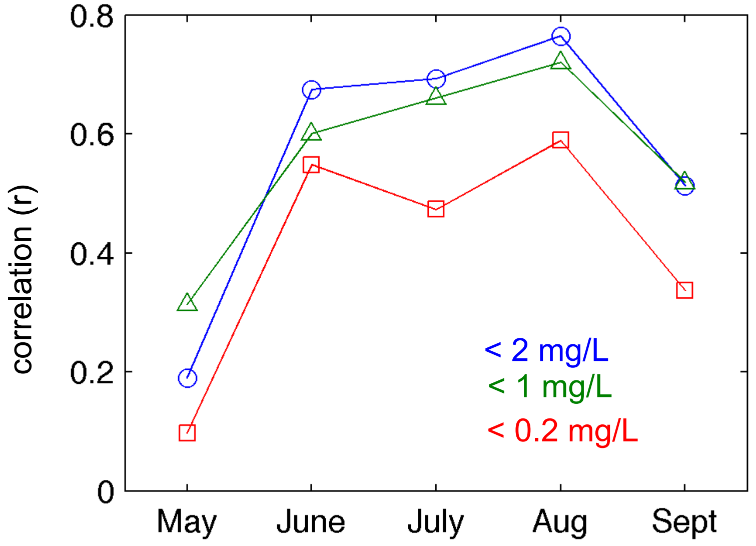
Outline

- Model hindcast skill and comparisons
  - Irby et al., BG, 2016 – comparison of 8 models for 2004-2005
  - Scully, L&O, 2016
- Model skill with hindcast vs. nowcast forcing
- Short-term operational forecasts
  - Hypoxia-SRM in ROMS Ecosystem Branch/Trunk
  - Identify end-users/stakeholders
- Scenario-based operational forecasts: EPA nutrient reduction strategies

Results from 1-term model, 30-year simulation



Correlation between 1-term model and observations of hypoxic volume by month (1984-2013)

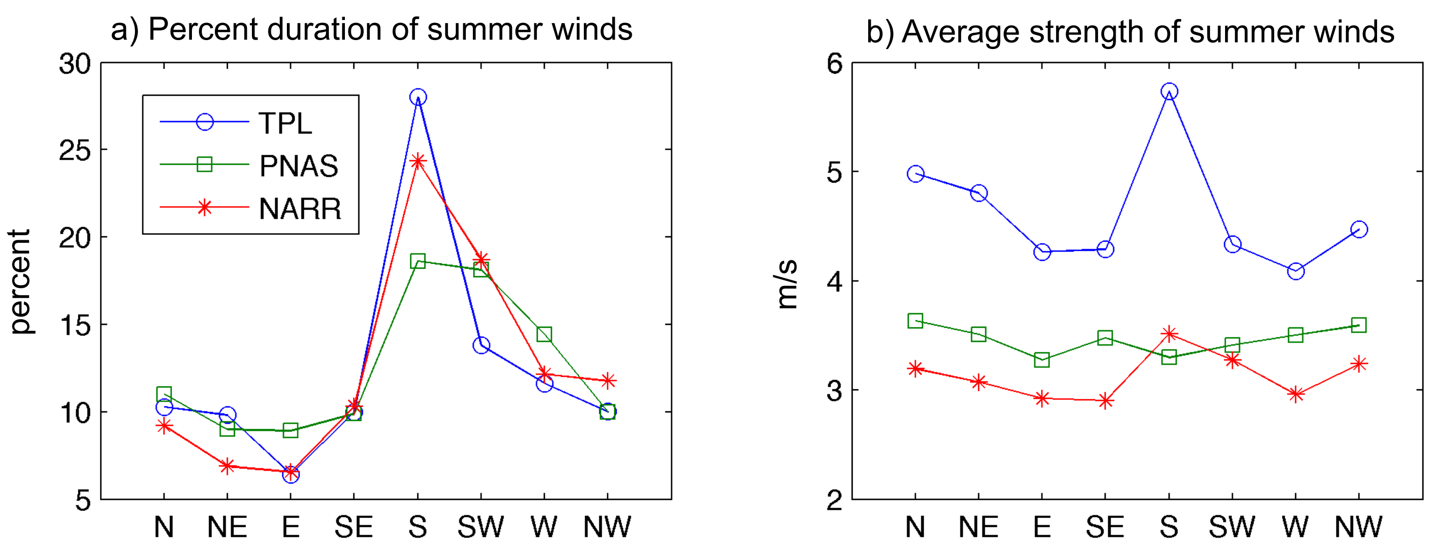


Model with no biological variability can explain over half the variance in hypoxic volume for July and August for the period 1984-2013.

Most Important variables to inter-annual variations in hypoxia

	CBBP Data			Model		
	Jan-June Susquehanna Discharge	Jan-June Susquehanna Nitrogen Load	June-August Wind Speed (TPL)	Jan-June Susquehanna Discharge	Jan-June Susquehanna Nitrogen Load	June-August Wind Speed (NARR)
< 2 mg/L	**0.67**	**0.61**	**-0.48**	**0.58**	**0.56**	**-0.76**
< 1 mg/L	**0.74**	**0.66**	**-0.42**	**0.58**	**0.55**	**-0.74**
< 0.2 mg/L	**0.81**	**0.86**	-0.14	**0.51**	**0.53**	**-0.67**

Importance of Accurate Winds

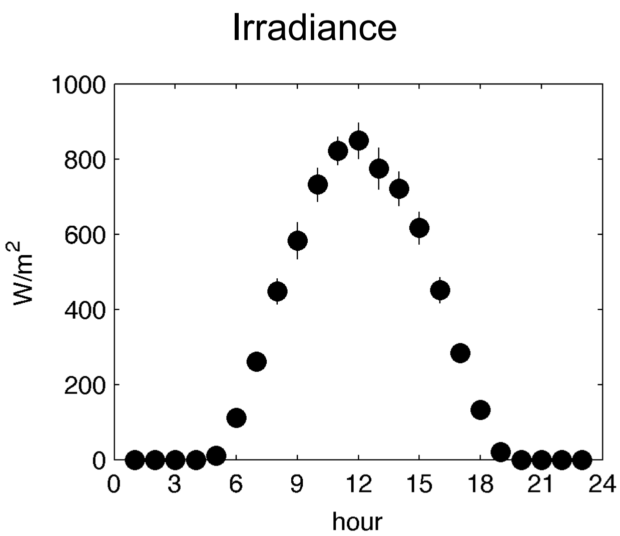


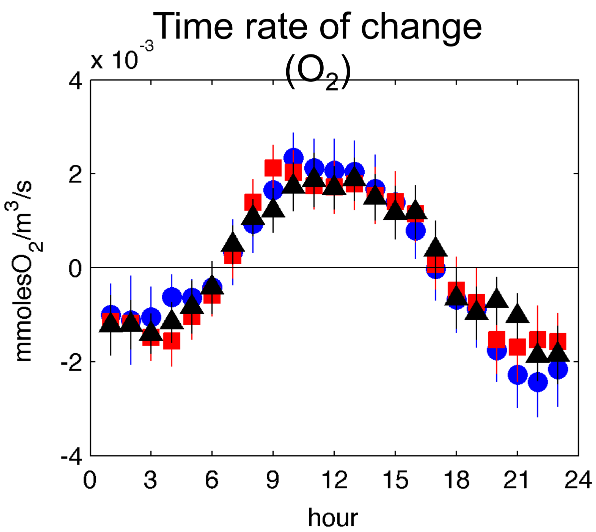
Importance of Accurate Winds (cont)

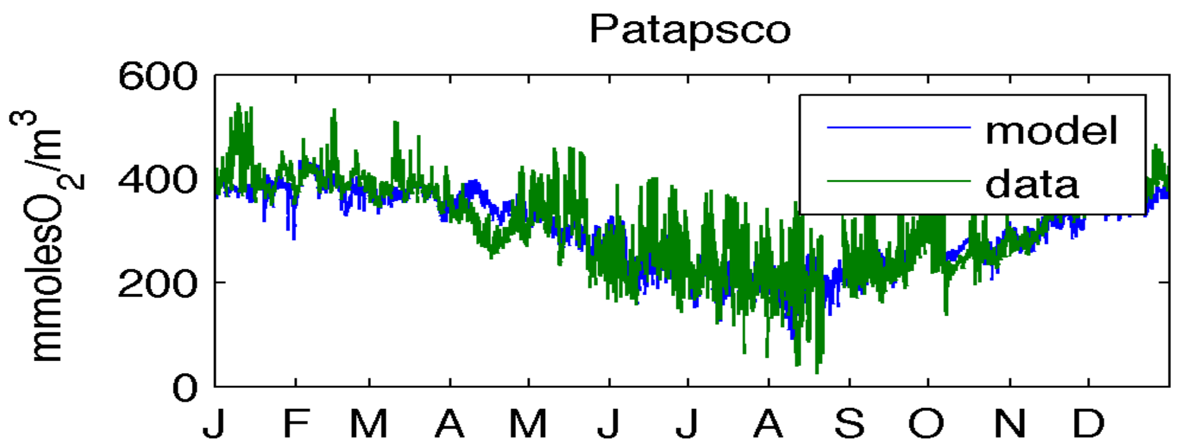
Table 4. Correlation coefficient (*r*) between mean summer (June–August) wind speed measured at various stations around Chesapeake Bay and the NARR model. Stations where wind speed is measured over water include Cove Point LNG pier (COV), YRL, RPL, CBBT, and TPL. Winds at PNAS are not measured over water. Data from the NARR model are taken from the grid location nearest TPL. The duration of available measurements is indicated for each station and correlations are based on available data. Bold font is used to highlight negative correlations.

COV (2007–2013)	YRL (2006–2013)	RPL (2005–2013)	CBBT (2007–2013)	TPL (1986–2013)	NARR (1984–2013)	
0.31	**−0.07**	**−0.28**	**−0.24**	0.24	0.51	PNAS (1984–2013)
	0.84	0.67	0.68	0.63	0.85	COV (2007–2013)
		0.86	0.80	0.81	0.81	YRL (2006–2013)
			0.69	0.81	0.68	RPL (2005–2013)
				0.55	0.44	CBBT (2007–2013)
					0.59	TPL (1986–2013)

Year 4 Future Work







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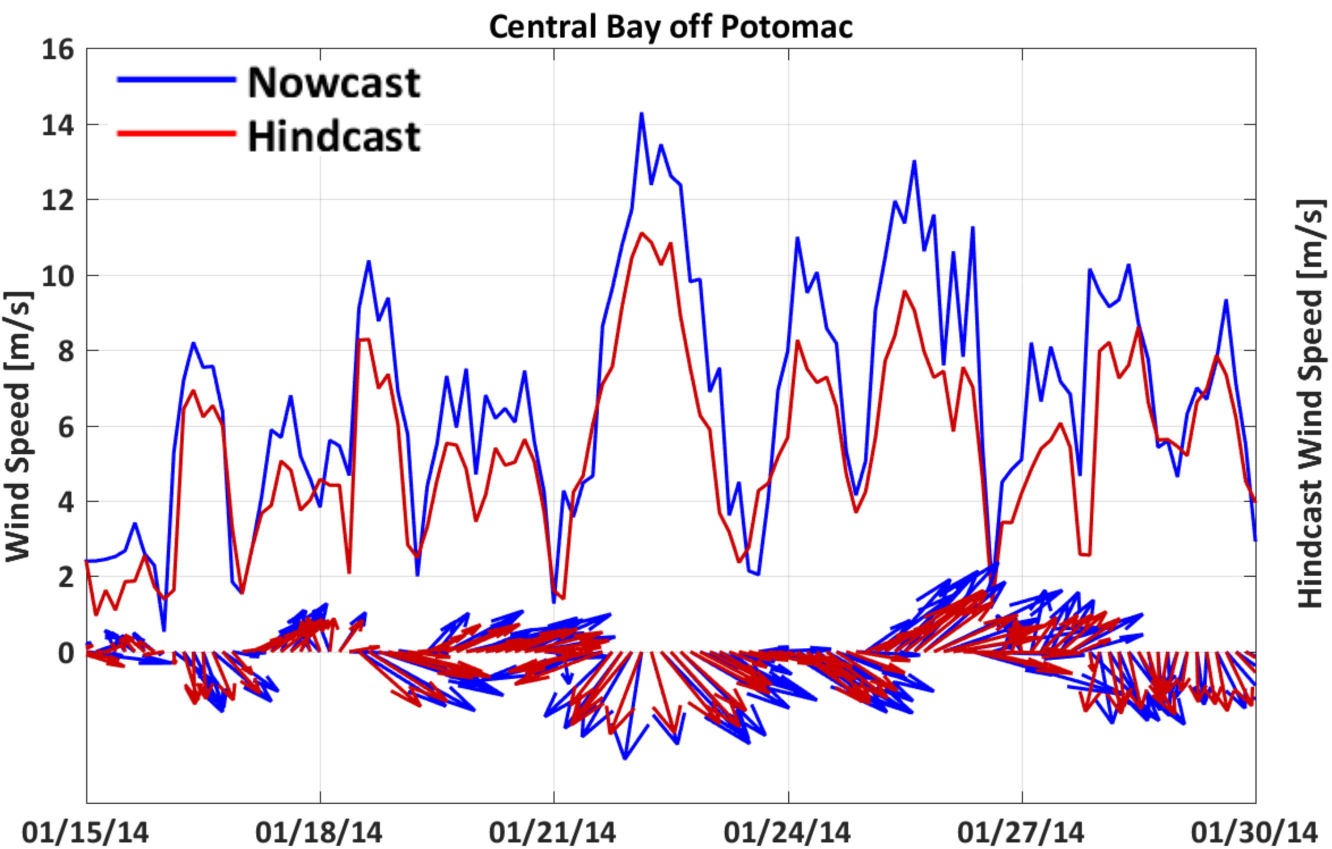
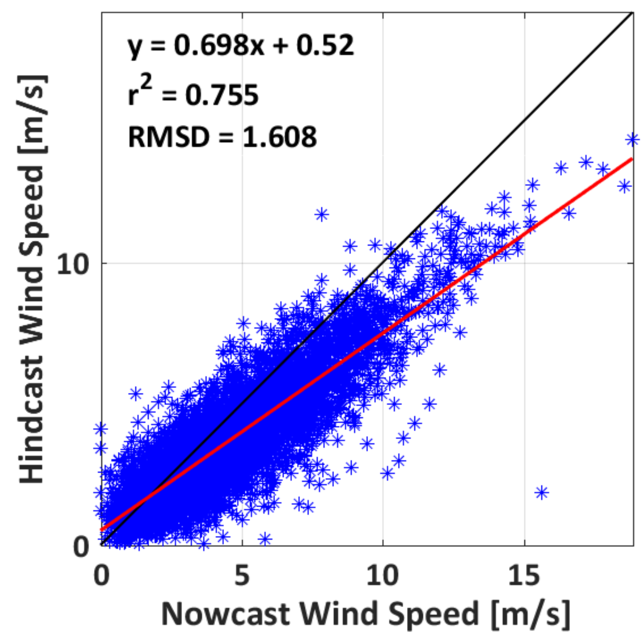
Skill of nowcasts vs. hindcasts

