

Presentations

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4-16-2014

## The estuarine hypoxia component of the Coastal Ocean Modeling Testbed (COMT)

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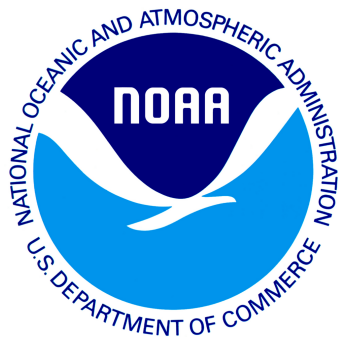
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# The Estuarine Hypoxia Component of the Coastal Ocean Modeling Testbed (COMT)

Lyon Lanerolle (NOAA CSDL)  
and the  
Estuarine Hypoxia COMT team

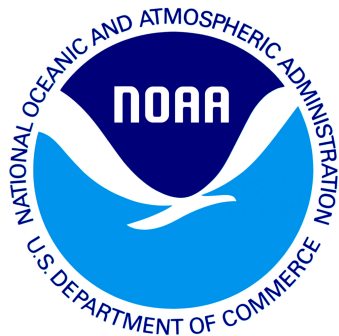


# A Community Coastal and Ocean Modeling Testbed (COMT)

to Improve Understanding and Operational Forecasts of Extreme Events and Chronic Environmental Conditions Affecting the U.S.

## Five Teams:

- 
- 1) Chesapeake Bay Estuarine Hypoxia Forecasting
  - 2) Integration of West Coast Operational Coastal & Ocean Models
  - 3) Puerto Rico/US Virgin Islands Inundation & Wave Forecasting
  - 4) Northern Gulf of Mexico Ecological Forecasting
  - 5) Cyberinfrastructure



# The Estuarine Hypoxia COMT Team

**VIMS:** Marjy Friedrichs (lead PI)

Carl Friedrichs (VIMS-PI)

Ike Irby (funded student)

Aaron Bever (consultant)

Jian Shen (collaborator)

Cathy Feng (collaborator)

**NOAA-CSDL:** Lyon Lanerolle (NOAA-PI)

Frank Aikman (collaborator)

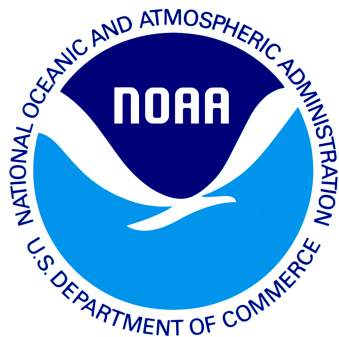
**WHOI:** Malcolm Scully (WHOI-PI)

**UMCES:** Raleigh Hood (UMCES-PI)

Hao Wang (funded student)

Wen Long (collaborator)

Jeremy Testa (collaborator)



# Estuarine Hypoxia Objective

To assess the readiness and maturity of a suite of existing coastal ecological community models for determining past, present and future hypoxia events within the Chesapeake Bay, in order to **accelerate the transition of hypoxia model formulations and products from “academic research” to “operational centers”**

## Chesapeake Bay EH centers include:

- NOAA/NOS/CO-OPS
- Chesapeake Bay Ecological Prediction System (CBEPS)
- EPA Chesapeake Bay Program (CBP)

