Delaware River Basin Commission

Designated Use Study:

Protection of Aquatic Life Use and Dissolved Oxygen Criteria

Namsoo Suk, Ph.D.
Director, Science and Water Quality Management

RFAC Meeting
April 9, 2019

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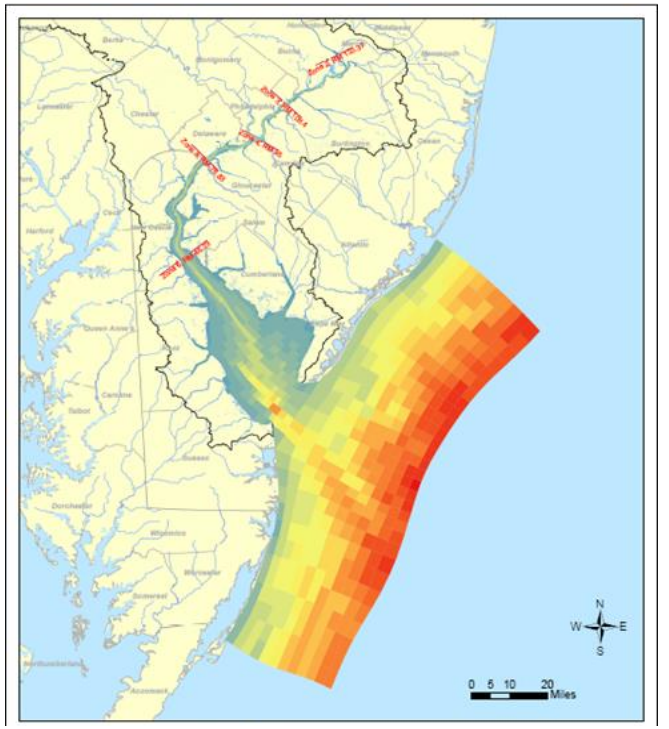
Outline

* Water Quality Standards
  - Designated Use
  - Water Quality Criteria
* Dissolved Oxygen (DO) History
* DRBC Resolution 2017-4
* Status of Development of Hydrodynamic and Water Quality Model



Water Quality Regulations

Water Quality Standards

Designated Uses:

e.g., Drinking water supply, protection and propagation of aquatic life, recreation in and on the water.

Criteria:

numeric and/or narrative parameters to protect the designated uses.

Antidegradation Policy And Procedures:

to maintain and protect existing water quality.

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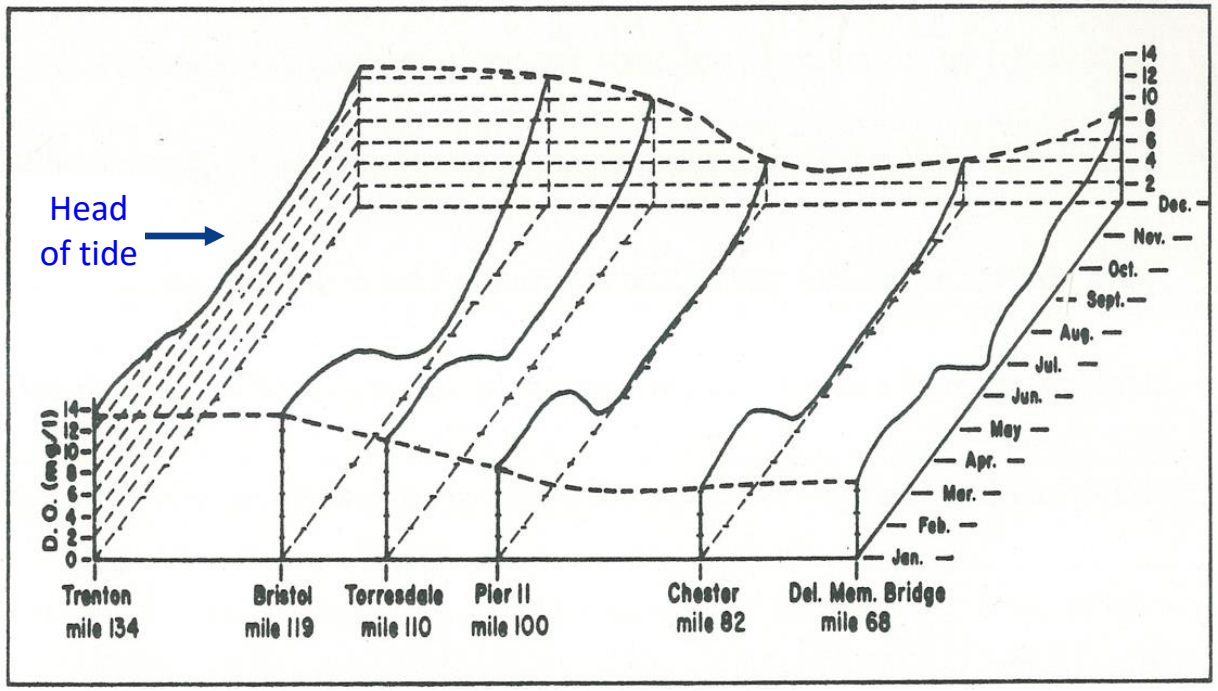
Dissolved Oxygen in Delaware Estuary



Mean monthly dissolved oxygen concentration –Tidal Delaware River, 1963

- Historically, summer DO near urban portions of estuary was too low for migratory fish to reach upstream to spawn
- Main causes of oxygen depletion
  - Carbonaceous Biochemical Oxygen Demand (CBOD): Oxidation of organic materials
  - Nitrogenous Biochemical Oxygen Demand (NBOD): Oxidation of ammonium (NH_4) to nitrate (NO_3)
- DRBC adopted water quality standards in 1967

Aquatic Life Designated Uses in Current DRBC Regulations since 1967

Urbanized portion of Delaware Estuary

Zone	River Mile	Aquatic Life Use	Migratory Fishes	24-hour average D.O. Criteria
2	108.4 – 133.4	**maintenance** and **propagation** of resident fish and other aquatic life	**passage** of anadromous fish	5.0 mg/l
3	95 – 108.4	**maintenance** of resident fish and other aquatic life	**passage** of anadromous fish	3.5 mg/l
4	78.8 – 95	**maintenance** of resident fish and other aquatic life	**passage** of anadromous fish	3.5 mg/l
5	70 – 78.8	**maintenance** of resident fish and other aquatic life	**passage** of anadromous fish	3.5 mg/l
	48.2 – 70	**maintenance** and **propagation** of resident fish and other aquatic life	**passage** of anadromous fish	4.5 – 6.0 mg/l
6	0 – 48.2	**maintenance** and **propagation** of resident fish and other aquatic life **maintenance** and **propagation** of shellfish	**passage** of anadromous fish	6.0 mg/l

