Quarterly Progress report on the Patapsco-Back MTM

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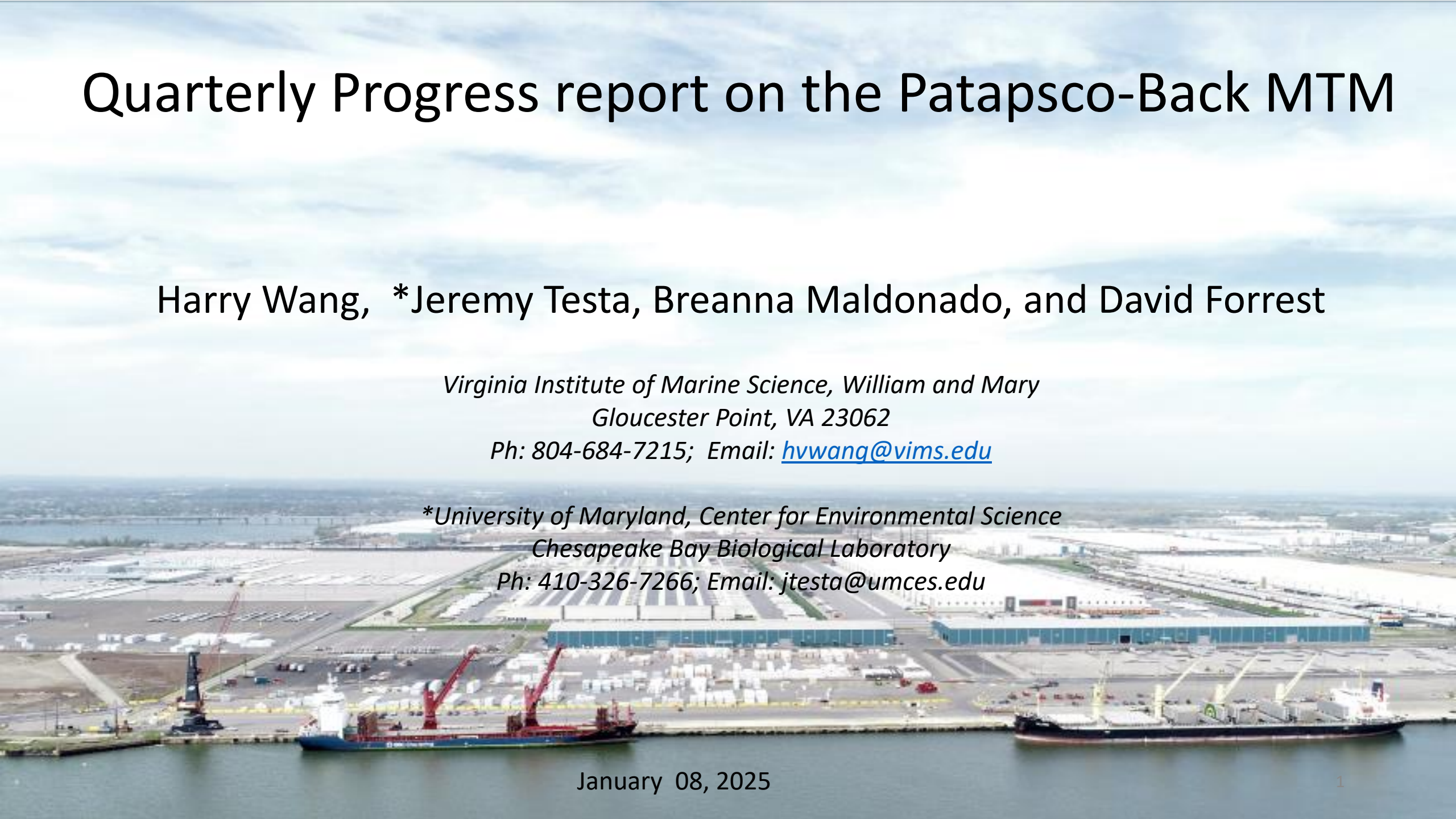


January 08, 2025

Outline:

I. Linking C&D canal in the Upper Bay

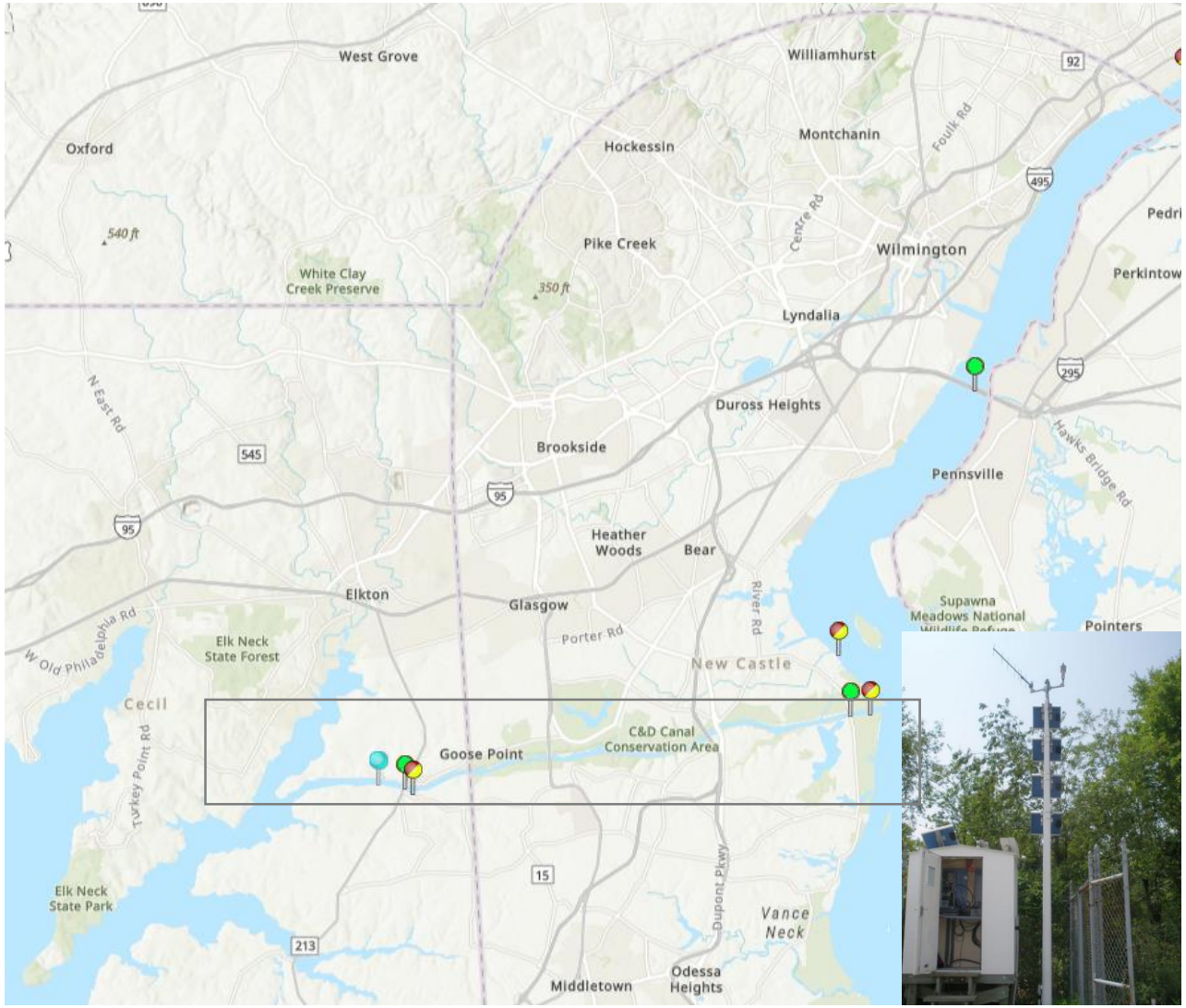
II. Setup Patapsco R., Gwynns Falls, and Jones Fall river discharges

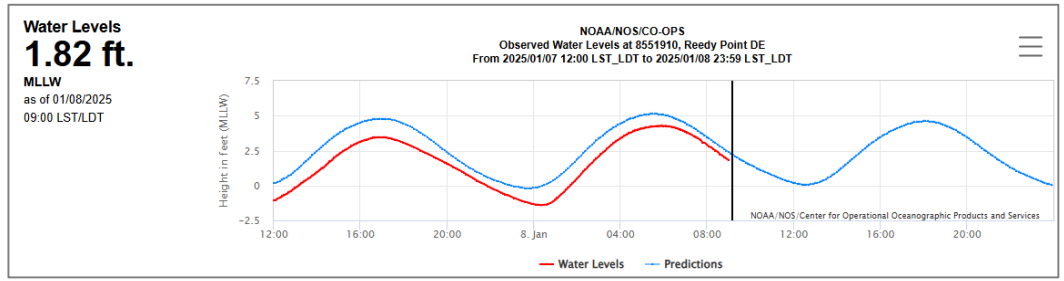
III. Recap long-term verification issues inside Baltimore Harbor at WT5.1

