

# Comparison of Shallow Water Models for Use in Supporting Chesapeake Bay Management Decision-making

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# Availability of Chester River data

**WQ** = semi-monthly  
cruise data in summer;  
otherwise monthly

**CMON** = 15 minute  
data (April – October);  
fixed platform

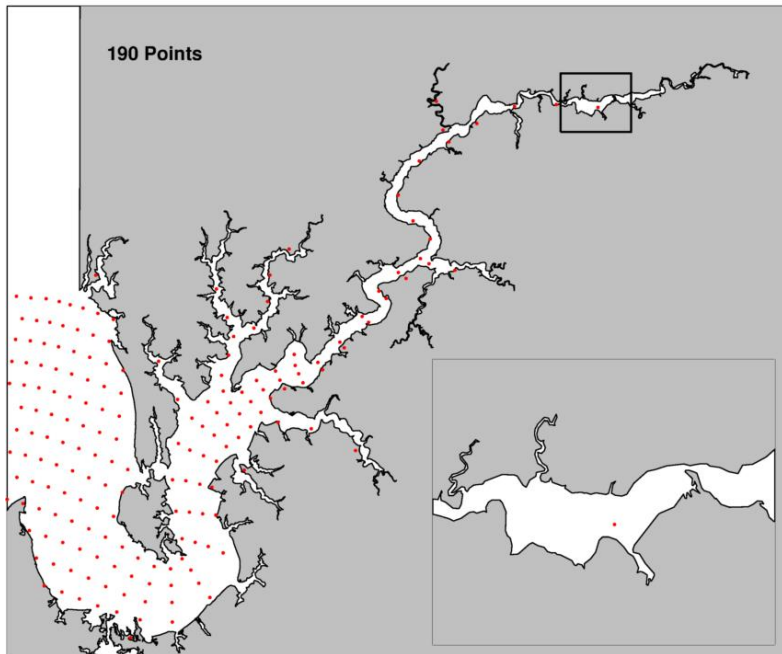
**DFLO** = ship visits  
stations weekly to  
monthly (May –  
August)

Orig. Station name	Years	Sta. Type	Used in time series	Used in along-river transects	Unused for now
ET4.1	2003-2010	WQ/DFLO		X	
ET4.2	2003-2010	WQ/DFLO		X	
XGG8251	2003-2010	WQ/DFLO			Kent Narr.
CHE0348	2003-2006	CMON/DFLO	X	X	
XIH0077	2003-2006	CMON/DFLO	X	X	
XHH3851	2005-2010	CMON/DFLO	X (Corsica)		
XHH4931	2006-2010	CMON/DFLO	X (Corsica)		
XHH4916	2006-2010	CMON/DFLO	X (Corsica)		
XHG8442	2009-2010	CMON/DFLO			Mouth
XHG2318	2009-2010	CMON/DFLO			Mouth
XGG8359	2007-2009	CMON			Kent Narr.
XGG8458	2007-2009	CMON			Kent Narr.
XHH5046	2005-2006	CMON			Corsica
XHG0859	2003-2006	DFLO		X	
XHG1579	2003-2006	DFLO		X	
GYI0001	2003-2006	DFLO			Grays Inn
XHG6496	2003-2006	DFLO			Langford Cr.
XHH6419	2003-2006	DFLO		X	
XHH4822	2003-2005	DFLO			Corsica
XGG9992	2003-2006	DFLO		X	
XIH3581	2003-2006	DFLO		X	
XHH7848	2003	DFLO		X	
XHH9362	2003	DFLO		X	
XIH1458	2003	DFLO		X	
XIH4495	2003	DFLO		X	

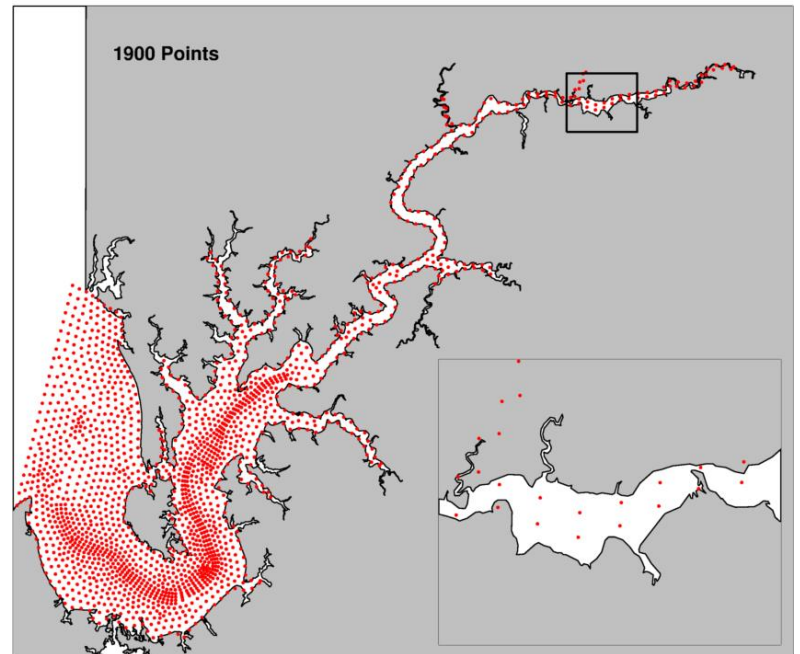
# Chester River Model Simulations

<b>Model</b>	<b>Month Provided</b>
CH3D:	March 2015
FVCOM:	March/ <u>May</u> 2015
ROMS-RCA:	March 2015 (Only 2003 Results)*
SCHISM CH3D bc:	March/ <u>May</u> 2015
SCHISM SCHISM bc:	March/ <u>May</u> 2015
SCHISM Low Res.:	March 2015 (Only 2003 Results)

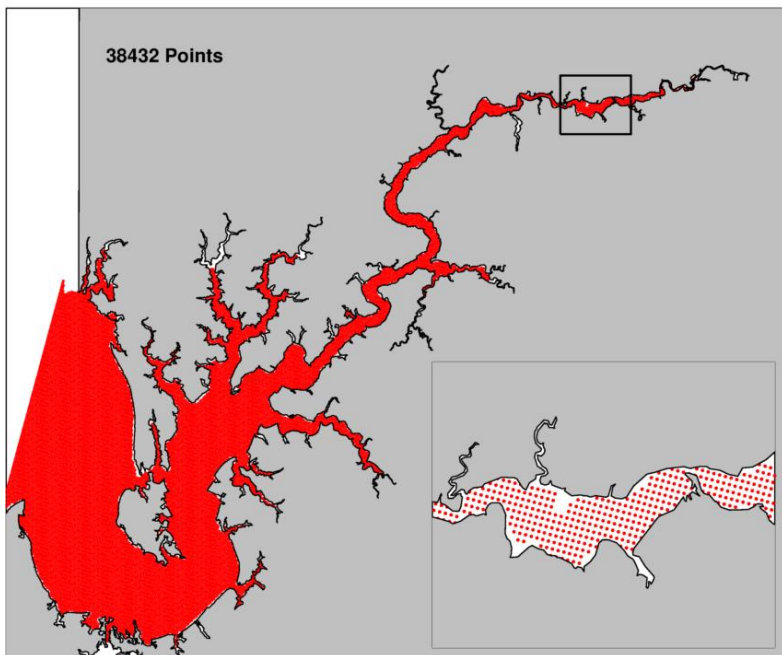
CH3D



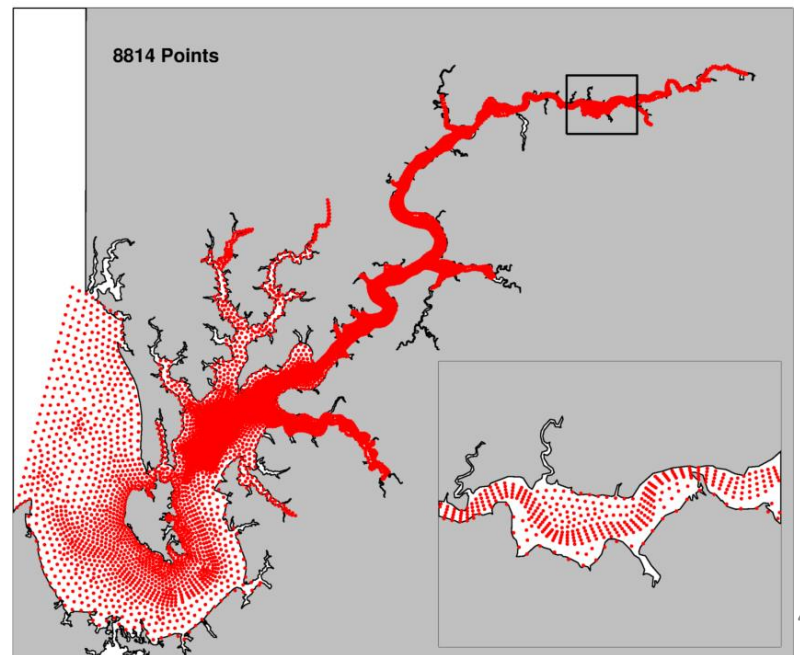
SCHISM Low Resolution



ROMS-RCA



SCHISM



# Initial Model-Data Comparisons

## 1. Temporal comparisons at specific stations

- 2003 – CHE0348 & XIH0077
- 2006 – CHE0348 & XIH0077 & 3 Corsica stations (surface and bottom for 2 stations)
- Salinity and temperature
- Time series of 15min data for two weeks
- Time series of tidally-averaged data for 6-9 months
- Scatter plot (15 min data)
- Summary Target diagram for 2006

## 2. Spatial comparisons for along-river transect

- 2003 and 2006
- Surface, bottom, and surface minus bottom salinity
- Temperature

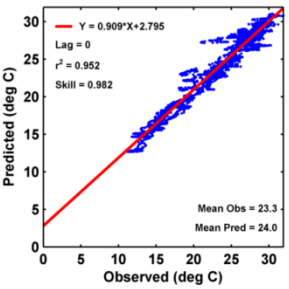
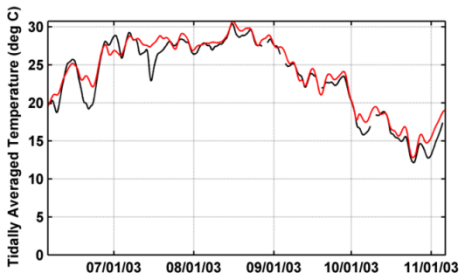
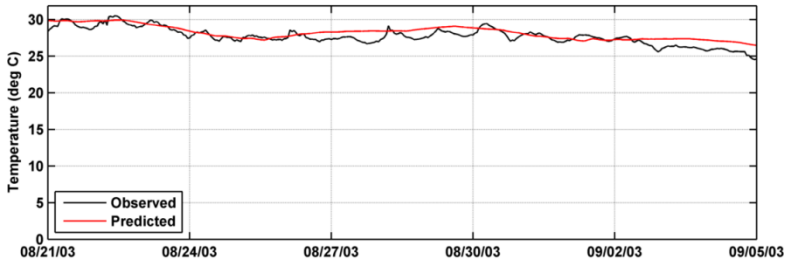
# Station CHE0348



# 2003 Temperature CHE0348

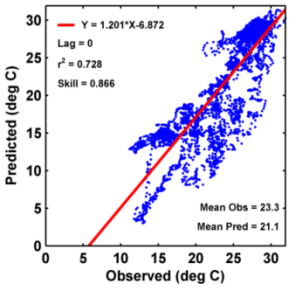
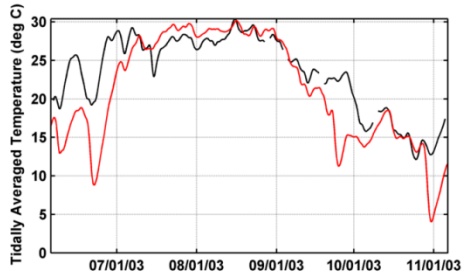
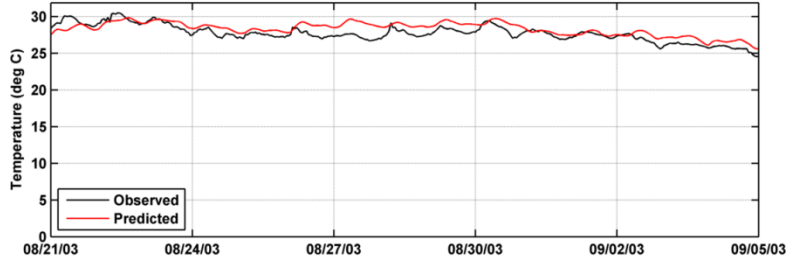
## CH3D

Water Temperature at Station CHE0348



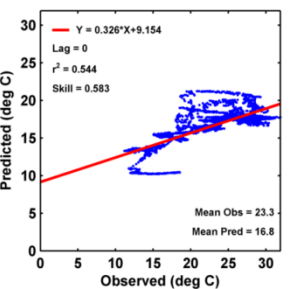
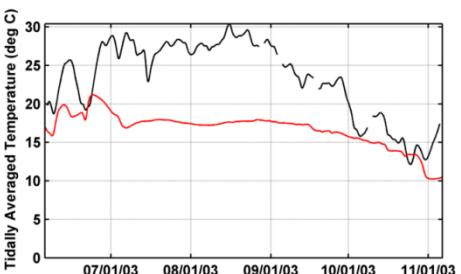
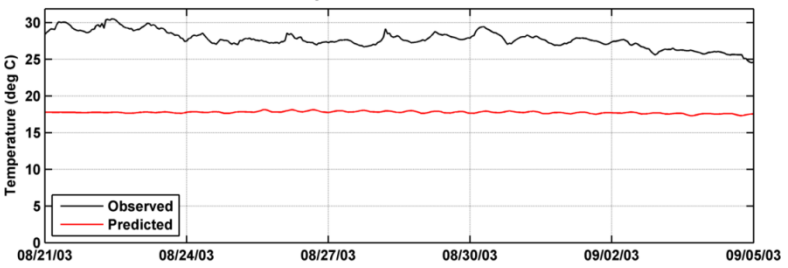
## FVCOM

Water Temperature at Station CHE0348



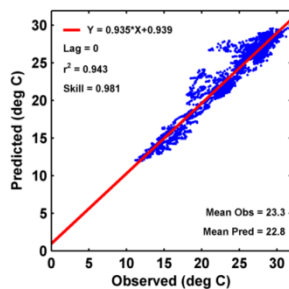
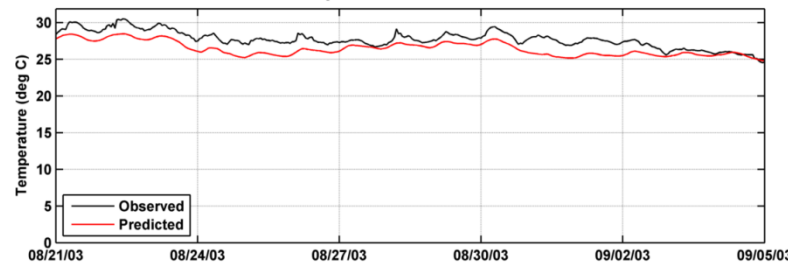
## ROMS-RCA

Water Temperature at Station CHE0348



## SCHISM, CH3D Boundary Conditions

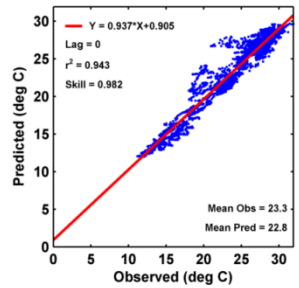
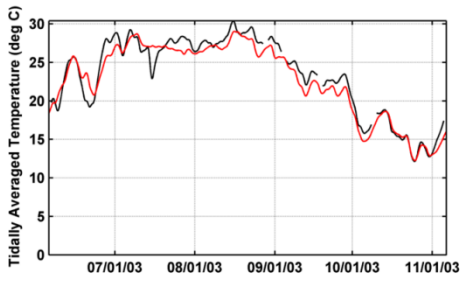
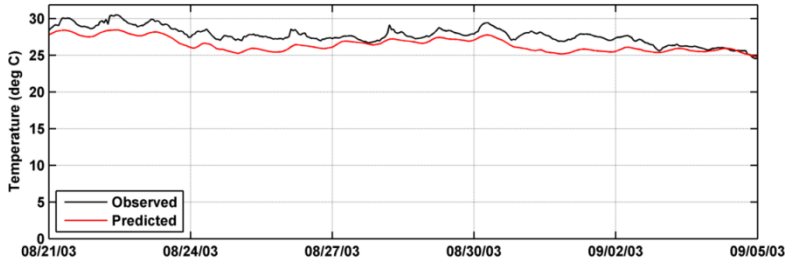
Water Temperature at Station CHE0348



# 2003 Temperature CHE0348

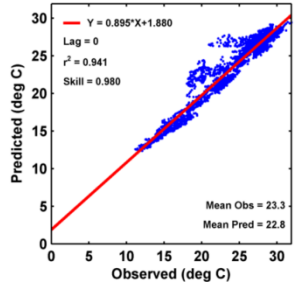
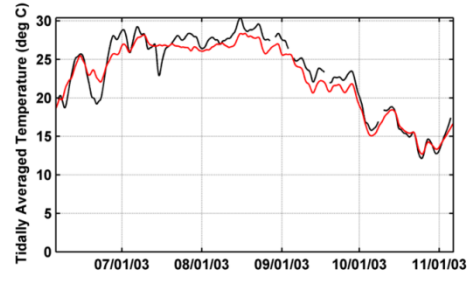
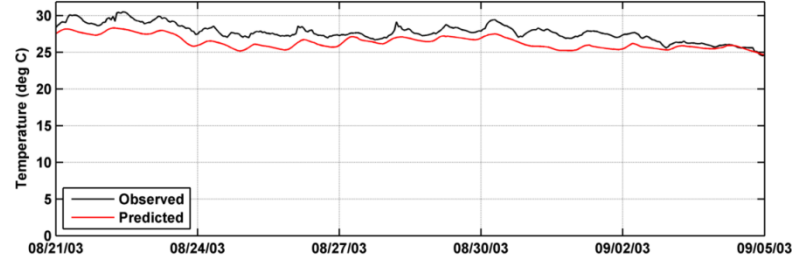
## SCHISM, SCHISM Boundary Conditions

Water Temperature at Station CHE0348



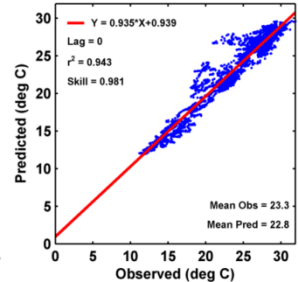
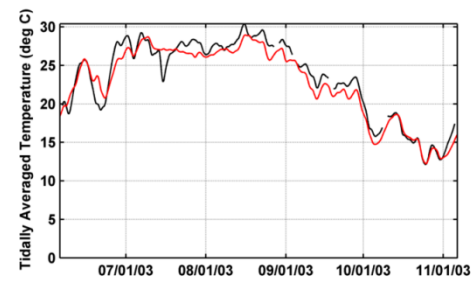
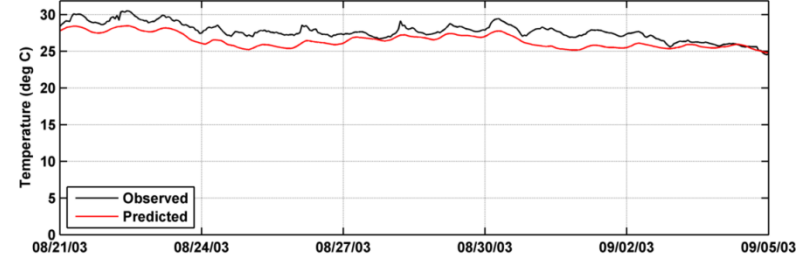
## Low-Res SCHISM