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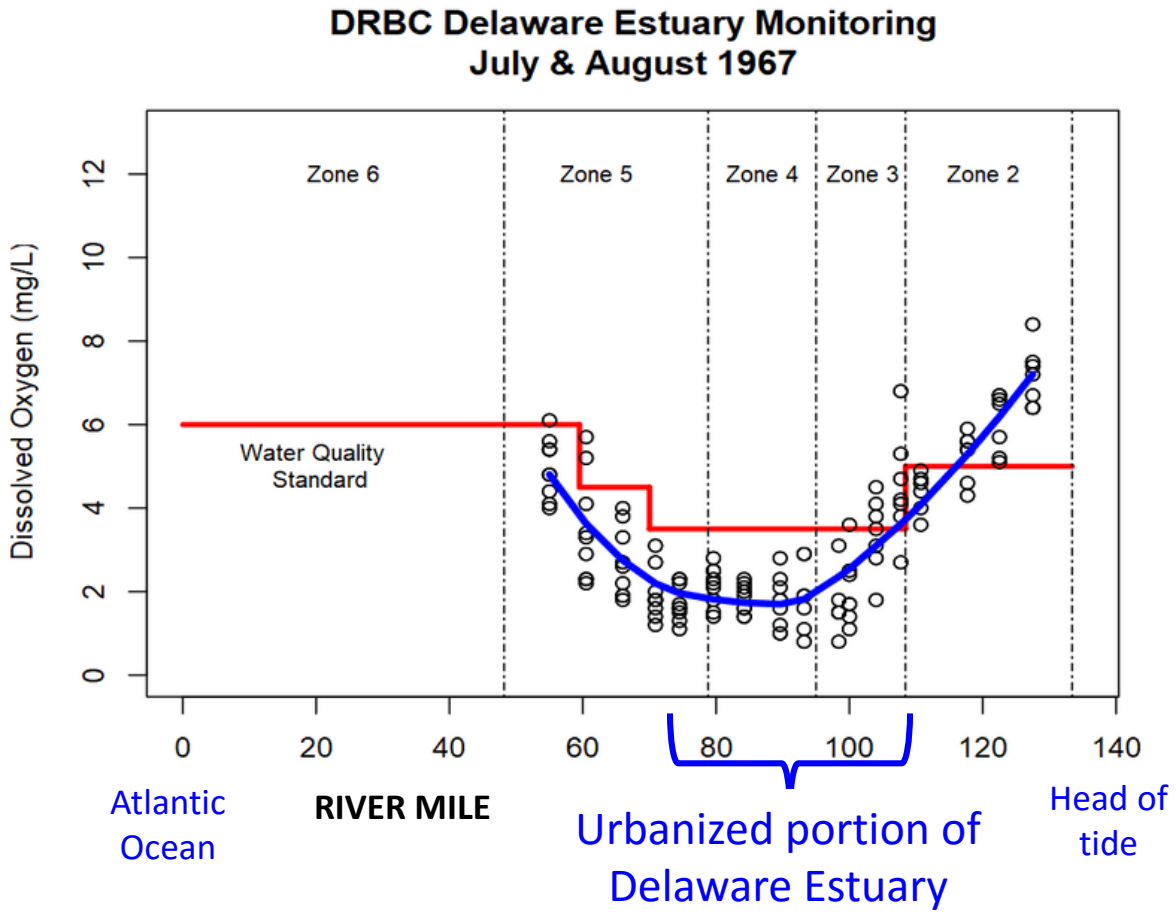
Dissolved Oxygen



- DRBC issued CBOD wasteload allocations (WLAs) for Zones 2 – 5 in 1968
- Implementation of CBOD WLAs
  - Via DRBC's dockets (equivalent to NPDES permit)
  - Over 70 point source dischargers get CBOD effluent load limits
  - Minimum required CBOD percent reduction
  - Secondary treatment added at wastewater treatment plants 70's & 80's – funding CWA
- By 2000's D.O criteria is nearly always met

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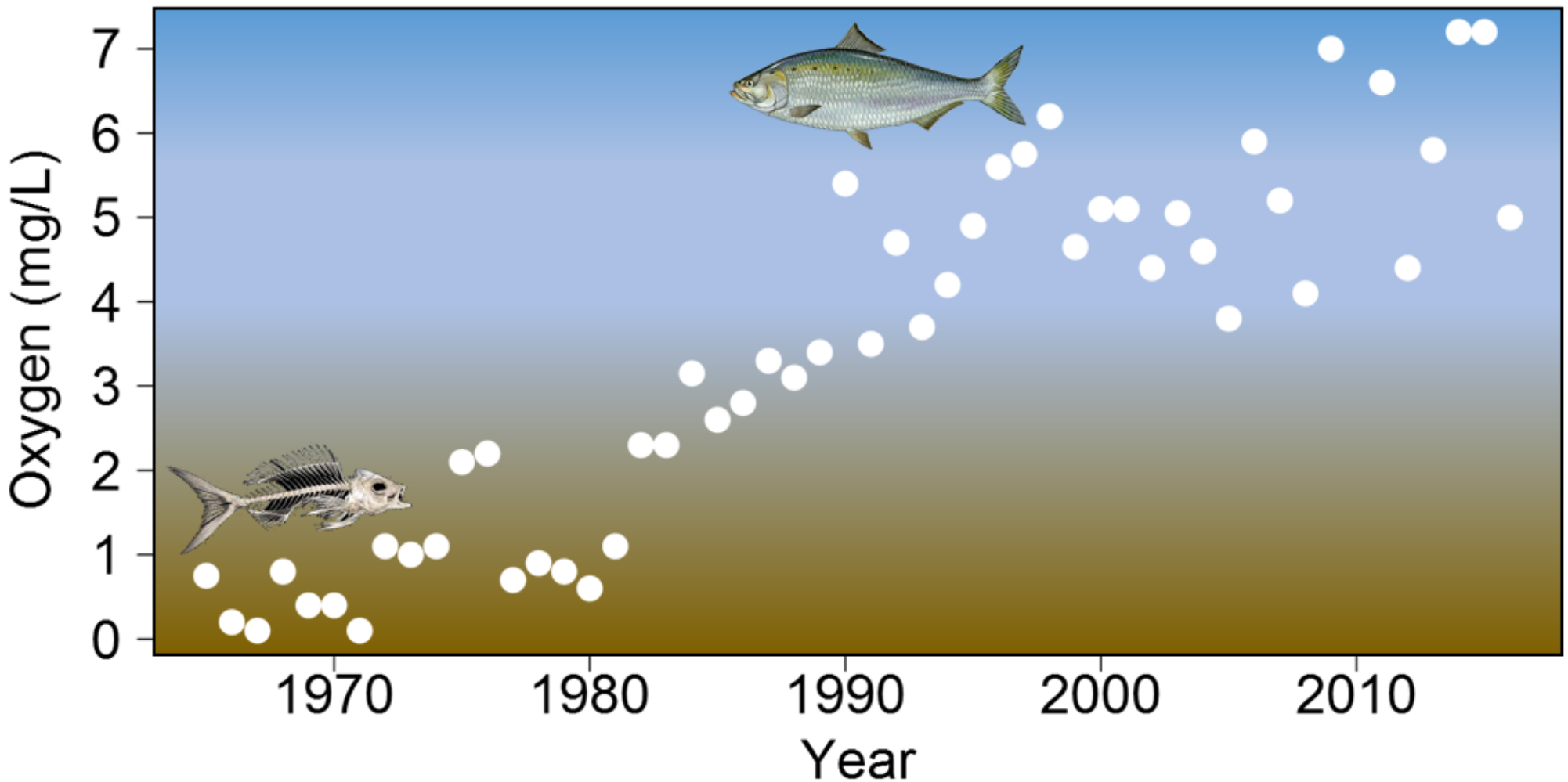
July Oxygen at Ben Franklin Bridge