# Estuarine Hypoxia Goal

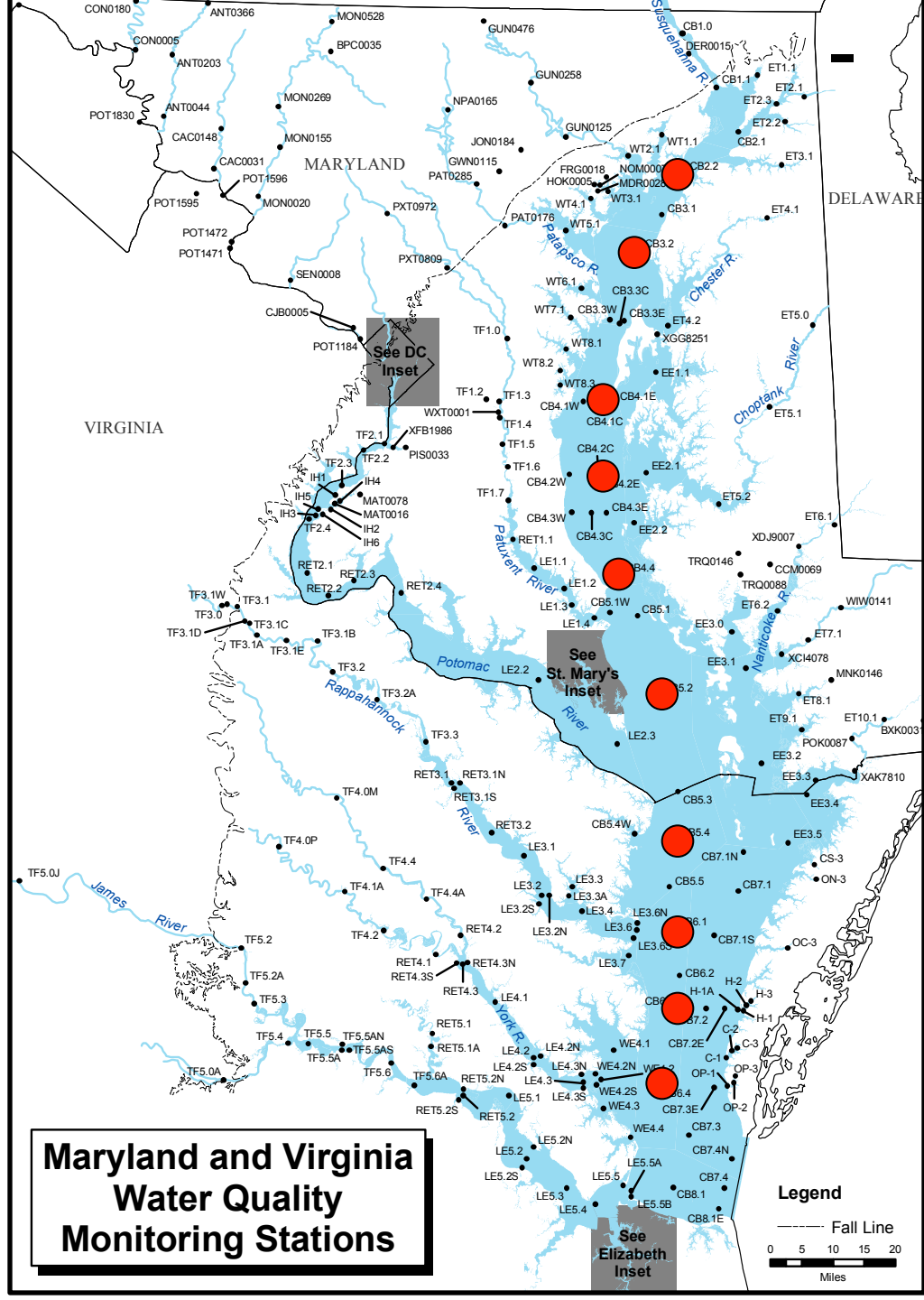
**Compare multiple models** within the Estuarine Hypoxia Testbed in order to improve existing:

1. **CBOFS short-term forecasting**: by incorporating new oxygen and physical model enhancements into the existing operational NOAA CO-OPS Chesapeake Bay Operational Forecast System (CBOFS) for evaluation during their next update
2. **CBEPS short-term forecasting**: by developing a 24/7 predictive capacity for nowcasting/forecasting of oxygen/hypoxic volume as part of CBEPS at the NOAA CBPO and UMCES
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# Model Comparisons via Chesapeake Testbed

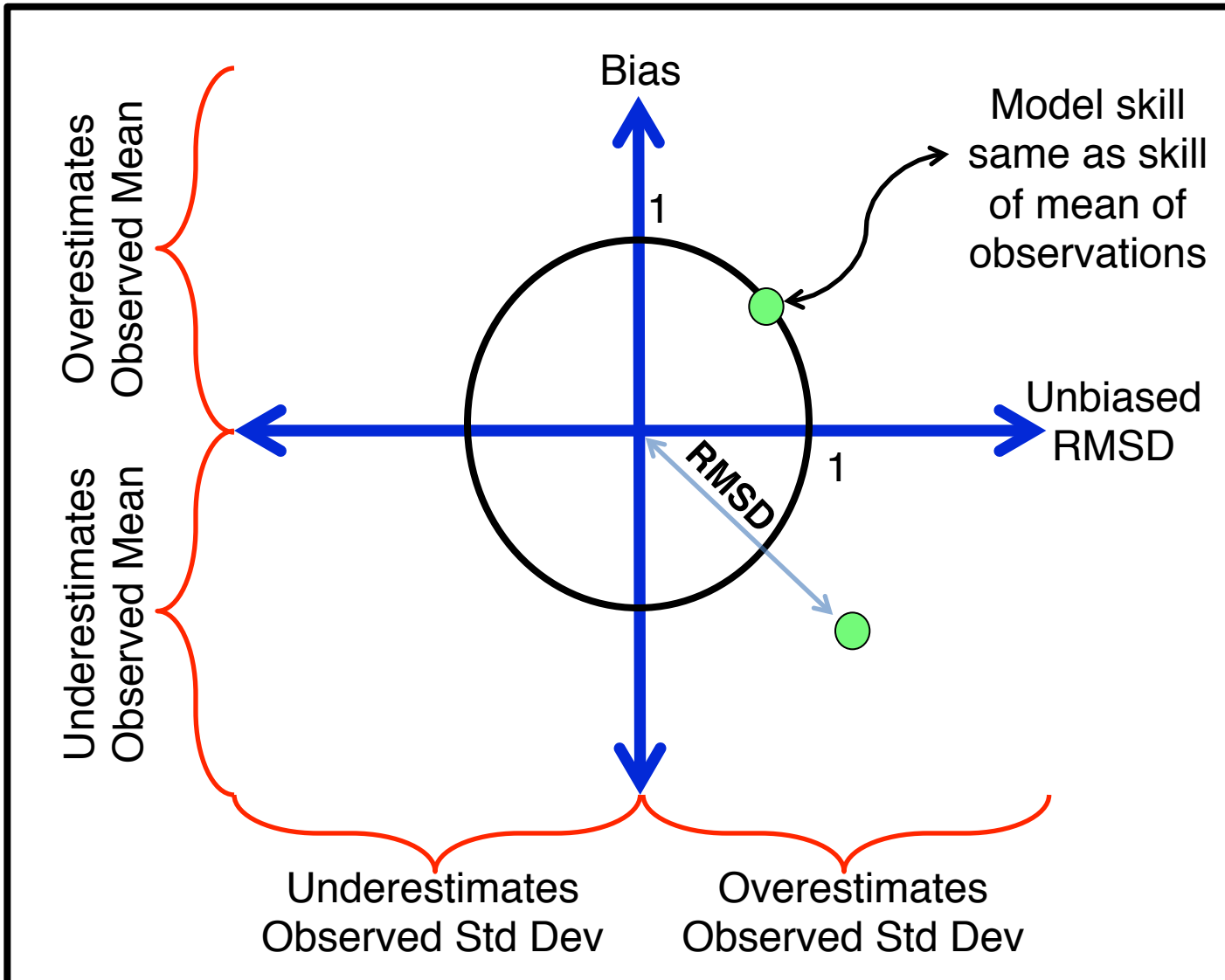
- Statistically compare output from four Chesapeake Bay models:
  - three ROMS models, varying biological complexity (ChesNENA, ChesROMS-BGC, ROMS-RCA)
  - biologically sophisticated CBP regulatory model (CH3D-ICM)
- How well do they reproduce the mean and seasonal variability of:
  - temperature, salinity, stratification, dissolved oxygen (DO), chlorophyll-a, and nitrate