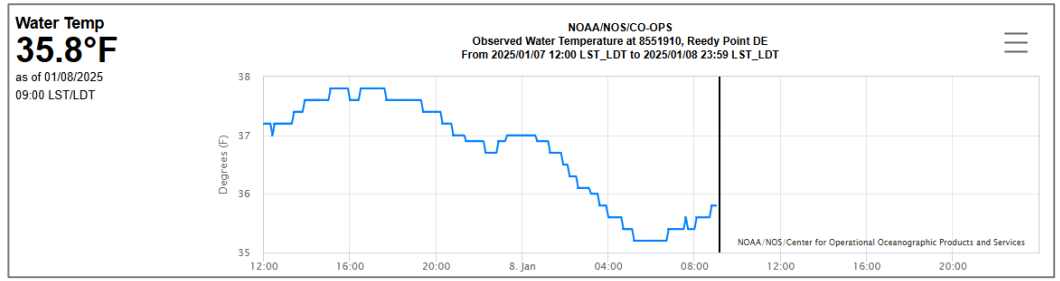
a. Re-gridding and depth at the Craighill and Swan channels
b. Updated long-term verification for temperature and salinity
c. Open boundary condition

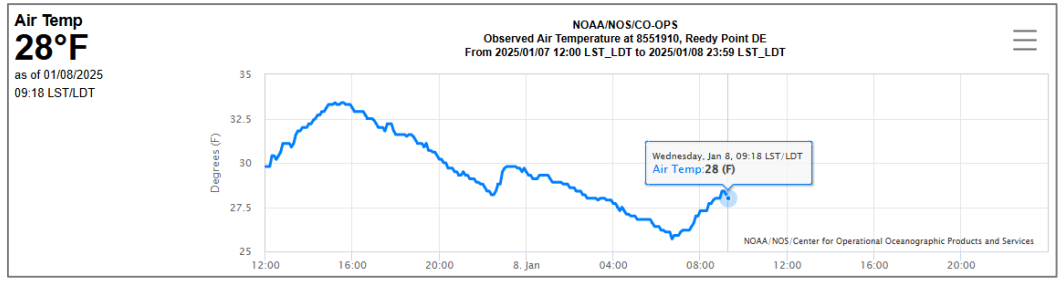
IV. Summary and discussion

I. Linking C&D canal at the Upper Bay





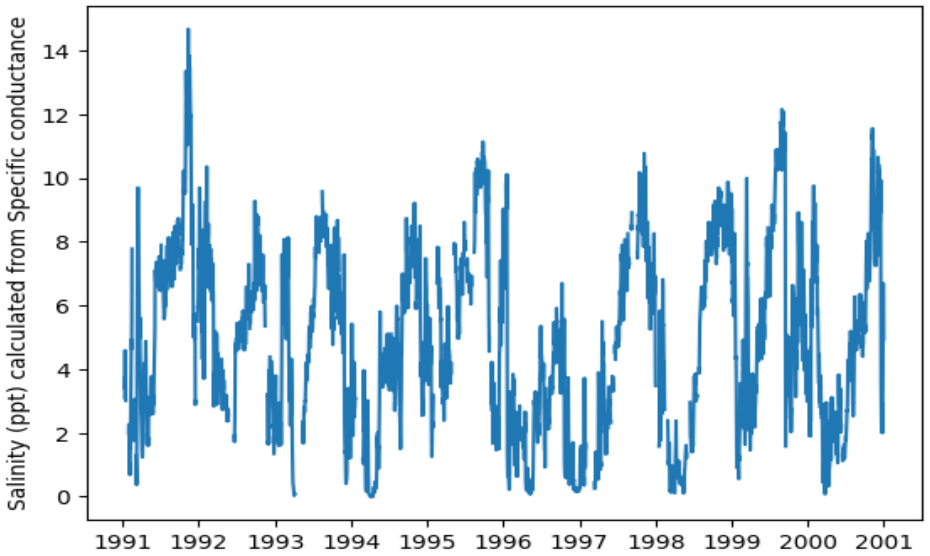




https://tidesandcurrents.noaa.gov/stationhome.html?id=8551910

NOAA Reedy Point station uniquely measures long-term time series for specific conductance, which were translated to daily salinity, as shown below.

Combining with real-time water temperature and water level, it provides an open boundary condition at the juncture where Chesapeake Bay meets Delaware Bay.

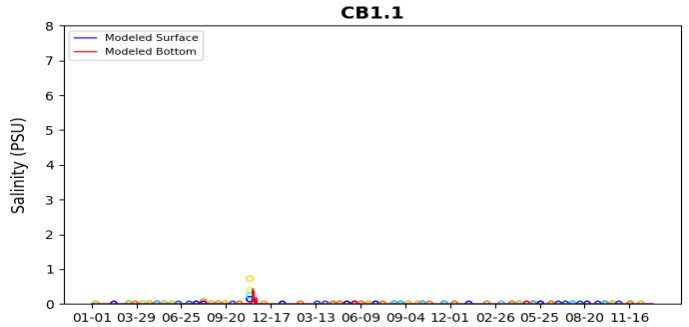


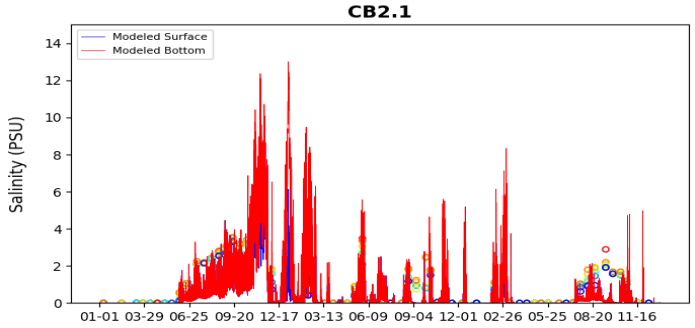
The influence of C&D canal on the Upper Bay

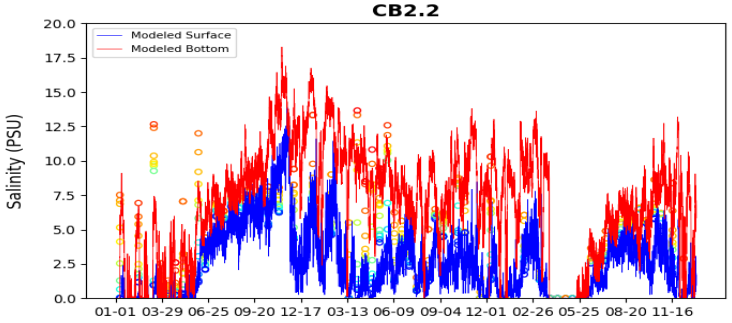
*Based on preliminary inspection, opening the C&D canal increases the bottom and surface salinity by about 0.5 – 1 ppt, more pronounced during the high flow conditions.

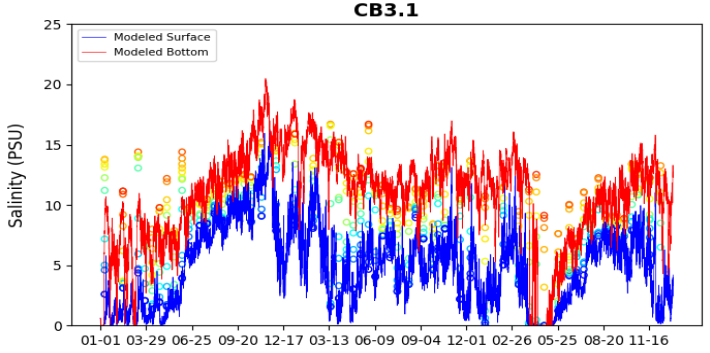
However, the extent of the influence only limited to CB1.1, CB2.1 and CB 2.2, in the Upper Bay, as shown on the right hand side for the comparison between OPBC closed versus opened.