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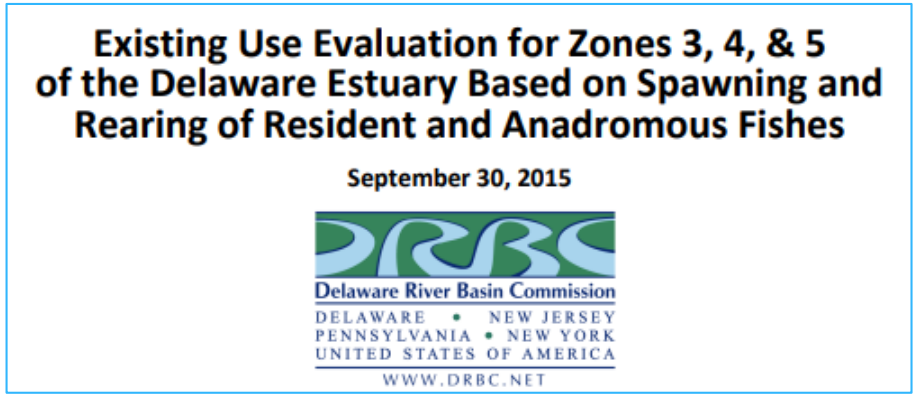
Evaluation of Existing Use

- Some strong evidence for successful reproduction for:
  - White Perch (Zones 3 & 4), Striped Bass (Zone 5)
- Some moderate evidence for successful reproduction for:
  - American Shad (Zone 3), Alewife (Zones 3 & 4), Bay Anchovy (Zones 4 & 5)
- Evidence for weak reproductive success in each Zone:
  - Atlantic Sturgeon (Zone 4), American Shad (Zone 4), Blueback Herring (Zones 3 & 4)

✓ Update to DRBC Water Quality Regulations needs to be considered



https://www.nj.gov/drbc/library/documents/ExistingUseRpt_zones3-5_sept2015.pdf

DRBC Resolution 2017-4

- Shared achievement & goals
  - Continuous water quality improvement
- Study to determine attainability of new DO criteria, with a fixed schedule
- Initiate rulemaking
- DO early action workgroup
- Recognition of Philadelphia Water Department's DO partnership

https://www.state.nj.us/drbc/library/documents/Res2017-04_EstuaryExistingUse.pdf

Adopted September 13, 2017

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Actions Underway

- Enhanced monitoring:
  - Point discharge monitoring
  - BoatRun to year-round
  - Added salinity at tidal boundaries
  - Added nitrate sensors at Trenton & Chester gages
  - Extensive tributary monitoring
  - Light extinction monitoring
  - Primary productivity study
- Engineering evaluation & cost estimate for improved WWTP ammonia & TN
  - Benefit analysis
- DO needs study for Delaware Estuary Biota by ANSDU (https://www.nj.gov/drbc/library/documents/Review_DOreq_KeySensSpecies_DelEstuary_ANStoDRBCnov2018.pdf)
- Development a linked hydrodynamic and water quality model
  - Model working group (Nov. 2018)
  - Model expert panel (Mar. 2018, 2019)

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DRBC Model Expert Panel Members

Name	Organization	Service
Dr. Carl Cerco	U.S. Army Corps of Engineers (Retired)	Panel Members
Dr. Bob Chant	Rutgers University	
Dr. Steve Chapra	Tufts University	
Tim Wool	U.S. EPA Region 4	
Dr. Vic Bierman	LimnoTech	Consultant to DRBC
Scott Hinz	LimnoTech	

Goal

- Develop a technically sound eutrophication model for the Delaware Estuary and Bay utilizing the current state of the science within a timeframe established by the Commission
  - Identify appropriate levels of source controls, especially in relation to dissolved oxygen

Targeted Schedule

	Activity	2017				2018				2019				2020				2021			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Designated Use Program Tasks	Hydrodynamic Model Development	x	x	x	x	x	x	x	x	x											
	Intensive Ambient Data Collection & Data Analysis	x	x	x		x	x	x	x	x											
	Water Quality Model Development and Calibration			x	x	x	x	x	x	x											
	Determination of higher levels of DO & protection to aquatic species.			x	x	x	x	x													
	Develop wasteload & load allocations																				
	Report Preparation																				

Legend

Program Tasks supported by the bordering states/DRBC Agreement

Lighter shading indicates preliminary or follow-up work

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Modeling Approach

- Develop a linked hydrodynamic and water quality model
  - Environmental Fluid Dynamics Code (EFDC)
  - Water Quality Analysis Simulation Program (WASP8)
- Assess available data and conduct additional monitoring to fill gaps
  - Sources
  - Ambient water
- Calibrate linked model
  - Historical data, primarily 2012-2013
  - Intensive monitoring period 2018-2019
- Conduct forecast simulations with calibrated model
  - Determine levels of external sources required to achieve varying levels of ambient dissolved oxygen

Modeling Progress to Date

- Preliminary calibration of EFDC hydrodynamic model
  - Water surface elevation
  - Salinity
  - Water temperature
- Continued cross-checking of EFDC-WASP8 linkage
  - Flow rates
  - Salinity transport
  - Mass balance check in WASP8
- WASP8 test simulations
  - TN and TP with chemical-biological kinetics turned off
  - Oxygen consumption by NH4-N, CBOD, and SOD

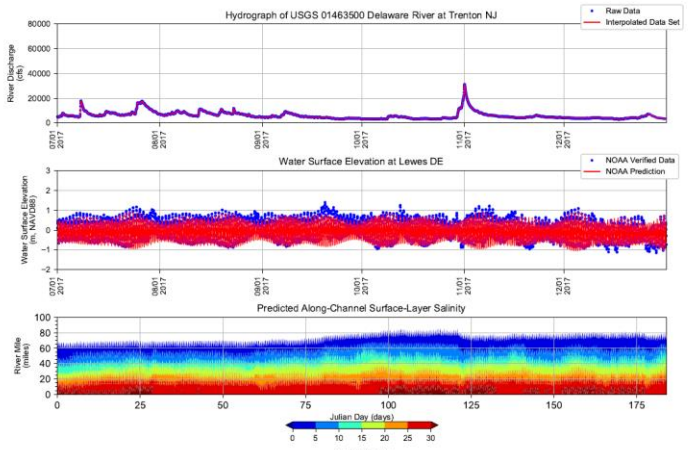

Figure --
Time History of Predicted Along-Channel Surface-Layer Salinity in Delaware River and Bay

Notes: Salinity less than 0.45 ppt or 250 ppm chloride concentration is blank out.
Run ID: EFDC_FGD_GVC_HYDRO_NFPNOC_1902-05