Water Temperature at Station CHE0348



## SCHISM, CH3D Boundary Conditions

Water Temperature at Station CHE0348

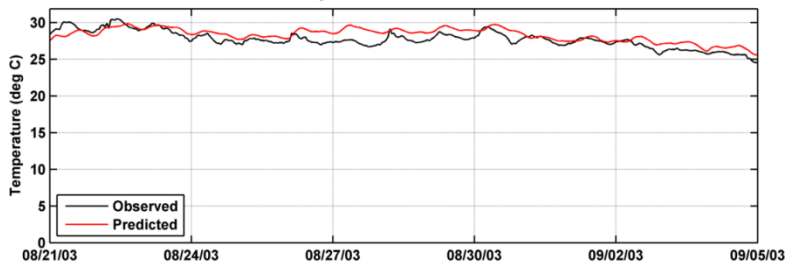


2003  
FVCOM

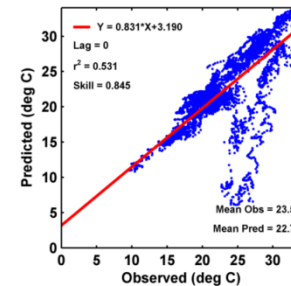
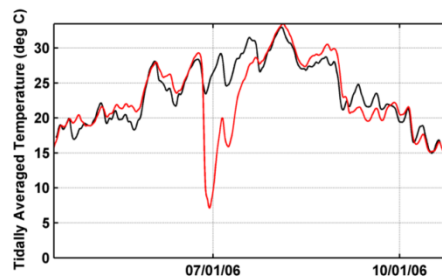
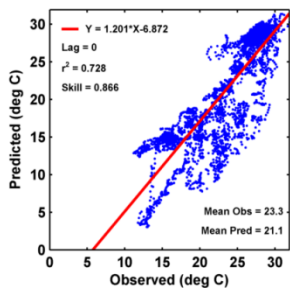
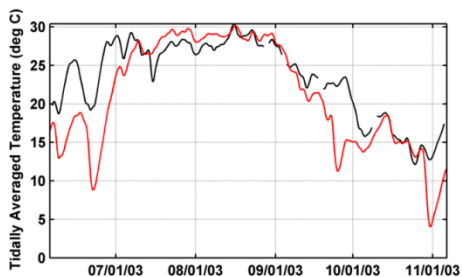
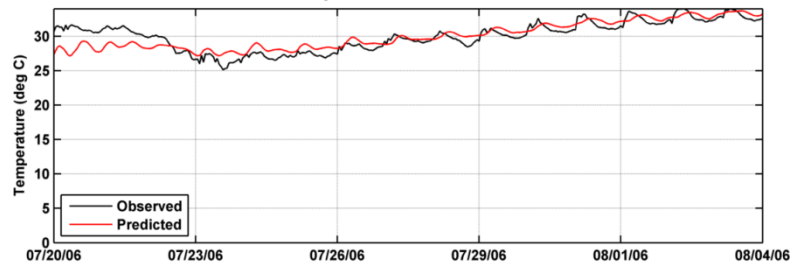
# Temperature

2006  
FVCOM

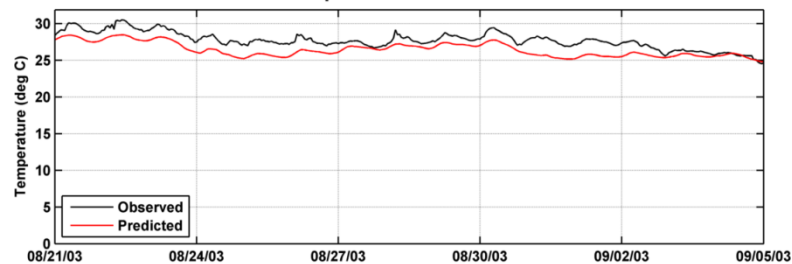
Water Temperature at Station CHE0348



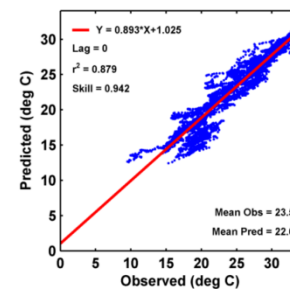
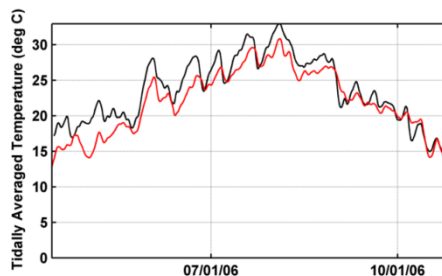
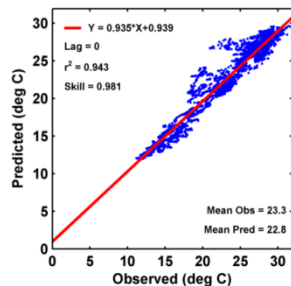
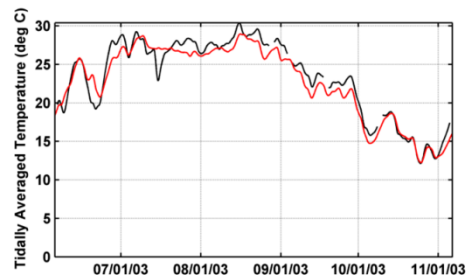
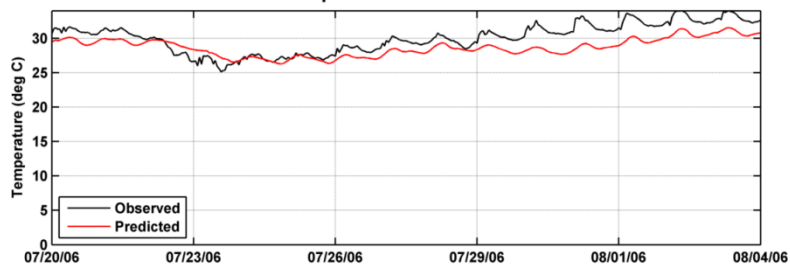
Water Temperature at Station CHE0348



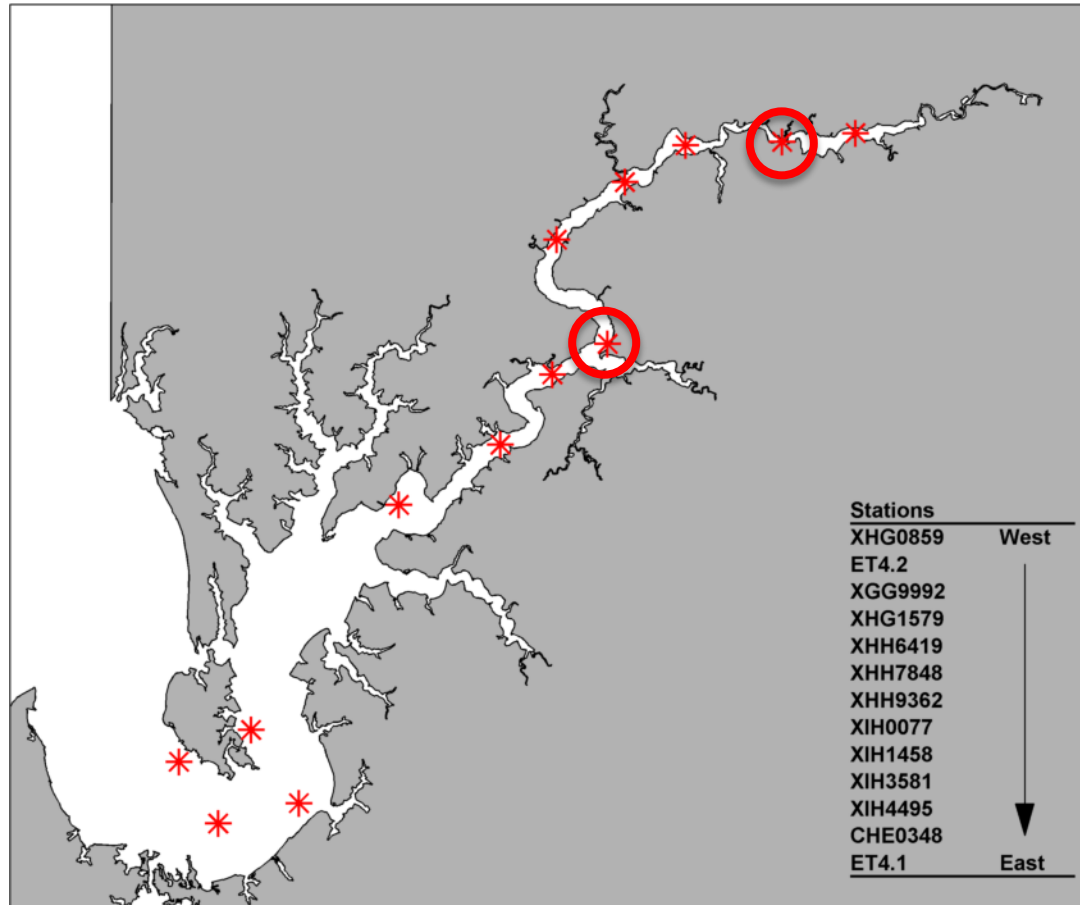
SCHISM, CH3D Boundary Conditions  
Water Temperature at Station CHE0348



SCHISM, CH3D Boundary Conditions  
Water Temperature at Station CHE0348



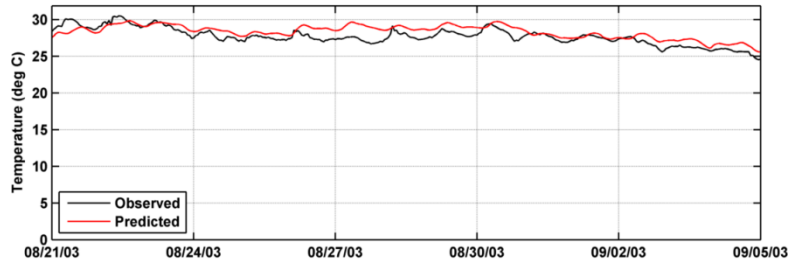
# Station CHE0348 (upstream) Station XIH0077 (downstream)



# 2003 Temperature CHE0348

## FVCOM

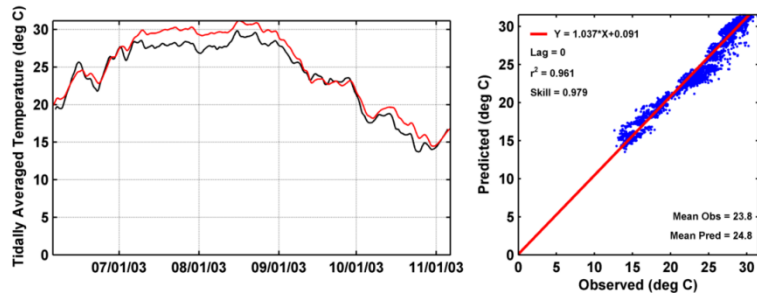
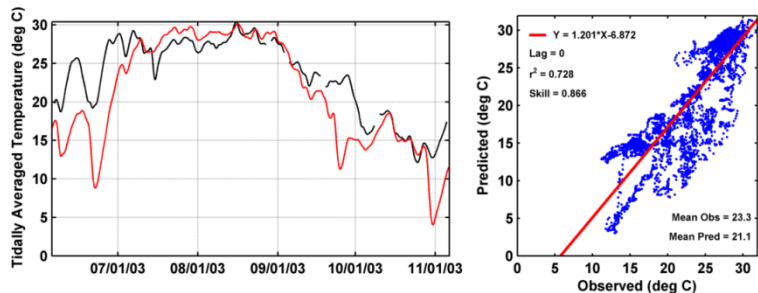
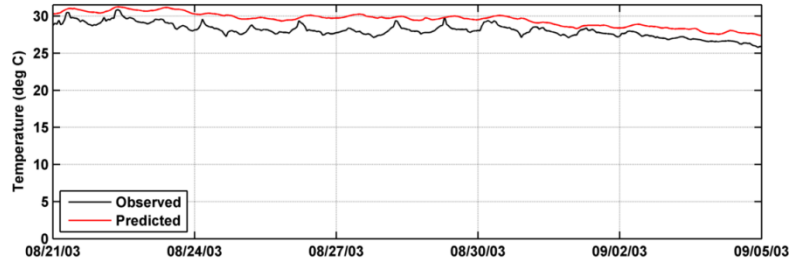
Water Temperature at Station CHE0348



# 2003 Temperature XIH0077

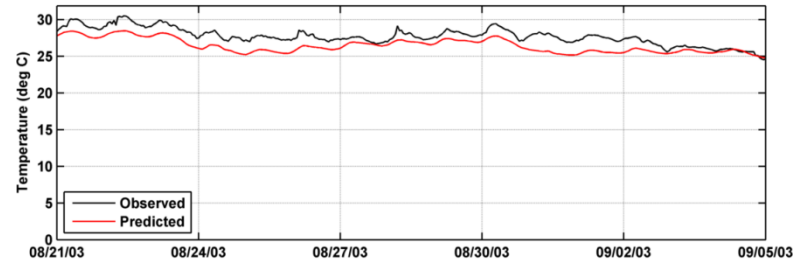
## FVCOM

Water Temperature at Station XIH0077



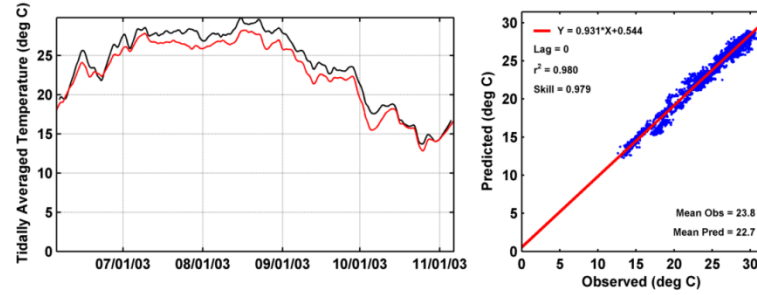
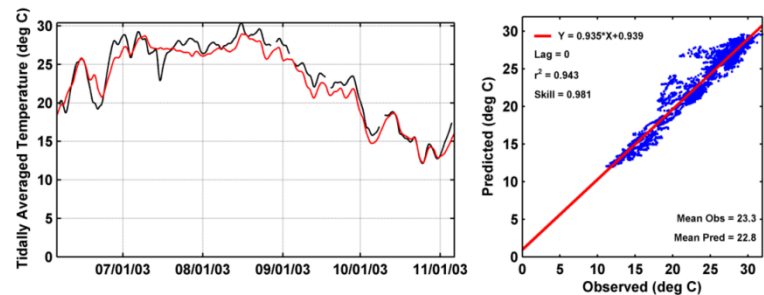
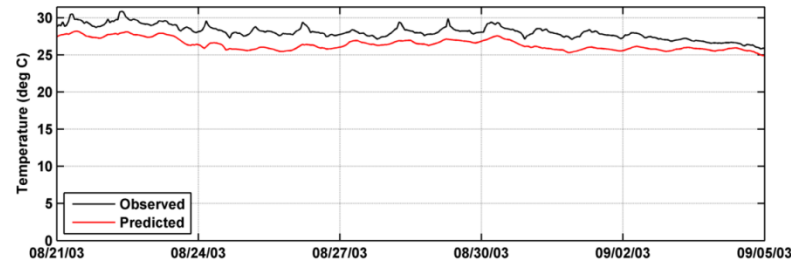
# SCHISM, CH3D Boundary Conditions

Water Temperature at Station CHE0348

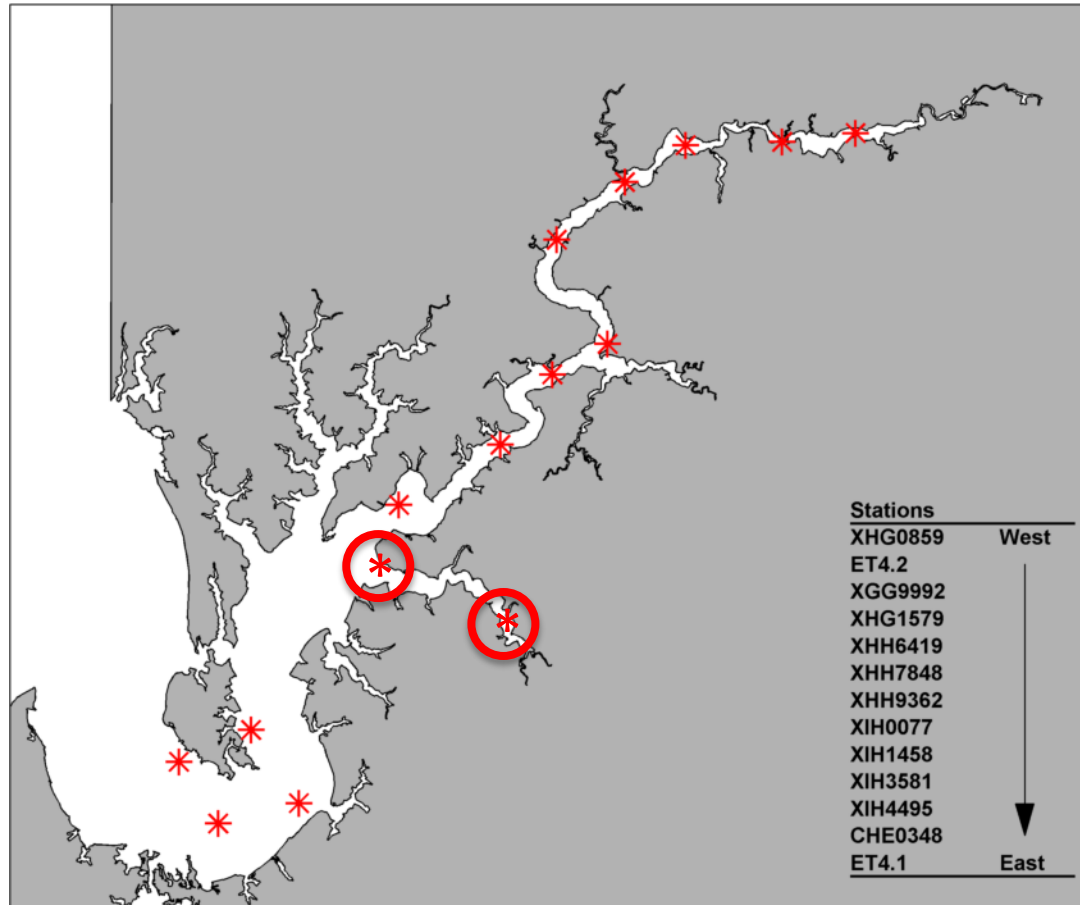


# SCHISM, CH3D Boundary Conditions

Water Temperature at Station XIH0077



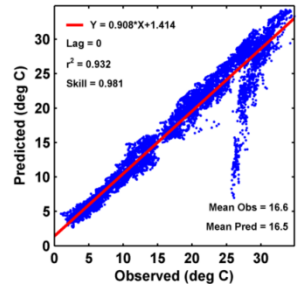
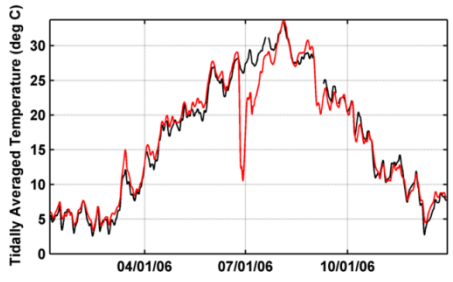
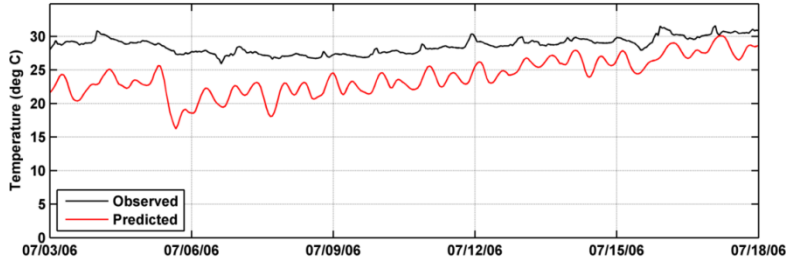
# Station XHH3851 (upstream Corsica) Station XHH4916 (downstream Corsica)