Closed

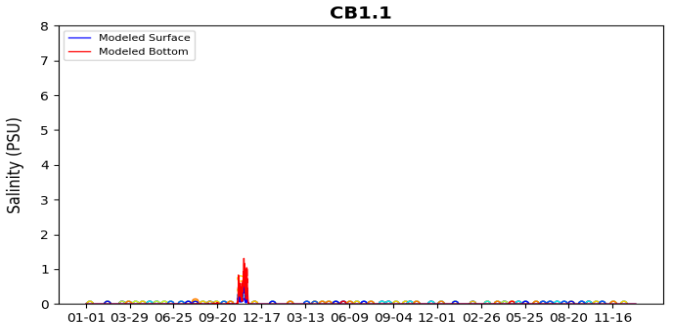


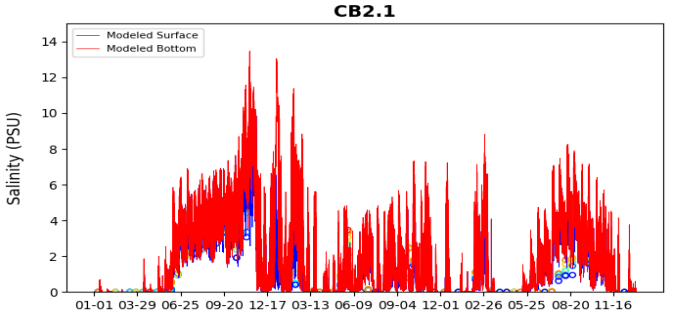


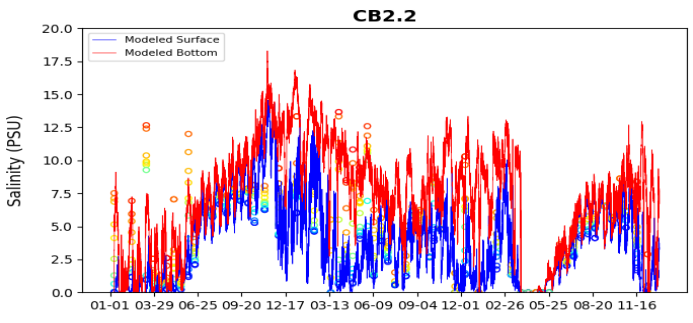


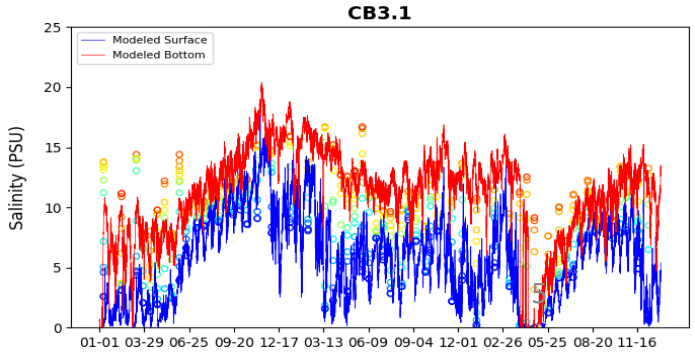


Opened



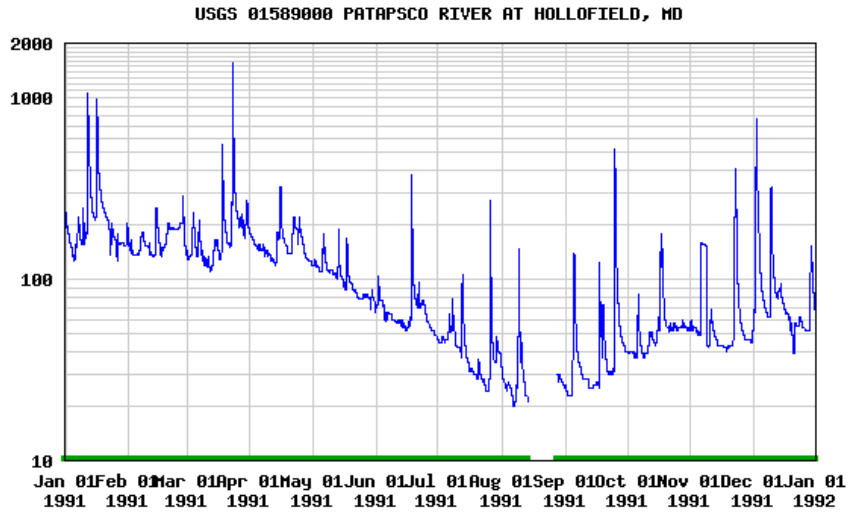


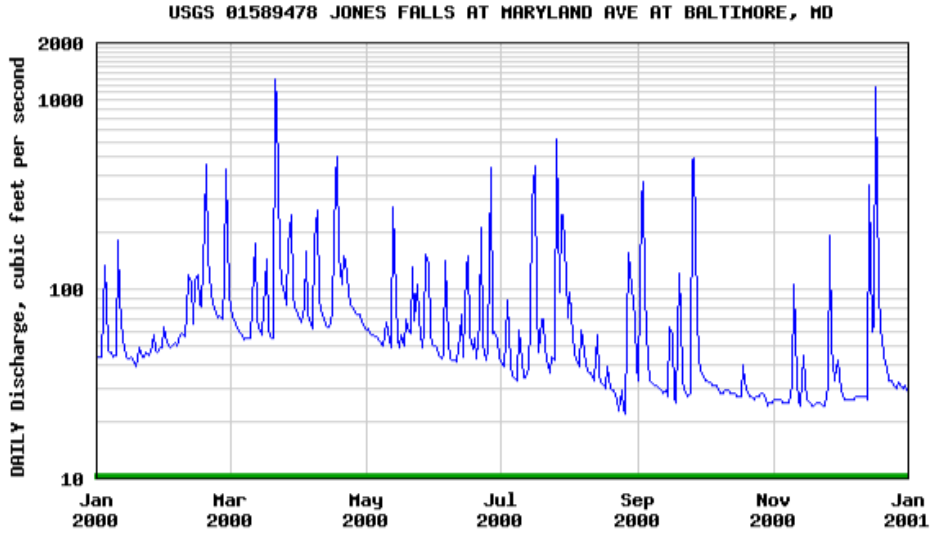


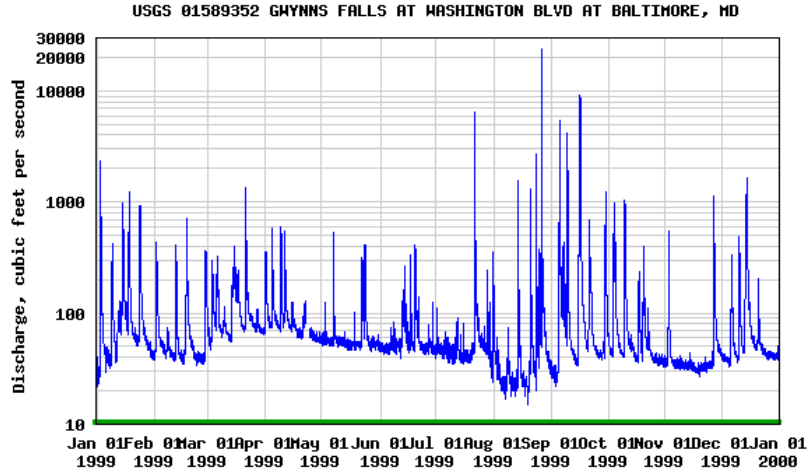


II. Setup Patapsco, Gwynns Falls, and Jones Fall river discharges

Because of predominantly the impervious surface, the urban runoff is characterized by spiky river discharge, driven from flash rainfall. Examples are shown below:

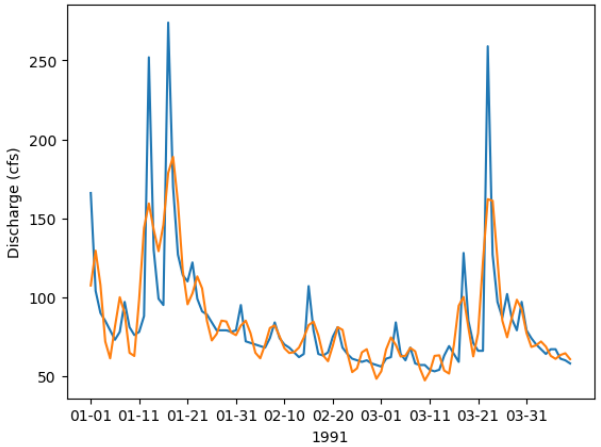




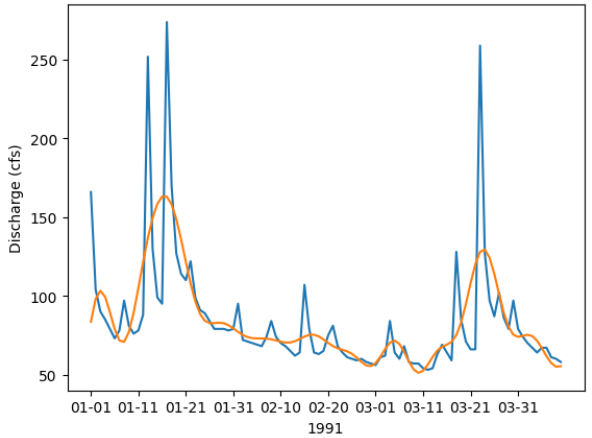


To construct the time series properly, we tested the 5 , 8, 10 and 15 days filters and, in the end, 10 days filter was chosen