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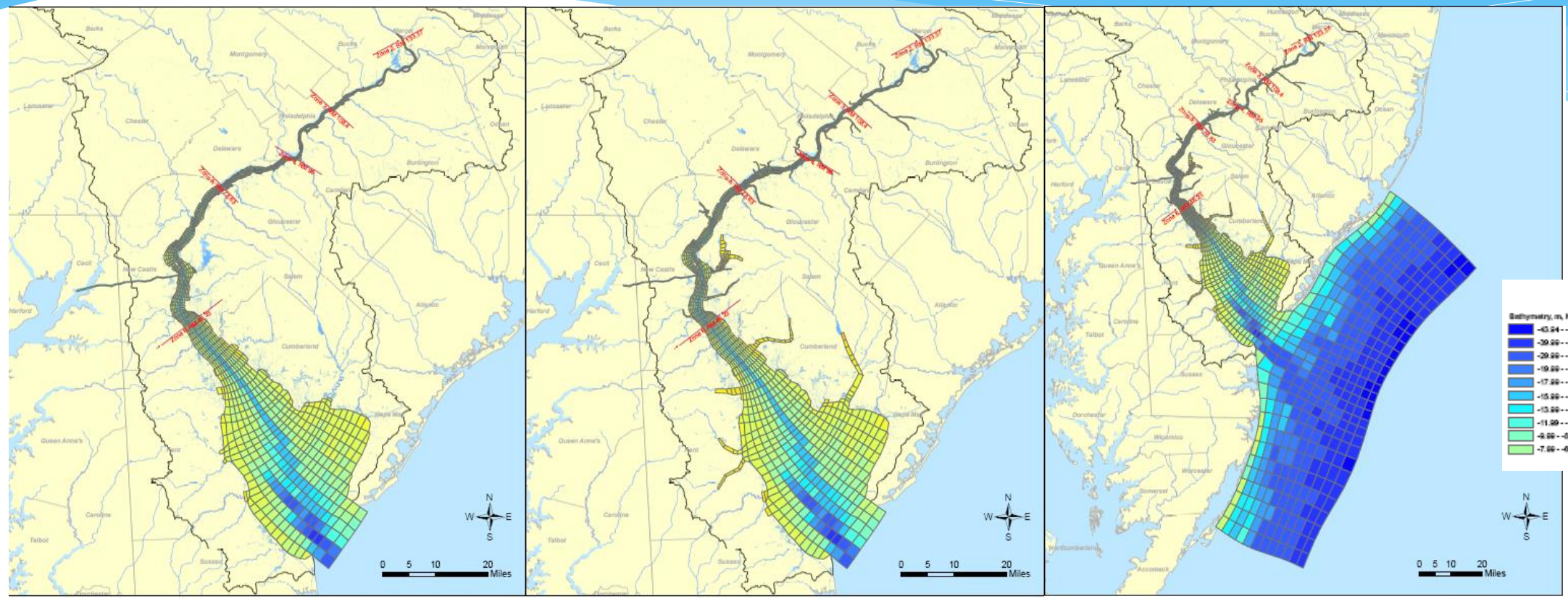
Hydrodynamics Model Grid - Bathymetry

- Model Grid and Bathymetry (Grid 5, Grid 1, and Grid 2) – Bathymetry *(Based on FEMA 2011 DEM, Reflects 2016 dredging depth). Vertical datum is NAVD88.*



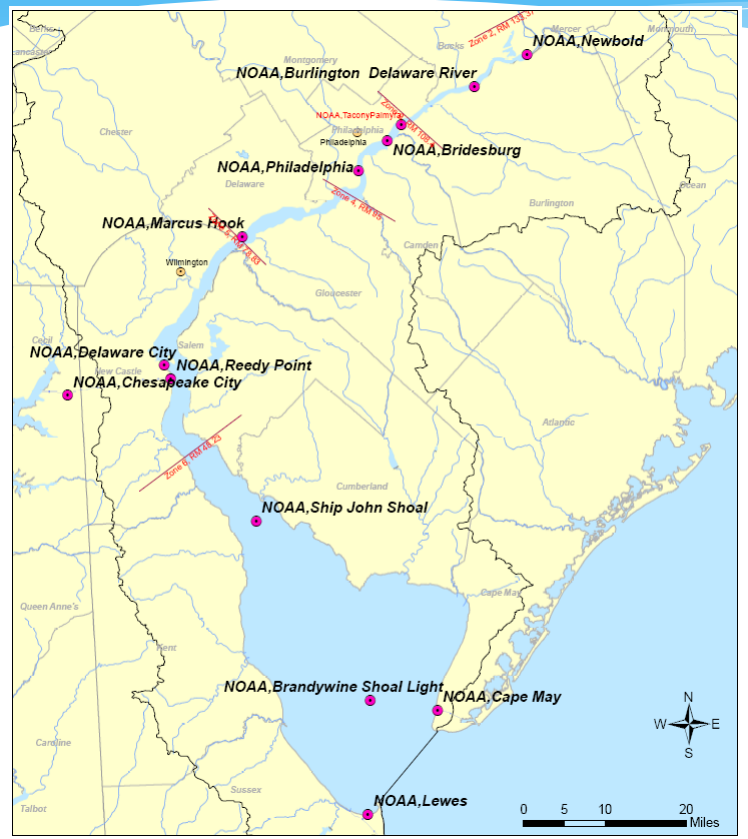
Grid 5, 1933 cells
Vertical Layers$_{max}$ = 5

Grid 1, 2281 cells
Vertical Layers$_{max}$ = 10

Grid 2, 2641 cells
Vertical Layers$_{max}$ = 20

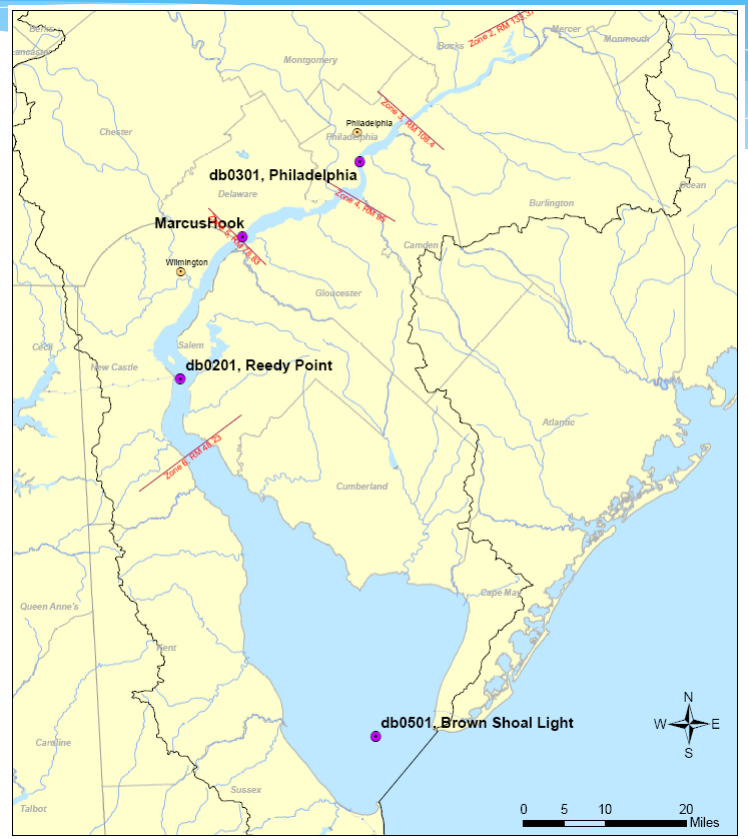
Data for Hydrodynamics Model Calibration