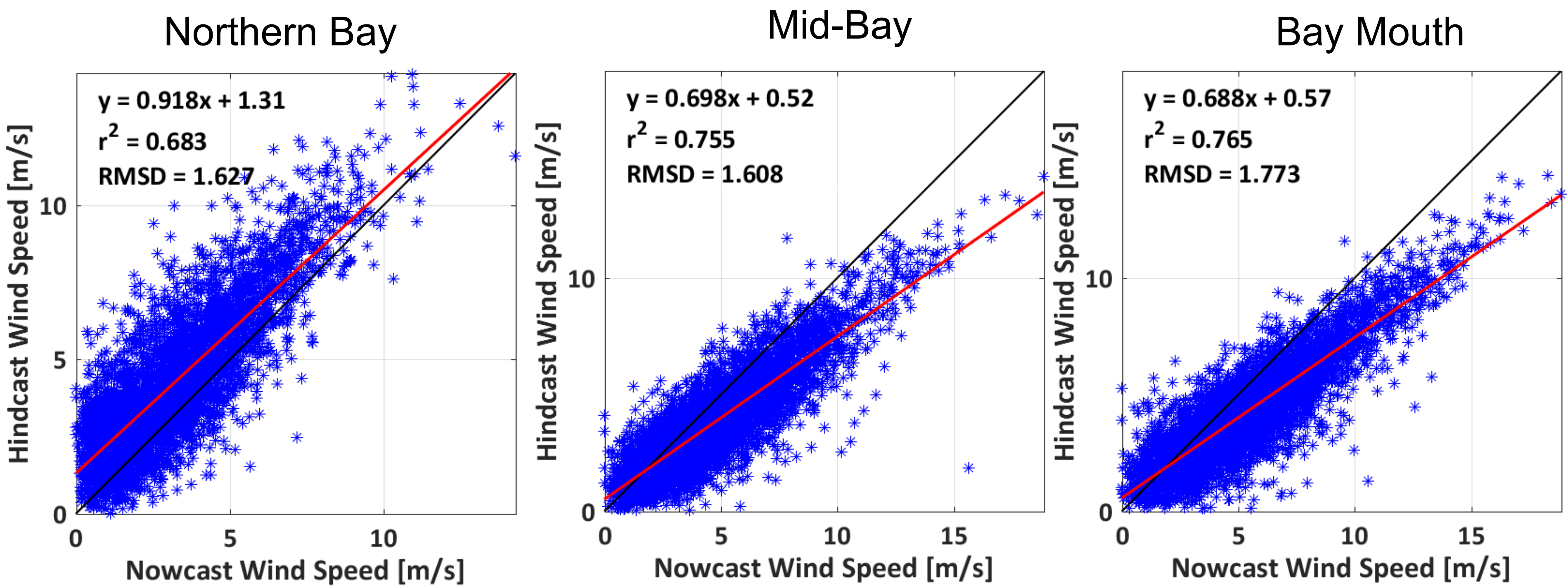
Nowcast forcing (CBOFS) = NAM (3 hour; 4 km)
Hindcast forcing (ChesROMS) = NARR (3 hour; 32 km)



1/2014 – 8/2015



Skill of nowcasts vs. hindcasts

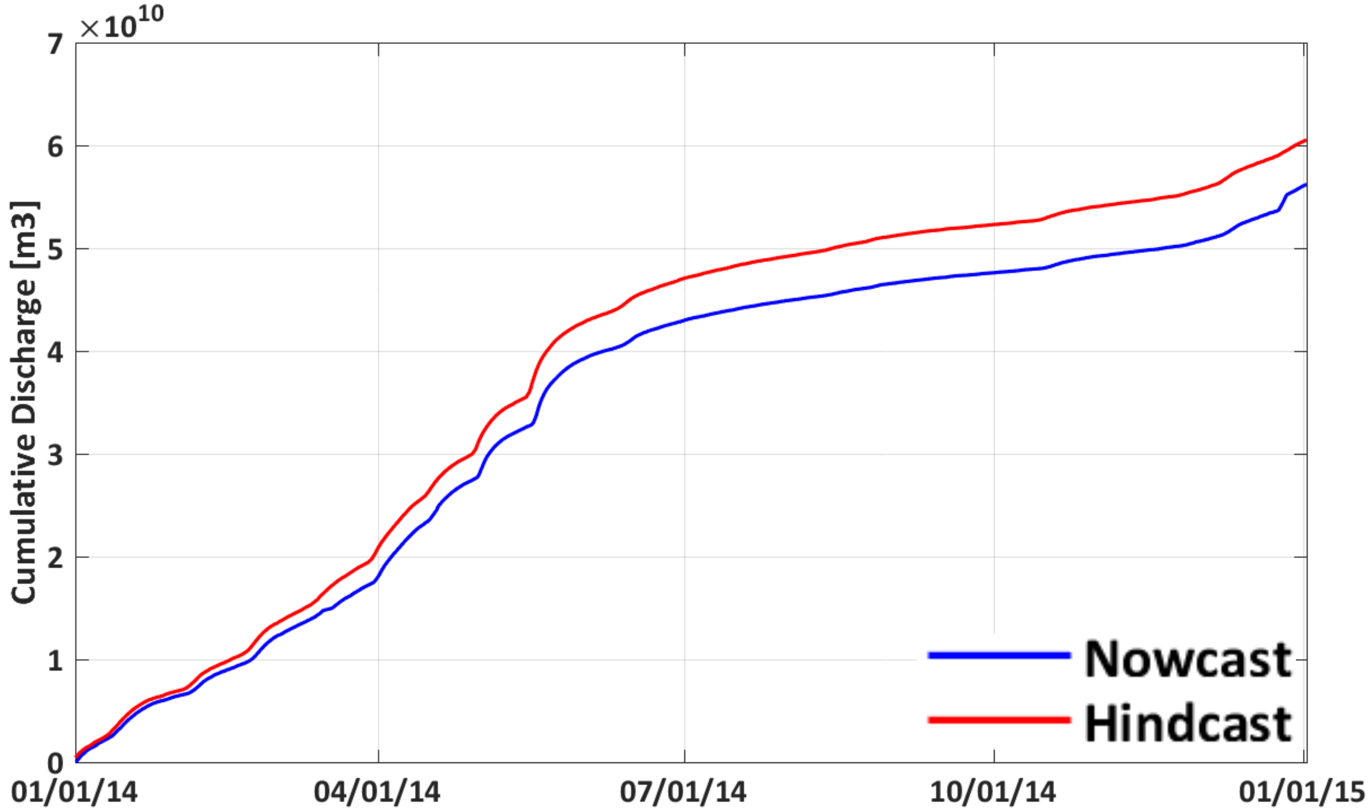


Nowcast (NAM) **winds** are **higher**, except in northern Bay

Skill of nowcasts vs. hindcasts

Nowcast forcing (CBOFS) = USGS gauges + scaling factors
Hindcast forcing (ChesROMS) = USGS gauges + scaling factors

River discharge



Mean **nowcast** river discharge is **lower**, due to different scaling factors

Skill of nowcasts vs. hindcasts

Nowcast forcing (1/2014 – 8/2015):

Stronger winds
Smaller freshwater inputs (rivers and no precipitation/evaporation)

Hindcast forcing (1/2014 – 12/2015):

Weaker winds
Larger freshwater inputs

Four model simulations with hypoxia-SRM (1term):

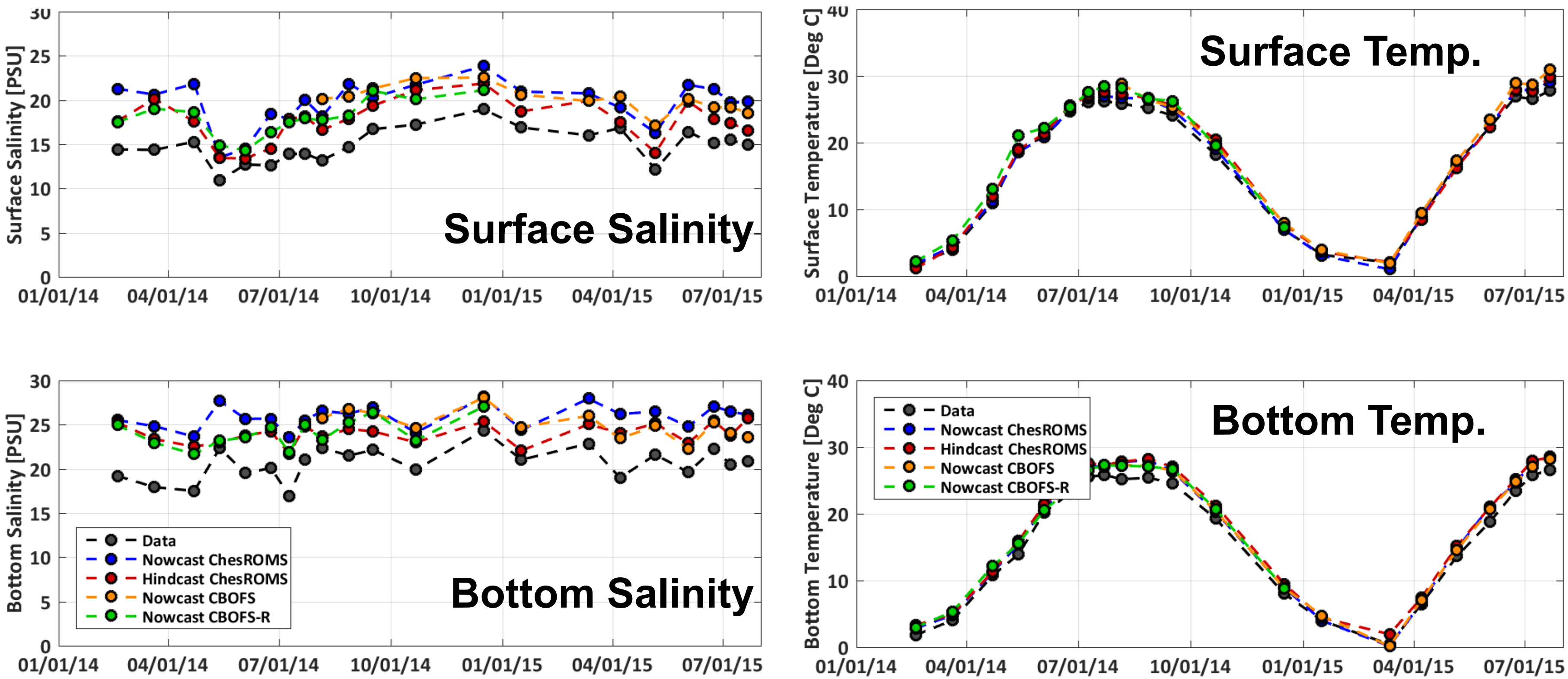
Nowcast ChesROMS (1/14-8/15)
Hindcast ChesROMS (1/14-12/15)
Nowcast operational CBOFS* (8/14-8/15)
Nowcast research CBOFS (1/14-1/15)

Nowcast ChesROMS
Hindcast ChesROMS
Nowcast CBOFS
Nowcast CBOFS-R

* No oxygen results yet

Skill of nowcasts vs. hindcasts

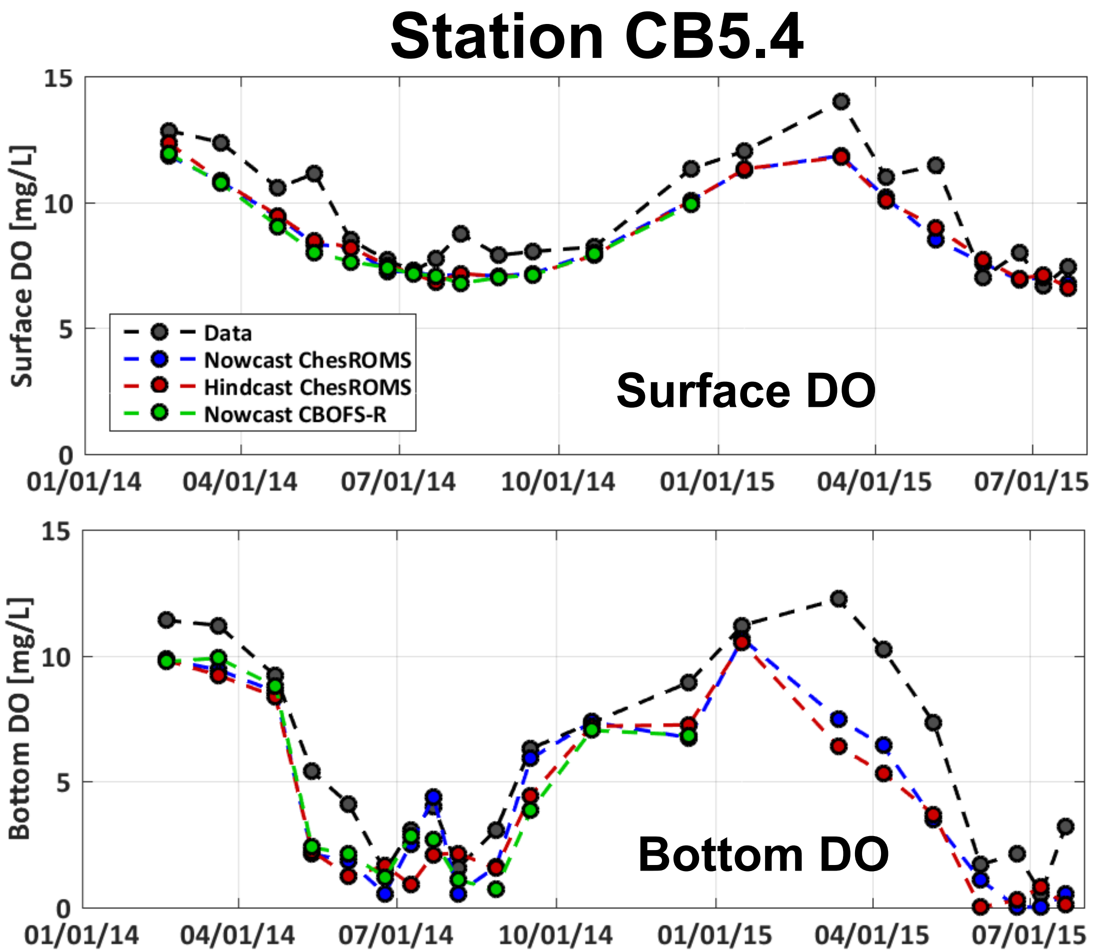
Station CB5.4



Temperature – all simulations are similar; slightly too warm in summer

Salinity – more difference between simulations; all too salty, but hindcast is better

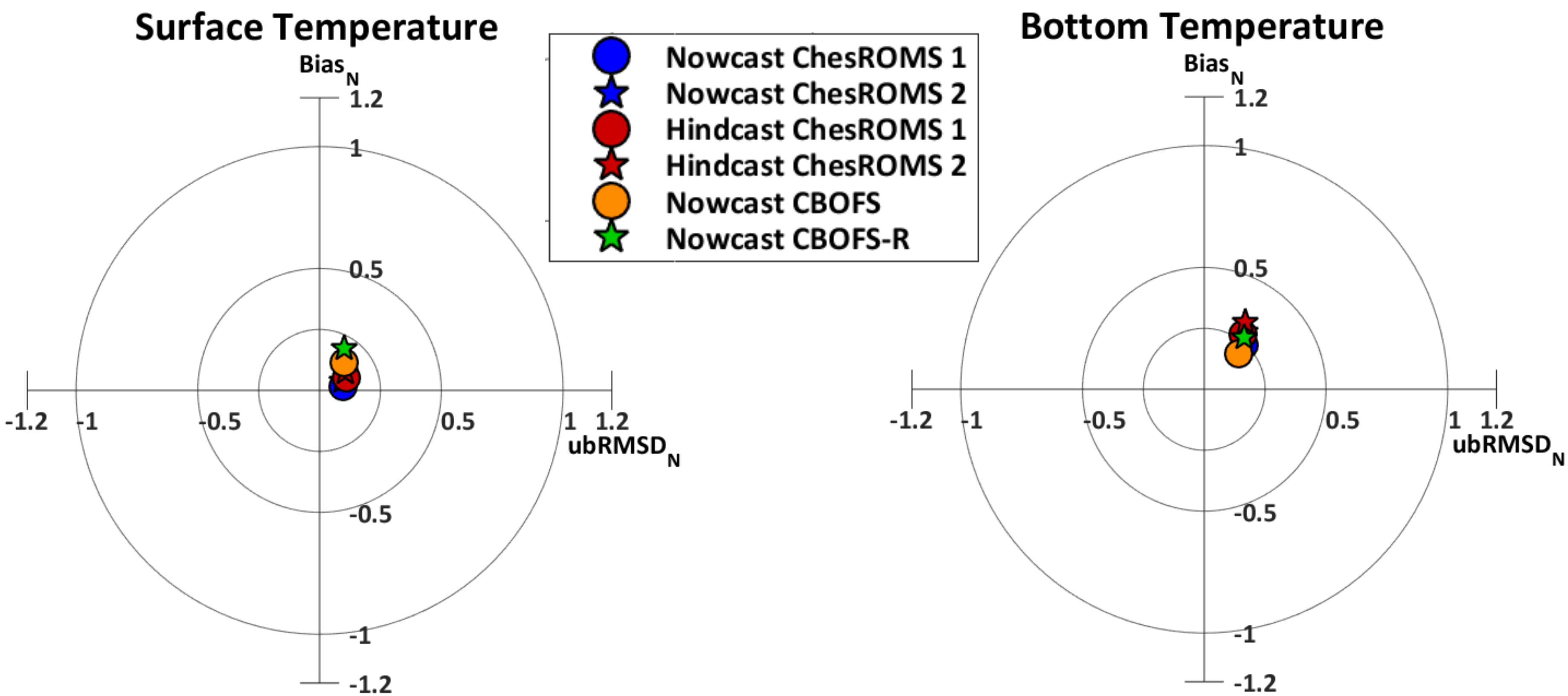
Skill of nowcasts vs. hindcasts



Surface – nearly identical; all too low (missing high production events)
Bottom – more difference between simulations; all too low DO, but nowcast better