# 2006 Temperature: XHH3851

FVCOM

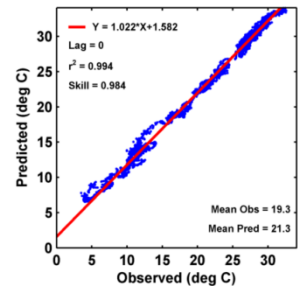
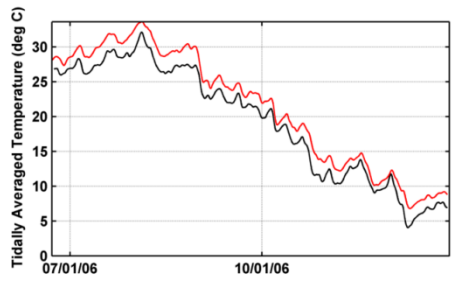
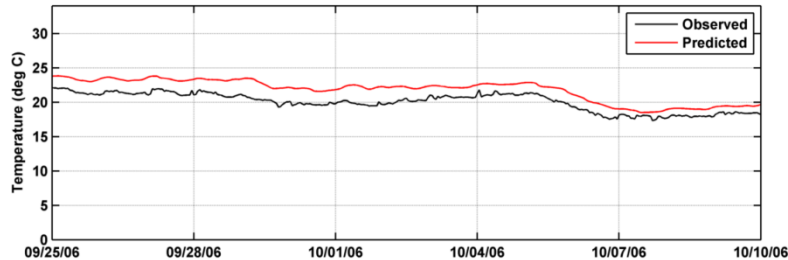
Water Temperature at Station XHH3851



# 2006 Temperature: XHH4916 Bottom (Mouth)

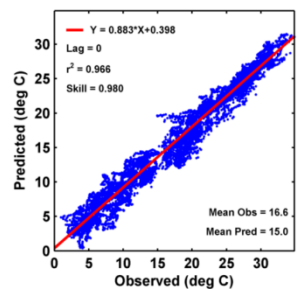
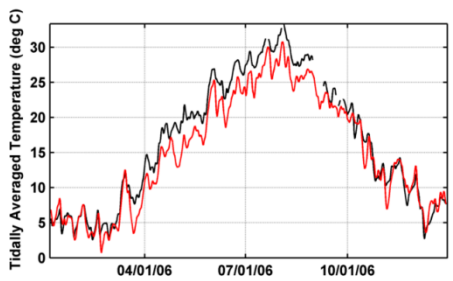
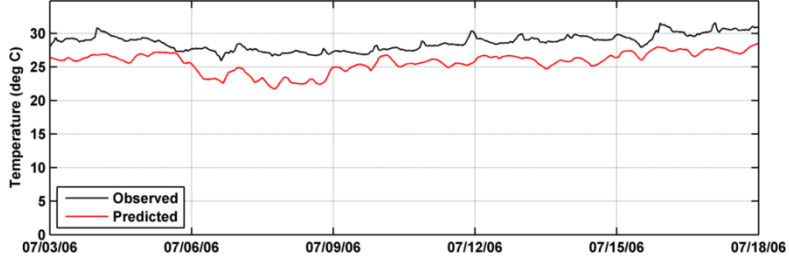
FVCOM

Water Temperature at Station XHH4916 Bottom



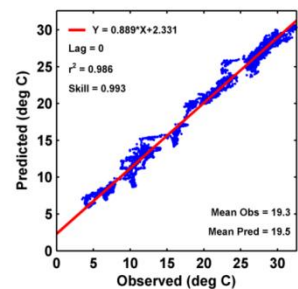
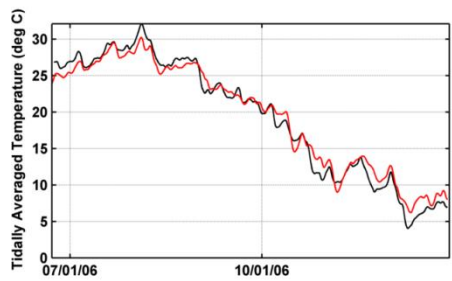
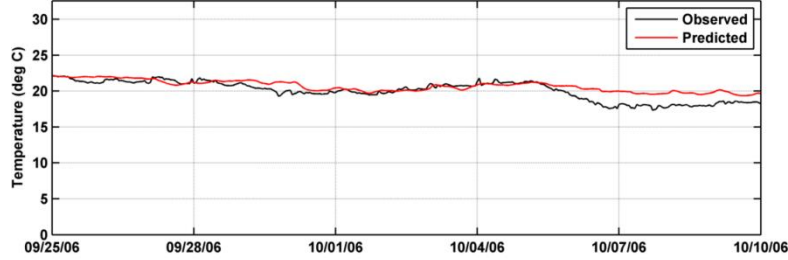
# SCHISM, CH3D Boundary Conditions

Water Temperature at Station XHH3851



# SCHISM, CH3D Boundary Conditions

Water Temperature at Station XHH4916 Bottom



# Chester River Model Simulations

## Temperature Time-series Results:

All models reproduce temperature well

    Regardless of resolution (low-res SCHISM and CH3D do well)

    Regardless of bc's

    Though true atmospheric forcing is needed!

Slightly better performance downstream in Chester and Corsica

Equally good performance at surface and bottom

Slightly better performance with SCHISM than FVCOM

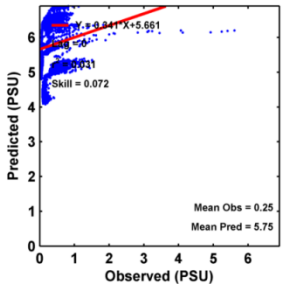
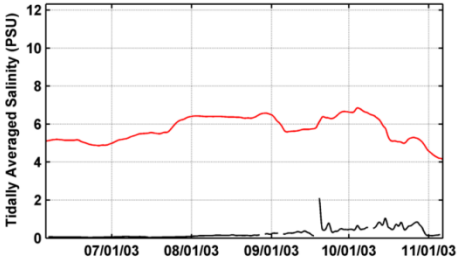
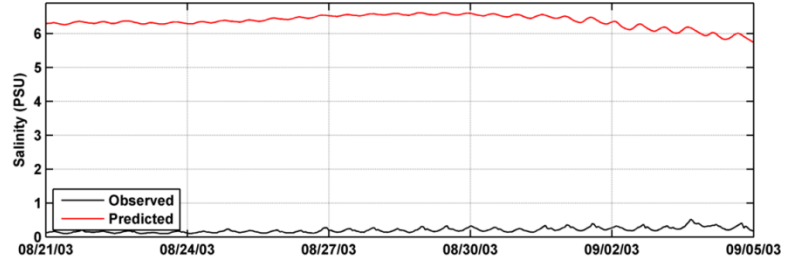
Equally good performance in 2003 and 2006

    Except for strange behavior with FVCOM in early July 2006

# 2003 Salinity CHE0348

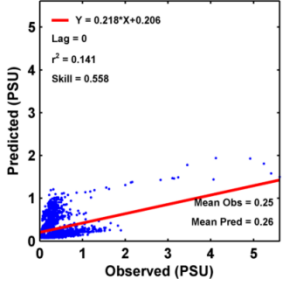
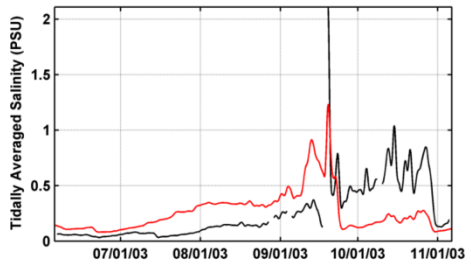
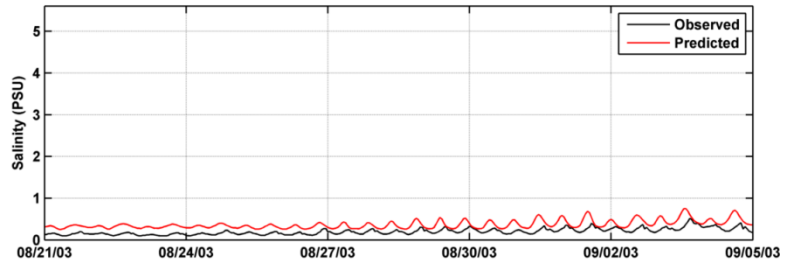
## CH3D

Salinity at Station CHE0348



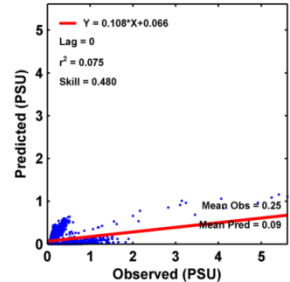
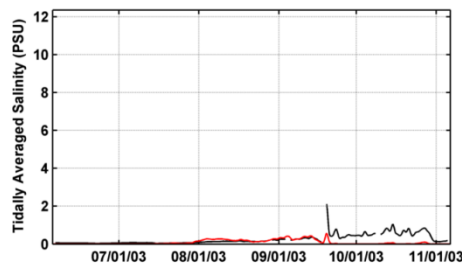
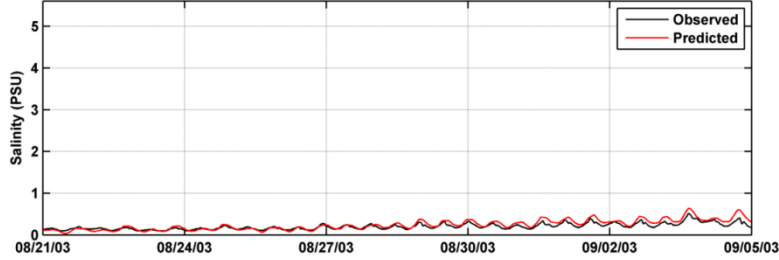
## FVCOM

Salinity at Station CHE0348



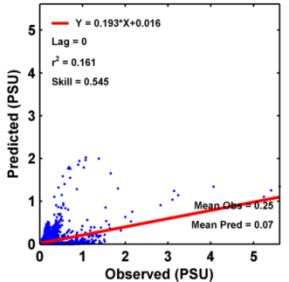
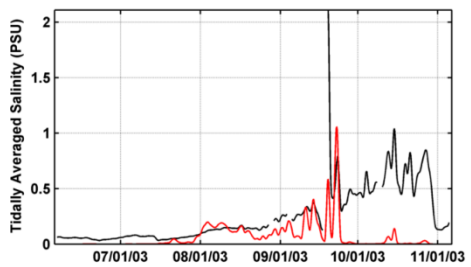
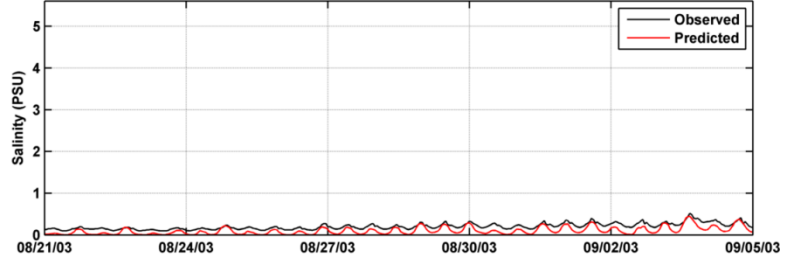
## ROMS-RCA

Salinity at Station CHE0348



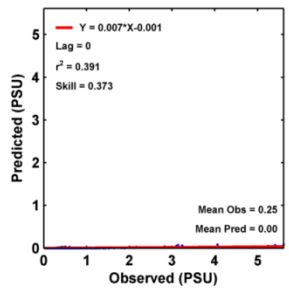
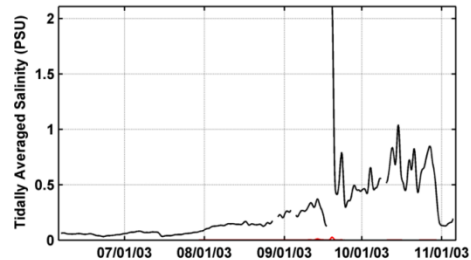
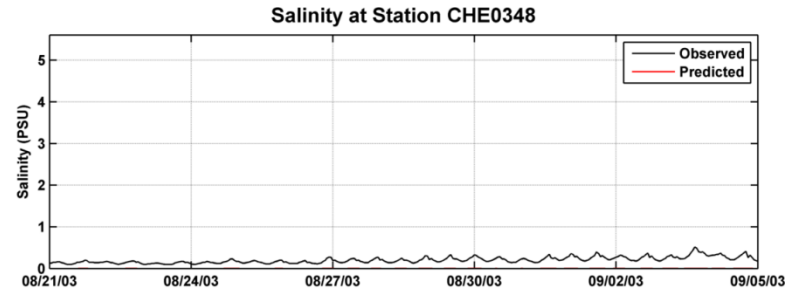
## SCHISM, CH3D Boundary Conditions

Salinity at Station CHE0348



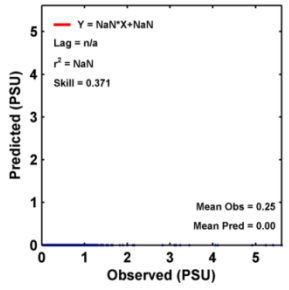
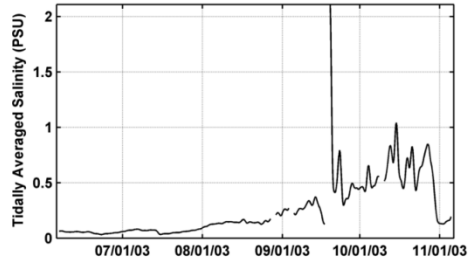
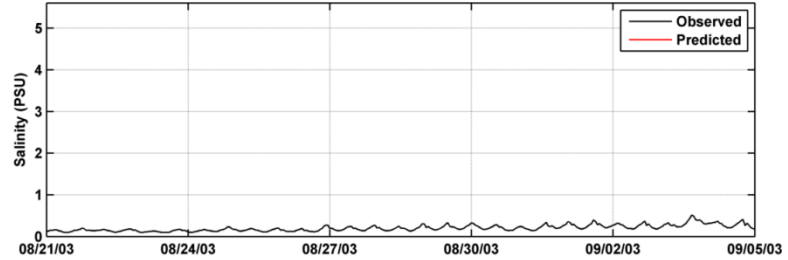
# 2003 Salinity CHE0348

## SCHISM, SCHISM Boundary Conditions



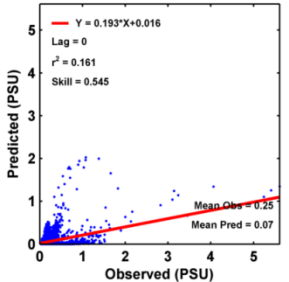
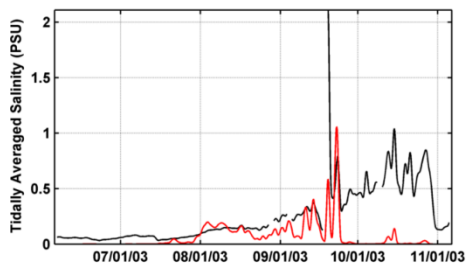
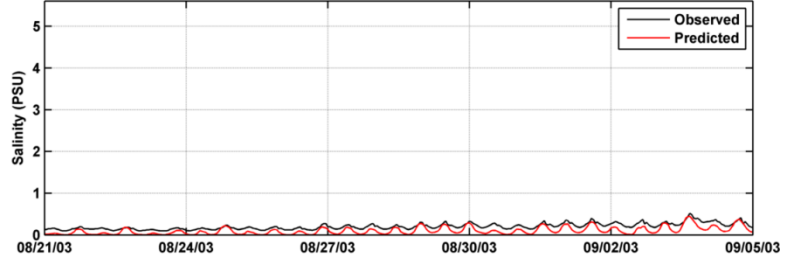
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Salinity at Station CHE0348



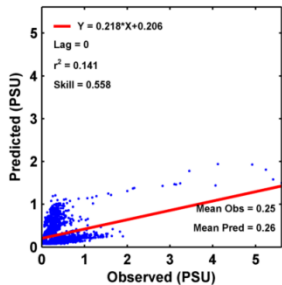
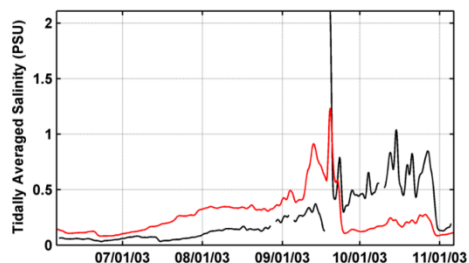
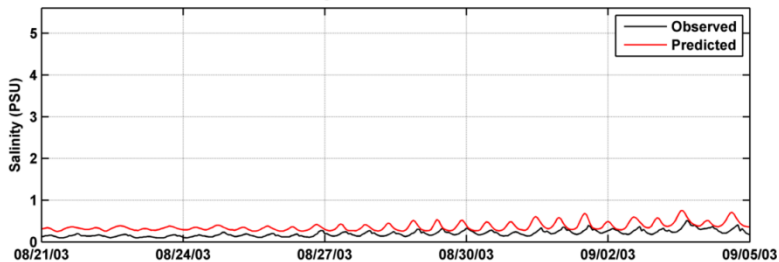
## SCHISM, CH3D Boundary Conditions

Salinity at Station CHE0348



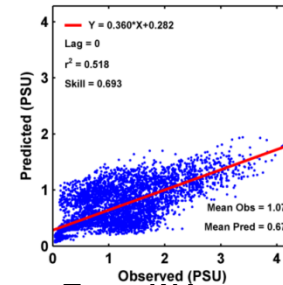
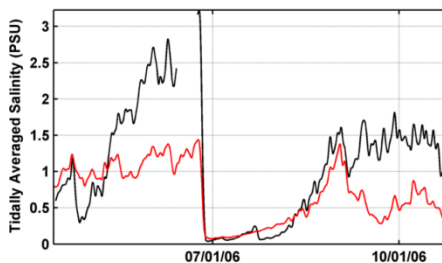
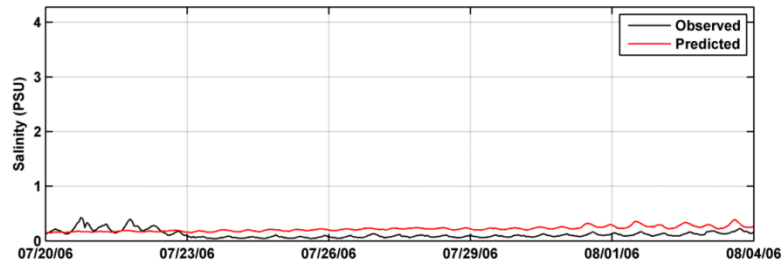
# 2003 FVCOM

Salinity at Station CHE0348



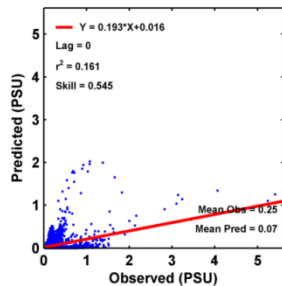
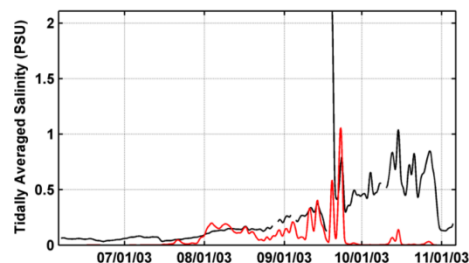
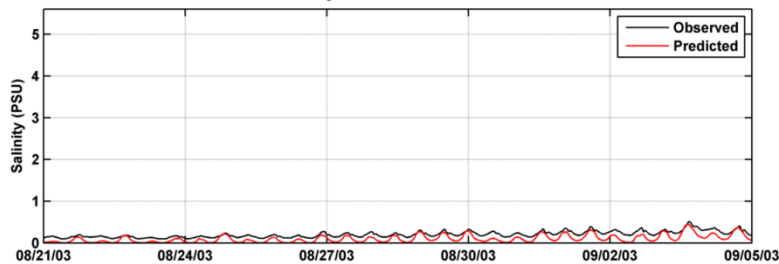
# 2006 FVCOM