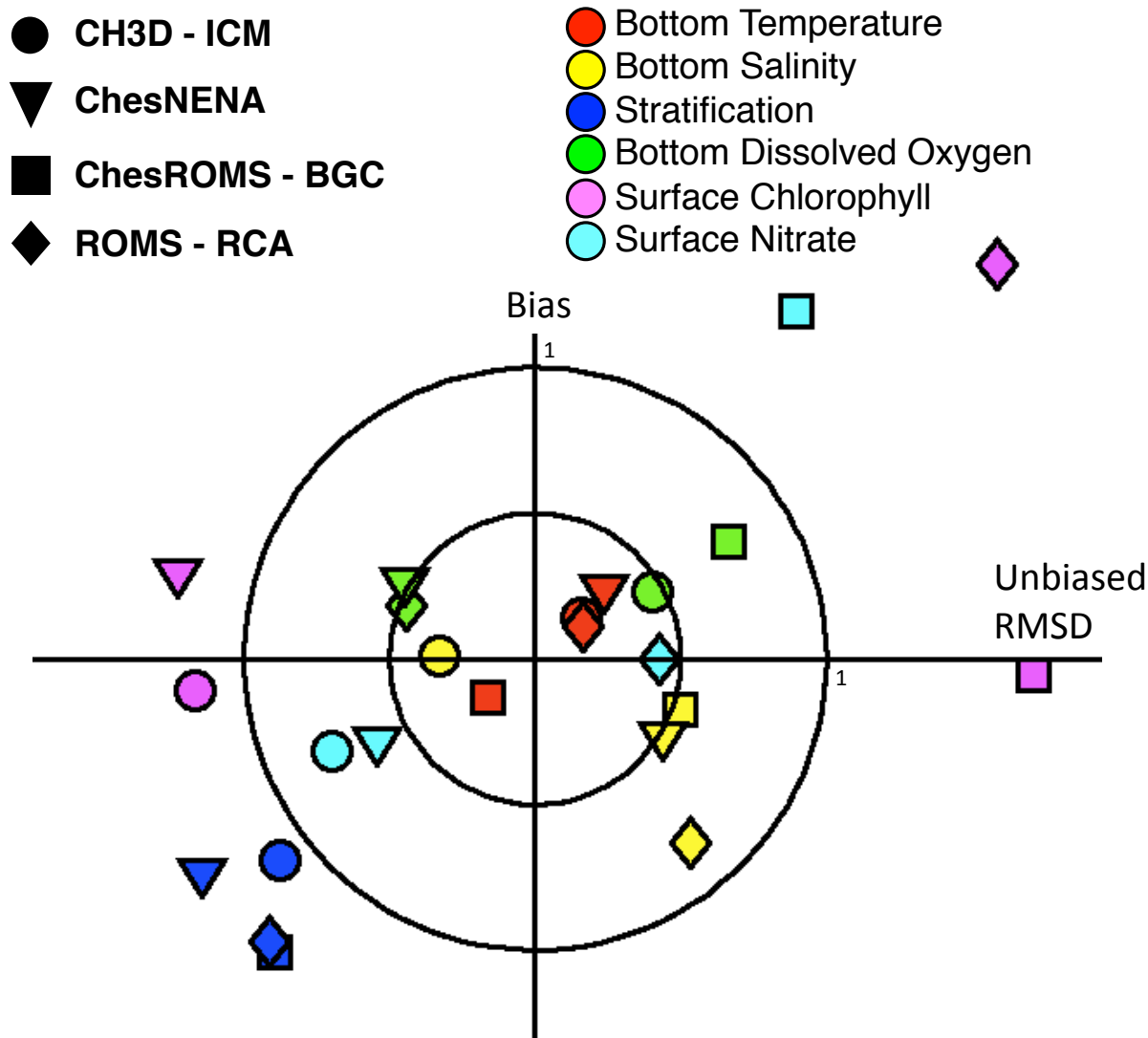
Compare  
simulations to  
observations at 10  
main stem stations  
for ~16 cruises in  
2004 and 2005