Skill of nowcasts vs. hindcasts

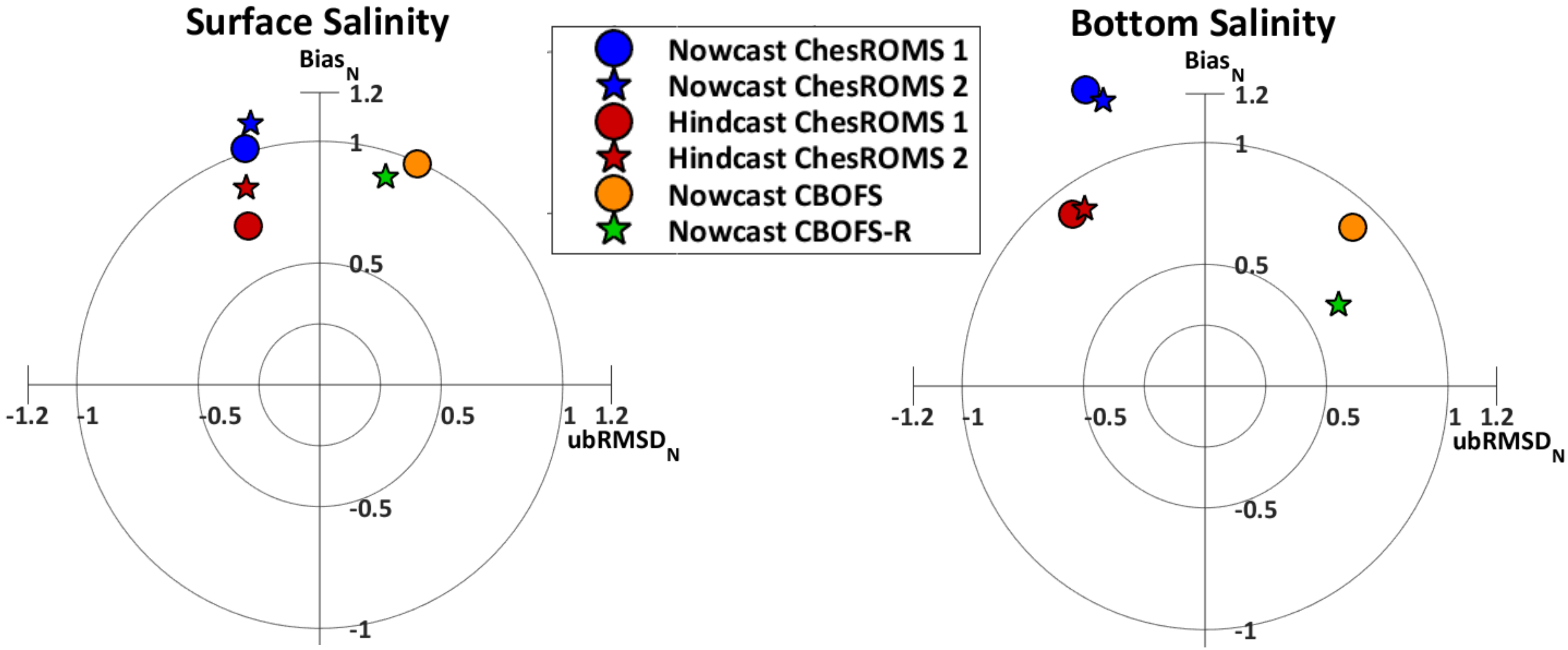
Temperature (13 stations)



All models do similarly well for temperature, independent of time period (shape) and model/forcing (color)

Skill of nowcasts vs. hindcasts

Salinity (13 stations)

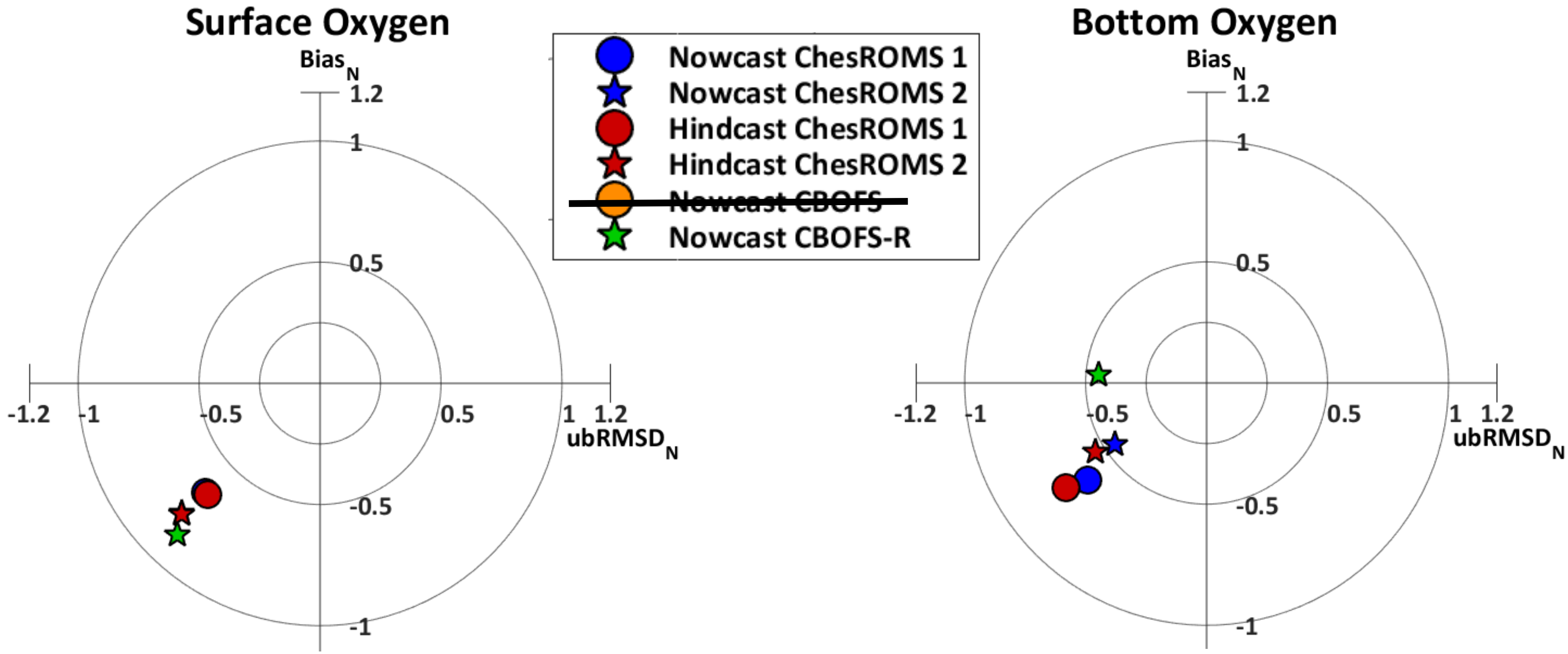


Differences in skill between nowcast/hindcast forcing (blue vs. red) and time periods (shapes) are small compared to ChesROMS/CBOFS differences

Lower skill of nowcast due to no evap/precip? lower river discharge?

Skill of nowcasts vs. hindcasts

Oxygen (13 stations)



Small differences in skill between nowcast/hindcast forcing (blue vs. red)
Nowcast slightly better (due to stronger winds?)

Skill of nowcasts vs. hindcasts

Summary

CBOFS nowcast forcing:

Salinity skill is ***lower*** (due to low river inputs and no precipitation/evaporation?)
Bottom DO skill is ***higher*** (due to stronger winds?)

Future Work

Y3: Compared results using ChesROMS hindcast forcing vs. CBOFS nowcast forcing
Y4: Compare results using CBOFS nowcast forcing to CBOFS forecast forcing (24, 48 and 72 hours)

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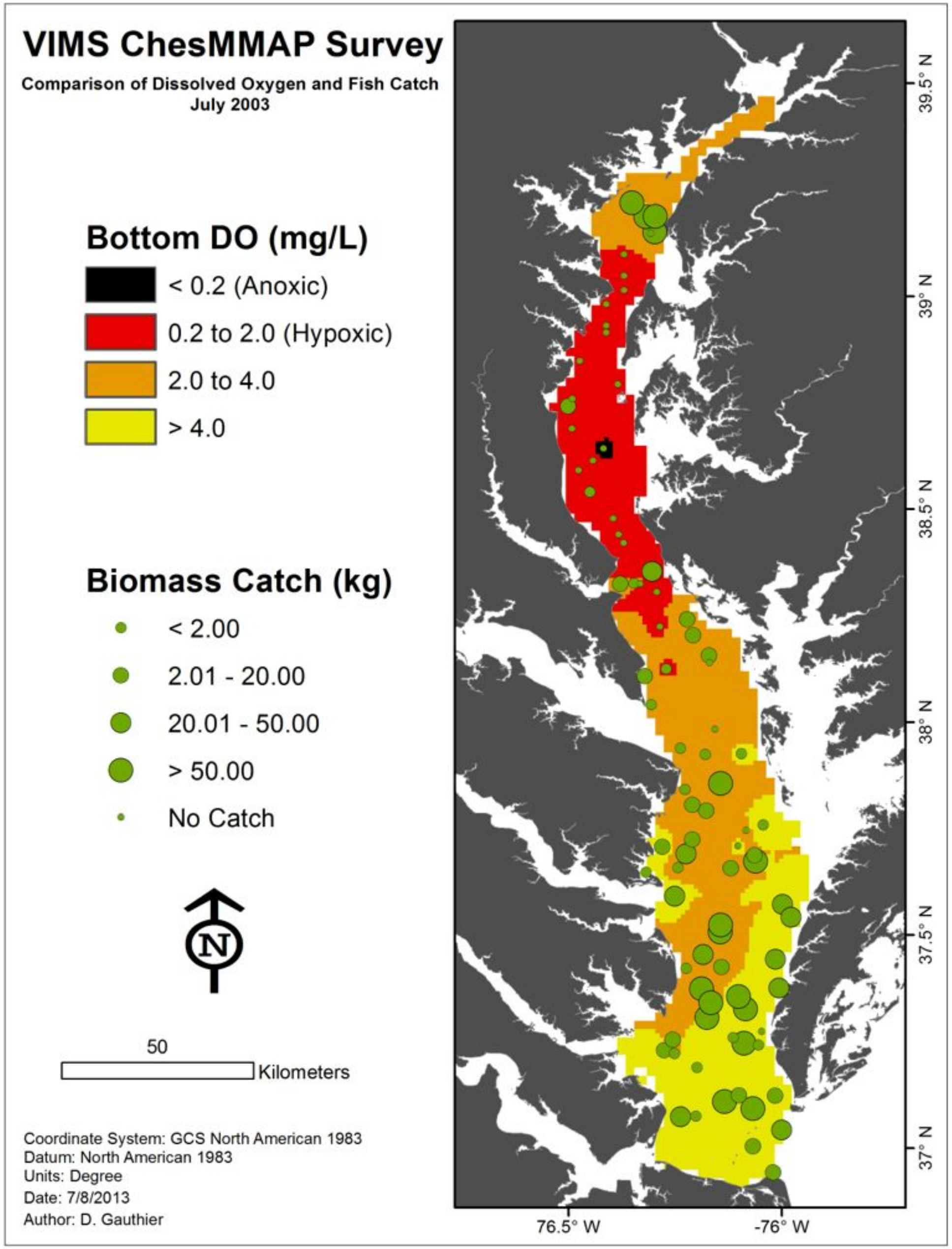
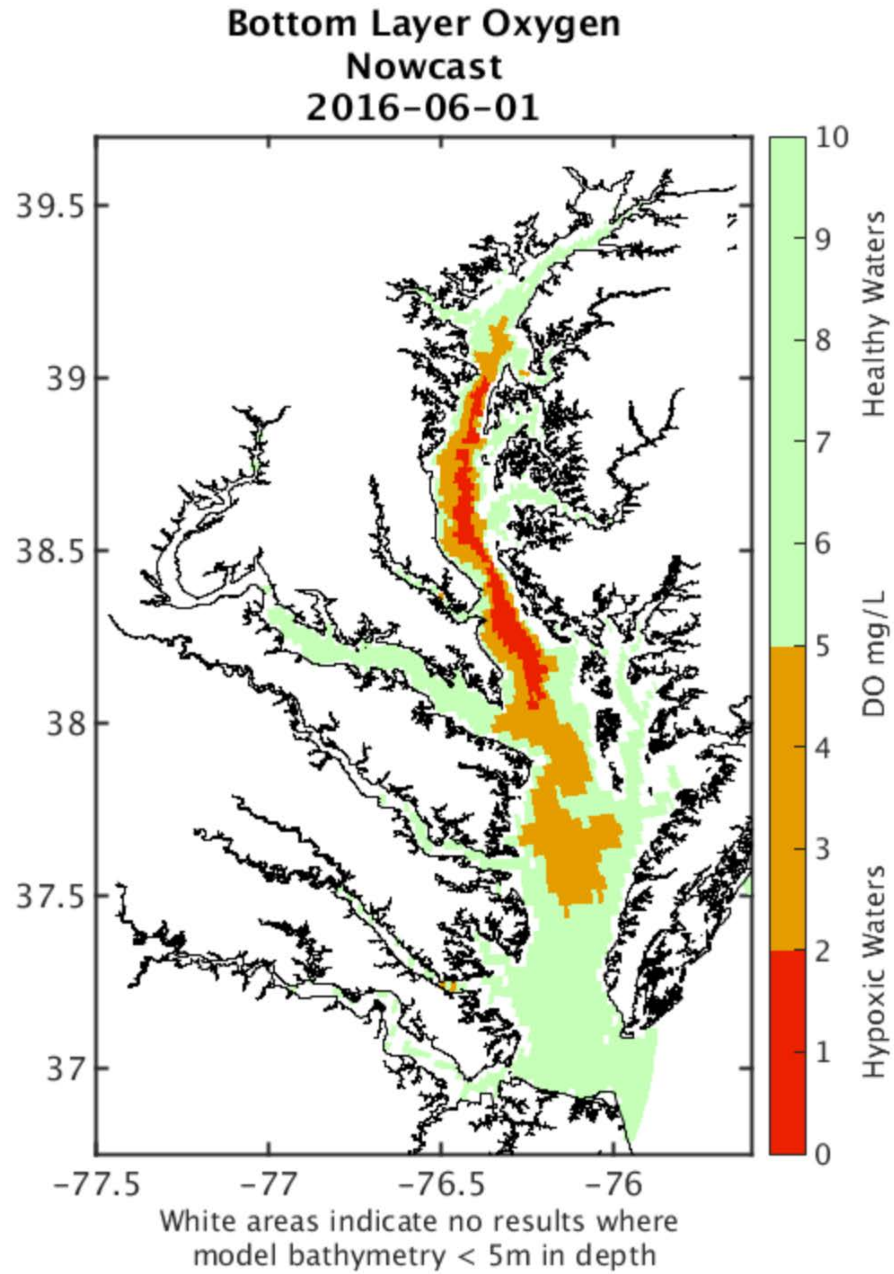
VIMS ChesMMAP monitoring shows much less fish biomass in hypoxic waters.