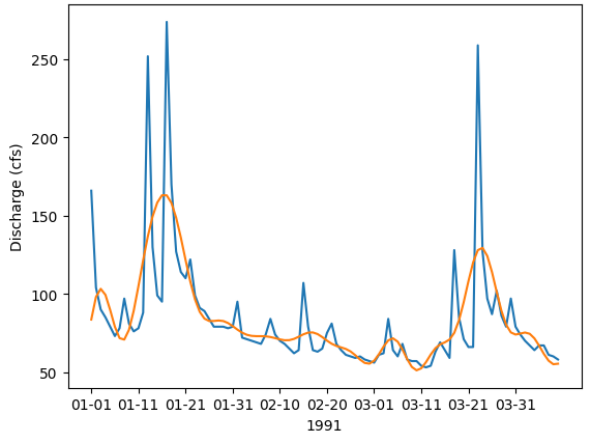
5-days filter



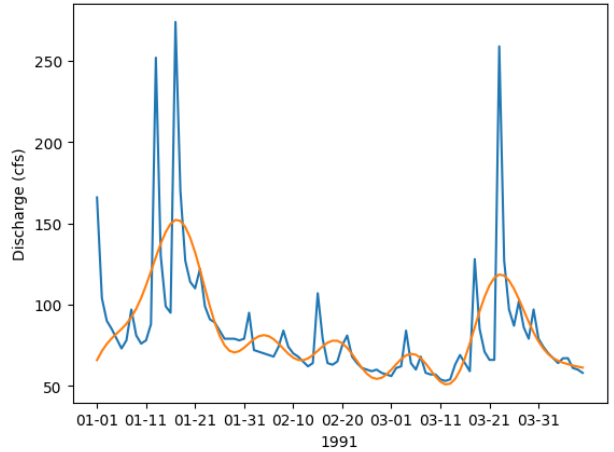
8-day filter



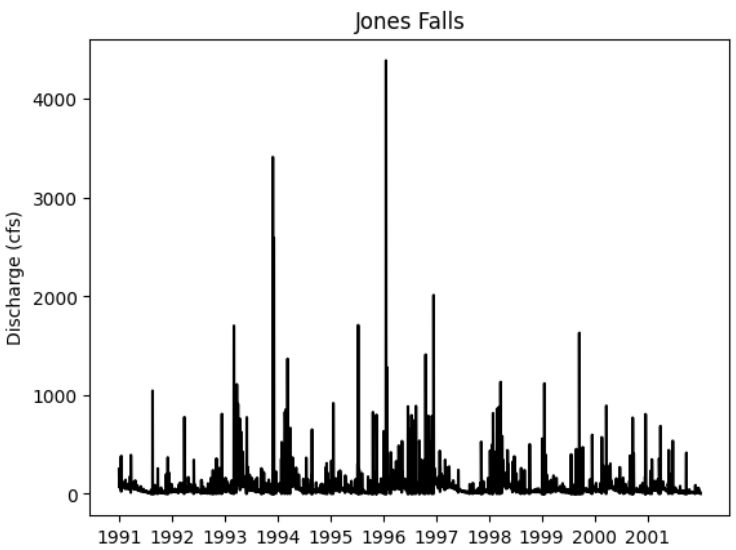
10-day filter

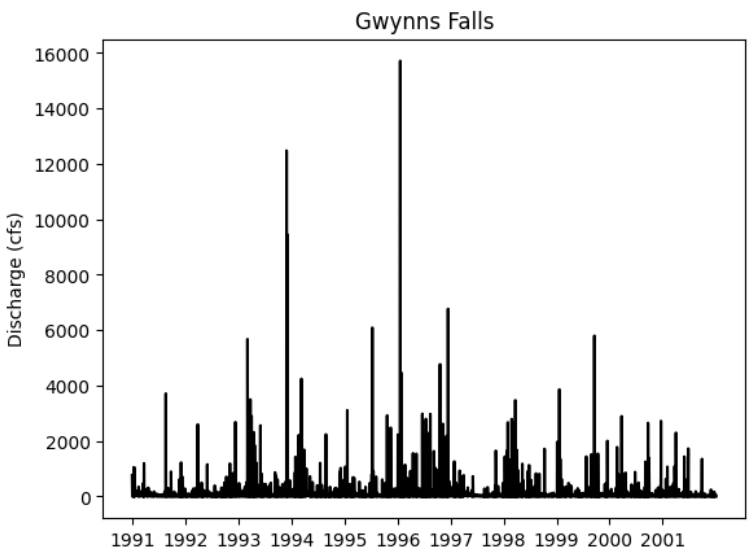


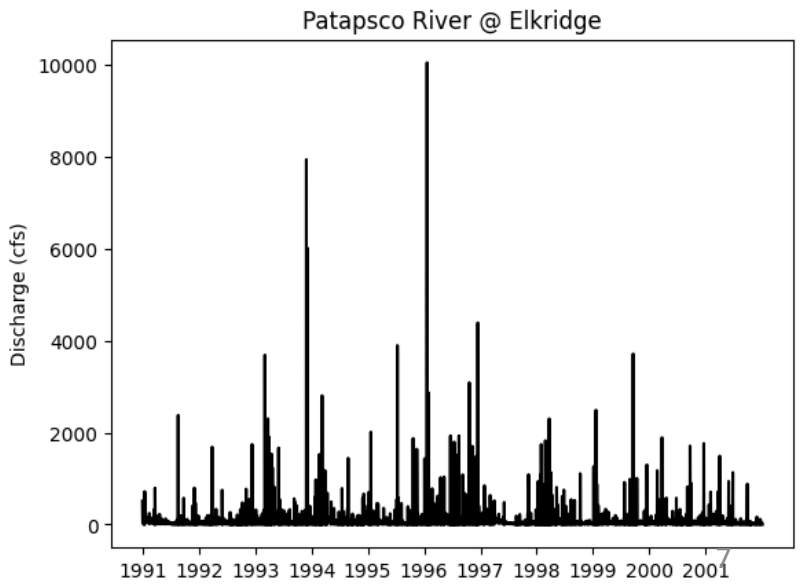
15-day filter



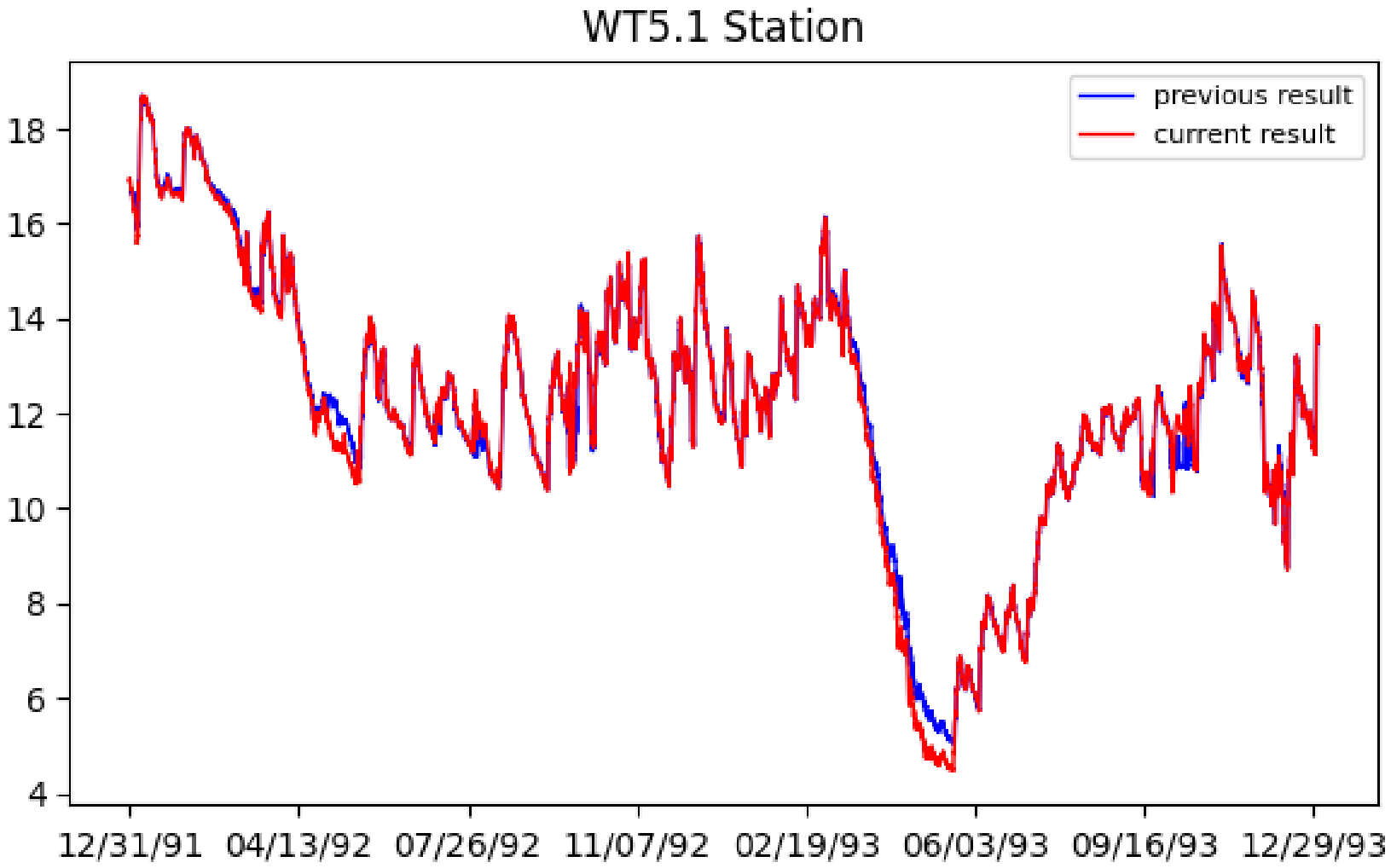
Using low-pass and high pass filter technique, final time series was constructed:







Compare WT5.1 Station to Previous Result (1992-1993)



Previous Result ->
Mean bottom salinity =
12.213 PSU

New Result ->
Mean bottom salinity =
12.165 PSU

III. Re-Cap issues inside Baltimore Harbor at WT5.1 (November 111/2024)

Previous summary:

1. The long-term (1991-1997) calibration for Patapsco/Back River is conducted for water level, temperature, and salinities.

2. The results show that most of the hydrodynamic variables in the Upper Chesapeake Bay are reasonably compared with the observation data, and the statistical skills are comparable to MBM results.

3. However, we have found that the salinity comparison inside the Harbor, especially the bottom salinity at WT5.1 were under-predicted by 3-5 ppt.