Salinity at Station CHE0348

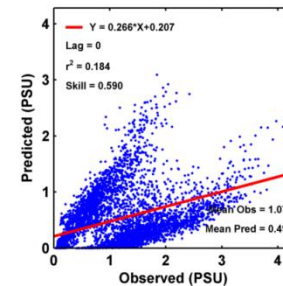
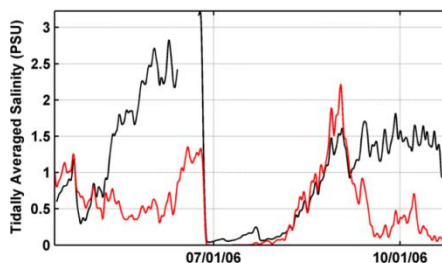
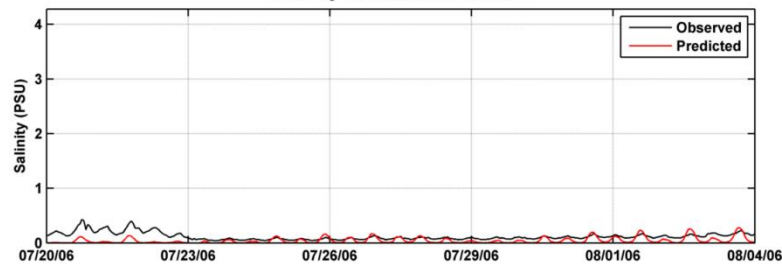


# SCHISM, CH3D Boundary Conditions

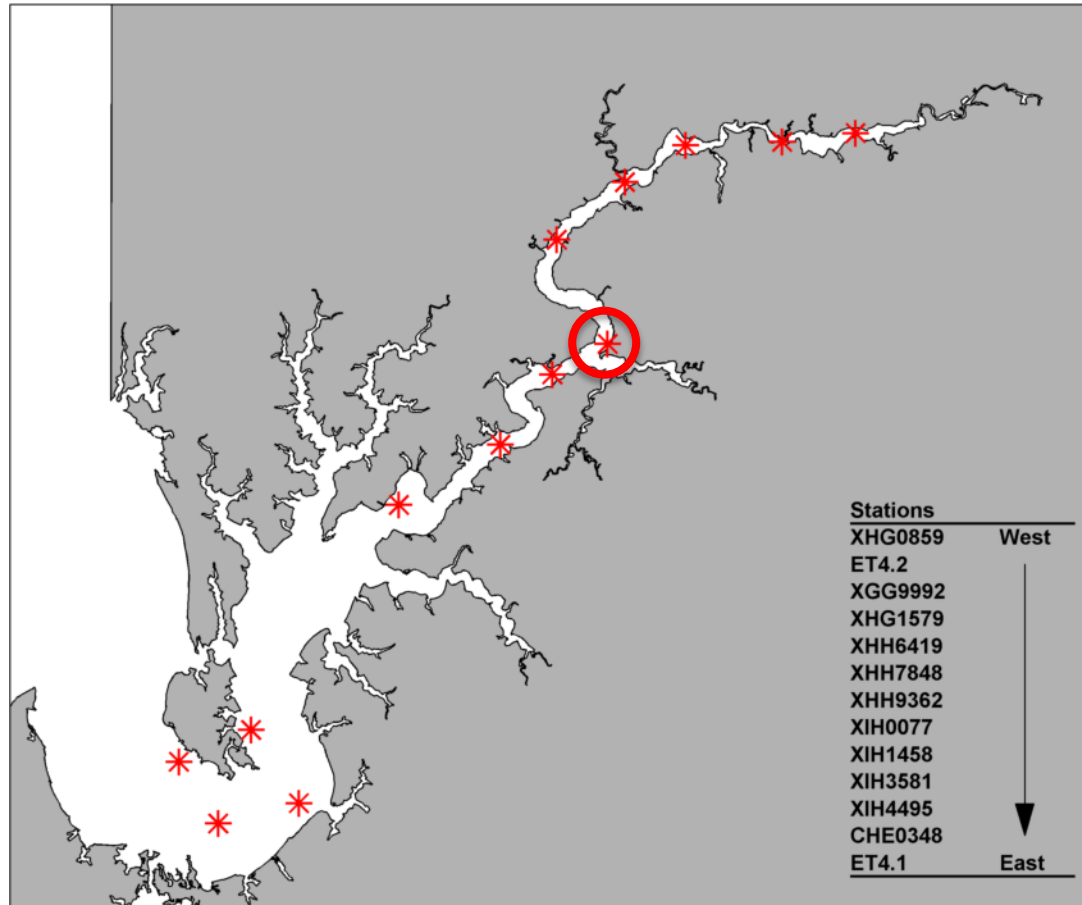
Salinity at Station CHE0348



Salinity at Station CHE0348



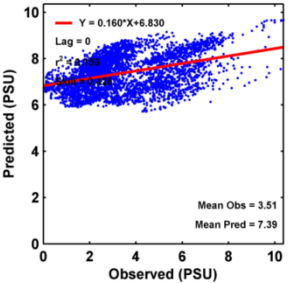
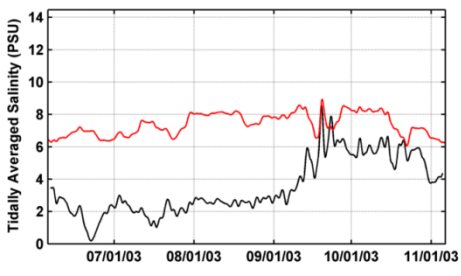
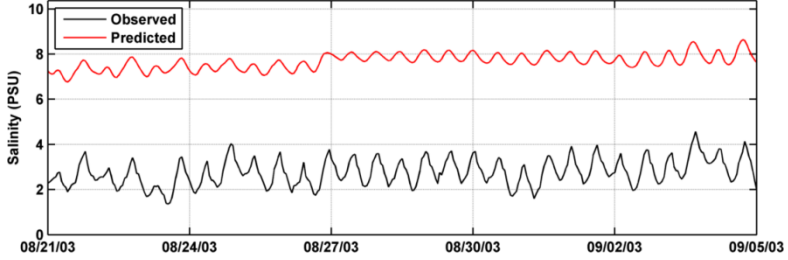
# Station XIH0077 (downstream)



# 2003 Salinity

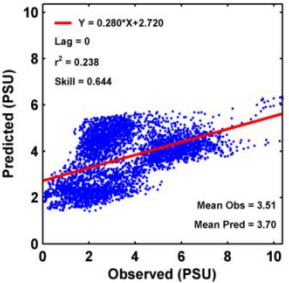
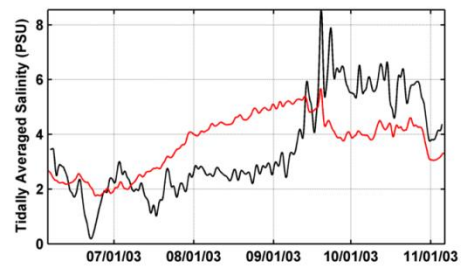
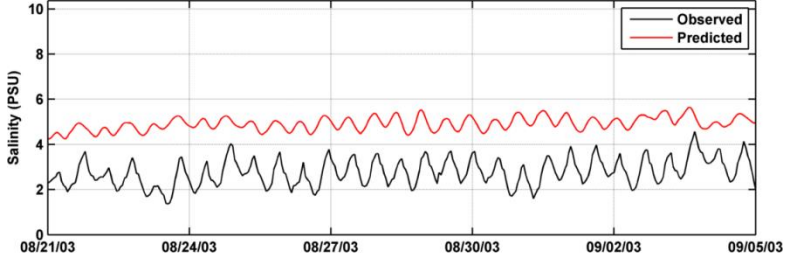
## CH3D

Salinity at Station XIH0077



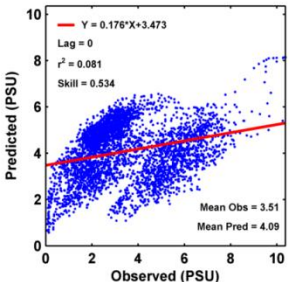
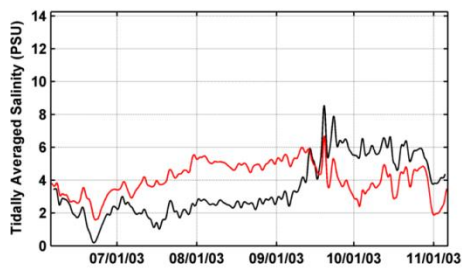
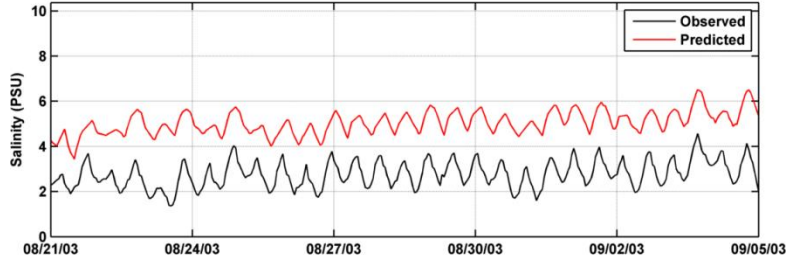
## FVCOM

Salinity at Station XIH0077



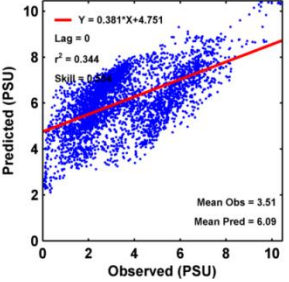
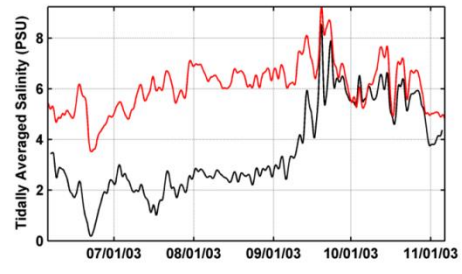
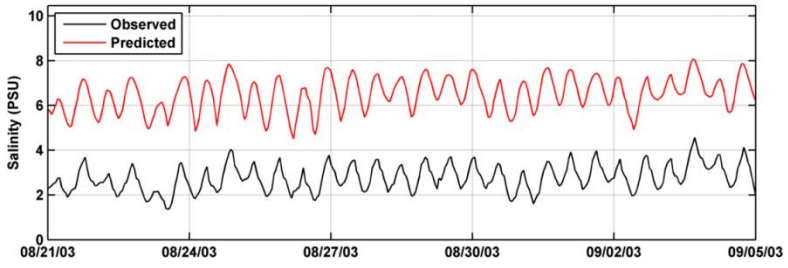
## ROMS-RCA

Salinity at Station XIH0077



## SCHISM, CH3D Boundary Conditions

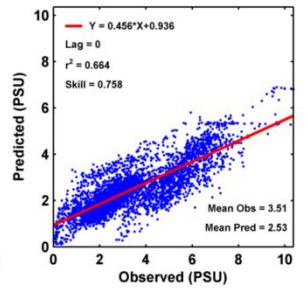
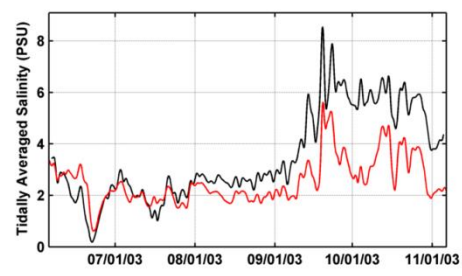
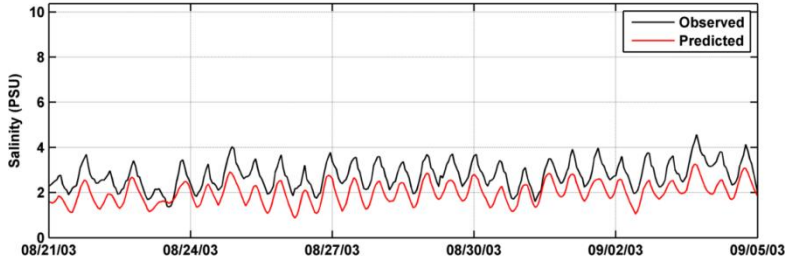
Salinity at Station XIH0077



# 2003 Salinity

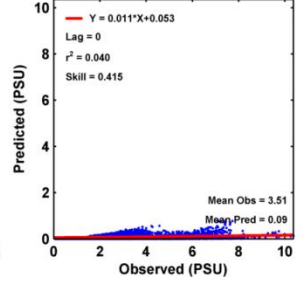
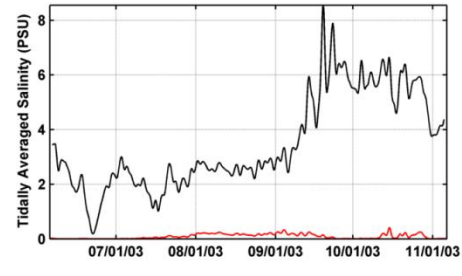
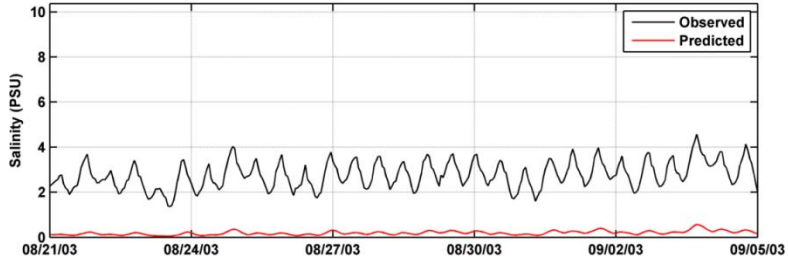
## SCHISM, SCHISM Boundary Conditions

Salinity at Station XIH0077



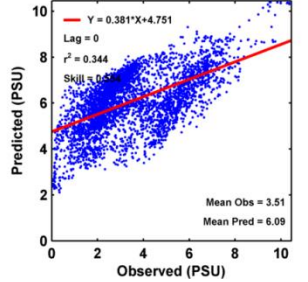
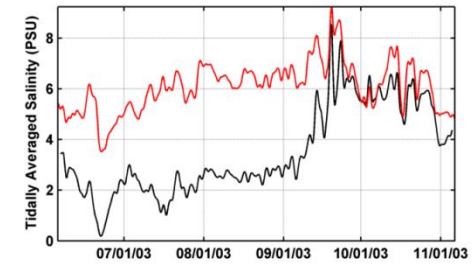
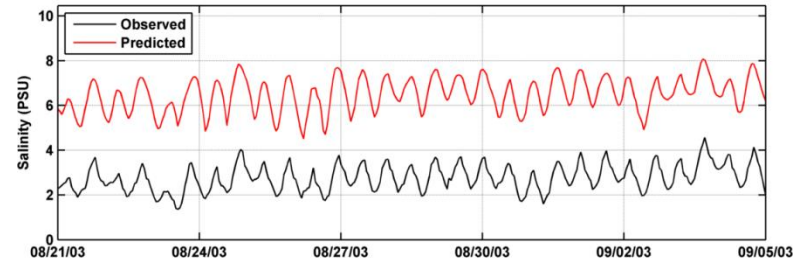
# Low-Res SCHISM

Salinity at Station XIH0077



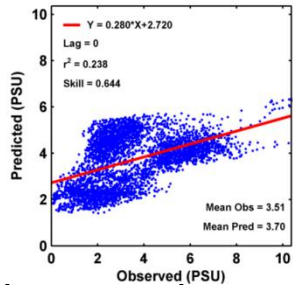
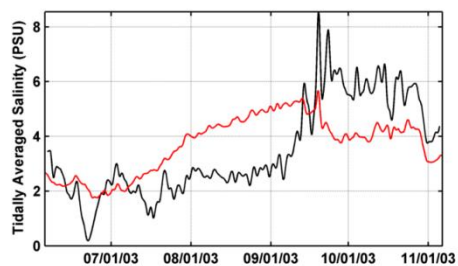
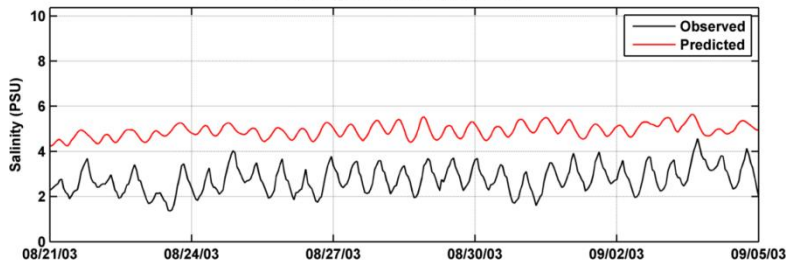
# SCHISM, CH3D Boundary Conditions

Salinity at Station XIH0077



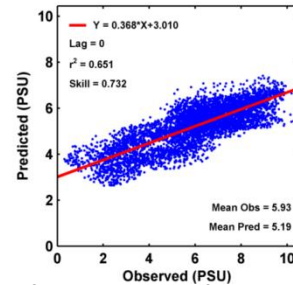
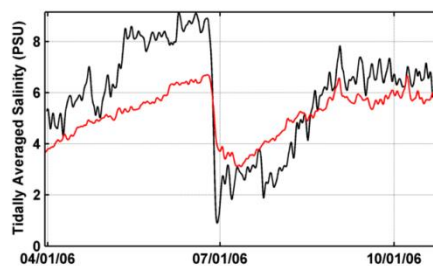
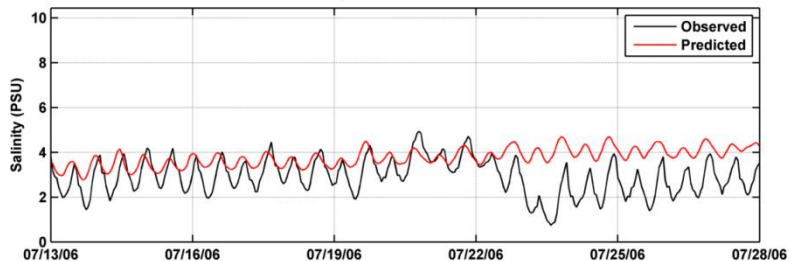
# 2003 FVCOM

## Salinity at Station XIH0077



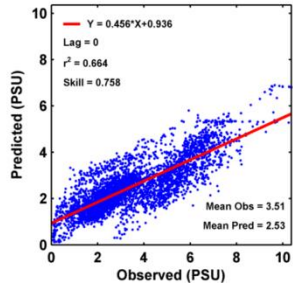
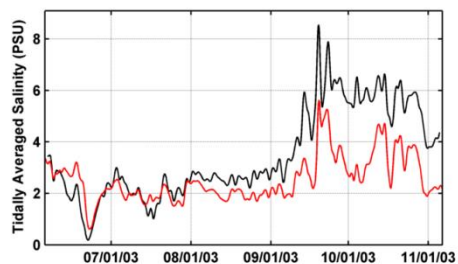
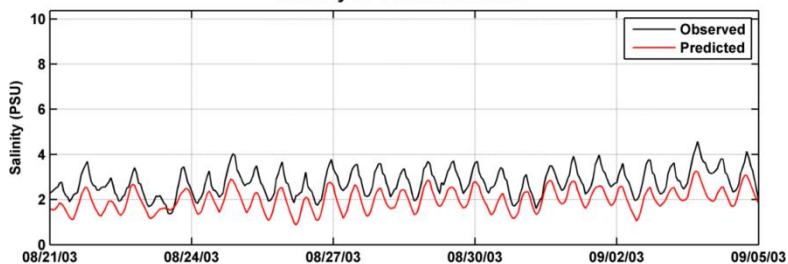
# 2006 FVCOM