(from Buchheister et al. 2013)



Hypoxia forecast tool:

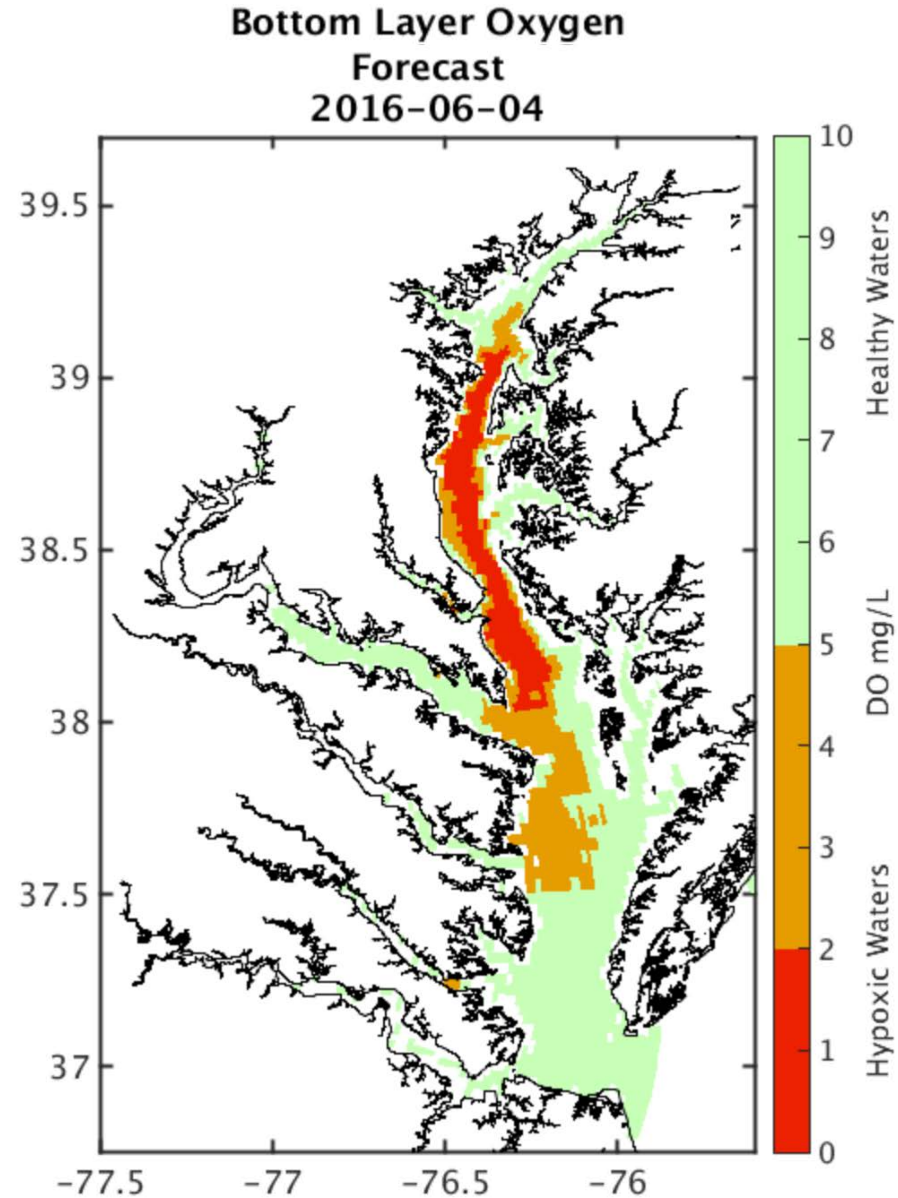
Bottom Oxygen Nowcast



(from Chesapeake Modeling Symposium, June 2016)

Hypoxia forecast tool:

Bottom Oxygen Forecast

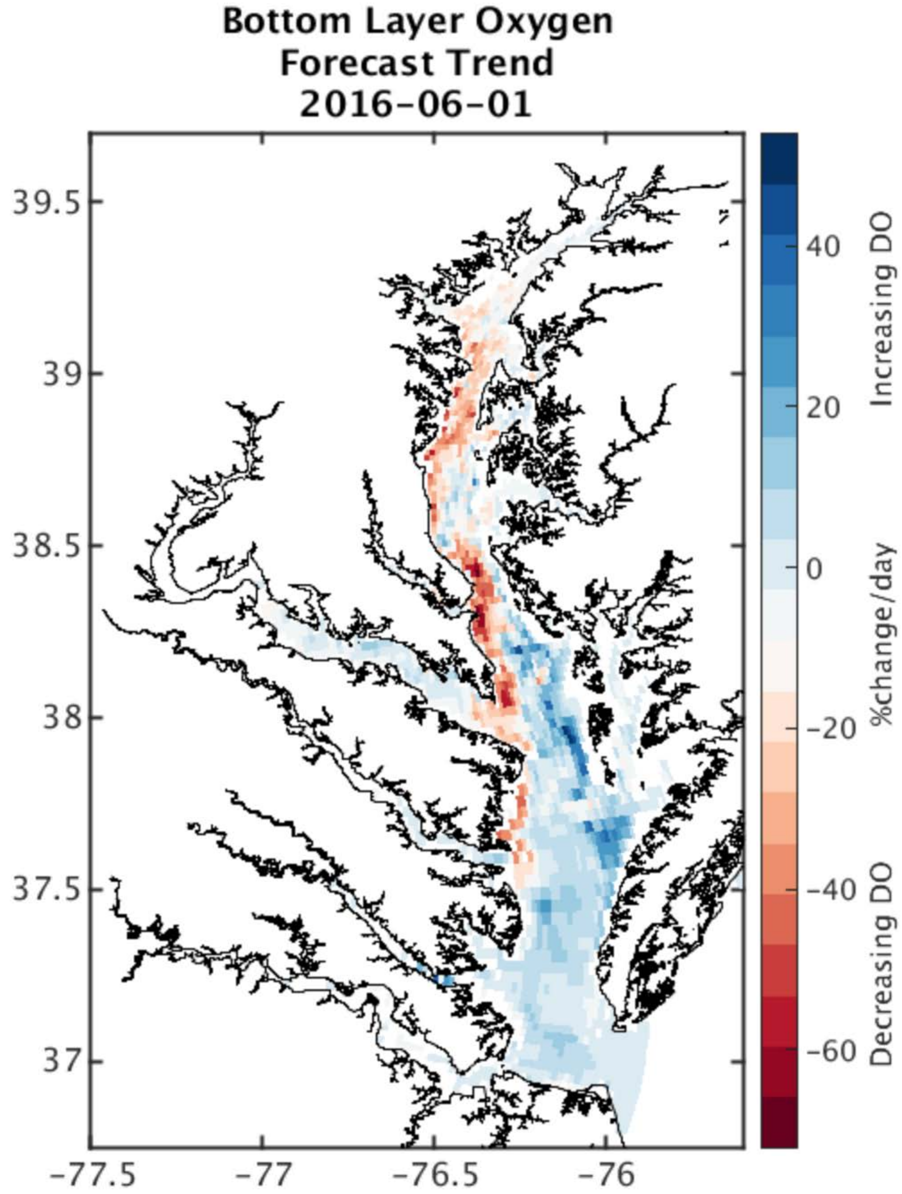


White areas indicate no results where model bathymetry < 5m in depth

(from Chesapeake Modeling Symposium, June 2016)

Hypoxia forecast tool:

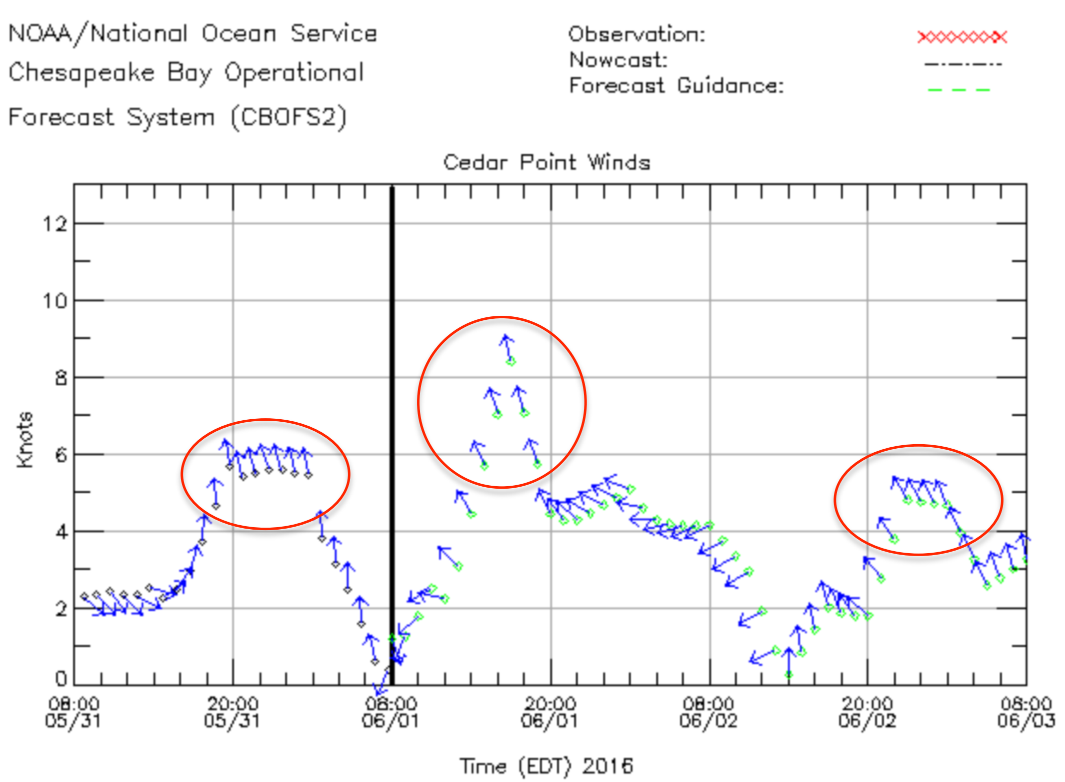
Bottom Oxygen Forecast Trend

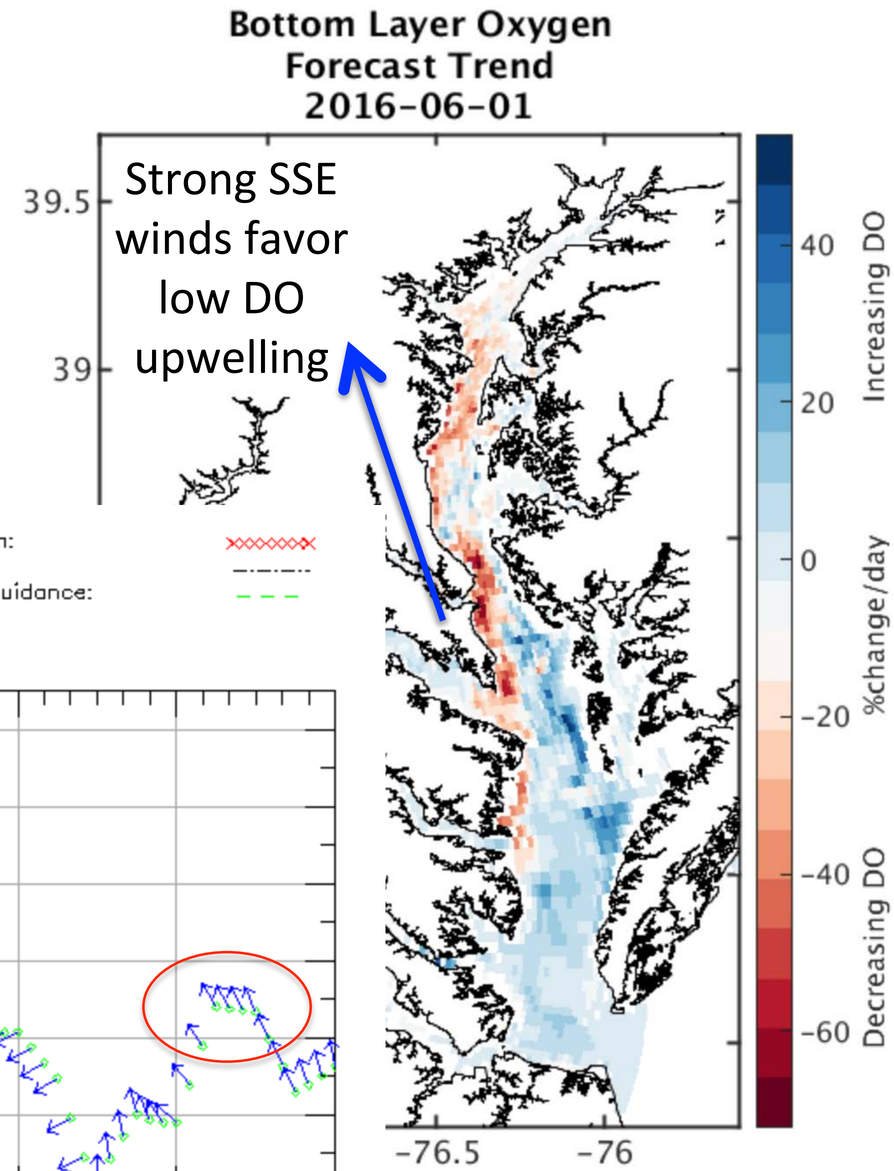


(from Chesapeake Modeling Symposium, June 2016)

Hypoxia forecast tool:

CBOFS wind nowcast/forecast



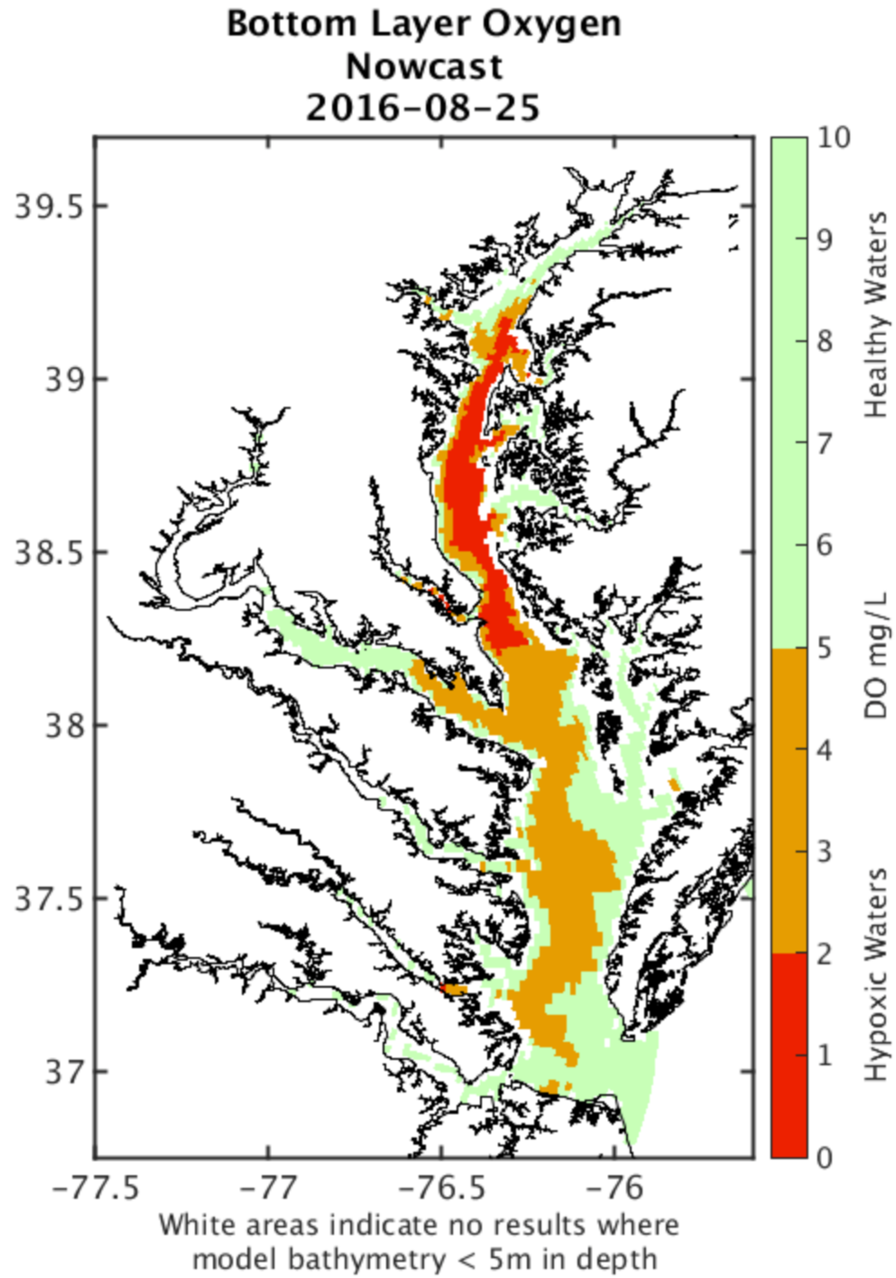


(from Chesapeake Modeling Symposium, June 2016)