Location of NOAA and USGS Stations



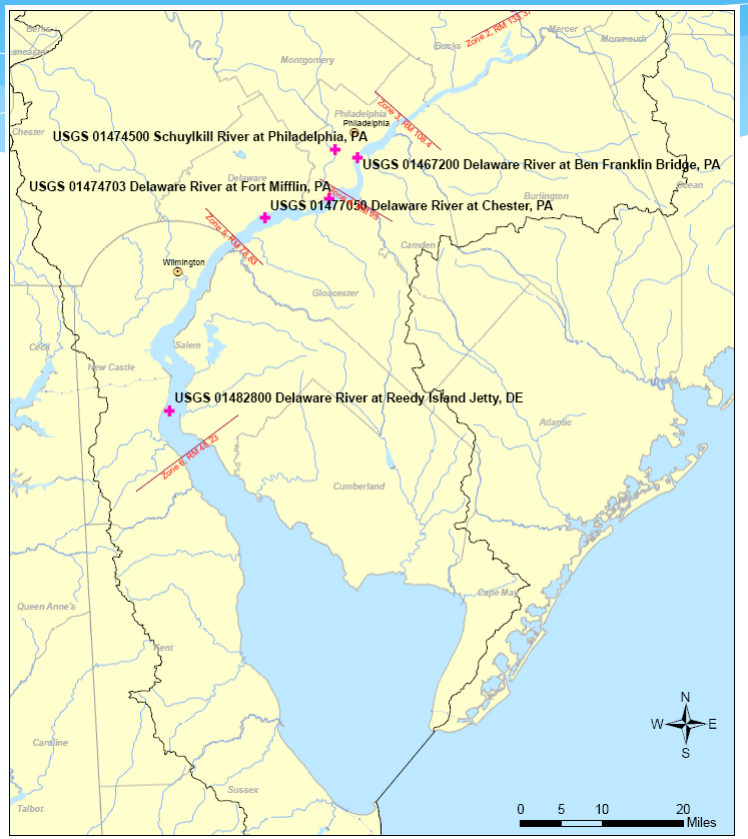
NOAA Stations

Tide/Water Temperature, Conductivity



NOAA Stations

Current Velocity



USGS Stations

Water Temperature, Specific Conductance

(Data from Reedy Island, Chester, and Ben Franklin Bridge were used)

Calibration Results – Grid 5 (2017-2018): Water Surface Elevation

Reedy Point

$Y = 0.9792\ X - -0.0145$
$R^2 = 0.9767$
$N = 17056$
$RMSE = 0.0961$
$ubRMSE = 0.0947$
$Bias = -0.0166$
$Skill = 0.9939$

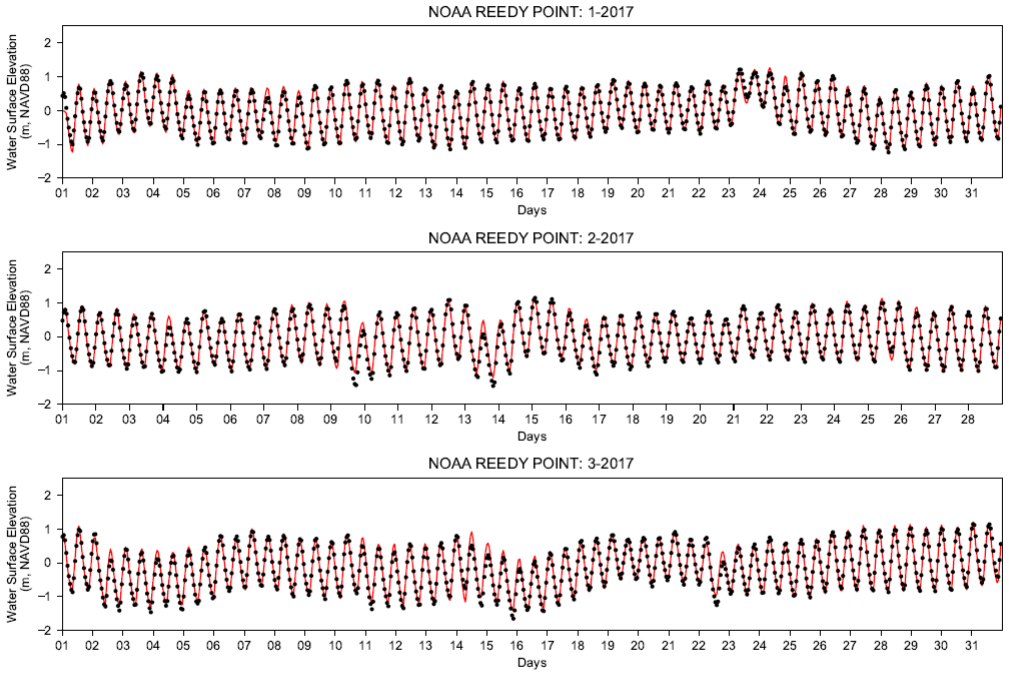


Figure XX

Observed and Predicted Water Surface Elevation at NOAA REEDY POINT

NOAA hourly verified data were used. Station ID: 8551910
Run ID: EFDC_FGD_GVC_HYDRO_NFPNOC_1902-05, Fine grid GVC, KC =5. CTE3=3.5
Spatial variable z0. 1933 cells. dt=20s. Sal adjustment = 3.5 ppt. NOAA NCDC weather data.

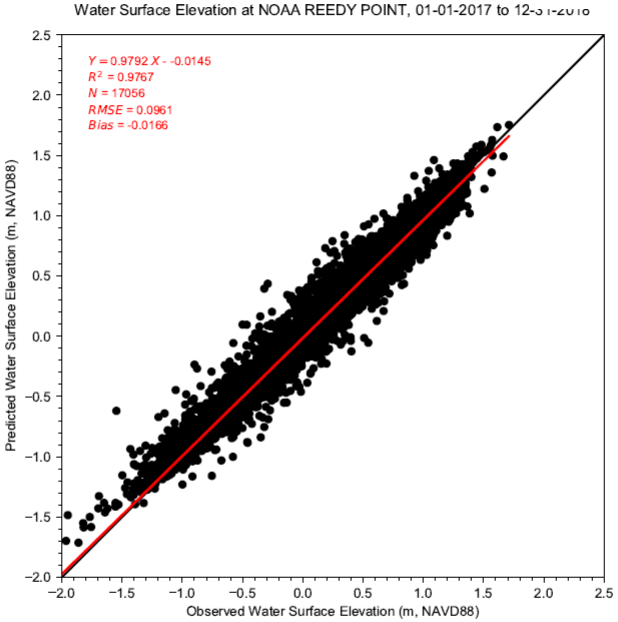


Figure --

Comparison of Observed and Predicted Water Surface Elevation at NOAA REEDY POINT

NOAA hourly verified data were used. Station ID: 8551910
Run ID: EFDC_FGD_GVC_HYDRO_NFPNOC_1902-05, Fine grid GVC, KC =5. CTE3=3.5
Spatial variable z0. 1933 cells. dt=20s. Sal adjustment = 3.5 ppt. NOAA NCDC weather data.