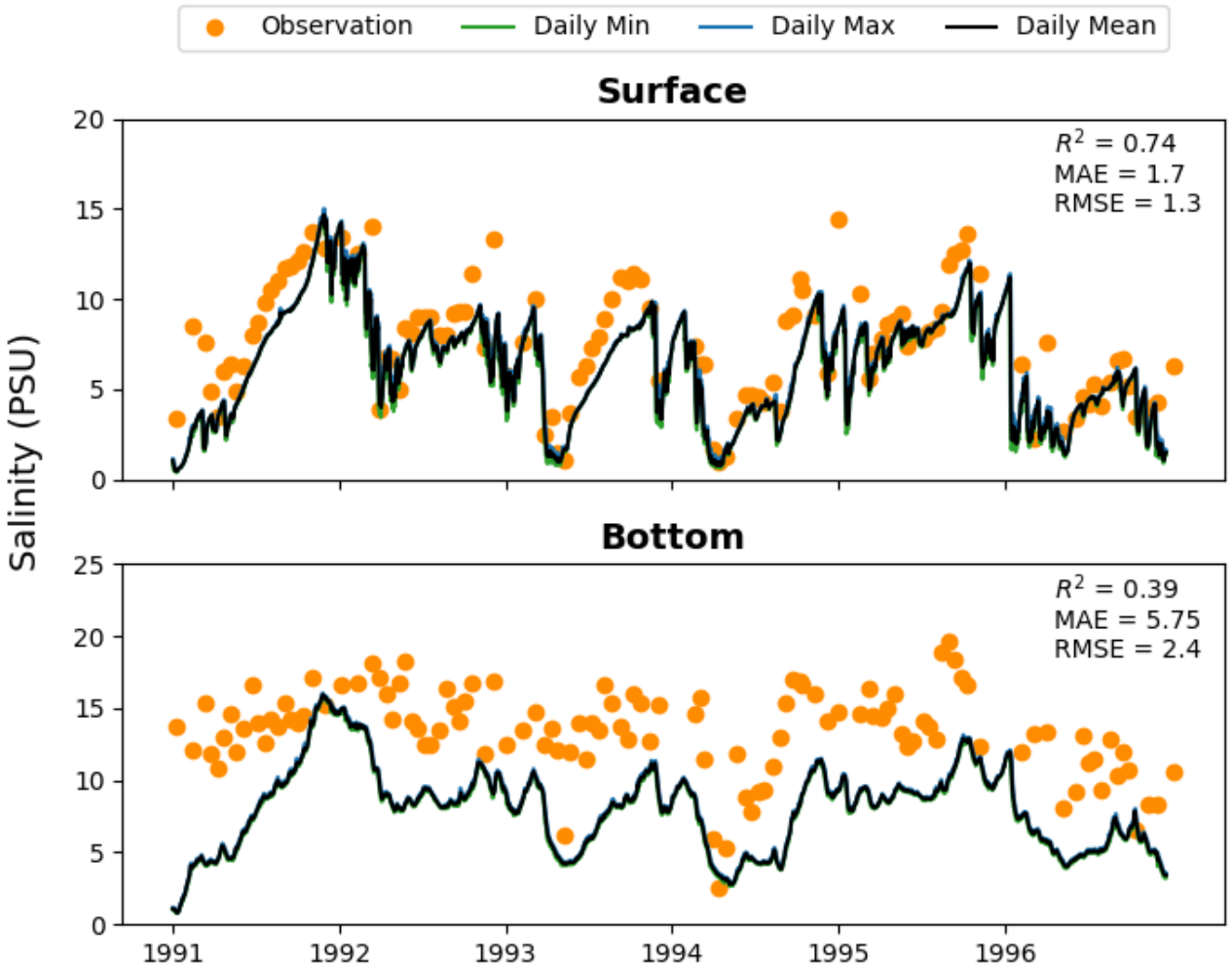
4. The potential causes are (1) uncertainty on the bathymetry data, (2) the grid resolution, and (3) possible involve the dynamics of "Density-driven exchange flow under the constriction".