## Salinity at Station XIH0077



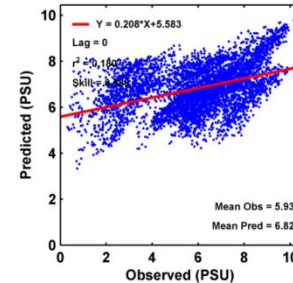
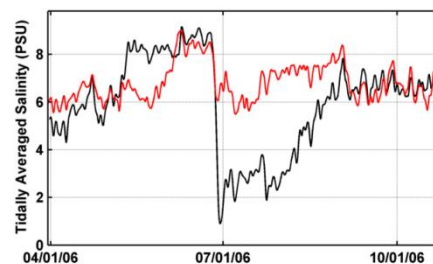
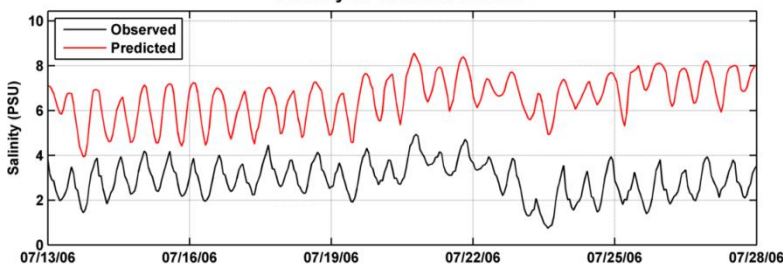
# SCHISM, SCHISM Boundary Conditions

## Salinity at Station XIH0077

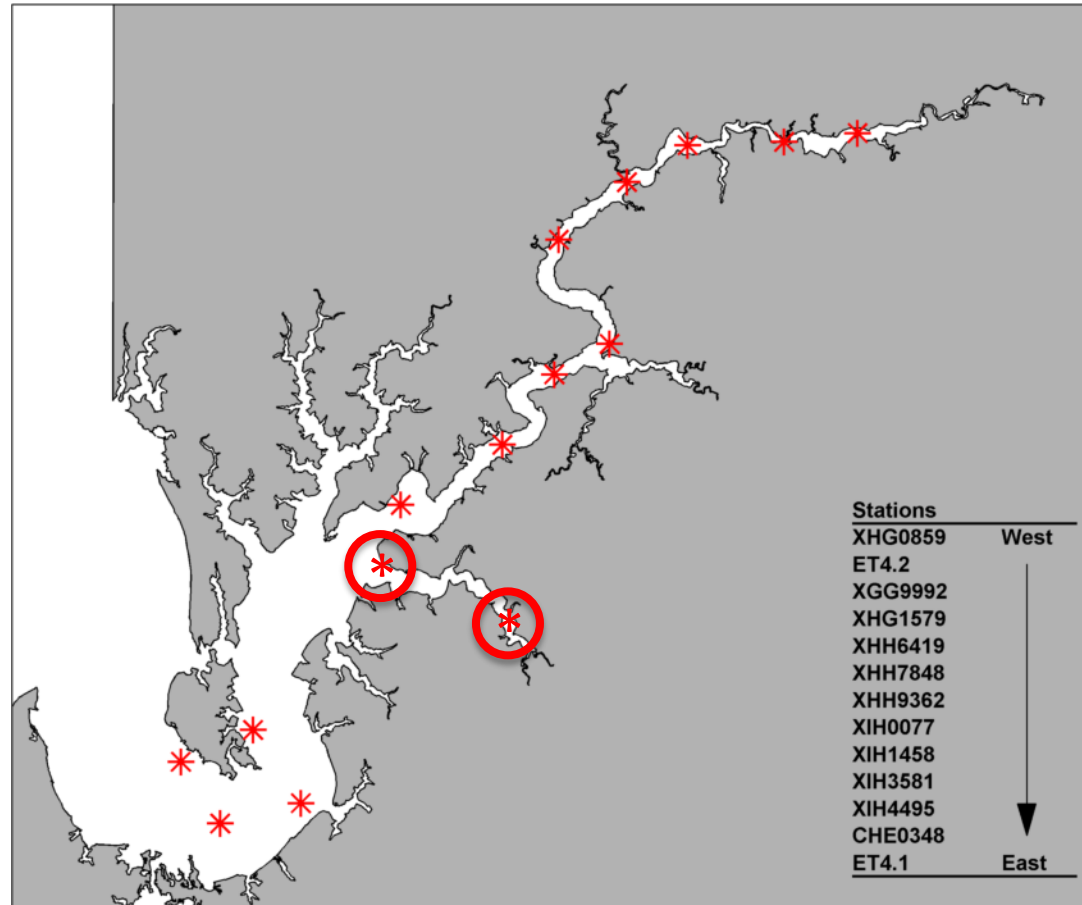


# SCHISM, SCHISM Boundary Conditions

## Salinity at Station XIH0077

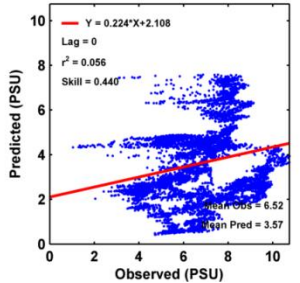
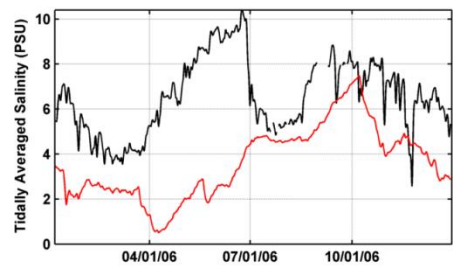
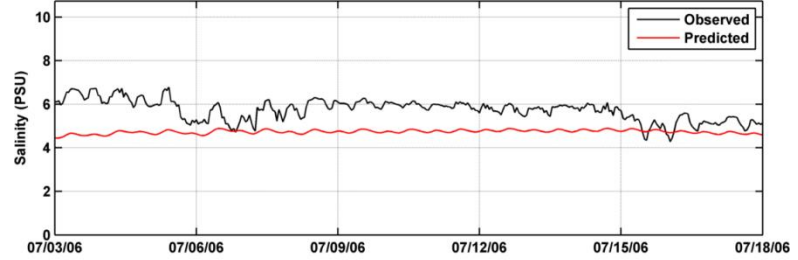


# Station XHH3851 (upstream Corsica) Station XHH4916 (downstream Corsica)



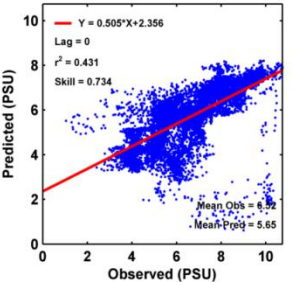
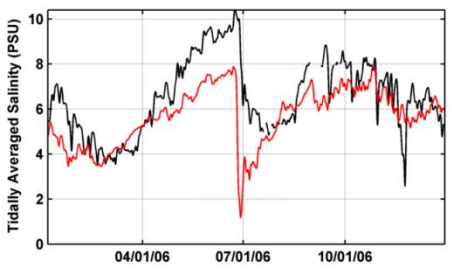
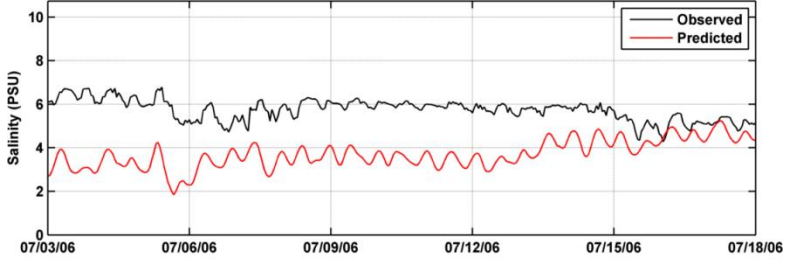
# 2006 Salinity: XHH3851 (upstream) CH3D

Salinity at Station XHH3851



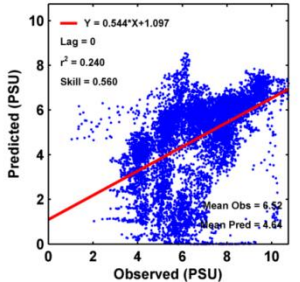
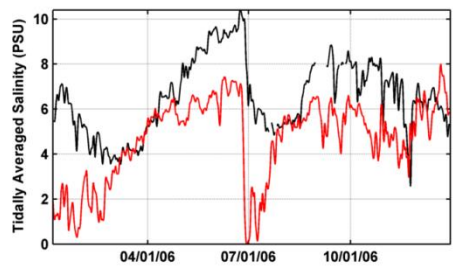
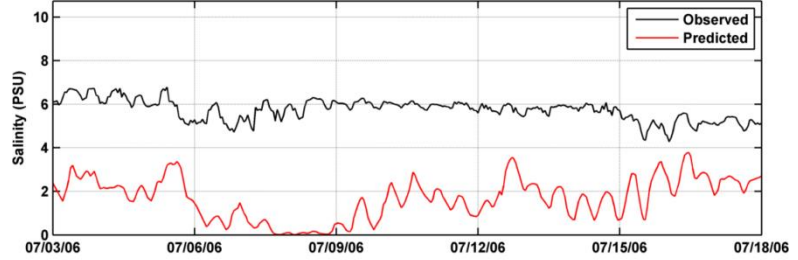
# FVCOM

Salinity at Station XHH3851



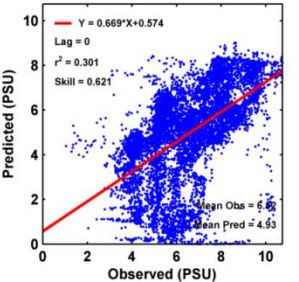
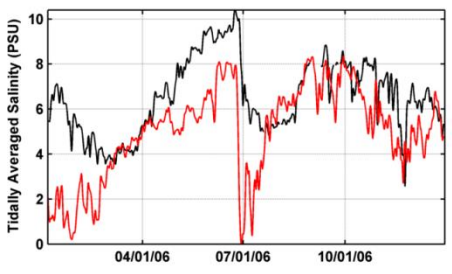
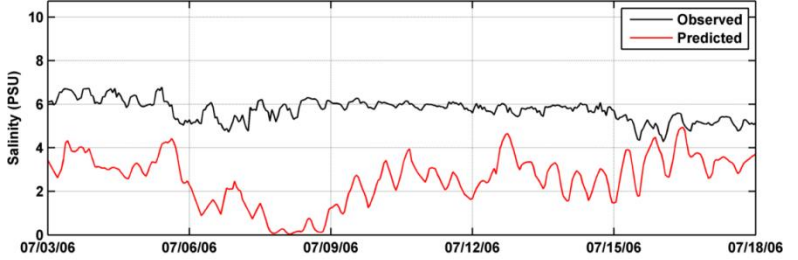
# SCHISM, SCHISM Boundary Conditions

Salinity at Station XHH3851



# SCHISM, CH3D Boundary Conditions

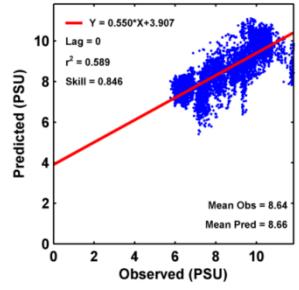
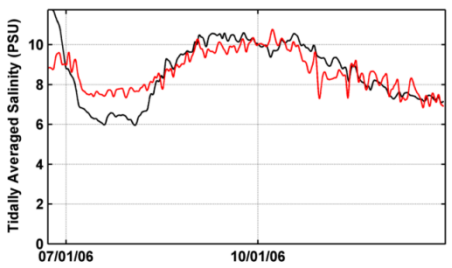
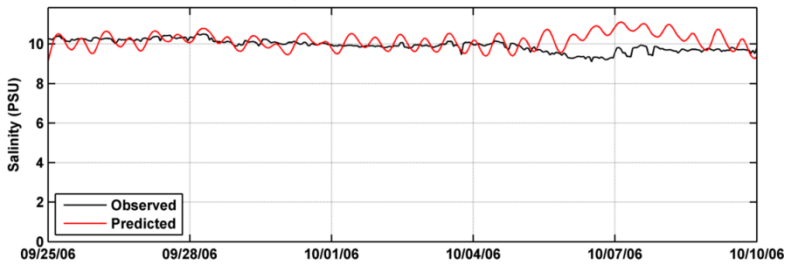
Salinity at Station XHH3851



# 2006 Salinity: XHH4916 Bottom (near Corsica mouth)

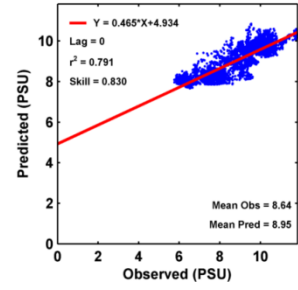
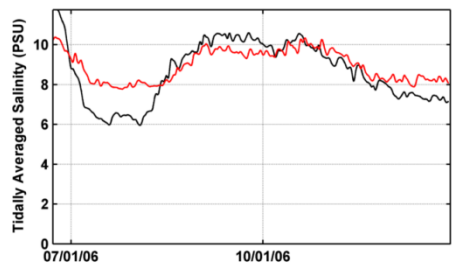
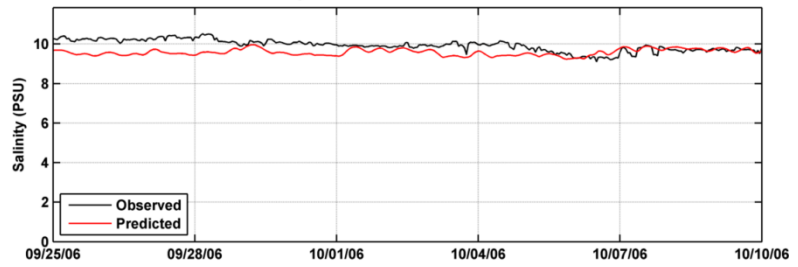
CH3D

Salinity at Station XHH4916 Bottom



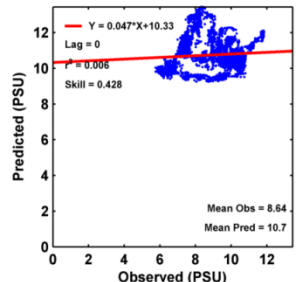
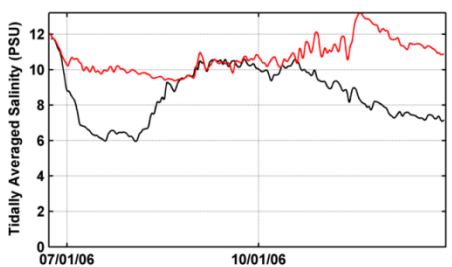
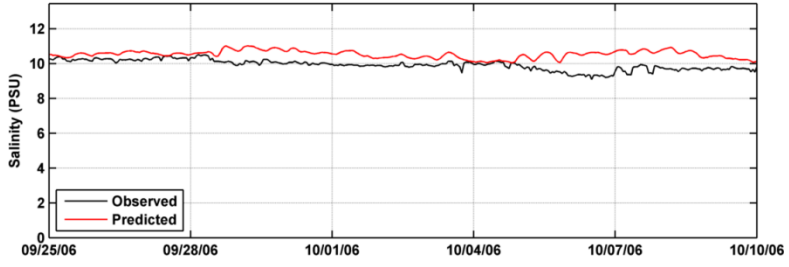
FVCOM

Salinity at Station XHH4916 Bottom



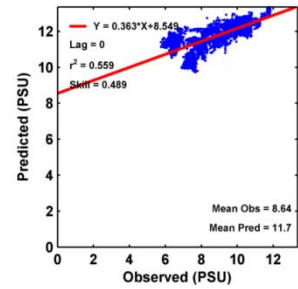
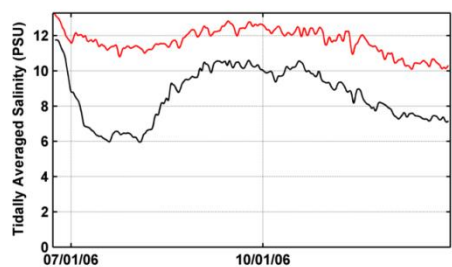
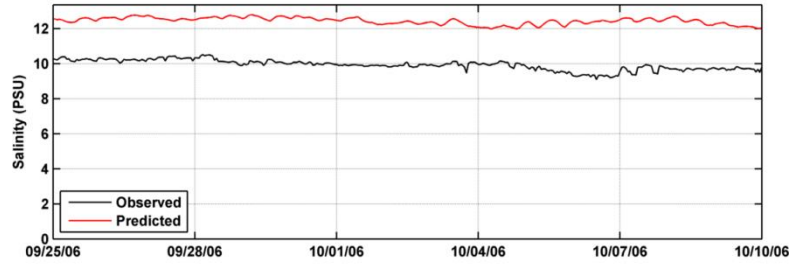
# SCHISM, SCHISM Boundary Conditions

Salinity at Station XHH4916 Bottom



# SCHISM, CH3D Boundary Conditions

Salinity at Station XHH4916 Bottom



# Chester River Model Simulations

## Salinity Time-series Results:

At upstream station:

- Low-res models have difficulty with salinity upstream

  - CH3D overestimates S upstream by 6psu

  - Low-res SCHISM underestimates S upstream

- Models do well in July (low S) but worse in August (high S)

- Models behaved similarly, reproducing large drop in S in July 2006

At mid-stream station:

- All models overestimate summer S

  - Using low-res SCHISM bc's dramatically improves 2003 SCHISM simulation

  - SCHISM does better in 2003; FVCOM does better in 2006

In Corsica:

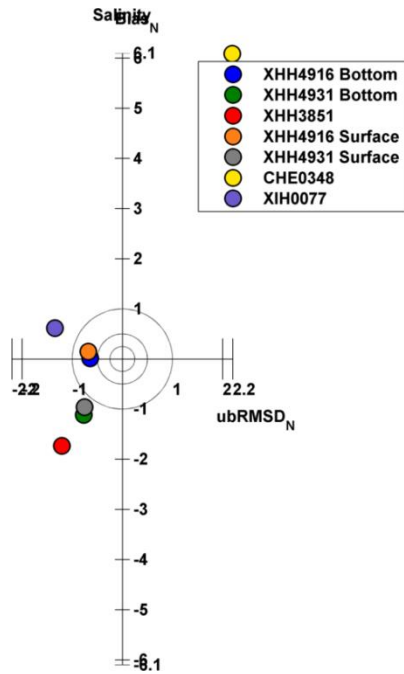
- CH3D does reasonably well, except upstream