# Model Skill Assessment via Target Diagrams





Overall skill of all four models (temporal + spatial variability):

- are **highest** in terms of **Temperature**
- are **similar** to each other in terms of **T, S, stratification** and **DO**
- are **different** in terms of **chlorophyll** and **nitrate**

# Model Comparisons via Chesapeake Testbed

- Regardless of complexity, models achieve similar skill scores in terms of seasonal variability of T, S, stratification and oxygen
  - All models reproduce DO better than variables that are typically thought to be primary influences on DO (stratification, chlorophyll, nitrate)
    - This is because seasonal DO variability is sensitive to T (solubility effect), and the models reproduce T very well
    - Modeled DO simulations may be very sensitive to any future increases in Bay temperature
- Oxygen forecasting is possible with simple biological formulation

# Estuarine Hypoxia Goal

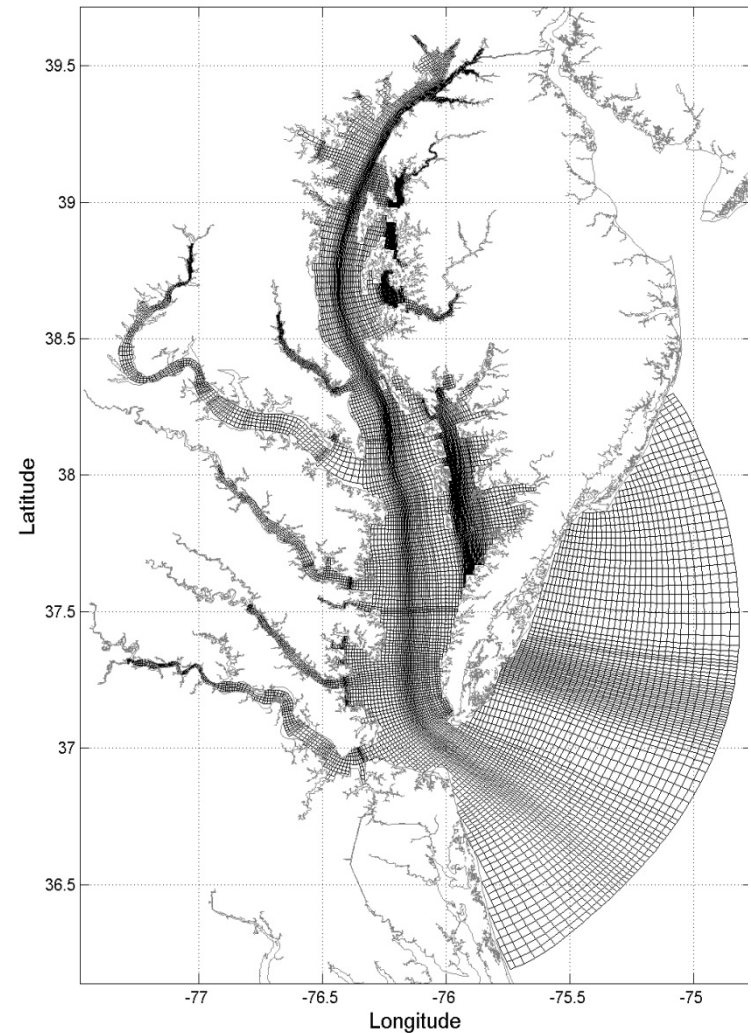
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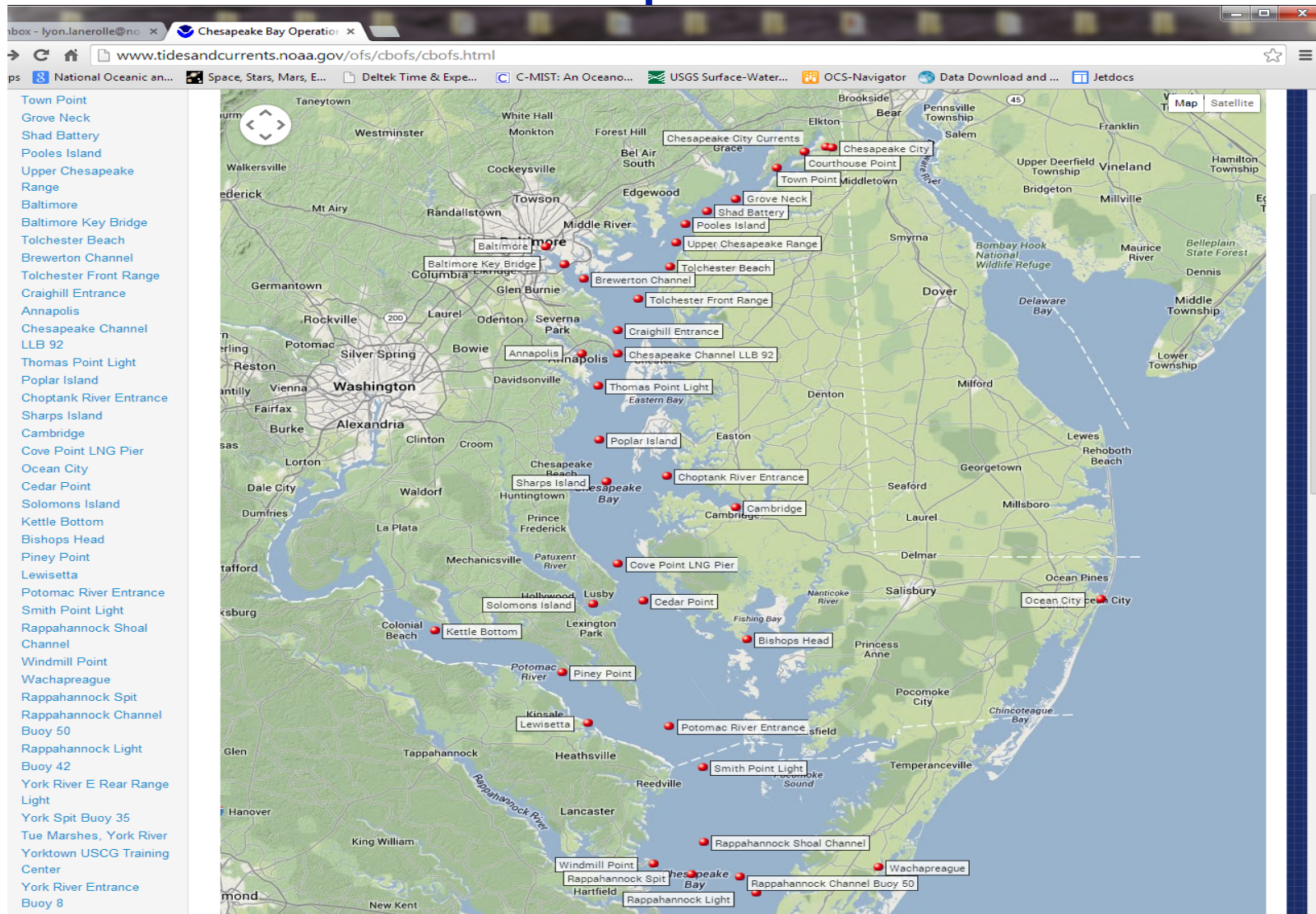
# CBOFS