Hypoxia forecast tool:

This morning:
http://goo.gl/7cGCdL

Bottom Oxygen Nowcast



Hypoxia forecast tool:

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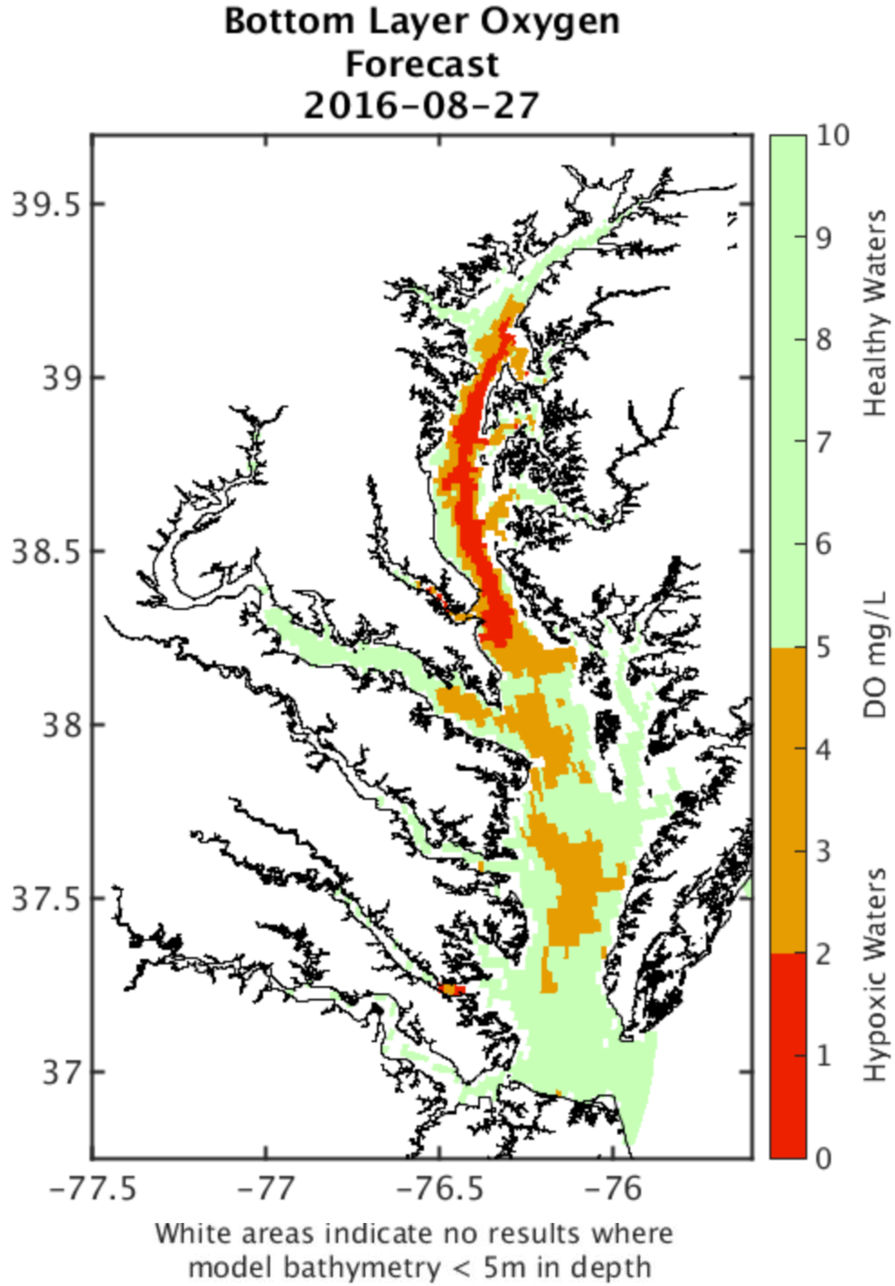
Bottom Oxygen Forecast



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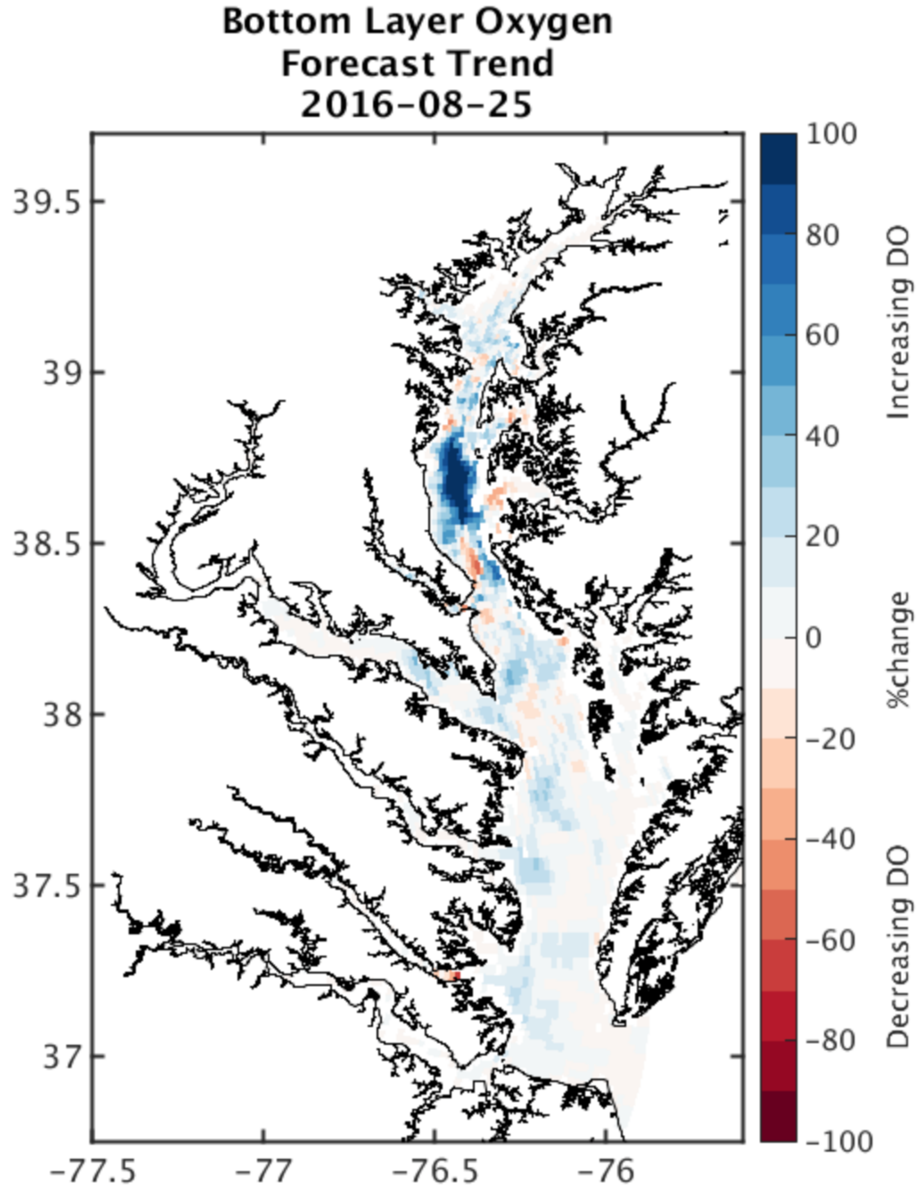
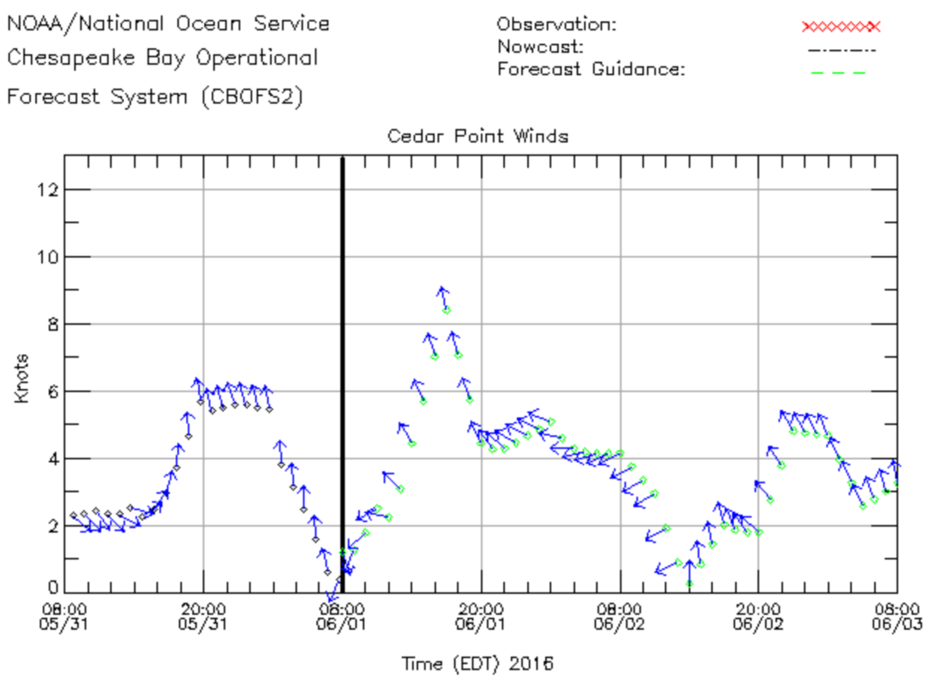
Bottom Oxygen Forecast Trend

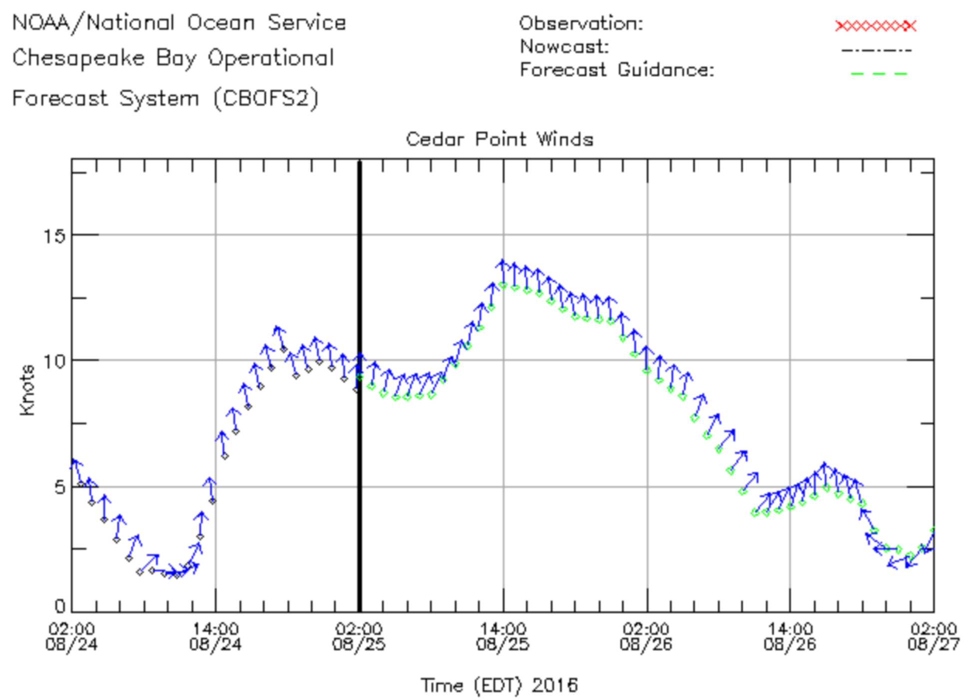


CBOFS winds forecast

Example from June 1 ≈ 9 knots



This morning ≈ 14 knots



Stakeholder workshop at VIMS on 4/25/2016

"Hypoxia Forecasts as a tool for Chesapeake Bay Fisheries: An Assessment of Stakeholder Interest"

-- 18 Attendees, including 10 fishers and 8 scientists/educators at VIMS in April 2016.
-- (Plus preliminary smaller meeting with 4 fishers in December 2015.)

Regarding likely use of hypoxia forecast tool in its present form:

-- Strong enthusiasm for hypoxia forecasts as a complementary tool along with other information sources.

-- Several captains who attended are already using real-time observations for planning (e.g., water clarity, water temperature, wave heights from NOAA CBIBS) and/or short-term model forecasts (e.g., currents from CBOFS via NOAA Tides & Currents).

-- Hypoxia forecasts of changing conditions beyond 3-days wouldn't be especially useful because of limited trust in detailed wind forecasts beyond 3-days.

-- Fishing sites of attendees are mainly chosen 3-days or less in advance and sometimes only a few hours in advance.

Stakeholder workshop at VIMS on 4/25/2016

Suggested modifications to hypoxia forecast tool forecast:

-- Additional depths for dissolved oxygen besides near-bottom are of interest.

-- Model results for shallower regions would be useful.

-- Interest in displays of short-term modeled and time-series at sites with real-time observations (e.g., at CBIBS buoys) with modeled and observed dissolved oxygen plotted together.

-- Time-series of past model results and observations (e.g., EPA cruise data) over past 12 months could be useful to (i) see multiple time-scales and (ii) track performance of model versus observations.

-- Would like multiple nowcast/forecast maps (oxygen, temperature, salinity, water clarity) available at one website geared toward support of fishing.

-- Nowcasts and forecasts of algal blooms are also desired.

VIMS 8/8/2016 press release picked up by AP

Researchers issue real-time forecasts of Chesapeake Bay dead zone

by David Malmquist | **August 8, 2016**

Simple model holds promise for anglers and other Bay users

Scientists to help fisherman avoid Chesapeake Bay dead zones

AP By The Associated Press
August 11, 2016 8:00 am

NORFOLK, Va. (AP) — Scientists say they will soon help Chesapeake Bay fisherman by mapping the water's low-oxygen dead zones in real time.

Poor oxygen levels often force fish out of the bay's cool bottom waters. William and Mary's Virginia Institute of Marine Science says it will show anglers where the fish may have gone.

Google Analytics

http://www.vims.edu - http://www.vims.... www.vims.edu [Go to this report]

Jul 1, 2016 - Aug 23, 2016

Content Drilldown

ALL » PAGE PATH LEVEL 1: /research/ » PAGE PATH LEVEL 2: /topics/ » PAGE PATH LEVEL 3: /dead_zones/ » PAGE: /research/topics/dead_zones/forecasts/cbay/index.php

All Users
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Explorer

VIMS press release

Page	Pageviews	Unique Pageviews	Avg. Time on Page	Bounce Rate	% Exit
	240 % of Total: 0.22% (109,410)	202 % of Total: 0.23% (87,725)	00:02:53 Avg for View: 00:01:29 (94.60%)	81.41% Avg for View: 68.09% (19.56%)	72.92% Avg for View: 46.57% (56.57%)
1. /research/topics/dead_zones/forecasts/cbay/index.php	**240** **(100.00%)**	202 (100.00%)	00:02:53	81.41%	72.92%

Year 4 Work Plan

-- Nowcast/forecast maps of DO computed from ChesROMS-ECB will be incorporated into the pseudo-operational hypoxia forecast tool.