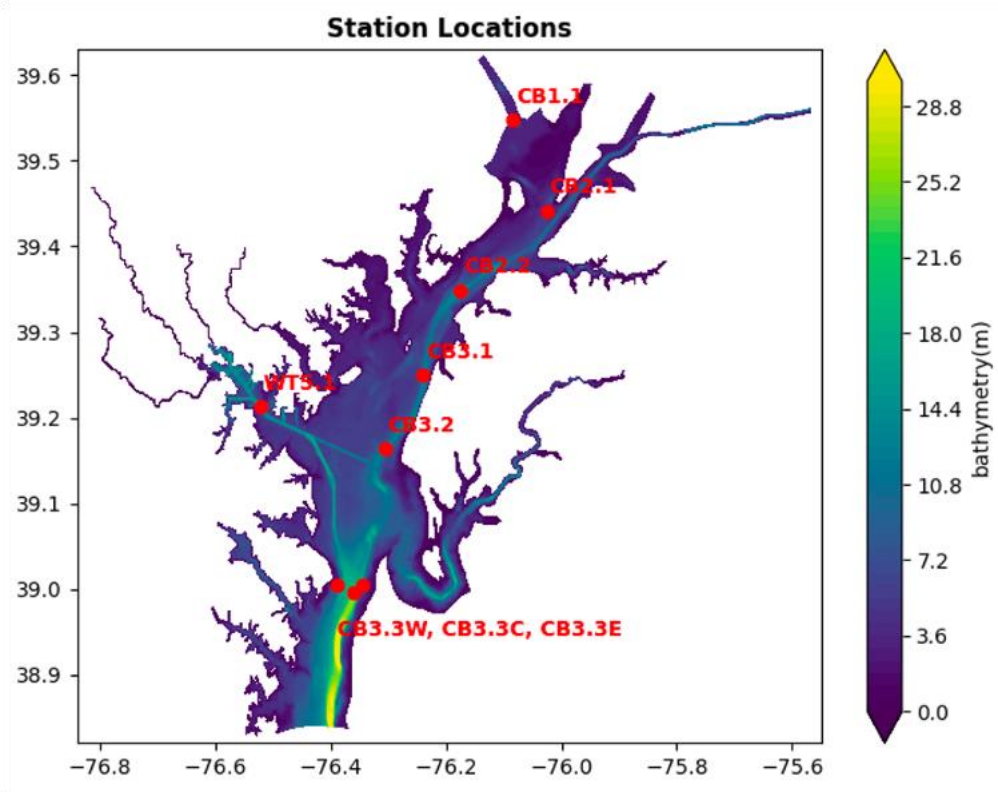
Future actions

1. Revision of model grid
2. Sensitivity test on Grashof number; the salt flux is proportional to $Gr_t A^2$

where $\boxed{Gr_t = g' H^3 / k_v^2}$ and $\boxed{A = H/L}$

WT5.1 Station

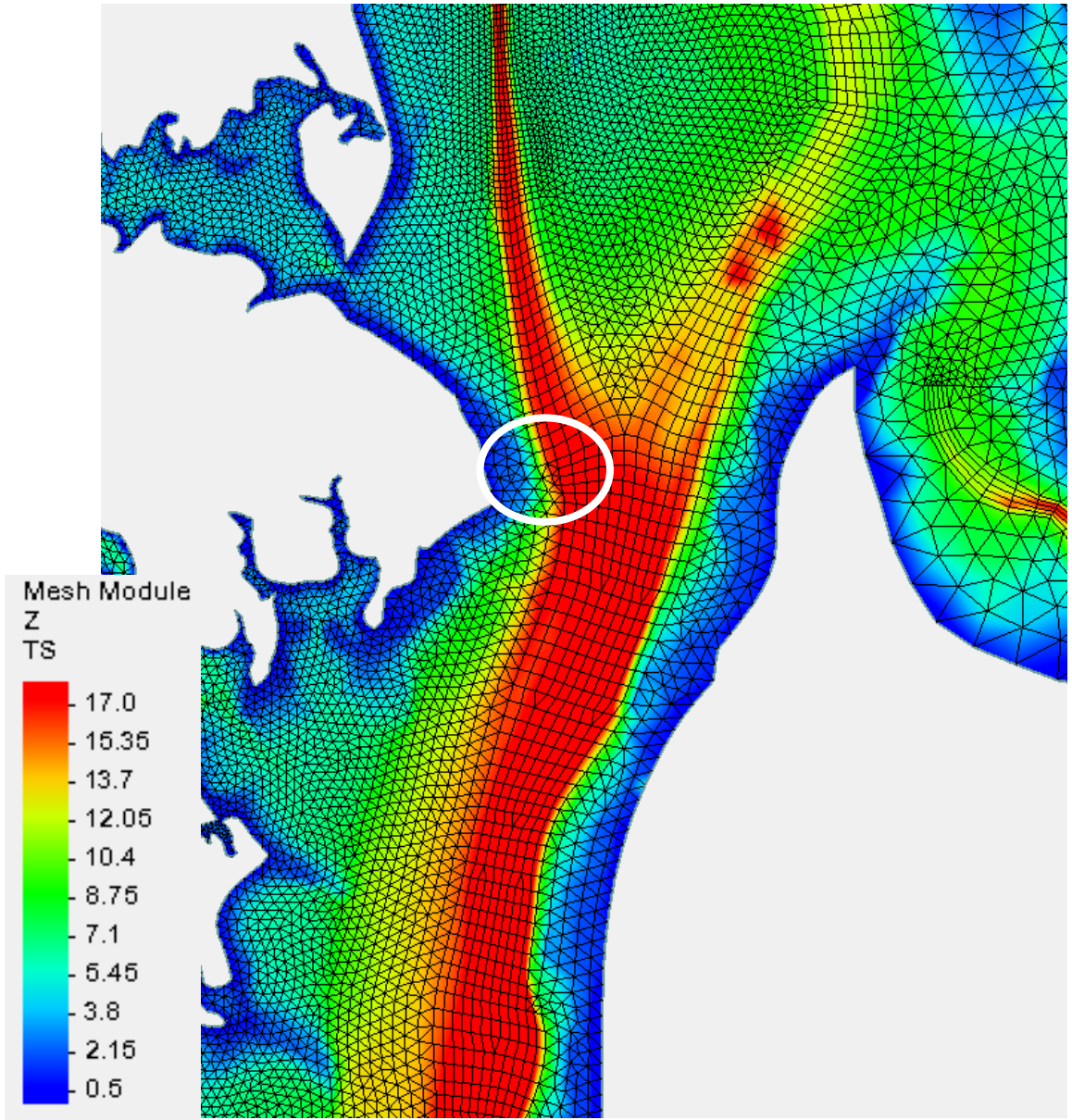