- CBOFS based on Regional Ocean Modeling System (ROMS)
- Grid generated in segments and pasted seamlessly using Delft3D-RGFGRID generator
- Bathymetry: NOS soundings cut-off at 2m depth
- Init Conds: NOAA T, S climatology for lower Bay and CBP profiles for upper Bay
- Rivers: discharge = USGS; T, S = CBP
- Outer Bdy Conds: T, S = NOAA climatology
- Outer Bdy Tides: tidal harmonic constituents for WL and barotropic currents from ADCIRC database
- No sediment, precipitation, wetting/drying or data assimilation

CBOFS Model Grid



# CBOFS – Model Output Archive Locations






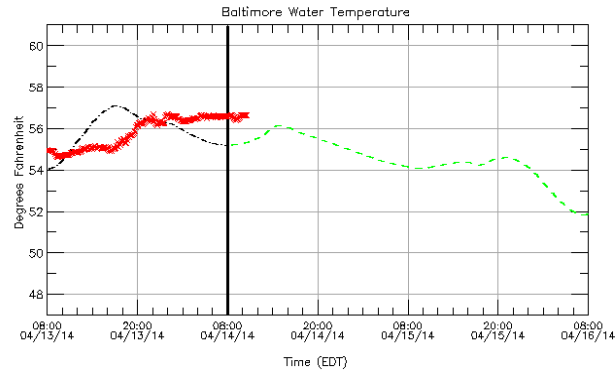
Archive water elevations, 3D currents, T and S at all of the above locations






# CBOFS – Model Outputs

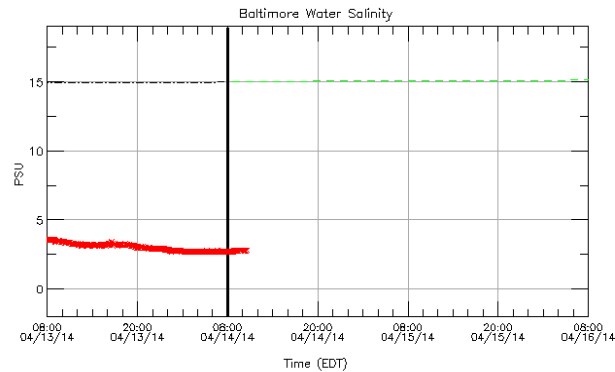
NOAA/National Ocean Service  
Chesapeake Bay Operational  
Forecast System (CBOFS2)

Observation:   
Nowcast:   
Forecast Guidance: 



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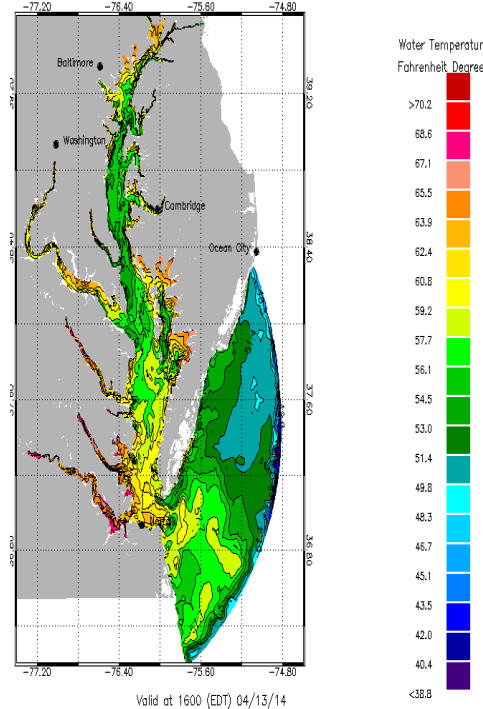
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## Chesapeake Bay OFS Water Temperature

March 13, 2014: CO-OPS is planning to turn off OPeNDAP services on the NOS OFS web pages on April 23, 2014.