-- Map products showing the mean and standard deviation of the multiple models will be posted to provide a measure of uncertainty.

-- Daily nowcast/forecast maps of temperature (T) and salinity (S) will be added to the site.

-- Differences from long-term climatologically averaged model output (1985-2005) for each variable (DO, S, T) will be included.

-- Because end-users expressed an interest in water clarity, we will also assess model skill of suspended particulate matter and light attenuation.

-- A workshop in Spring 2017 will be conducted to obtain end-user input on the improved pseudo-operational model products.

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Scenario-based forecasts: EPA nutrient reduction strategies

Ike Irby, VIMS Ph.D. student

Goal:

To compare impact of EPA nutrient reductions (TMDLs: Total Maximum Daily Loads) on attainment of water quality standards as estimated by an <u>EPA regulatory model</u> (CH3D-ICM) and a <u>research model</u> (ChesROMS-ECB).

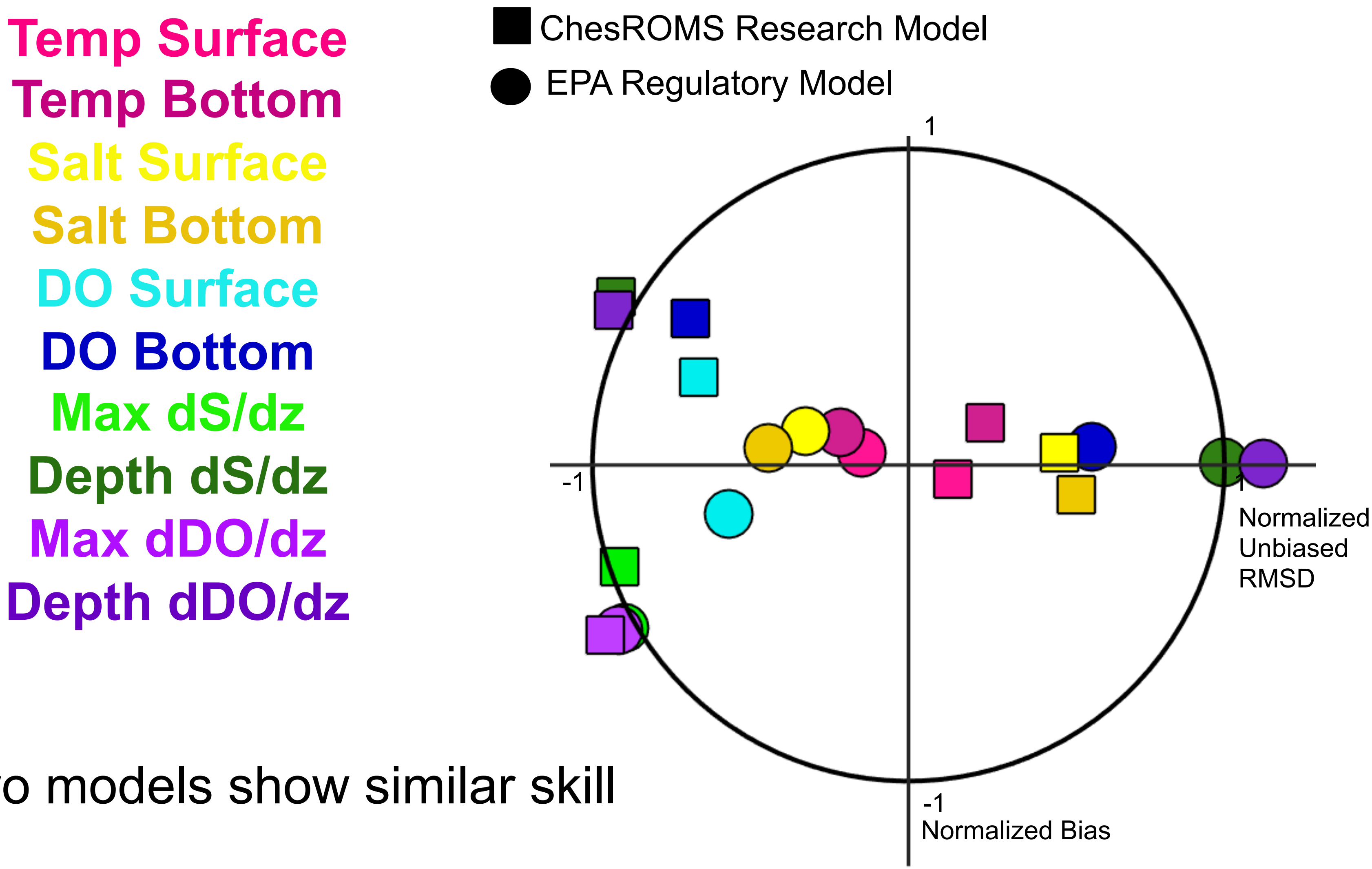
Scenario-based forecasts: EPA nutrient reduction strategies

Methods

- Compare model skill for standard run (1991-2000)
- Comparison of DO change resulting from EPA's TMDL nutrient reduction (1993-1995)
- Use same methods as EPA to identify whether Water Quality Standards (WQS) have been met, assuming these nutrient reductions

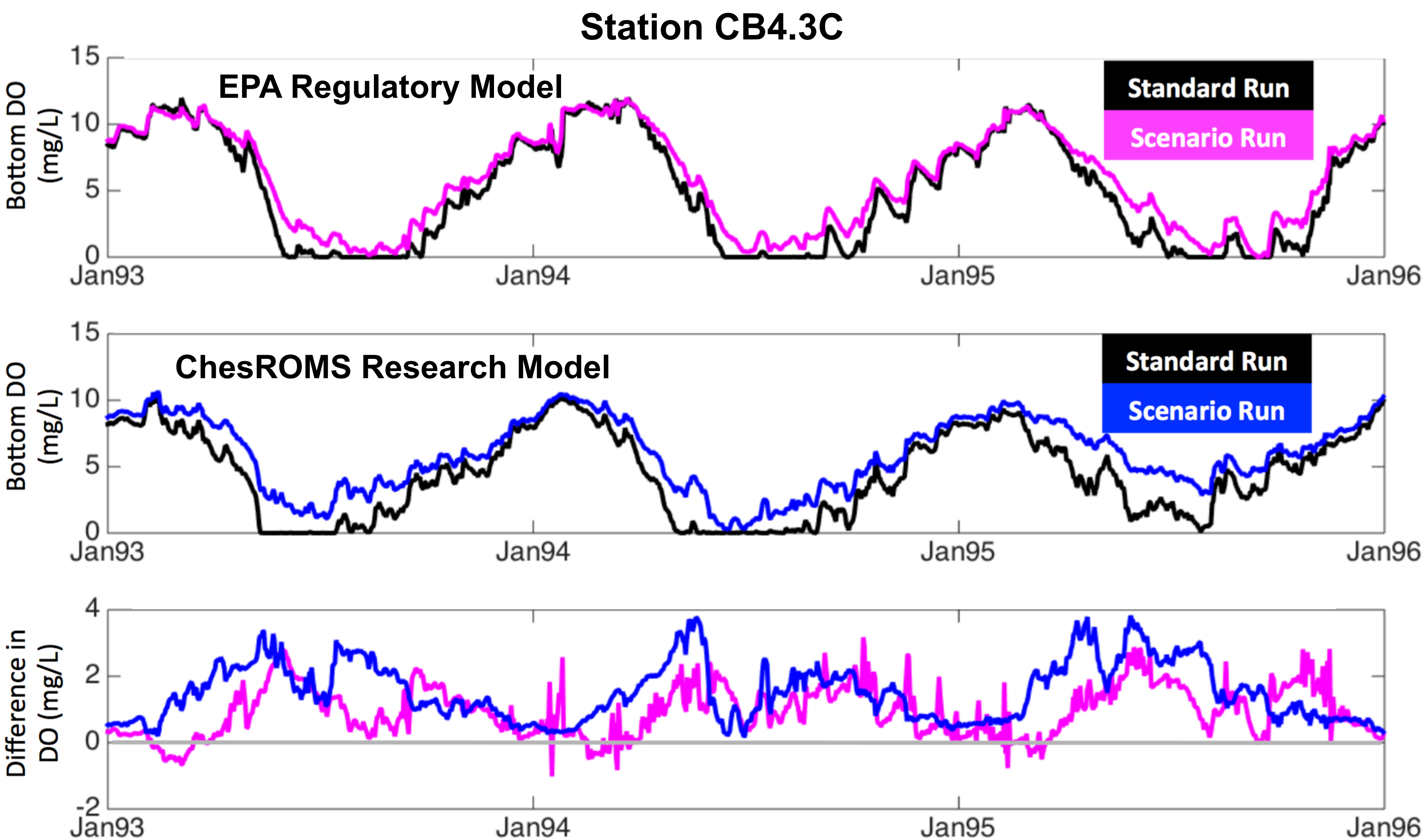
Skill Assessment 1991-2000
(EPA calibration period)

Summary Target Diagram for 25 stations (15 main stem, 10 tributary)



- Two models show similar skill

Model Results at Mid-Bay Main Stem Station

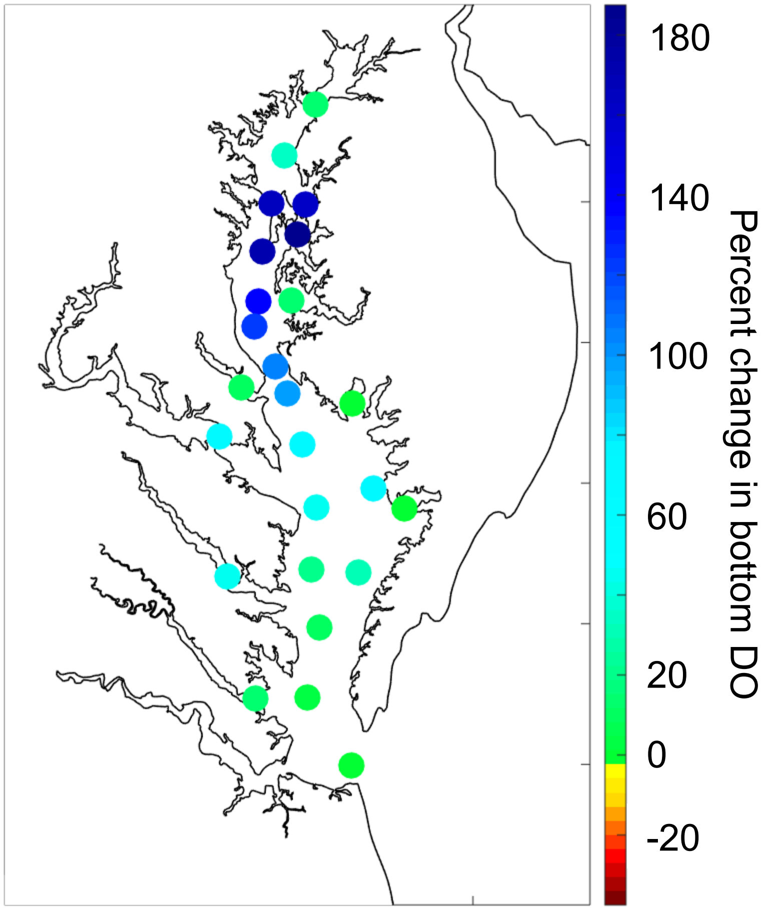


- Average bottom DO increase is similar, but higher for ChesROMS Research Model

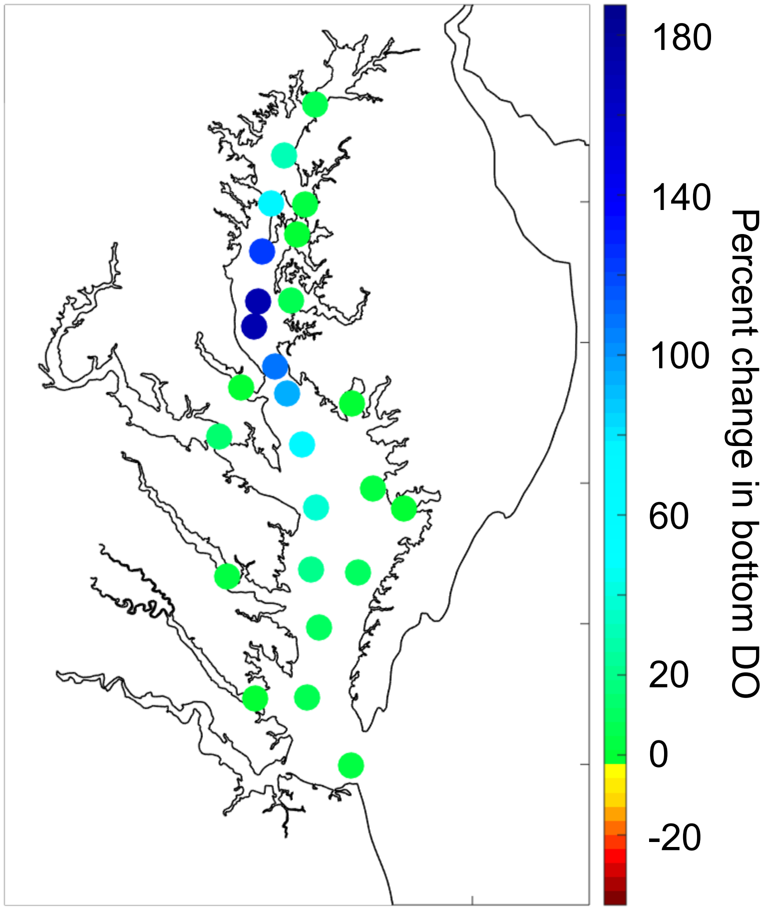
Impact of Nutrient Reduction on Summer DO