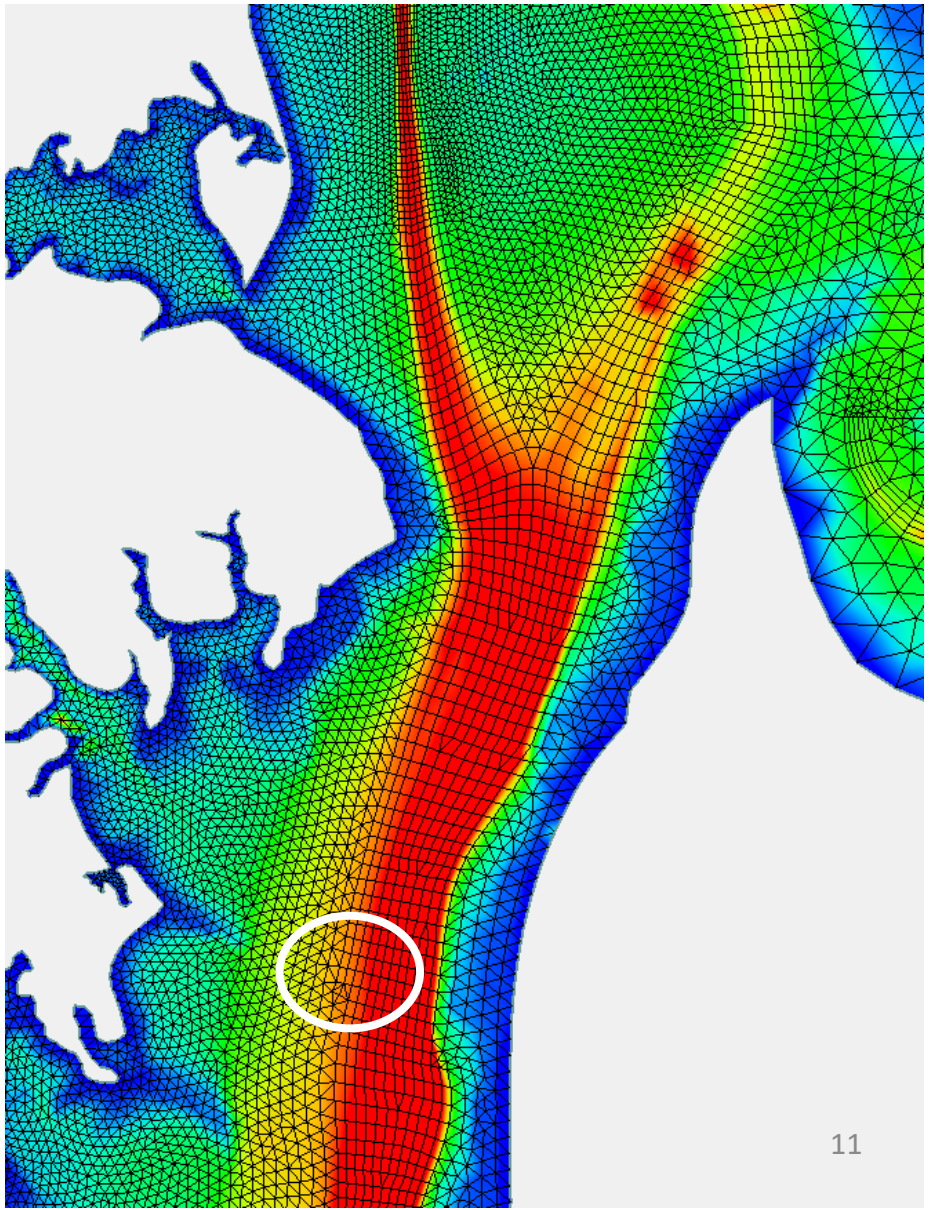
Grid Modification

Previous Grid

Newly Modified Grid

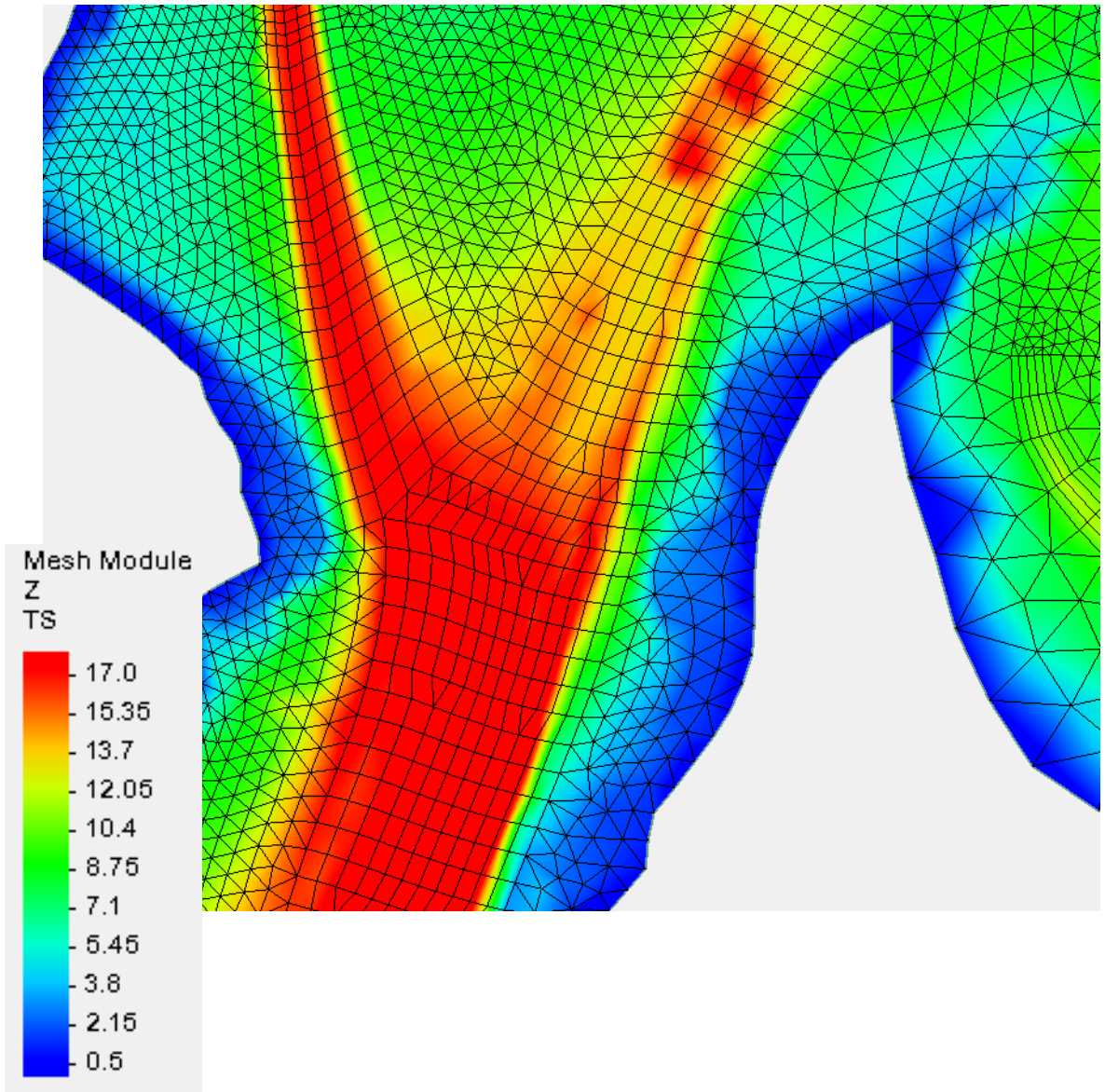


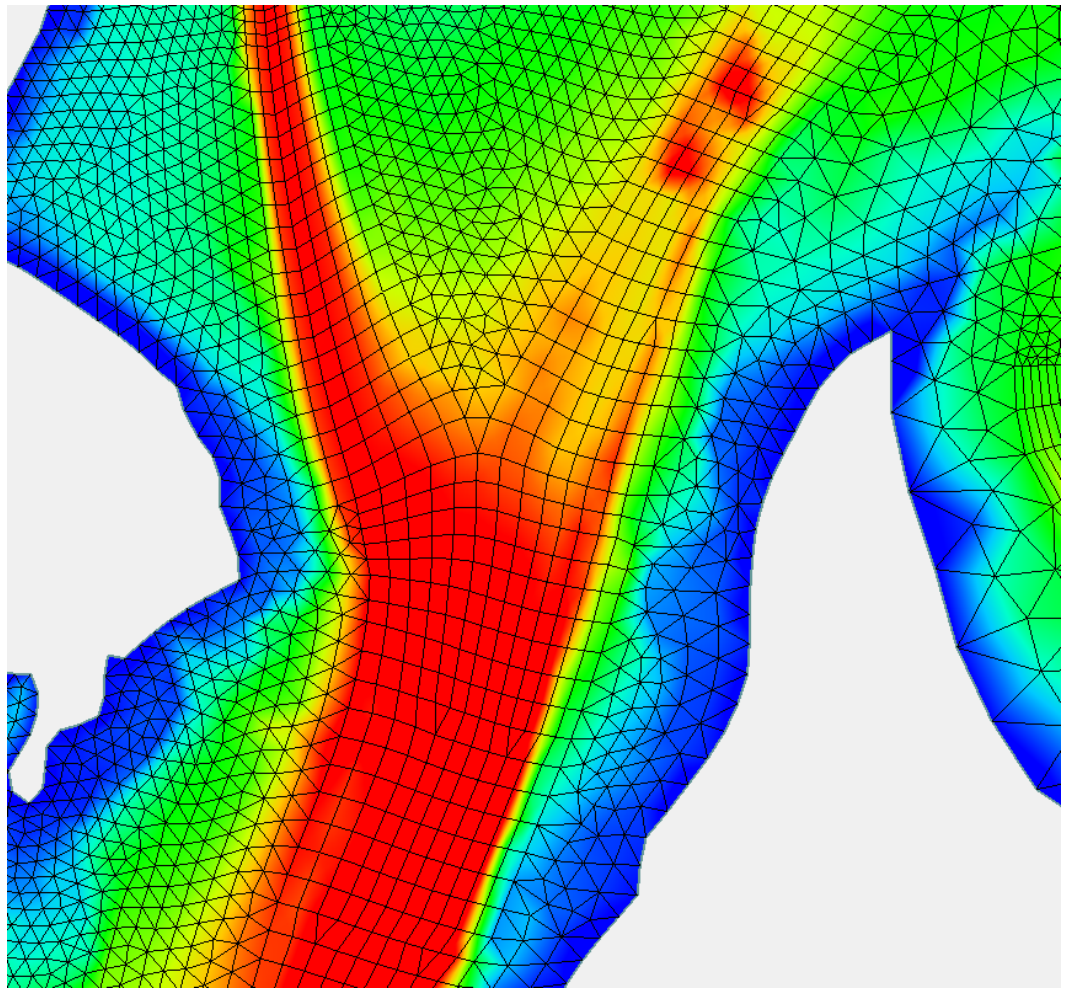
Extended western side of Craighill quad channel further south