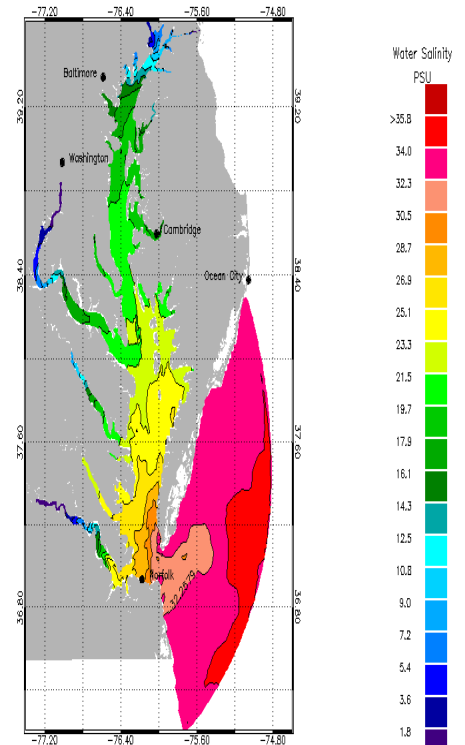
Model forecast information is based on a hydrodynamic model and should be considered as computer-generated nowcast



## Chesapeake Bay OFS Salinity Nowcast

March 13, 2014: CO-OPS is planning to turn off OPeNDAP services on the NOS OFS web pages on April 23, 2014.

Model forecast information is based on a hydrodynamic model and should be considered as computer-generated nowcast



# CBOFS

**Goal 1: CBOFS short-term forecasting** Incorporate new oxygen and physical model enhancements into the existing operational NOAA CO-OPS CBOFS for evaluation during their next update

## **Progress to Date:**

- Staying in touch with NOS/CO-OPS on their salinity improvements
- COMT colleagues have recommended updated model options (advection scheme, TKE parameter, etc...)

## **Ongoing Work:**

- Re-run CBOFS (2.5y) with new model options and updated code
- Compare multiple physical simulations; assess model skill relative to other COMT models
- Incorporate “best” constant biology DO model into CBOFS (Year 2?)
- Compare multiple DO simulations; assess model skill
- Finalize CBOFS code and have it ready for NOS/CO-OPS next update



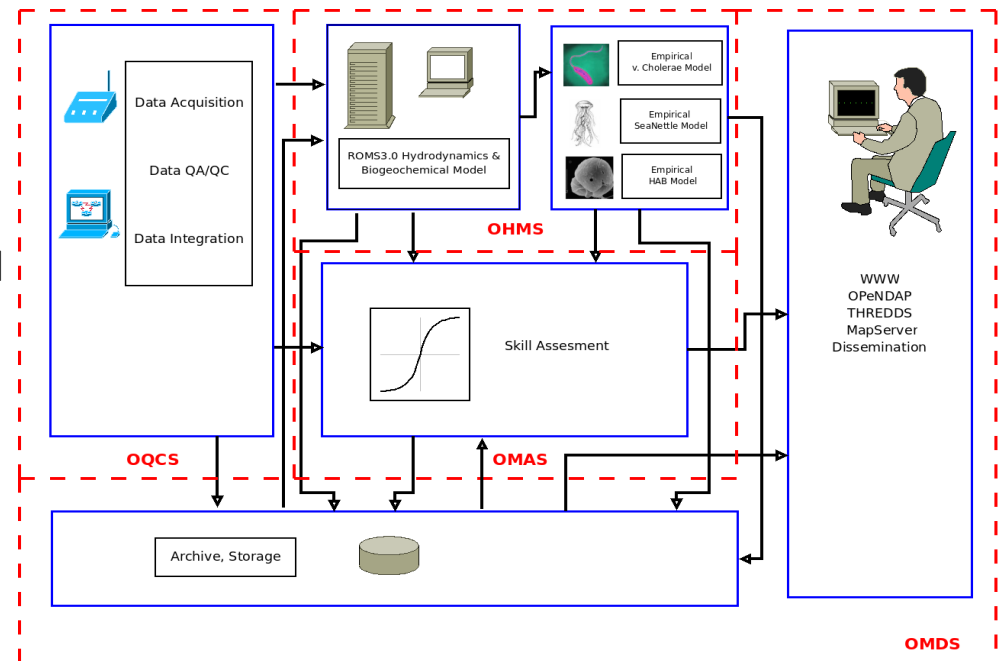
# Estuarine Hypoxia Goal

**Compare multiple models** within the Estuarine Hypoxia Testbed in order to improve existing:

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# Chesapeake Bay Ecological Prediction System (CBEPS) and Model Framework