Calibration Results – Grid 5: (2012) Depth-Averaged Current Velocity

Reedy Point

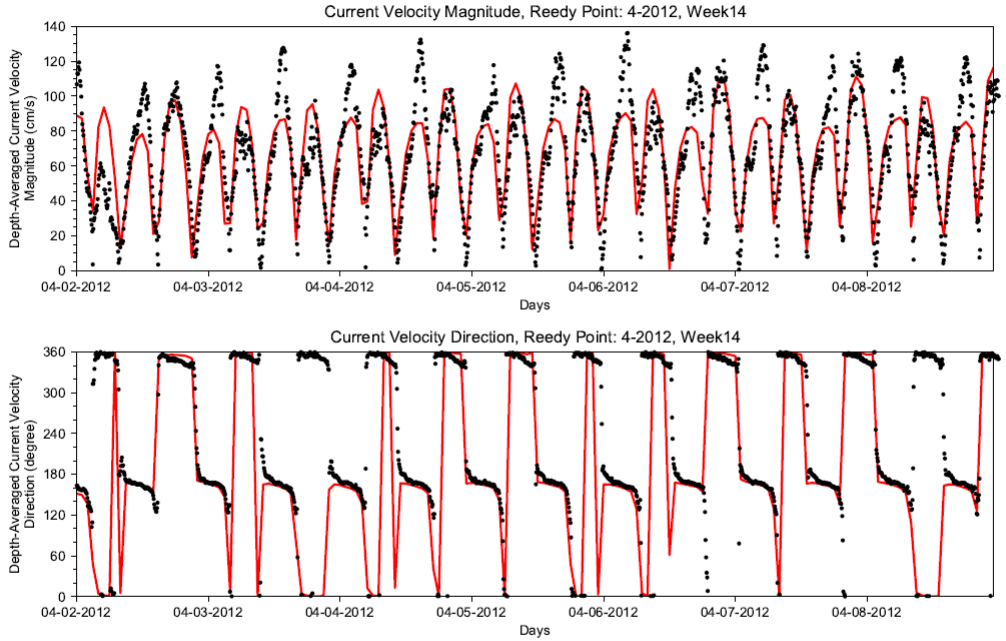


Figure XX

Observed and Predicted Depth-Averaged Current Velocity at Reedy Point

Notes: current velocity data were downloaded from NOAA CMIST website. Station ID: DB0201, Reedy Point
Run ID: EFDC_FGD_GVC_HYDRO_NFPNOC_1902-06, Fine grid GVC, KC =5. CTE3=3.5, dt=15s. Salinity adjustment = 3.5 ppt.

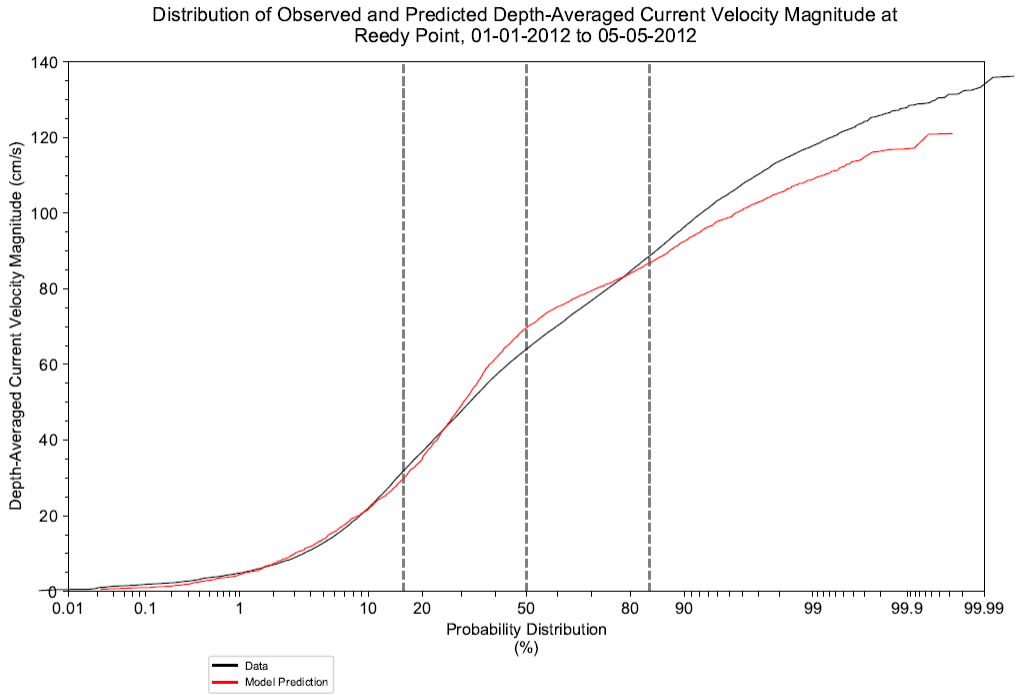


Figure --

Distribution of Observed and Predicted Depth-Averaged Current Velocity at Reedy Point

Notes: Station ID: DB0201
Run ID: EFDC_FGD_GVC_HYDRO_NFPNOC_1902-06, Fine grid GVC, KC =5. CTE3=3.5, dt=15s. Salinity adjustment = 3.5 ppt.

Calibration Results – Grid 5: Salinity (2017-2018)