DO Percent Change at Bottom

EPA Regulatory Model



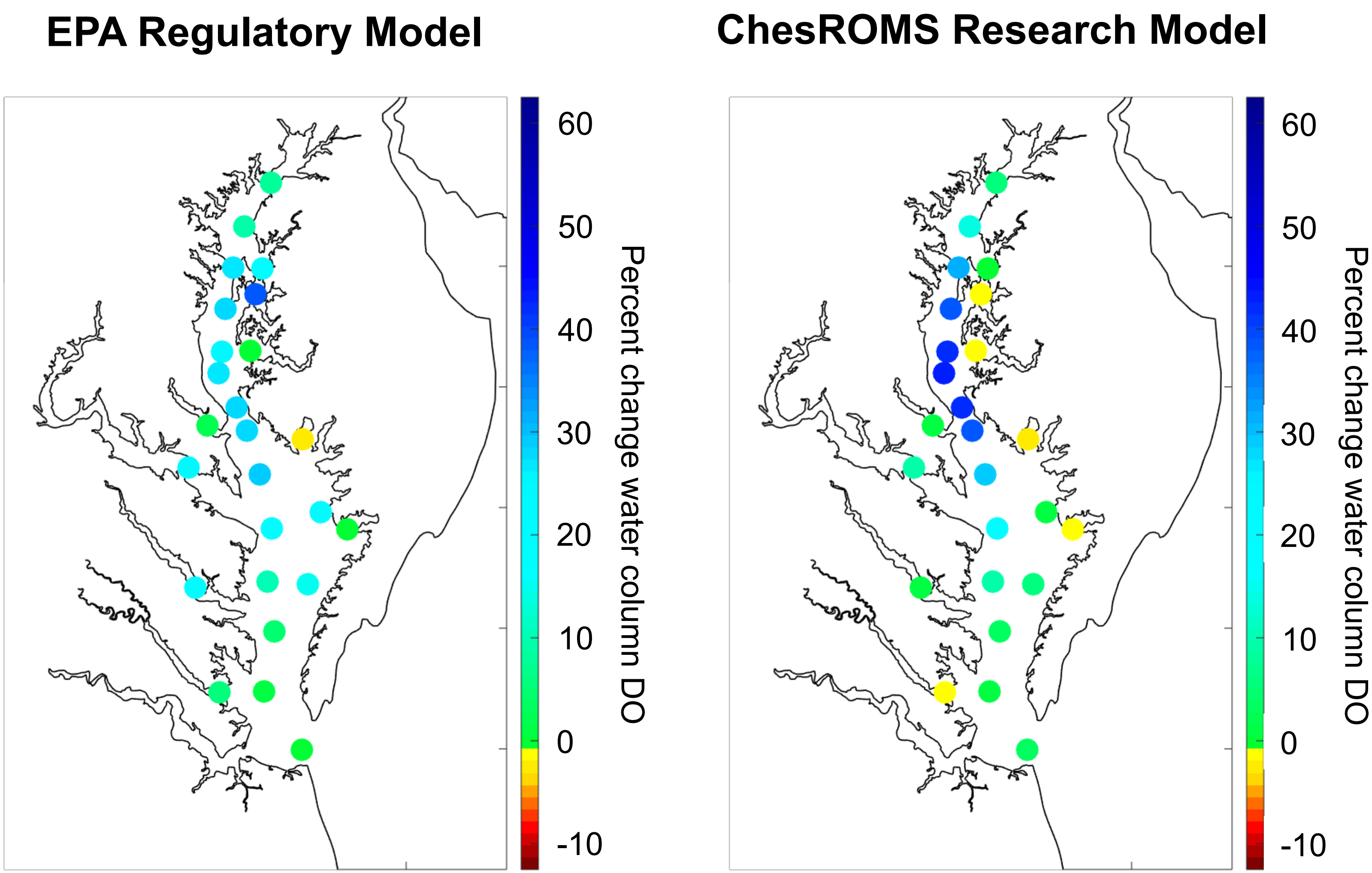
ChesROMS Research Model



Percent increase in bottom DO is very similar for both models

Impact of Nutrient Reduction on Summer DO

DO Percent Change over Whole Water Column

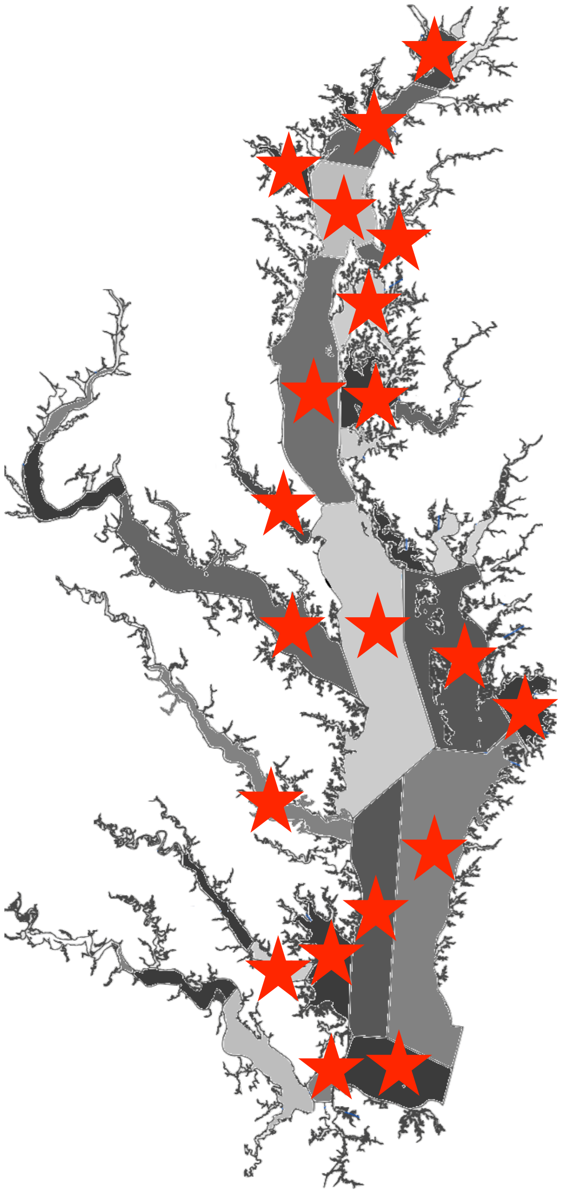


Percent DO increase higher in water column is greater in ChesROMS Research Model

Water Quality Standards

- Bay is divided into 92 segments

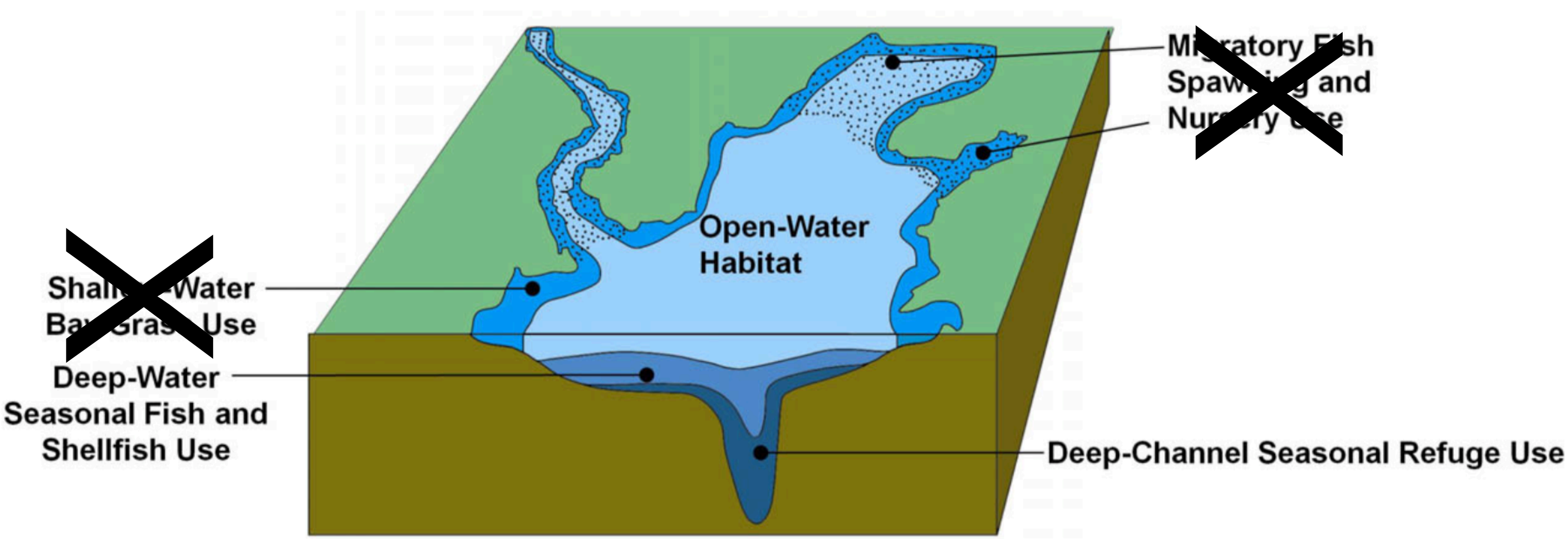
Water Quality Standards



- **Bay is divided into 92 segments**
  - We focus on the 20 main stem and lower tributary segments

Water Quality Standards

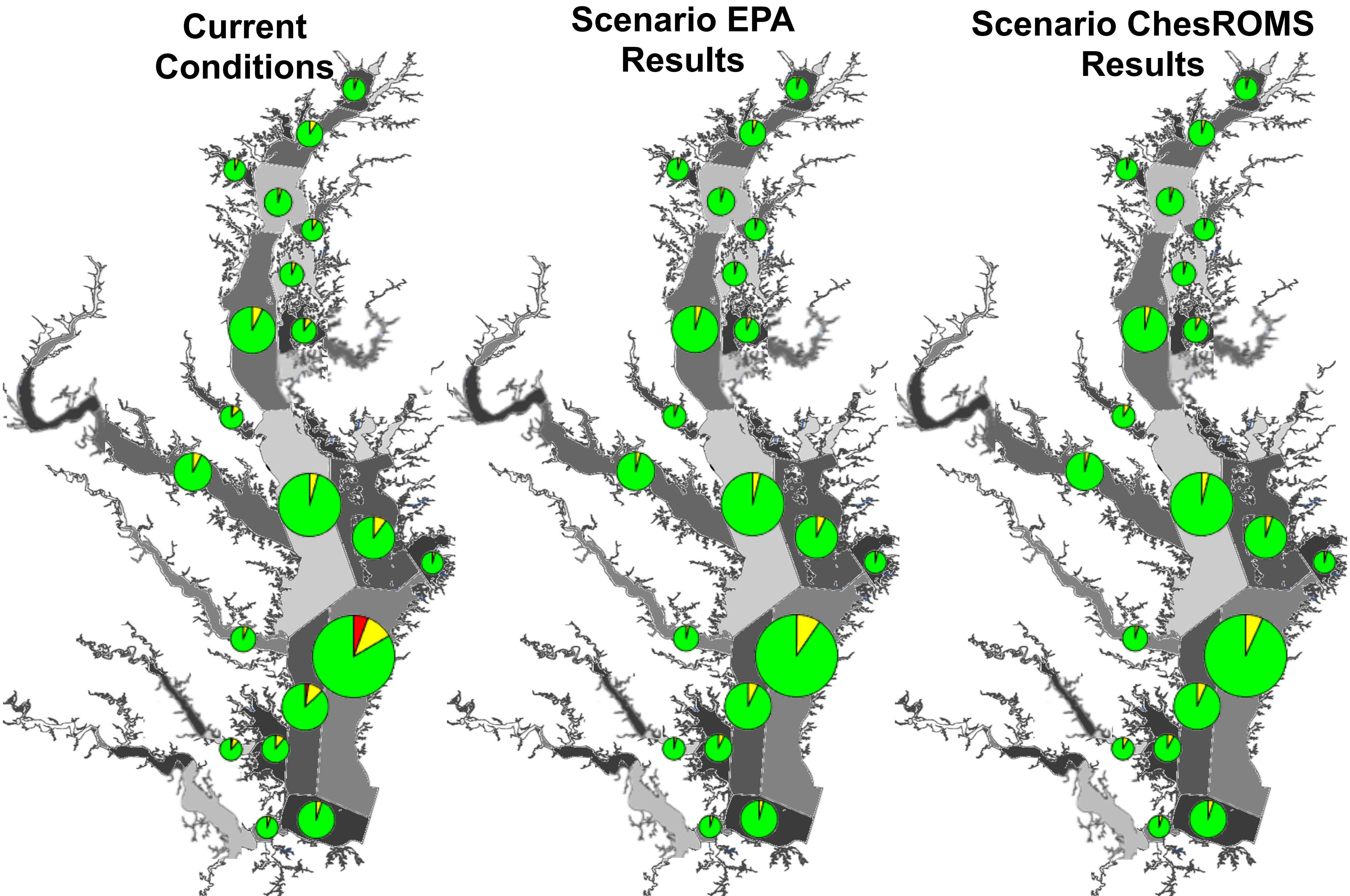
- **Bay is divided into 92 segments**
  - We focus on the 20 main stem and lower tributary segments
- **Designated Uses**
  - We focus on the: Open Water, Deep Water, and Deep Channel



Water Quality Standards

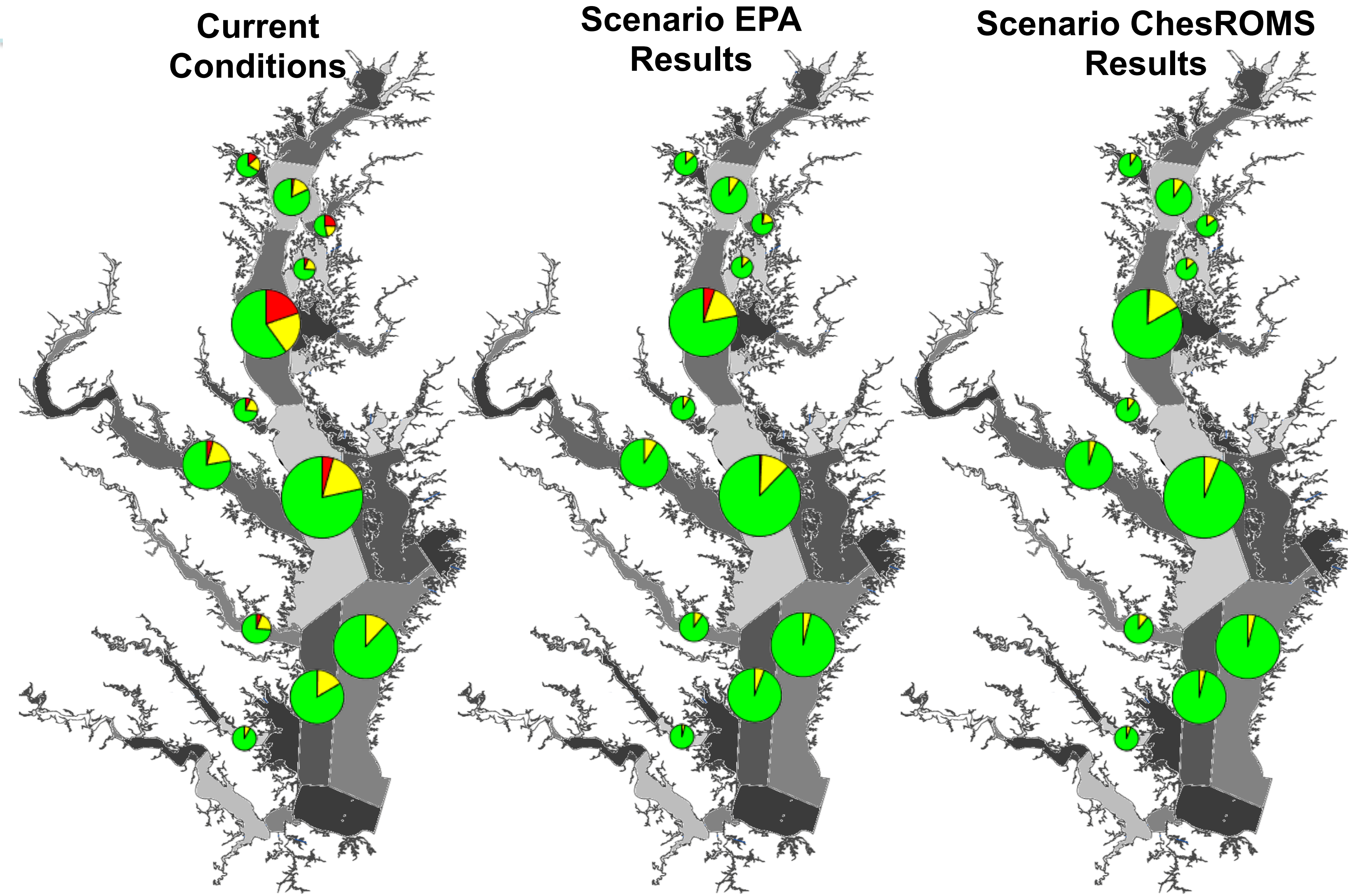
- **Bay is divided into 92 segments**
  - We focus on the 20 main stem and lower tributary segments
- **Designated Uses**
  - We focus on the: Open Water, Deep Water, and Deep Channel
- **Stoplight Analysis**
  - Green = WQS met
  - Yellow = WQS not met, but allowable
  - Red = WQS not met, beyond allowable