- Coupled hydrodynamic/biogeochemical model (ChesROMS) running “operationally” at UMCES (formally supported by NOAA/NCBO)
- Nowcasts = real time USGS river discharge; Forecasts = assume river flows persist for 3 days
- Atmospheric forcing for 3-day forecasts from the North American Meteorological Model
- Simple seasonal climatologies/flow for biogeochemical boundary conditions
- Baywide nowcasts & 3 day forecasts of T and S are generated daily and posted
- Baywide ecological nowcasts & 3 day forecasts of Sea Nettles and Vibrio are generated daily, based on T, S logistical regression models (Vibrio not posted)



# CBEPS Nowcasting/Forecasting Sea Nettles:

<http://chesapeakebay.noaa.gov/forecasting-sea-nettles>

- Maps generated daily and posted on website
- Nowcasts and 3-day forecasts
- **Sea Surface Temperature**

20 Jan 2014

**NOAA** CHESAPEAKE BAY OFFICE  
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

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### Forecasting Sea Nettles

The jellyfish often encountered in the Chesapeake Bay in the summer is the sea nettle *Chrysaora quinquecirrha*. Knowing where and when to expect this biotic nuisance may help to alleviate an unpleasant encounter.

Select Mode :  
 Nowcast  
 Forecast

Date: 01/20/2014

Select Map Layer :  
 Daily Nettle Forecast  
 Sea Surface Temp  
 Sea Surface Salinity

Select Base Layer :  
 Hybrid  
 Normal  
 Satellite  
 Terrain

Temp ( $^{\circ}\text{C}$ )  
35+  
30  
25  
20  
15  
10  
5  
<math>< 0</math>

UMCES Jelly Cam

#### Sea Nettle Project Links

- ▶ [Identify Jellyfish](#)
- ▶ [Forecasting Project Background](#)
- ▶ [Habitat Model](#)
- ▶ [Salinity Model](#)
- ▶ [Satellite Sea Surface Temperatures](#)

#### Related Sea Nettle Links

- ▶ [Ghostly Nettles Haunt Bay](#)
- ▶ [Scientist Looks to Data from the Past to Gauge Restoration Expectations](#)

Sea nettle probabilities—updated hourly—are also available at each of the ten [NOAA Chesapeake Bay Interpretive Buoy System](#) observing locations.

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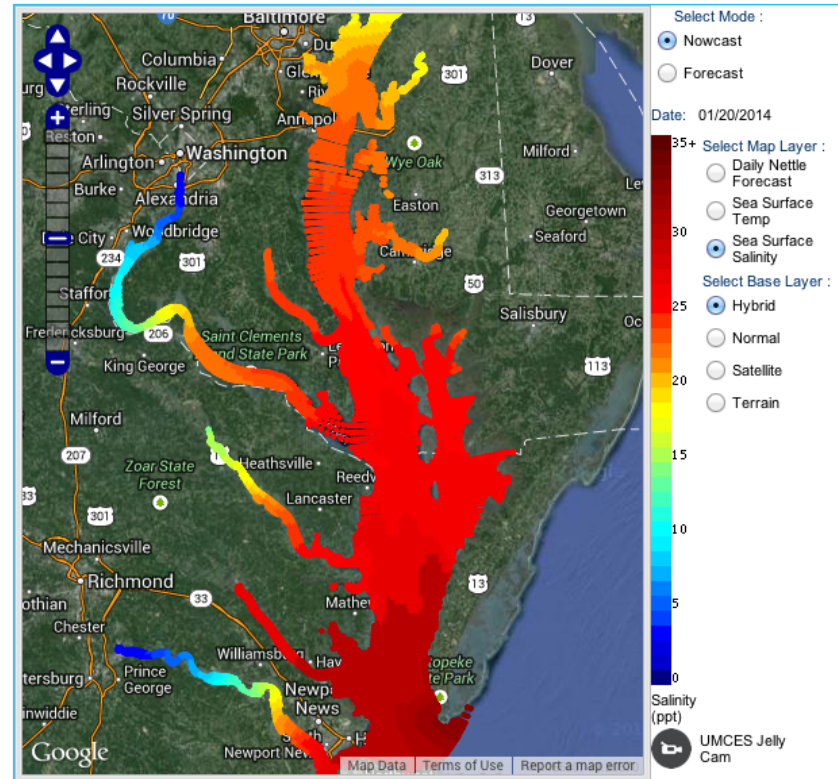