- FVCOM does quite well

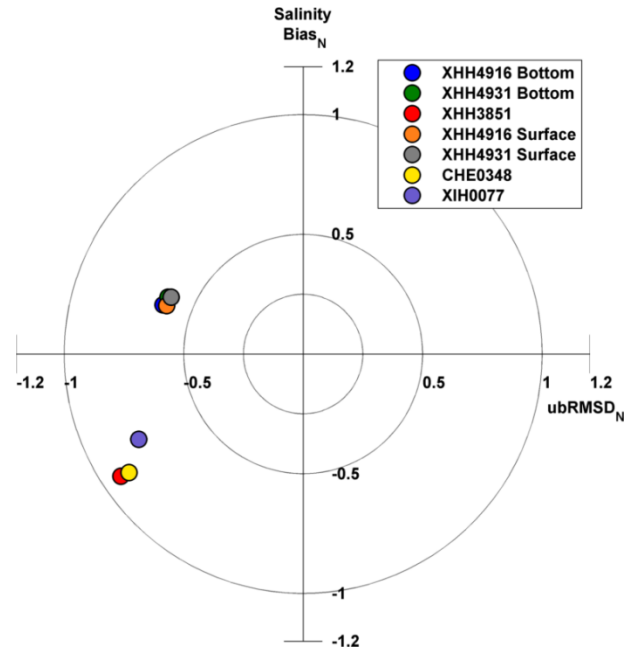
- SCHISM does better with SCHISM bcs

# 2006 Salinity

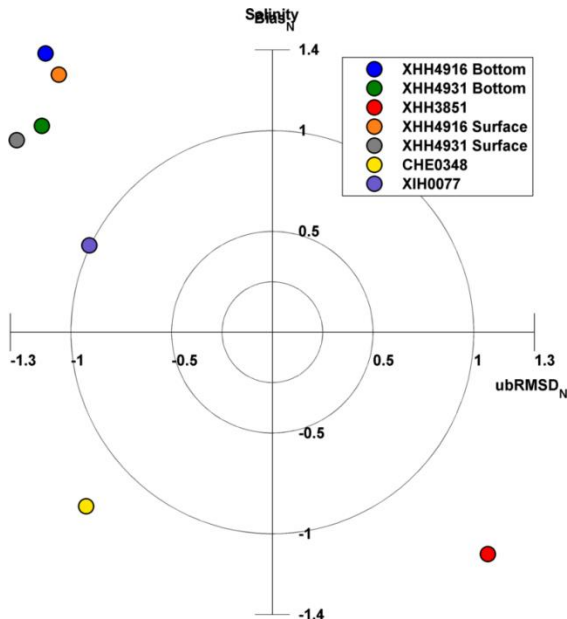
CH3D



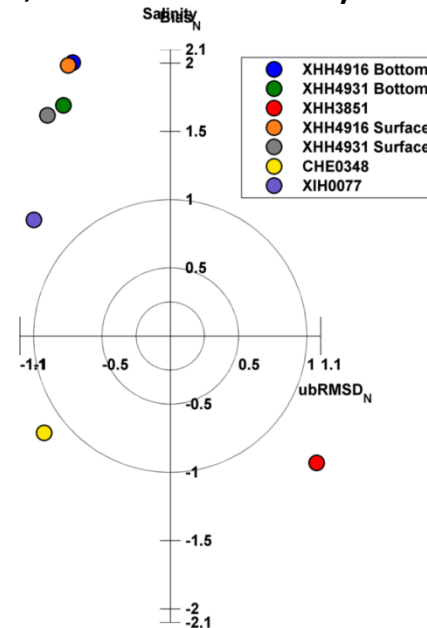
FVCOM



SCHISM, SCHISM Boundary Conditions



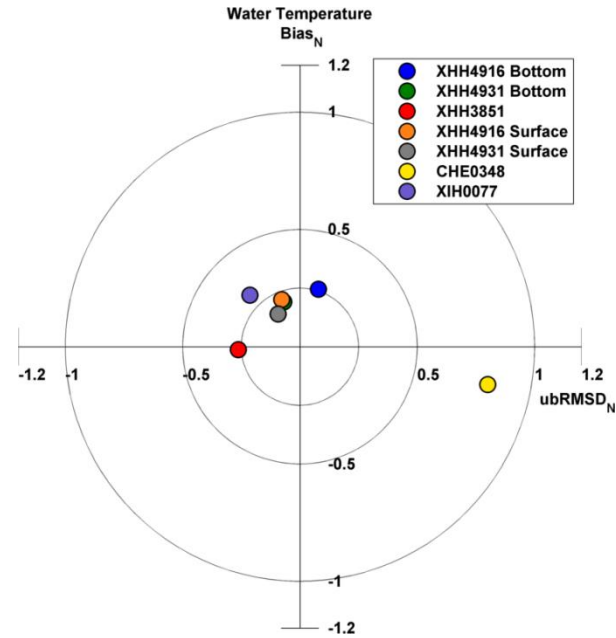
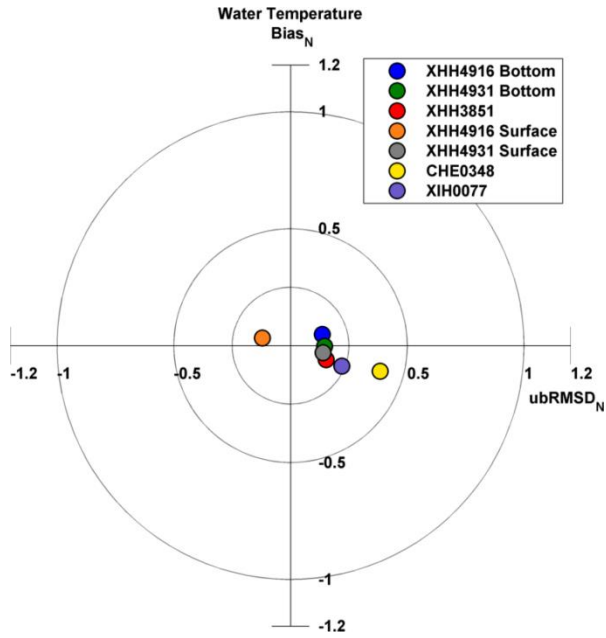
SCHISM, CH3D Boundary Conditions



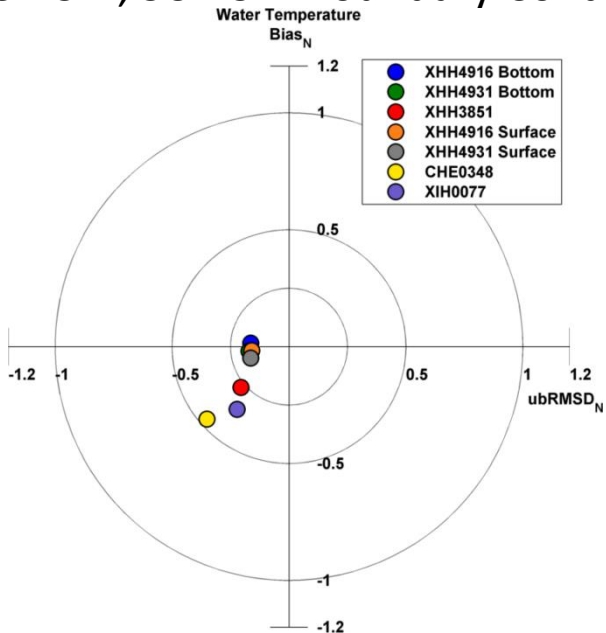
CH3D

# 2006 Temperature

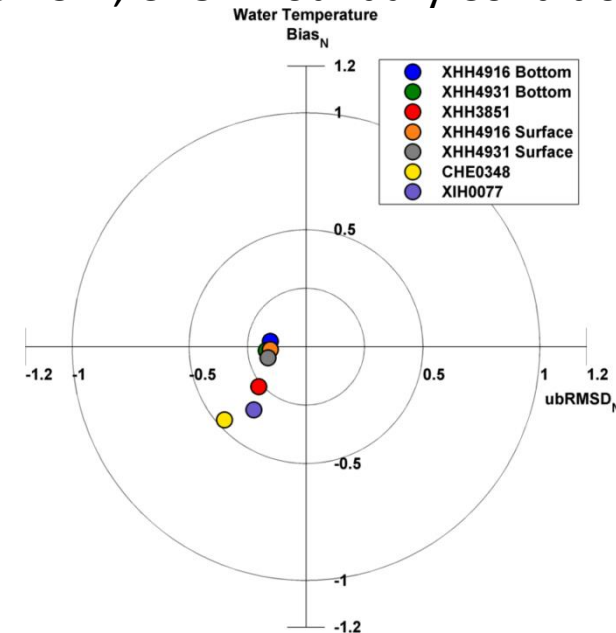
FVCOM



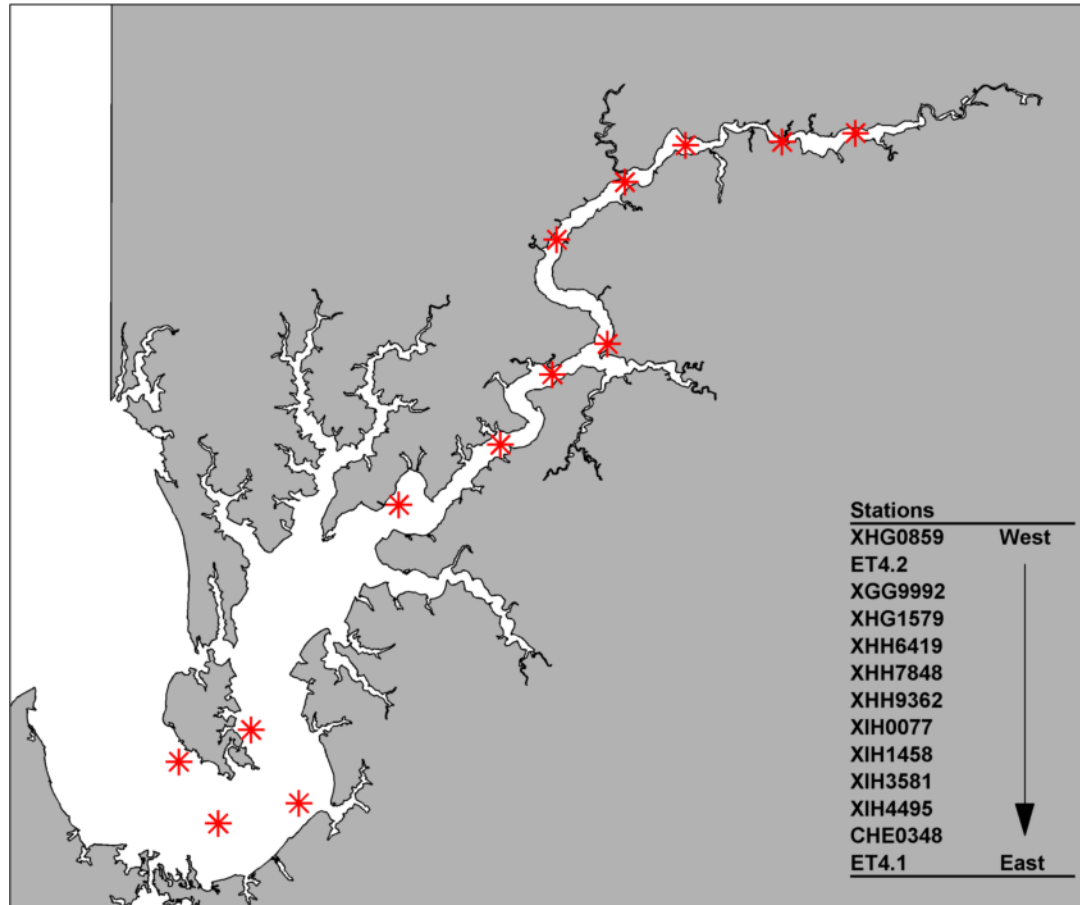
## SCHISM, SCHISM Boundary Conditions



## SCHISM, CH3D Boundary Conditions



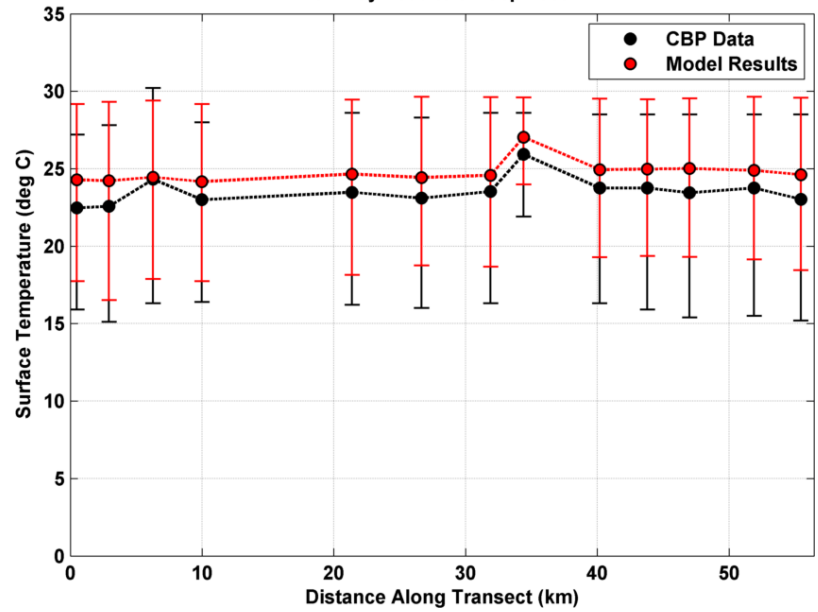
Chesapeake Bay Program data plotted as a transect from west to east. Average of profiles from May 1<sup>st</sup> through September 1<sup>st</sup> in 2003 and 2006. The 2006 transects have less stations and are a subset of those shown here, due to available data.