Open Water



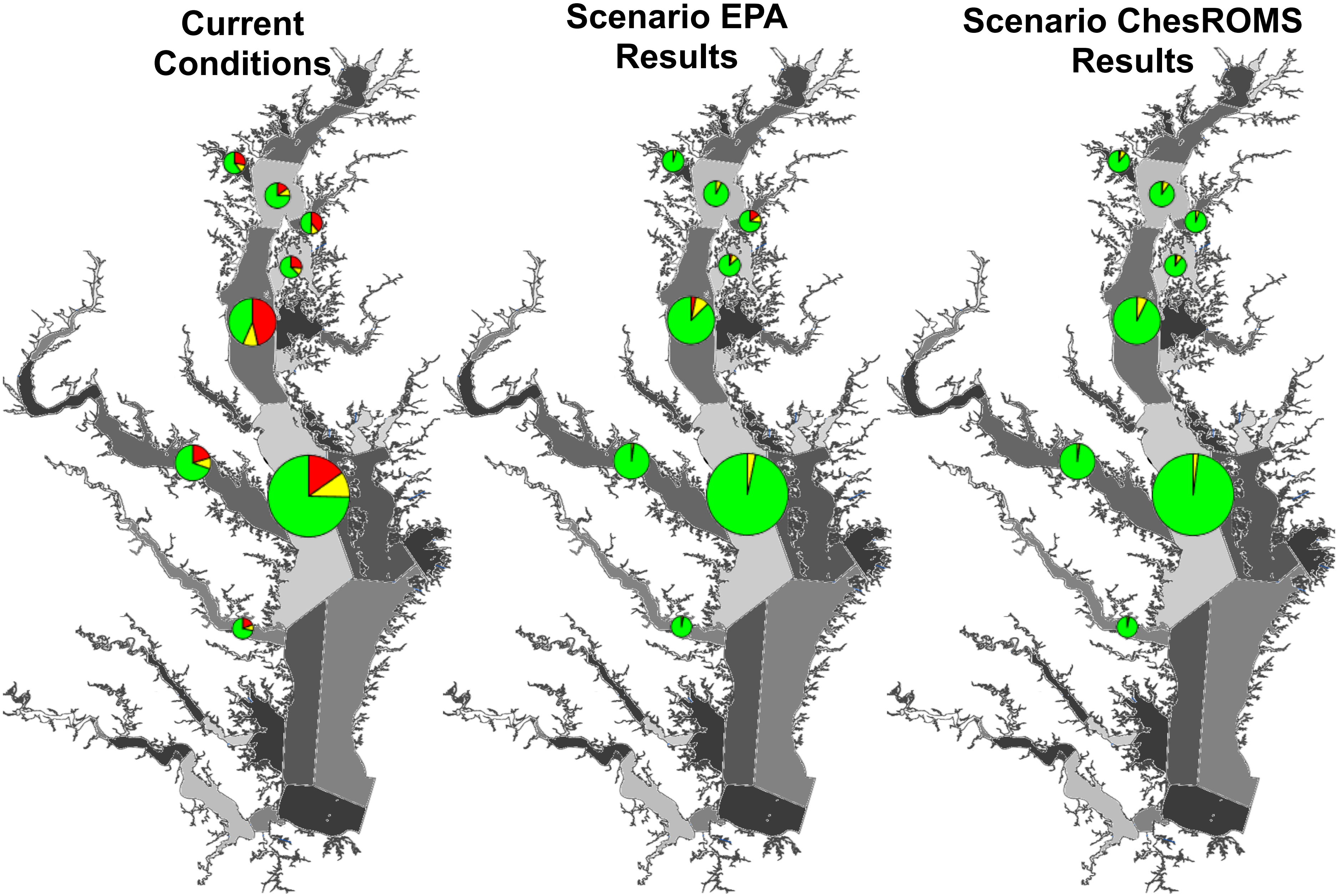
Circle Area represents Designated Use Volume

Deep Water



Circle Area represents Designated Use Volume

Deep Channel



Circle Area represents Designated Use Volume

Summary

- Very different models have very similar skill
- % change in DO due to nutrient reductions…
  - is similar between models at bottom
  - is greater in the ChesROMS Research model higher in water column
- % attainment of WQS between the models…
  - is most similar higher in water column
  - is less similar in deeper water
  - This is largely a result of the way WQS attainment rules are structured: green/yellow = GOOD, red = BAD

Implication: These "multiple model" results should increase stakeholder confidence that the TMDL reductions are appropriate for improving Chesapeake Bay water quality

Future Y4 Work

- Repeat for other wet/dry years
- Repeat with additional models
- Assess the impact of climate change on the potential success of the EPA’s planned nutrient reductions (TMDL’s)

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Extra Slides

Archival of Model Output

Existing archived model output + observations

Dataset

- cb_hypoxia
  - 2004-2005/
  - CHESROMS_1termDO_2004-2005/
  - CHESROMS_1termDO_2004-2005_surfsat/
  - ChesROMS_1termDO_1984-2013/
  - ChesROMS_1termDO_1984_2013_surfsat/
  - ChesROMS_forcing_2013_2015/
  - NOAACSDL_ROMS/
  - ROMS_RCA/
  - VIMS_CHesROMS-ECB/
  - observations/

Initial TDS Installation at My Group see Info
THREDDS Data Server [Version 4.3.23 - 20140826.1617] Documentation

Archival of Model Output

Future Work:

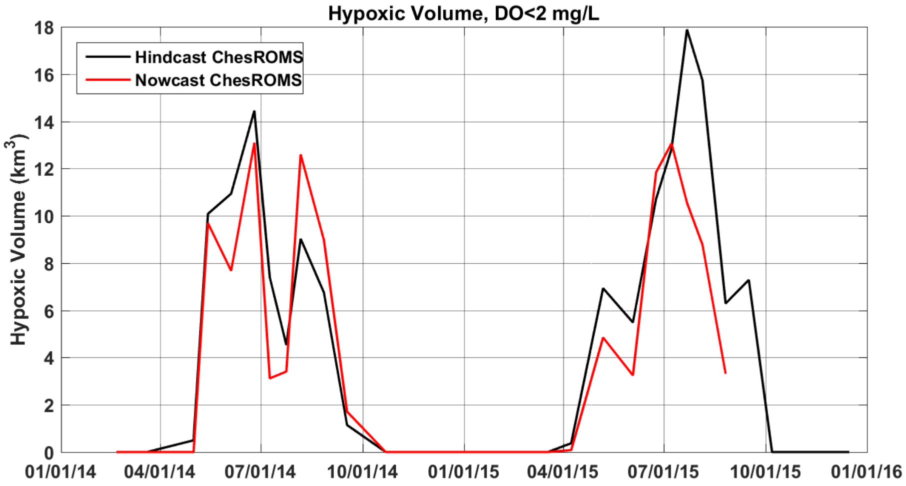
- Organize model output into publications:
  - Bever et al., 2013; Irby et al., 2016; Scully et al., 2016
- Future entries:
  - EPA reduction scenarios
  - Climate change impacts on EPA reduction scenarios
  - Sensitivity studies with ChesROMS-BGC
  - Model results with hindcast vs. nowcast vs. forecast forcing

Extra Slides

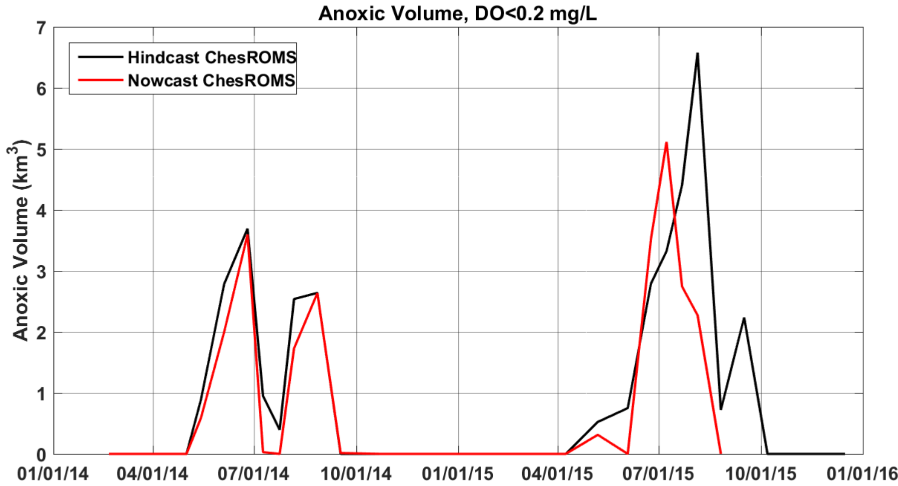
Open-water fish and shellfish use	30-day mean ≥ 5.5 mg/L (tidal habitats with 0–0.5 ppt salinity)	Growth of tidal-fresh juvenile and adult fish; protective of threatened/endangered species	Year-round
	30-day mean ≥ 5 mg/L (tidal habitats with >0.5 ppt salinity)	Growth of larval, juvenile, and adult fish and shellfish; protective of threatened/endangered species	
	7-day mean ≥ 4 mg/L	Survival of open-water fish larvae	
	Instantaneous minimum ≥ 3.2 mg/L	Survival of threatened/endangered sturgeon species[a]	
Deep-water seasonal fish and shellfish use	30-day mean ≥ 3 mg/L	Survival and recruitment of Bay anchovy eggs and larvae	June 1–September 30
	1-day mean ≥ 2.3 mg/L	Survival of open-water juvenile and adult fish	
	Instantaneous minimum ≥ 1.7 mg/L	Survival of Bay anchovy eggs and larvae	
	Open-water fish and shellfish designated use criteria apply		October 1–May 31
Deep-channel seasonal refuge use	Instantaneous minimum ≥ 1 mg/L	Survival of bottom-dwelling worms and clams	June 1–September 30
	Open-water fish and shellfish designated use criteria apply		October 1–May 31

Skill of nowcasts vs. hindcasts

Hypoxic Volume
DO < 2 mg/L



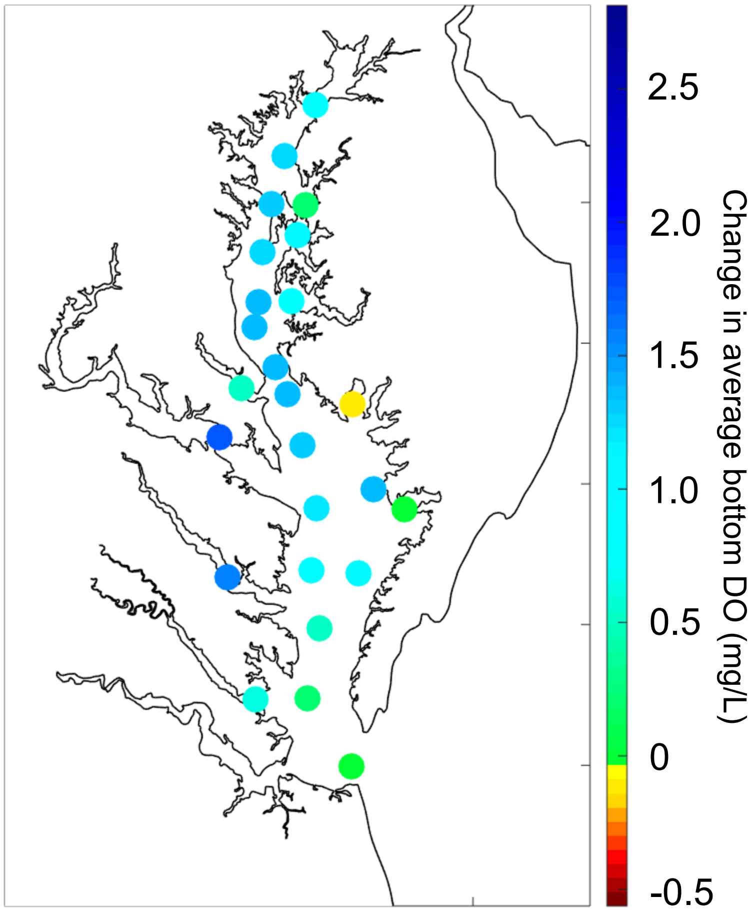
Anoxic Volume
DO < 0.2 mg/L



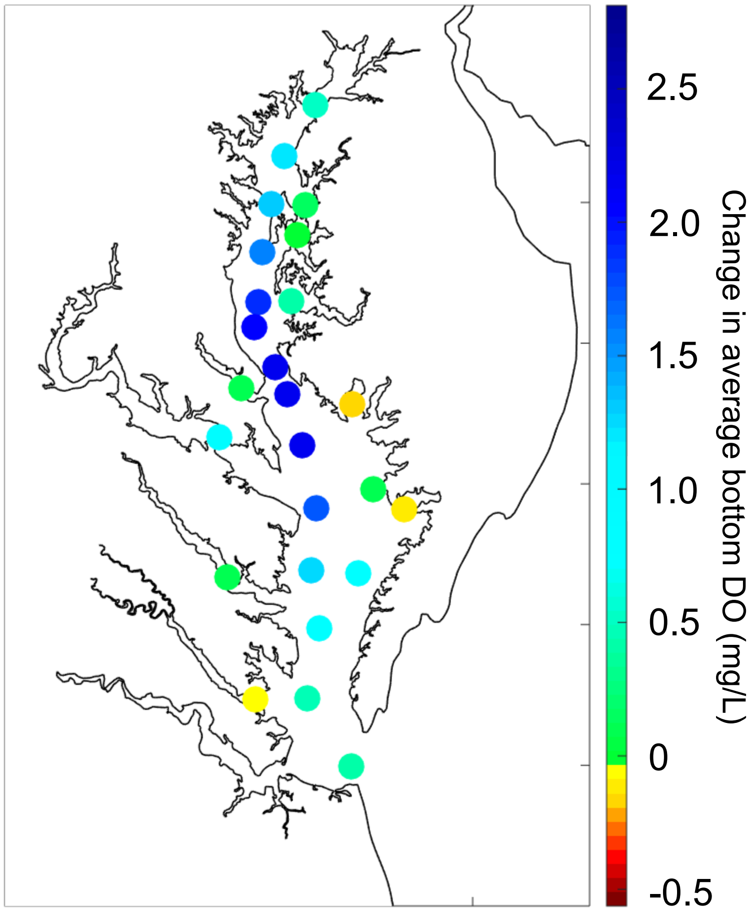
Impact of Nutrient Reduction on Summer DO

Bottom DO

EPA Regulatory Model



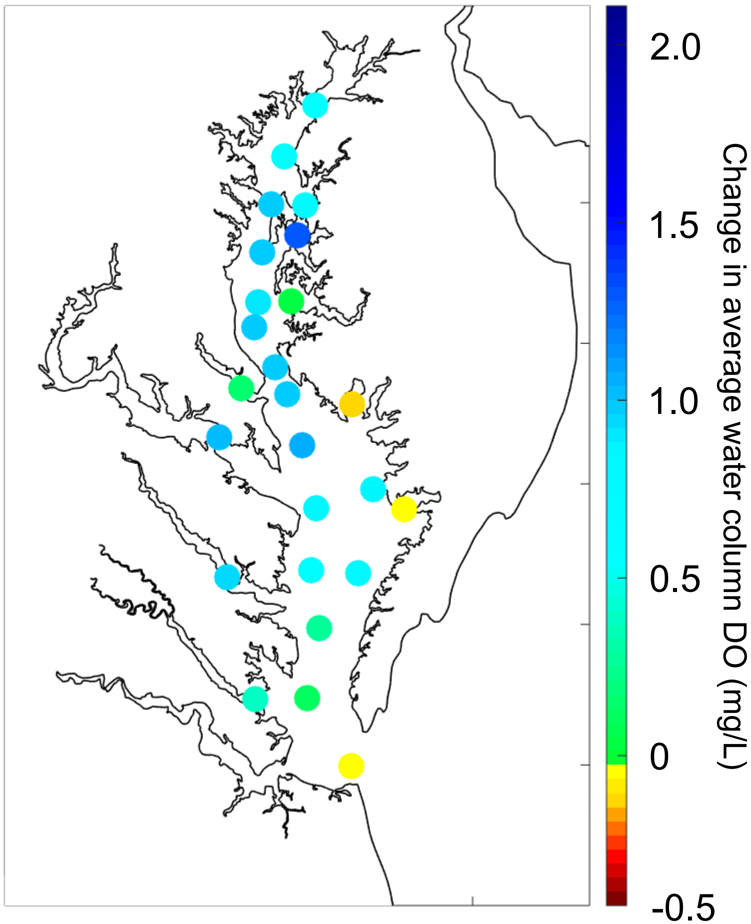
ChesROMS Research Model



Impact of Nutrient Reduction on Summer DO

Whole Water Column

EPA Regulatory Model



ChesROMS Research Model