Reedy Island

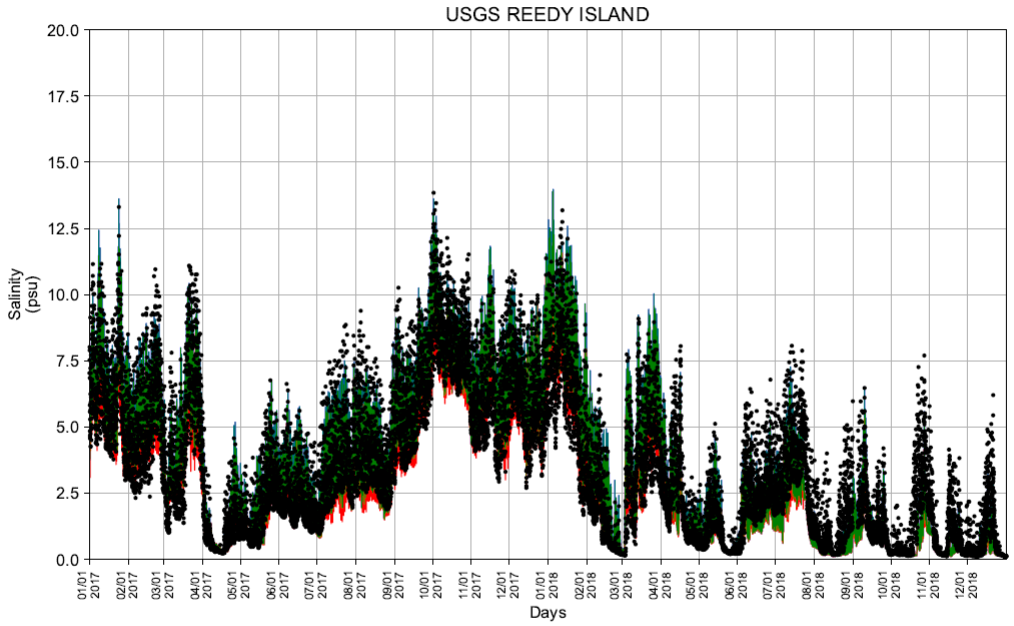


Figure XX

Observed and Predicted Salinity at USGS REEDY ISLAND

Station ID: 01482800, USGS REEDY ISLAND
Run ID: EFDC_FGD_GVC_HYDRO_NFPNOC_1902-05, Fine grid GVC, KC =5. CTE3=3.5, dt=15s. Salinity adjustment = 3.5 ppt.

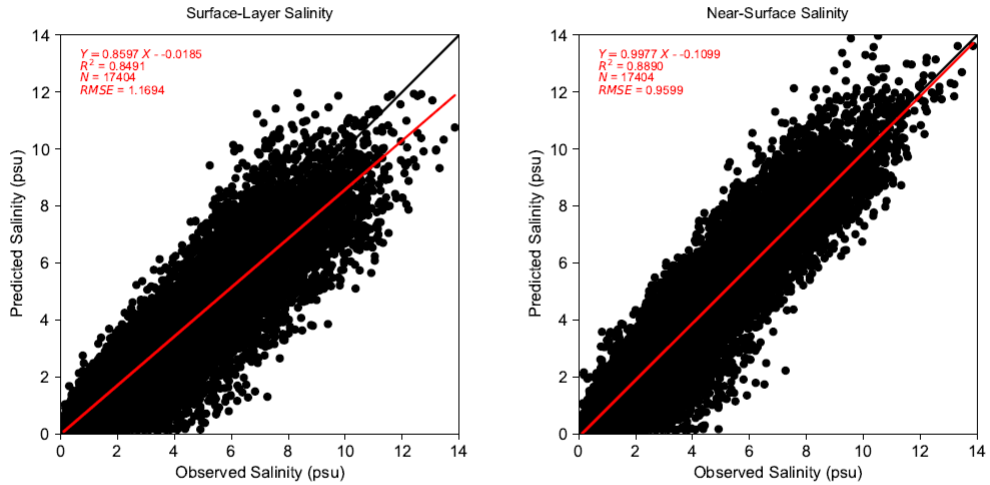


Figure --

Comparison of Observed and Predicted Salinity at
USGS REEDY ISLAND during 01-01-2017 to 12-31-2018 period.

Station ID: 01482800
Run ID: EFDC_FGD_GVC_HYDRO_NFPNOC_1902-05, Fine grid GVC, KC =5. CTE3=3.5, dt=15s. Salinity adjustment = 3.5 ppt.

Calibration Results – Grid 5: Water Temperature

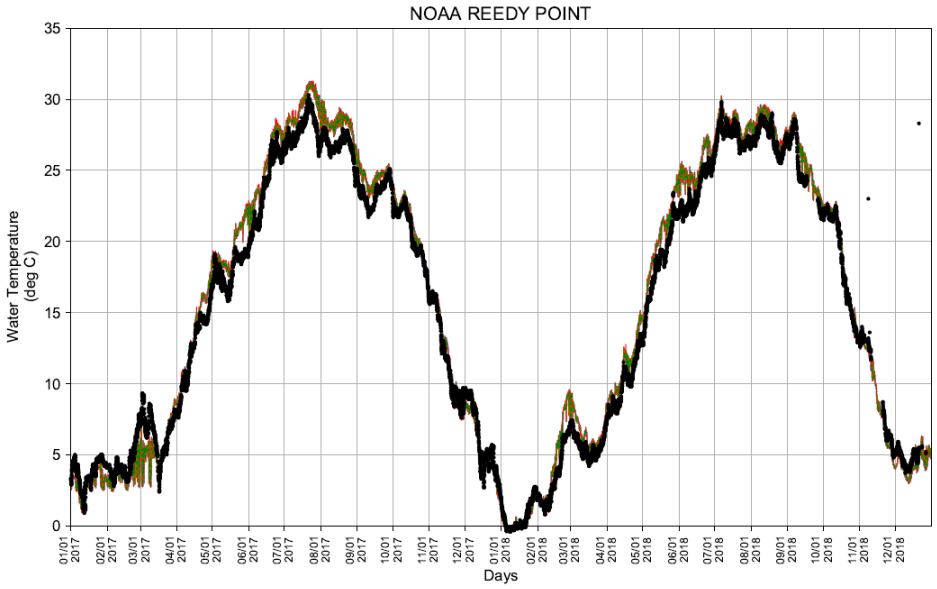


Figure XX

Observed and Predicted Water Temperature at NOAA REEDY POINT

Station ID: 8551910, NOAA REEDY POINT
Run ID: EFDC_FGD_GVC_HYDRO_NFPNOC_1902-05, Fine grid GVC, KC =5. CTE3=3.5, Salinity adjustment = 3.5 ppt. NOAA NCDC weather data were used. dt=15s