# 2003 Surface Temperature (error bars are ranges; Bottom Salinity and 2006 are similar)

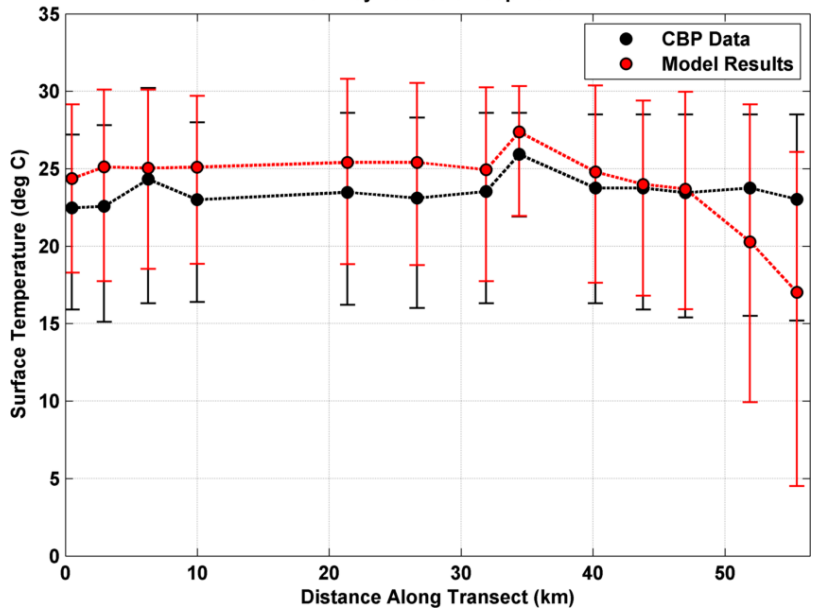
## CH3D

01-May-2003 to 01-Sep-2003



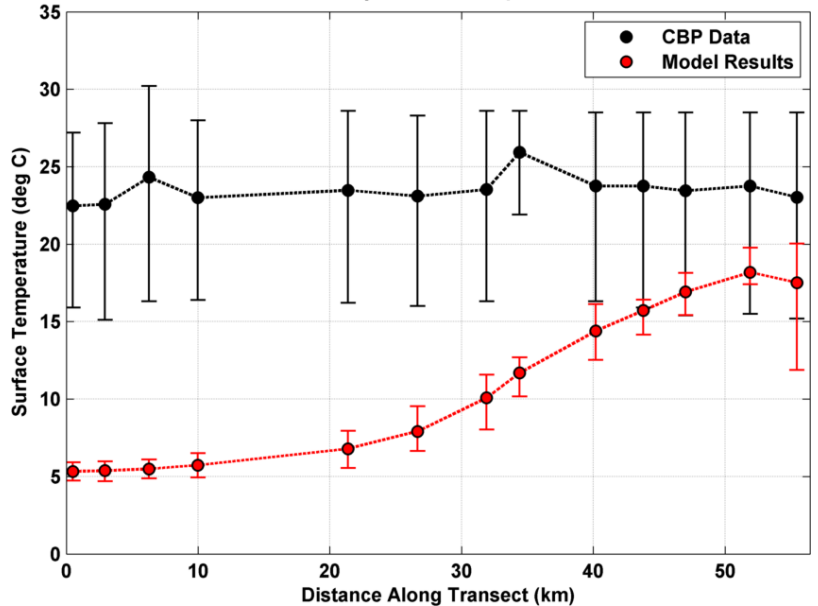
## FVCOM

01-May-2003 to 01-Sep-2003



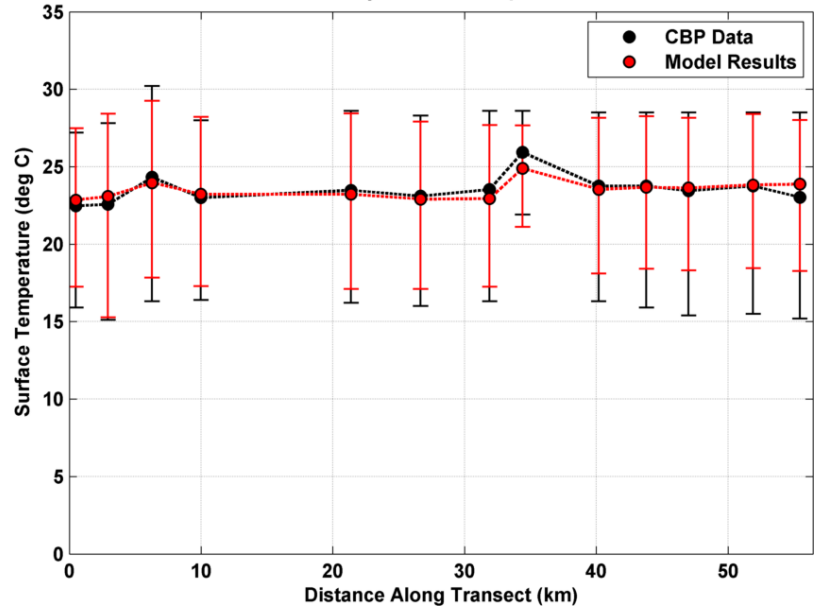
## ROMS-RCA

01-May-2003 to 01-Sep-2003



## SCHISM, CH3D Boundary Conditions

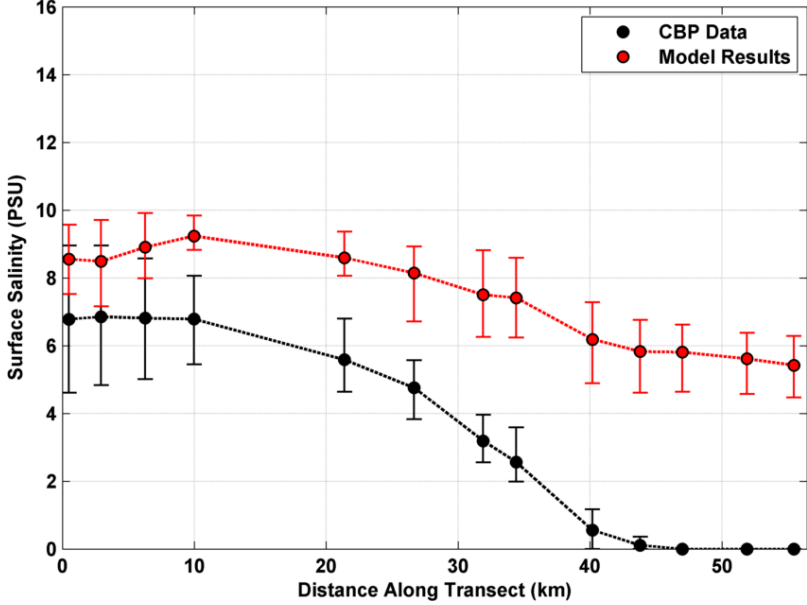
01-May-2003 to 01-Sep-2003



# 2003 Surface Salinity

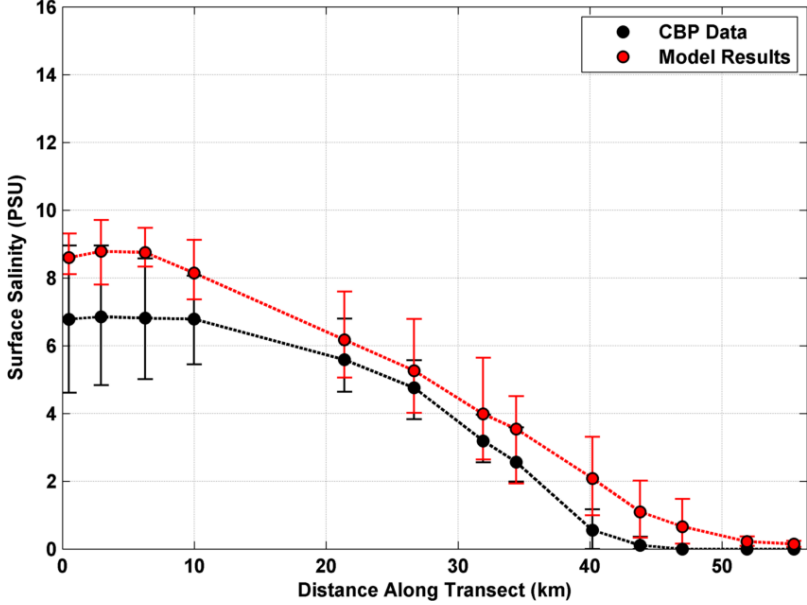
## CH3D

01-May-2003 to 01-Sep-2003



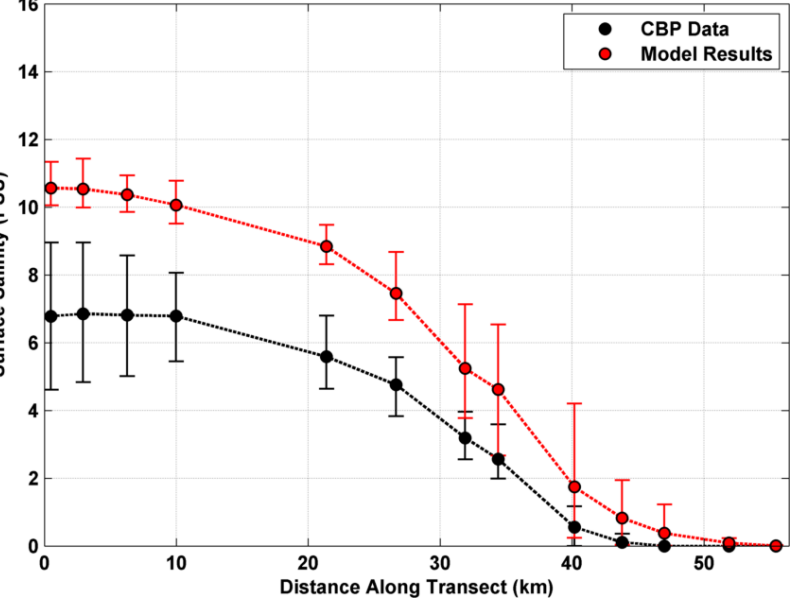
## FVCOM

01-May-2003 to 01-Sep-2003



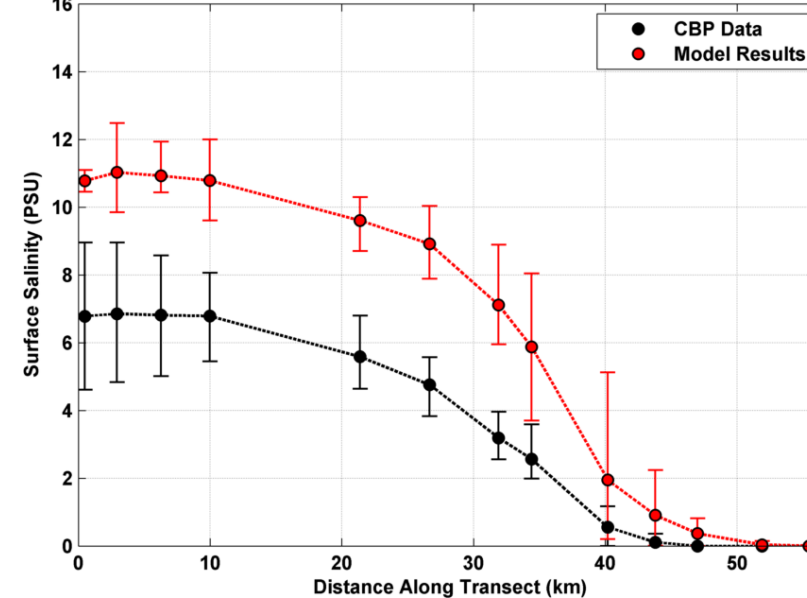
## ROMS-RCA

01-May-2003 to 01-Sep-2003



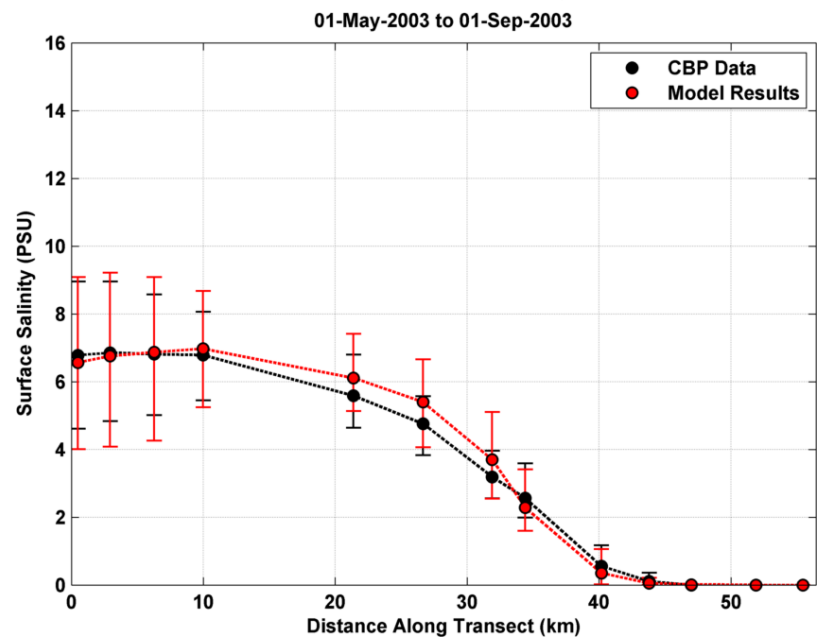
## SCHISM, CH3D Boundary Conditions

01-May-2003 to 01-Sep-2003

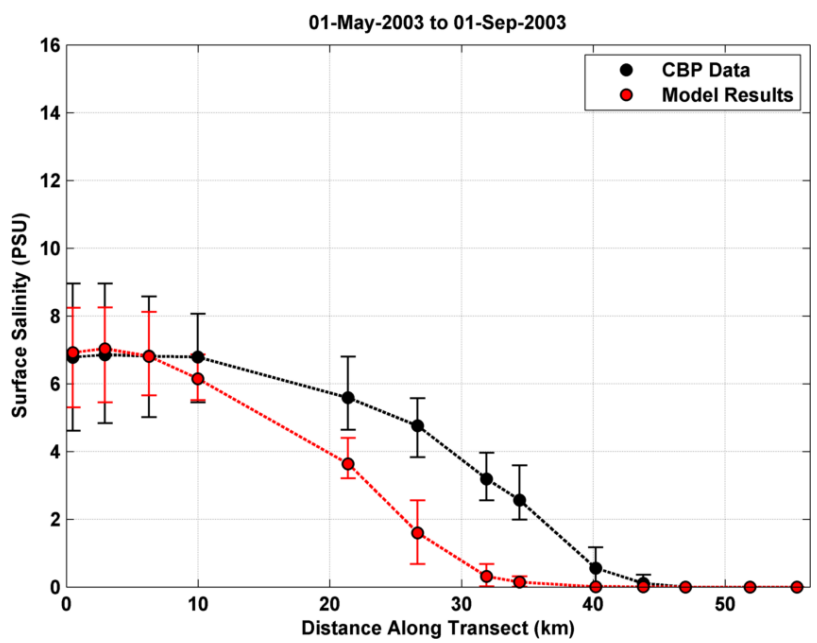


# 2003 Surface Salinity

## SCHISM, SCHISM Boundary Conditions

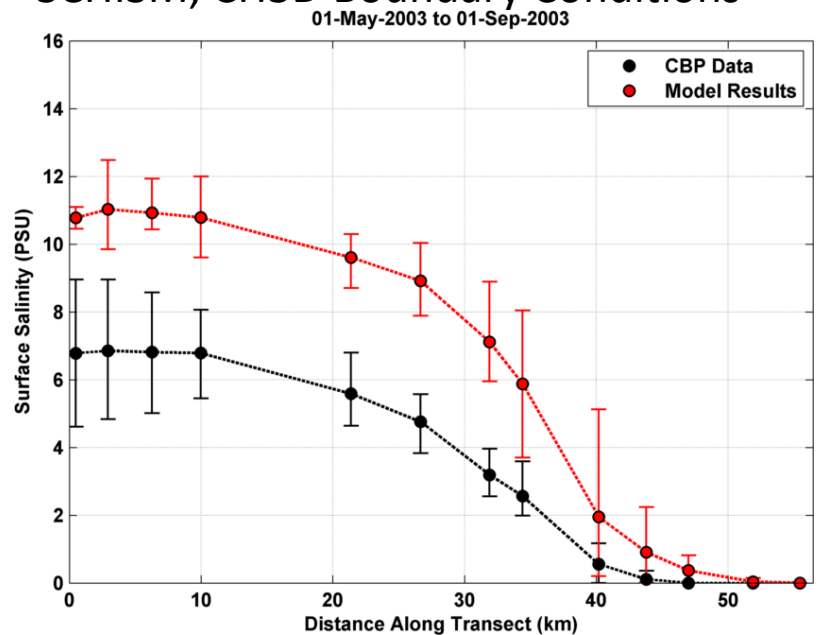


## Low-Res SCHISM



- CH3D too salty upstream
- Using CH3D bc's, ROMS and SCHISM were too salty at river mouth
- Using SCHISM bc's, SCHISM performed much better
- Low res SCHISM too fresh upstream

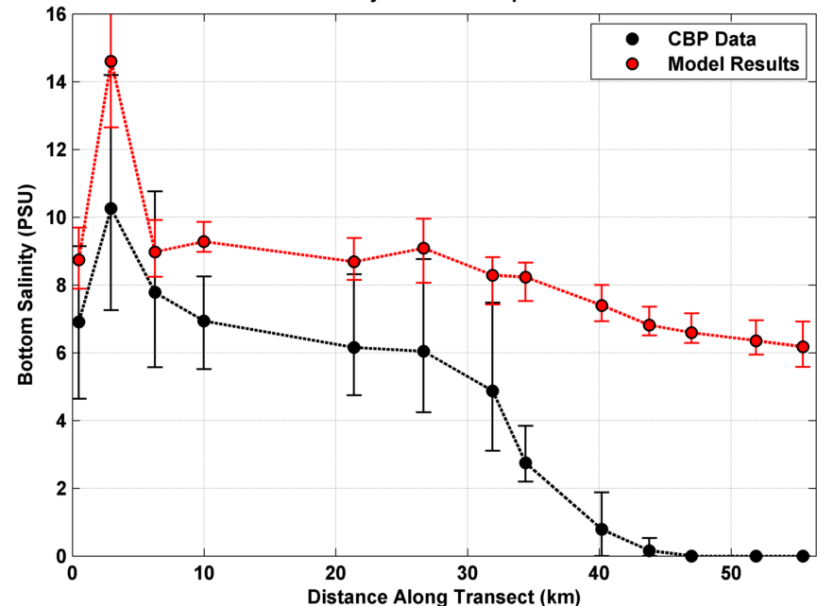
## SCHISM, CH3D Boundary Conditions



# 2003 Bottom Salinity

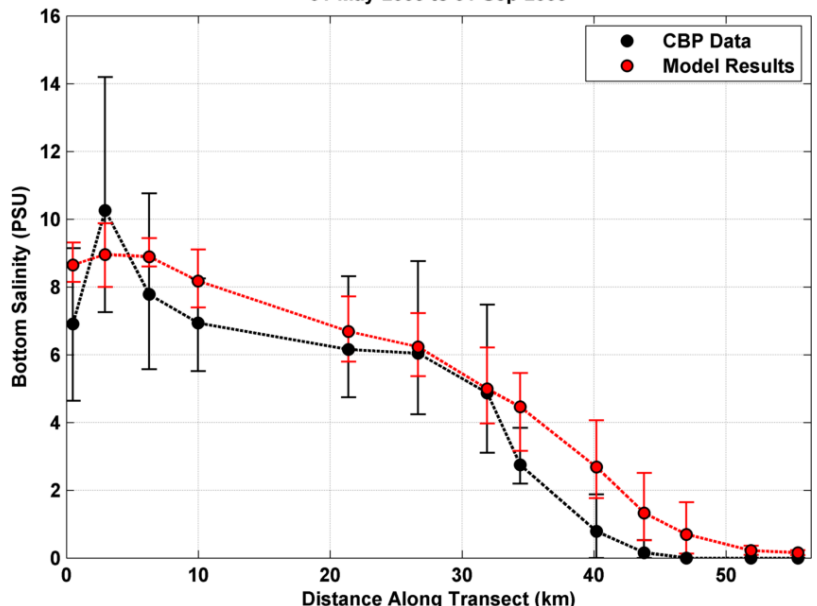
## CH3D

01-May-2003 to 01-Sep-2003



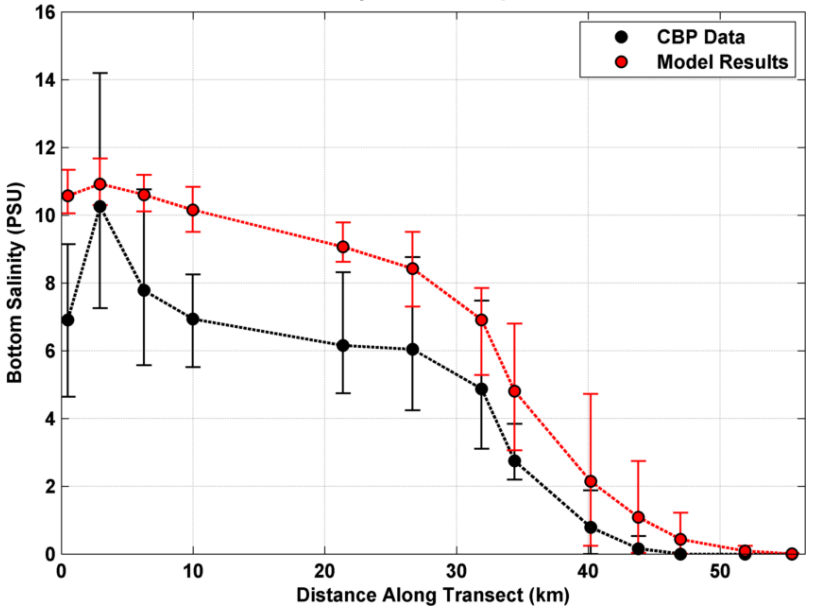
## FVCOM

01-May-2003 to 01-Sep-2003



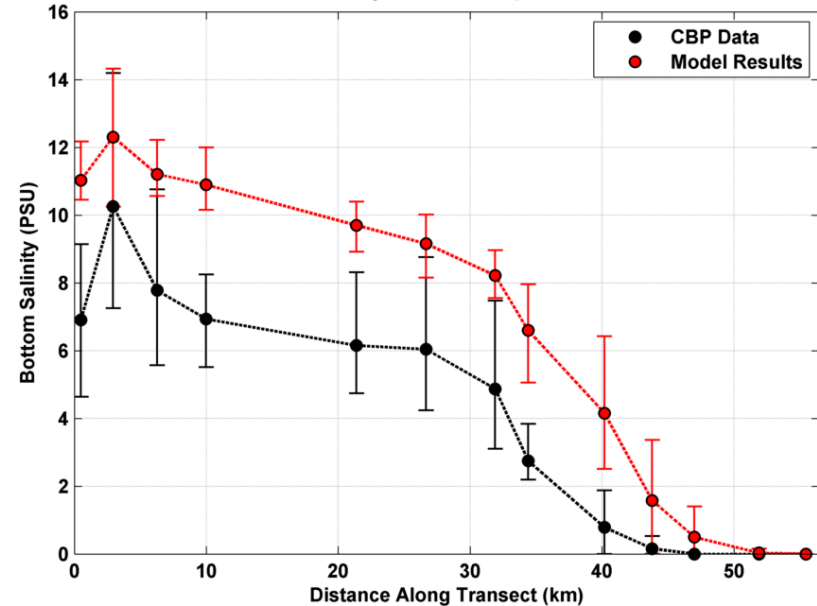
## ROMS-RCA

01-May-2003 to 01-Sep-2003



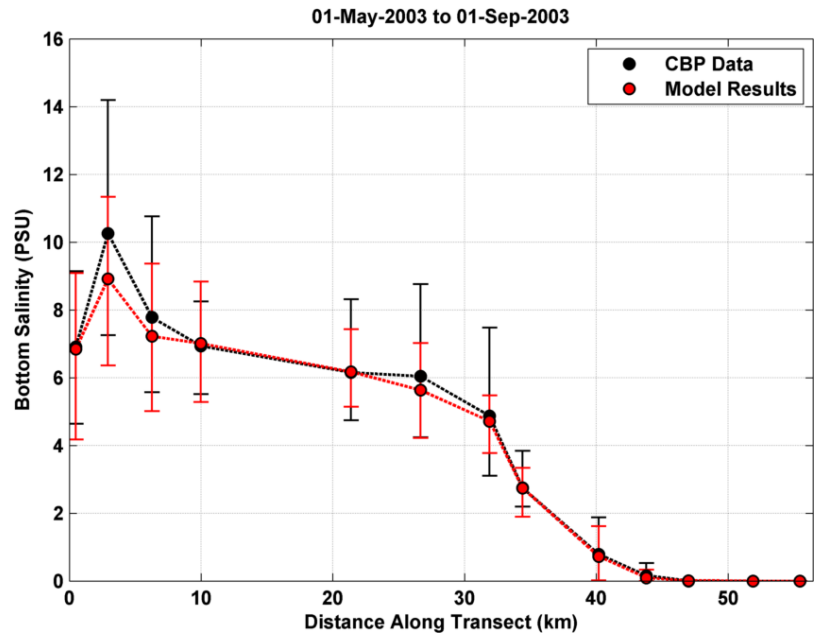
## SCHISM, CH3D Boundary Conditions

01-May-2003 to 01-Sep-2003

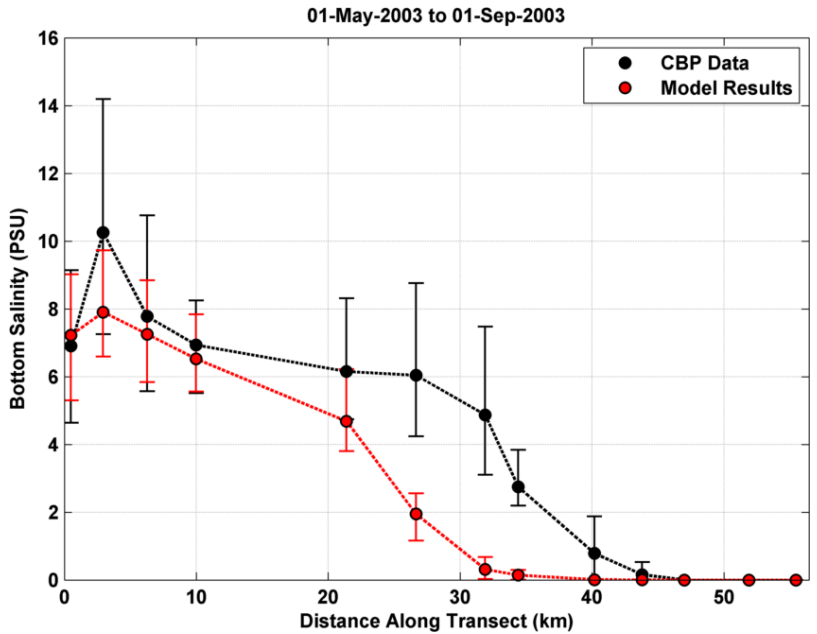


# 2003 Bottom Salinity

## SCHISM, SCHISM Boundary Conditions



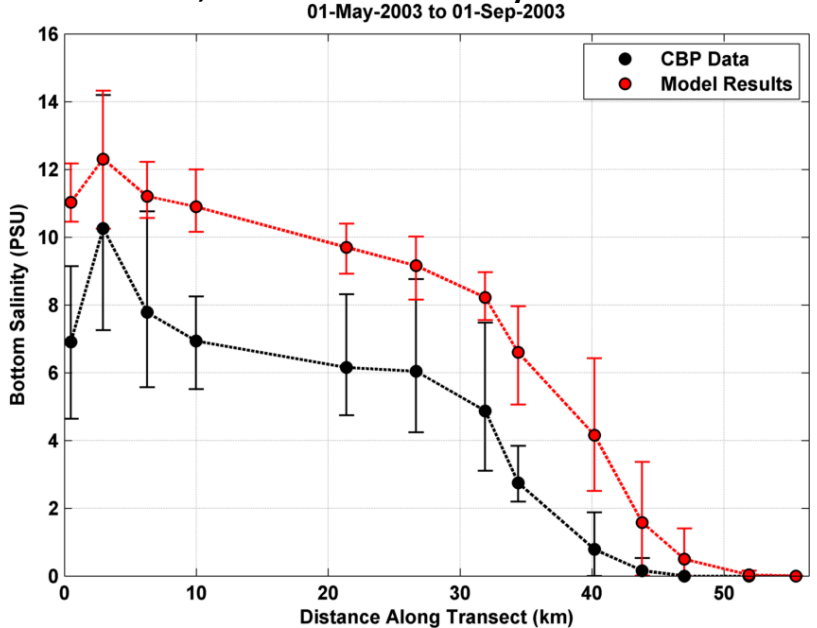
# Low-Res SCHISM



Same Trends:

- CH3D too salty upstream
- Using CH3D bc's, ROMS and SCHISM were too salty at river mouth
- Using SCHISM bc's, SCHISM performed much better
- Low res SCHISM too fresh upstream

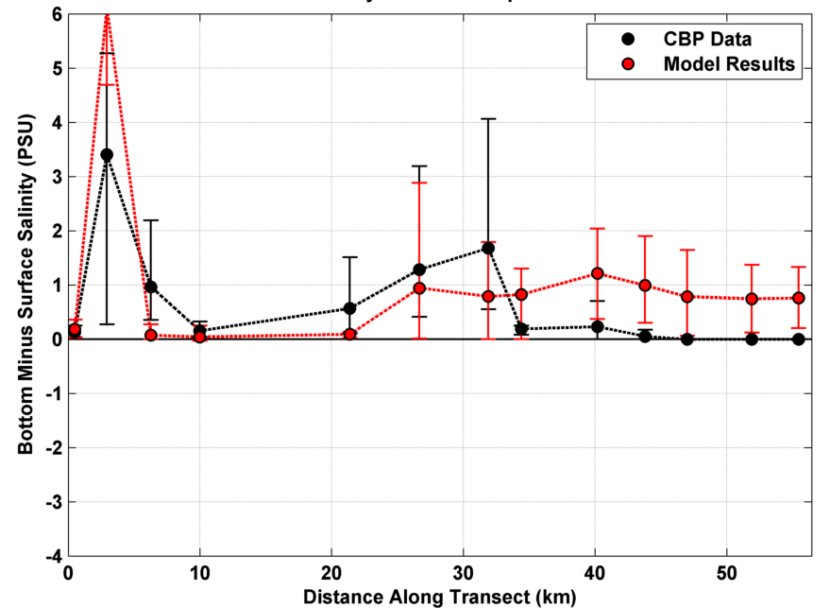
# SCHISM, CH3D Boundary Conditions



# 2003 Bottom minus Surface Salinity

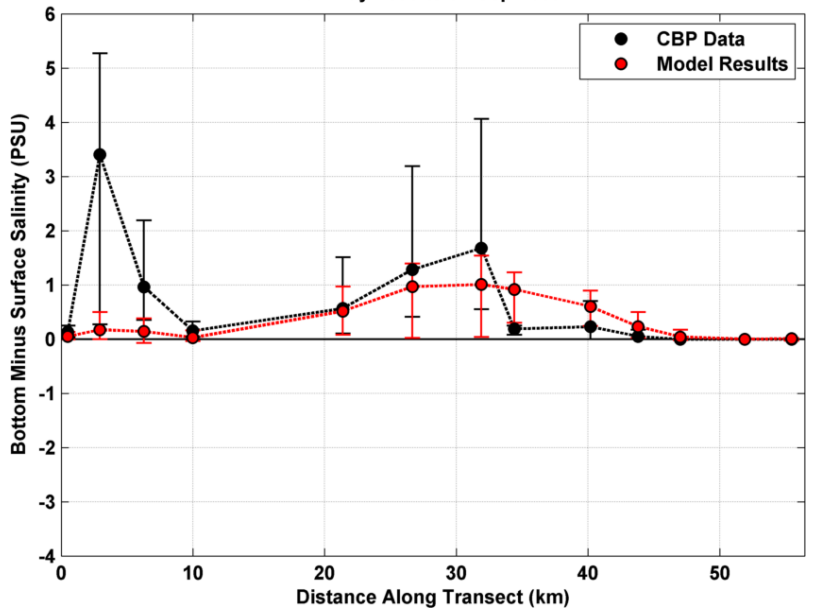
## CH3D

01-May-2003 to 01-Sep-2003



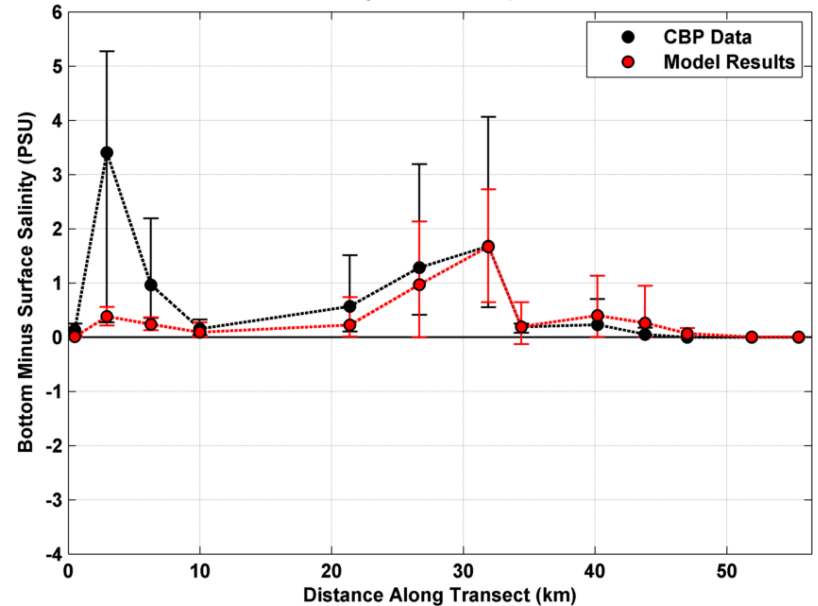
## FVCOM

01-May-2003 to 01-Sep-2003



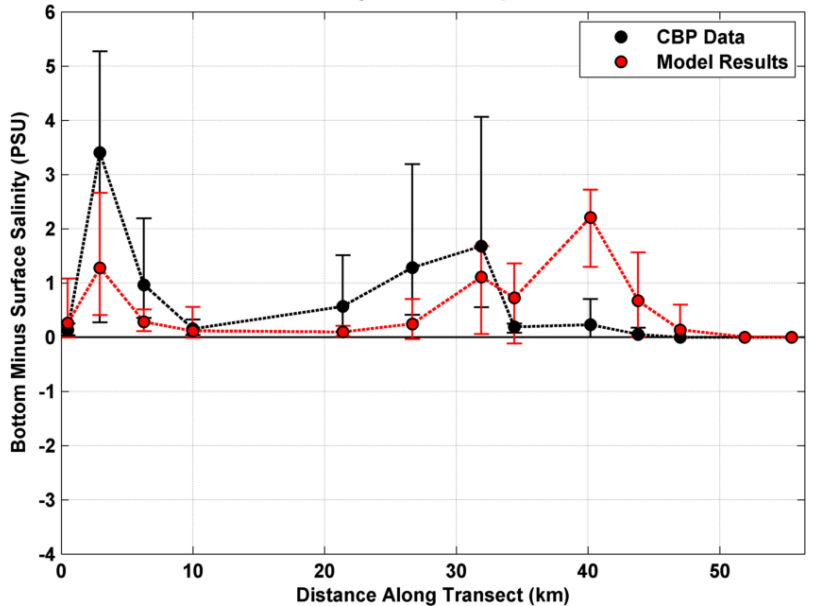
## ROMS-RCA

01-May-2003 to 01-Sep-2003



## SCHISM, CH3D Boundary Conditions

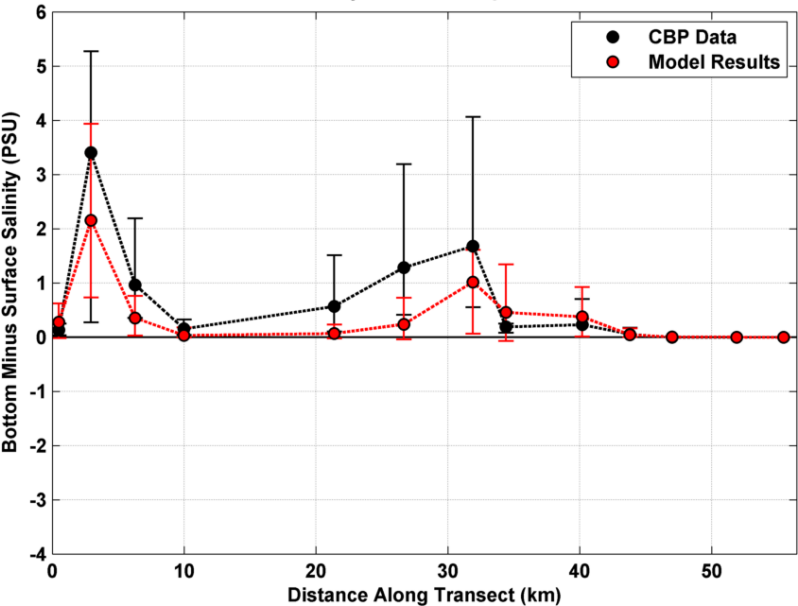
01-May-2003 to 01-Sep-2003



# 2003 Bottom minus Surface Salinity

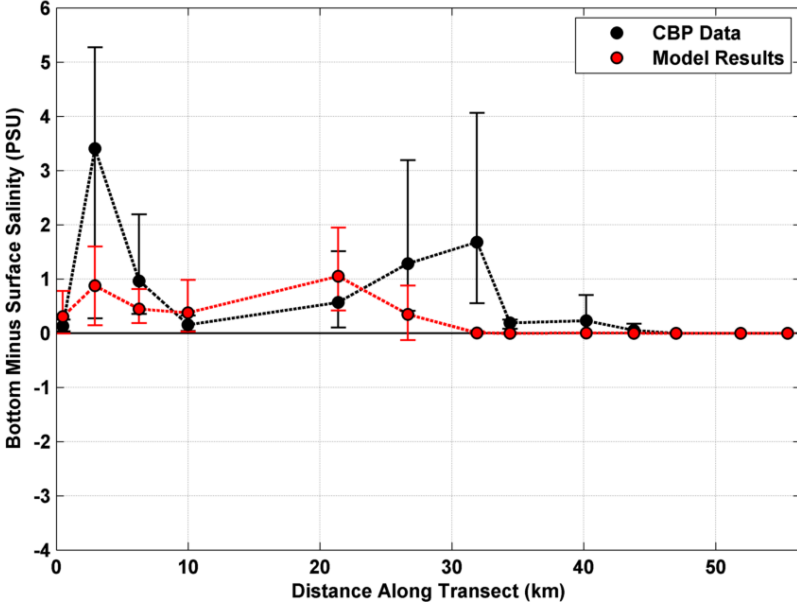
## SCHISM, SCHISM Boundary Conditions

01-May-2003 to 01-Sep-2003



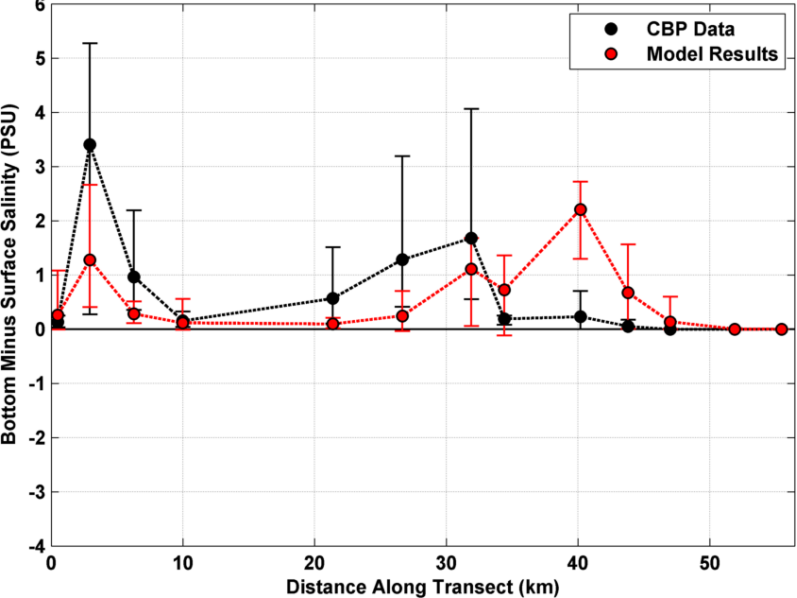
# Low-Res SCHISM

01-May-2003 to 01-Sep-2003



# SCHISM, CH3D Boundary Conditions

01-May-2003 to 01-Sep-2003

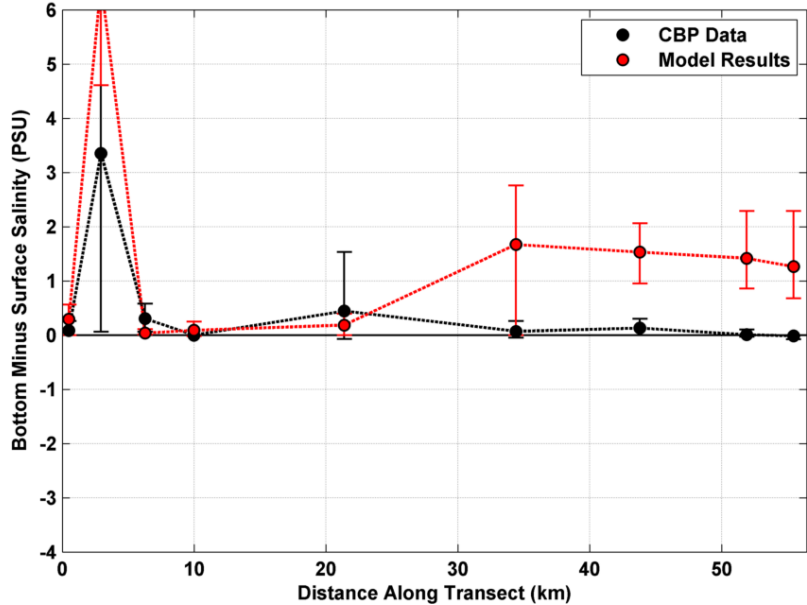


- All models too well mixed downstream (except CH3D)
- ROMS did particularly well
- Odd performance of SCHISM-CH3D at 40km (not there in earlier results)

# 2006 Bottom minus Surface Salinity

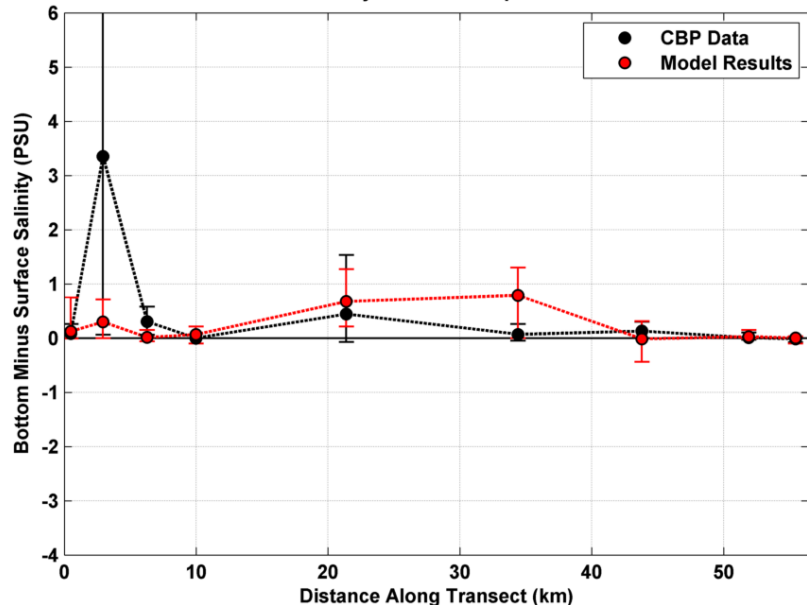
## CH3D

01-May-2006 to 01-Sep-2006



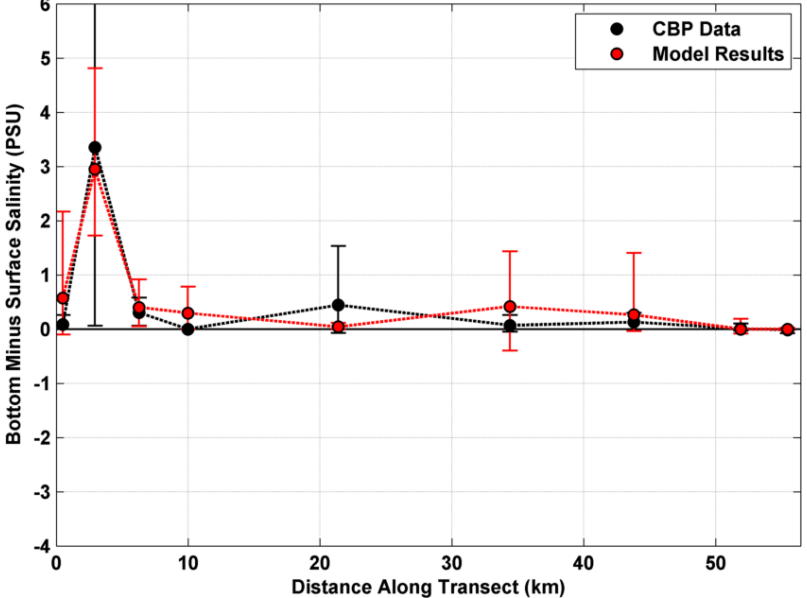
## FVCOM

01-May-2006 to 01-Sep-2006



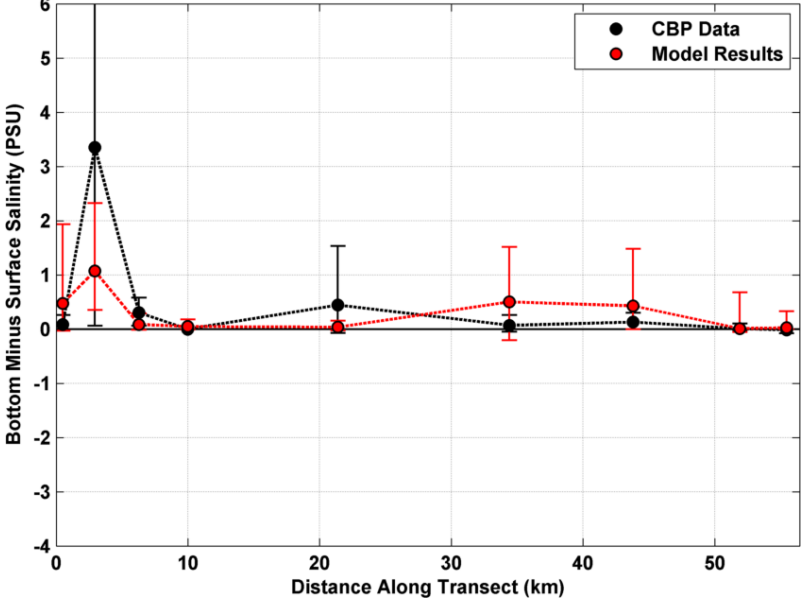
## SCHISM, SCHISM Boundary Conditions

01-May-2006 to 01-Sep-2006



## SCHISM, CH3D Boundary Conditions

01-May-2006 to 01-Sep-2006



# Chester River Model Simulations

## Spatial Transect Results:

Temperature:

All models look good (except FVCOM at most upstream station?)

Salinity:

CH3D too salty upstream

Low-res SCHISM too fresh upstream

Using CH3D bc's, ROMS and SCHISM were too salty at river mouth

SCHISM does better with SCHISM bcs

FVCOM Does well

Stratification:

CH3D too well mixed upstream and downstream

Other models too well mixed downstream

ROMS did particularly well

SCHISM did much better with SCHISM bcs

# Take home messages:

- No problem (almost) with temperature! (if atm forcing is used)
  - SCHISM does very well
- CH3D (and low-res SCHISM) have significant problems reproducing salinity in very shallow water (as expected)
- Salinity simulations are very sensitive to open boundary conditions
  - Other models try SCHISM bc's?
  - SCHISM/ROMS try implementing CH3D bc's differently?
- Seasonal trends in salinity are a challenge for SW models
- ROMS does very well in terms of stratification

**Suggestions for other comparisons are welcome!**