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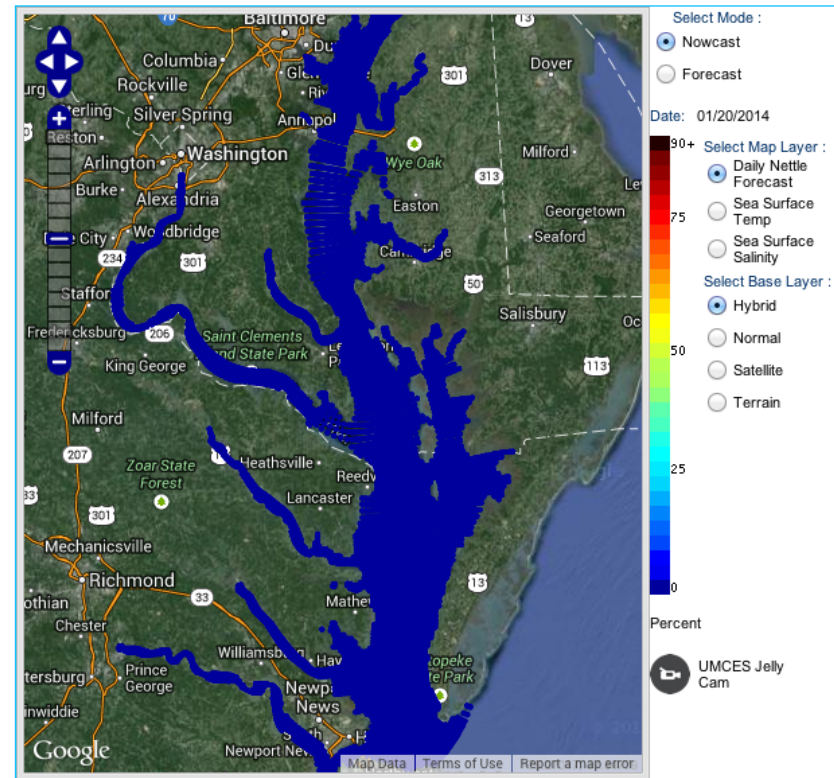


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- Sea Surface Salinity
- Sea Nettles
- **Vibrio (not posted)**

20 Jan 2014

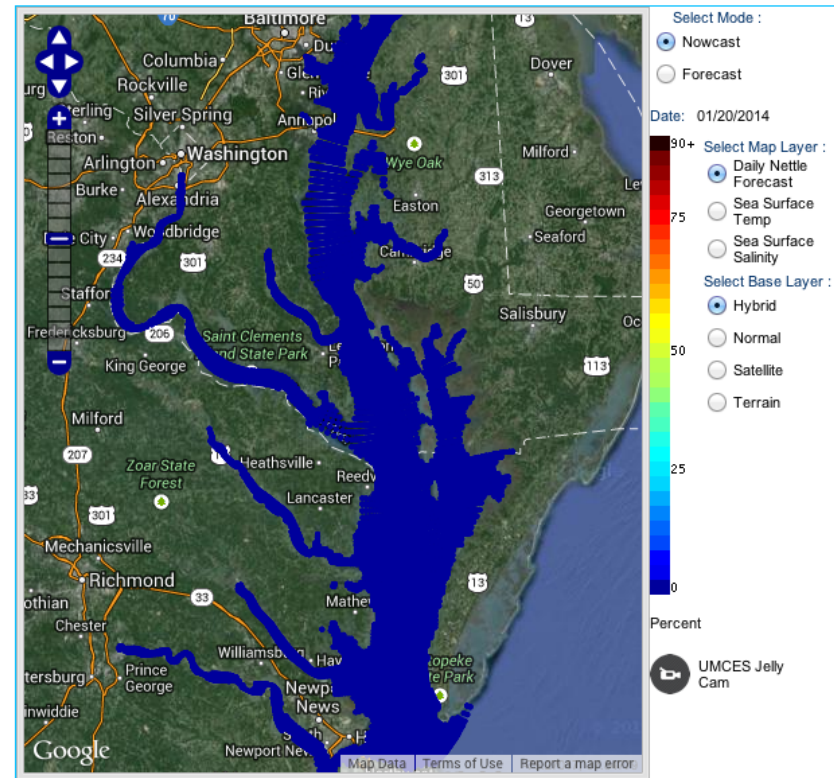


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# Chesapeake Bay Ecological Prediction System (CBEPS)

**Goal 2: CBEPS short-term forecasting** Develop a 24/7 predictive capacity for nowcasting/forecasting of oxygen/hypoxic volume at NOAA CBPO & UMCES

## Progress to Date:

- Currently running 3 day forecasts “operationally” at UMCES for Chesapeake-biogeochemistry (based on “old” version of ChesROMS)
- Developed “sea nettles” forecast – transitioned to a 24/7 demonstrative product at NOAA through CBOFS (Success!) – still need to carry out skill assessment
- Other organisms act similarly, e.g. *Vibrio*

## Ongoing Work:

- Add simple DO formulation to list of variables forecasted
- Update ChesROMS physics
- Ultimately merge features of two ROMS-BGC models: ChesNENA and ChesROMS

# Estuarine Hypoxia Goal

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# CBP Scenario-based Forecasting

## Progress to Date:

- Developed methodology to use an alternate hydrodynamic+biogeochemical model to reproduce Water Quality Standards for CBP
- EPA Chesapeake Bay Program folks are enthusiastic about our proposed effort to assess confidence/uncertainties in their regulatory model

## Future Work:

- Run alternate model(s) with CBP's nutrient reduction scenarios.
- Apply CBP protocol to both sets of model scenarios
- For each model, identify when/where Bay will meet required “water quality standards”
- How do the model results diverge? Where/when are the greatest uncertainties in the TMDLs computed from these model results?

# The Estuarine Hypoxia COMT model skill comparisons are improving:

- NOAA CBOFS nowcasts/forecasts
- UMCES CBEPS nowcasts/forecasts
- CBP scenario-based forecasts