2017-2018

Reedy Point

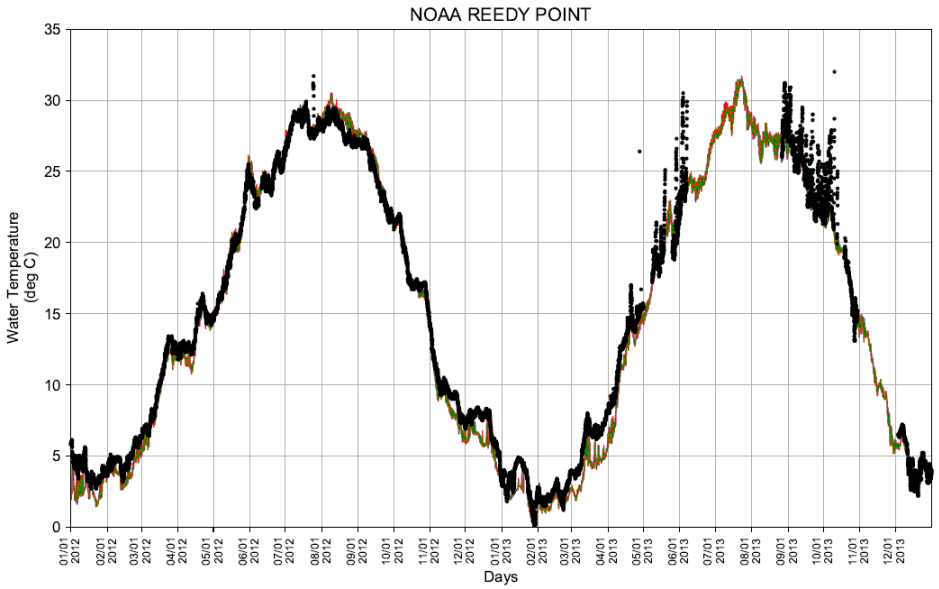


Figure XX

Observed and Predicted Water Temperature at NOAA REEDY POINT

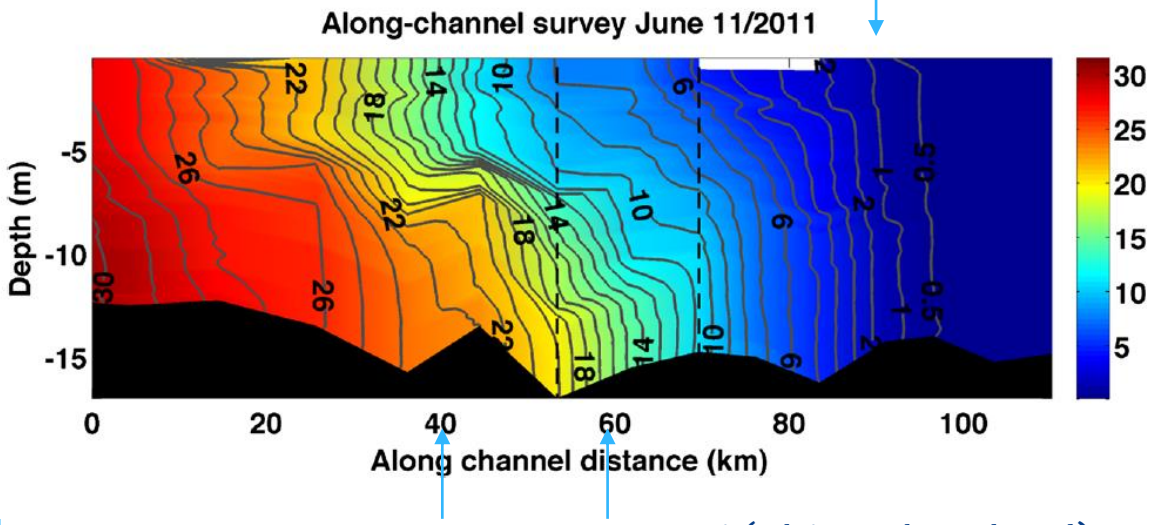
Station ID: 8551910, NOAA REEDY POINT
Run ID: EFDC_FGD_GVC_HYDRO_NFPNOC_1902-06, Fine grid GVC, KC =5. CTE3=3.5, Salinity adjustment = 3.5 ppt. NOAA NCDC weather data were used. dt=15s

2012-2013

Calibration Results – Grid 1 (more vertical layers): Vertical Stratification

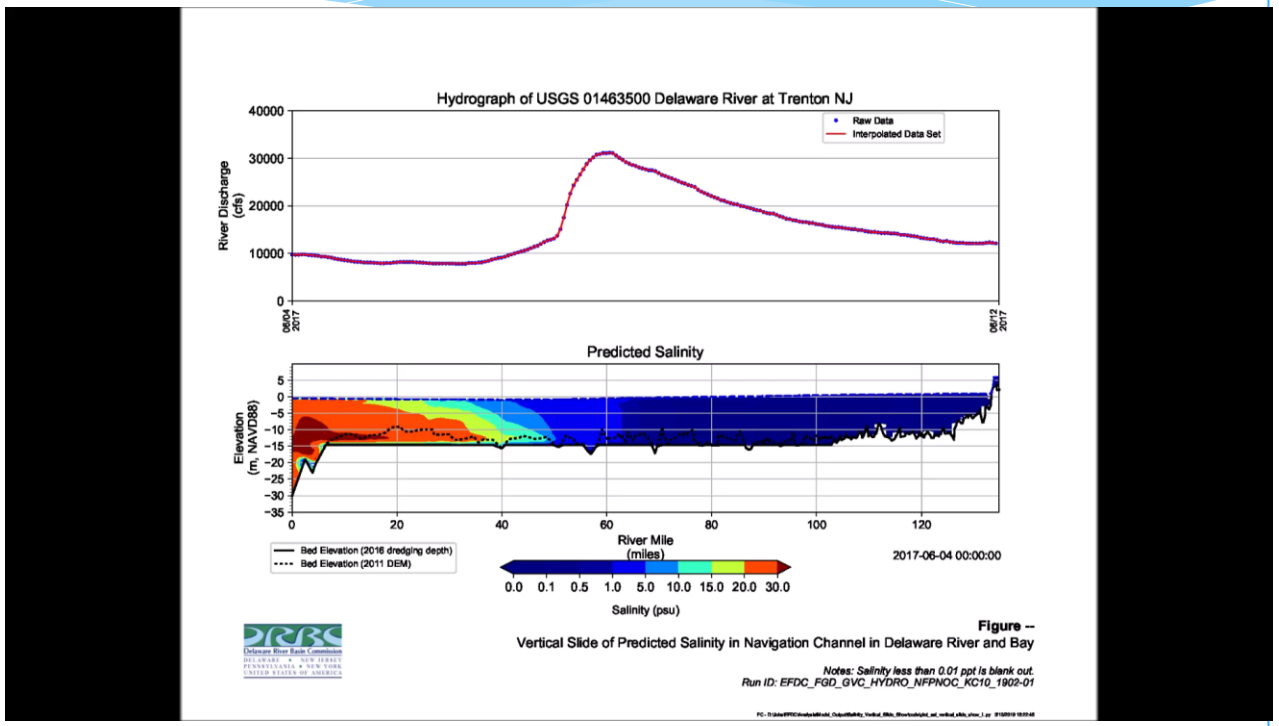
Ross et al (2015) - Ship John Shoal, near surface salinity ~ 13 ppt, near bottom is about ~ 18 ppt (oyster bed data)

58.5 mi (Reedy Point)



25 mi

37 mi (Ship John Shoal)



Mar´ıa Aristiz´abal · Robert Chant (2014)
- 2011 survey data. Flow at Trenton is about 75,000 to 80,000 cfs

June 4 to 12, 2017 (Model Results)

Path Forward

from March 2019 Model Expert Panel Meeting

- Significant progress on model development and calibration since March, 2018
- Finalize calibration of EFDC hydrodynamic model
- Evaluate and resolve EFDC - WASP8 linkage issues
- Develop and refine remaining model inputs to WASP8
- Begin calibration of WASP8
- Implement Expert Panel recommendations to monitoring program

Linkages between FFMP and DU Study

- There is a close relationship between water quantity and water quality
  - Assimilative capacity for any pollutants is governed by available flows
  - For example, for the protection of aquatic life, DRBC WQ Regulation defines the design flow at Trenton as 2,500 cfs and flows from other tributaries as 7Q10 flows
- Multiple levels of hydrodynamic models are calibrated will be developed
- Plan to simulate for year 2011 where Rutgers Univ. collected spatial and temporal salinity profile data in lower estuary and Bay
- Models developed under the Designated Use Study will be available to support other Commission needs

Questions?

e-Mail: Namsoo.Suk@drbc.gov

Phone: (609) 477-7235

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