Previous Grid

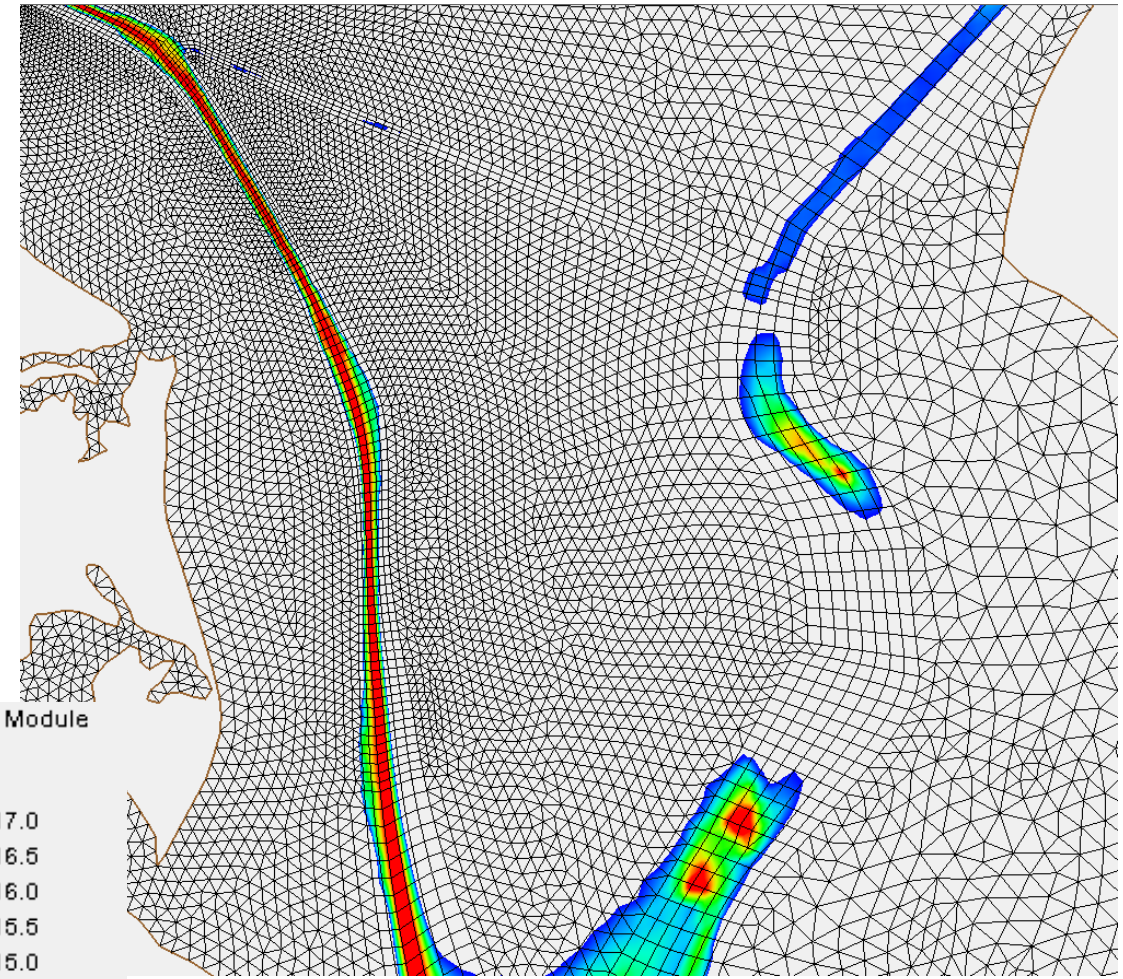
Newly Modified Grid

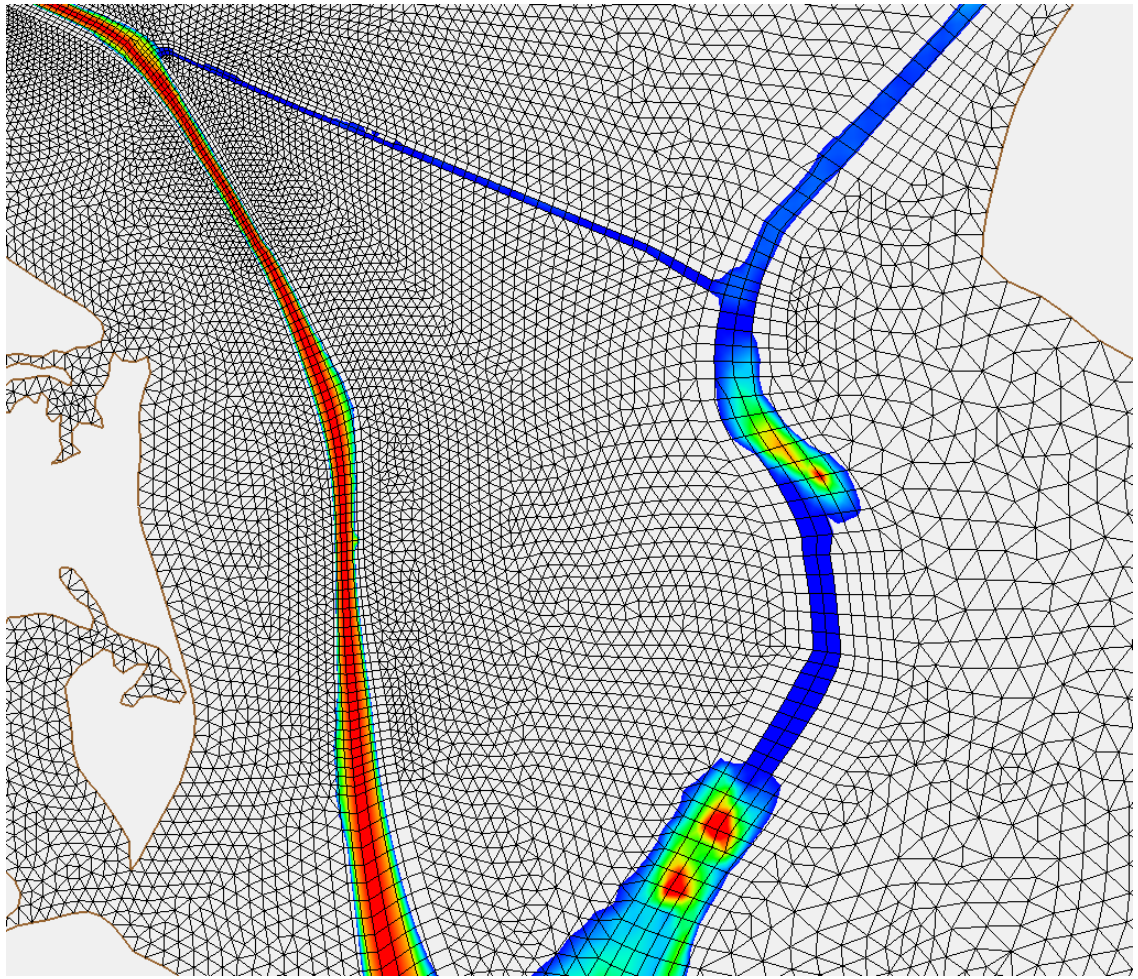


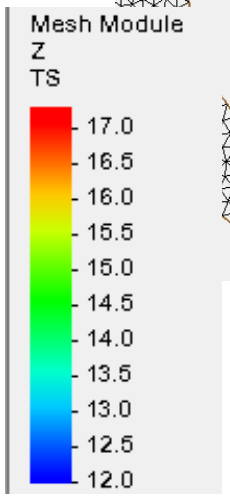


Previous Grid

Newly Modified Grid

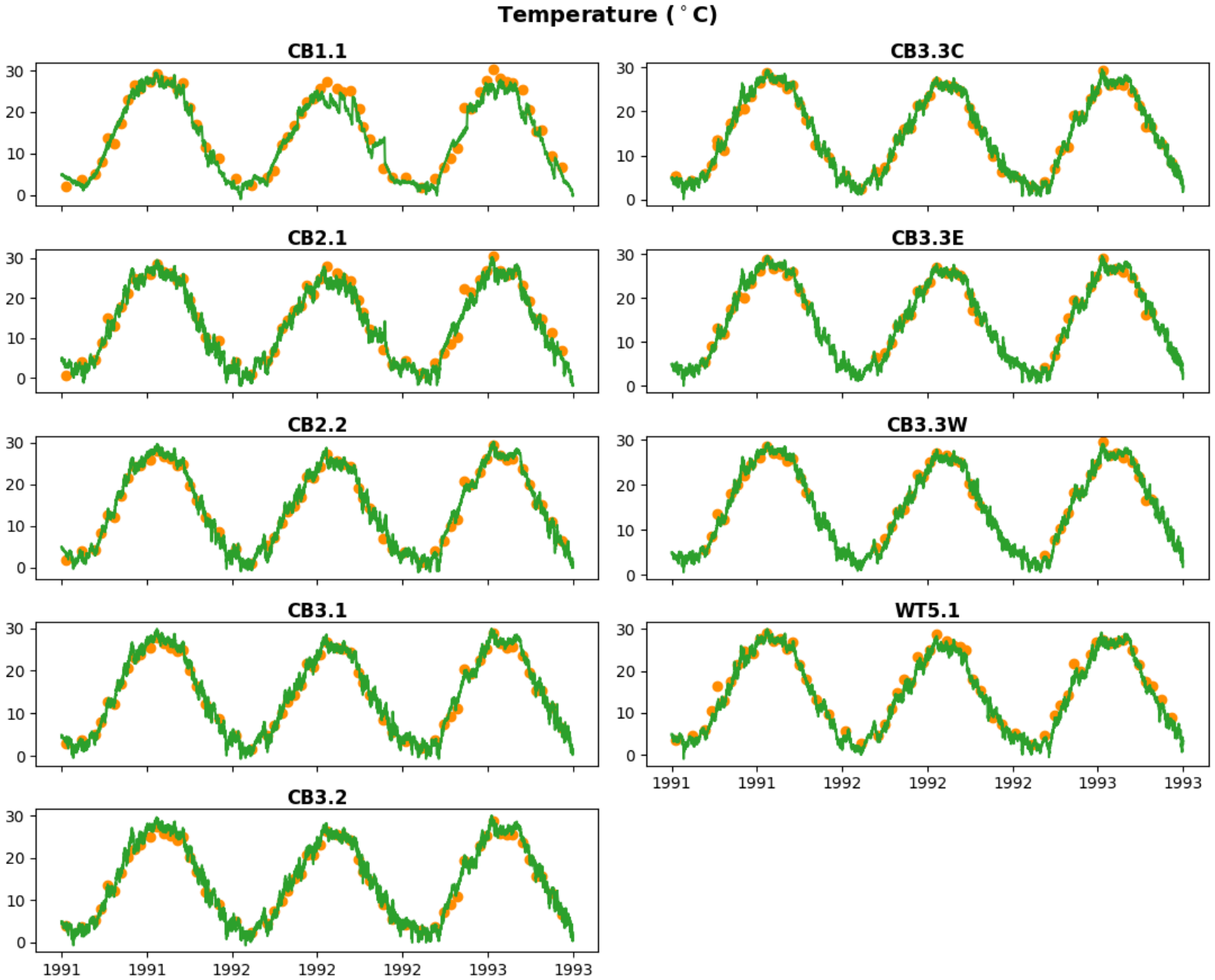




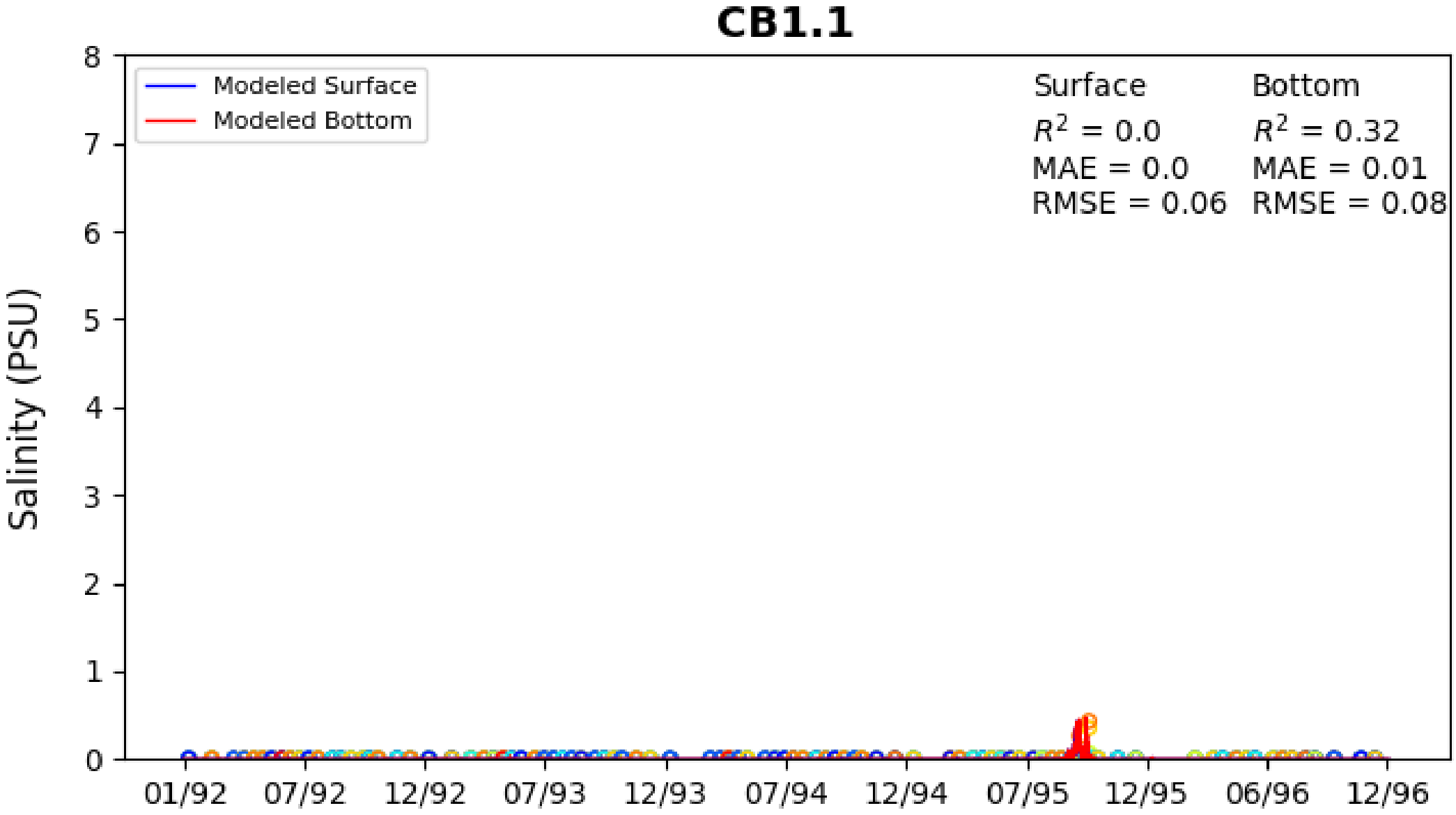


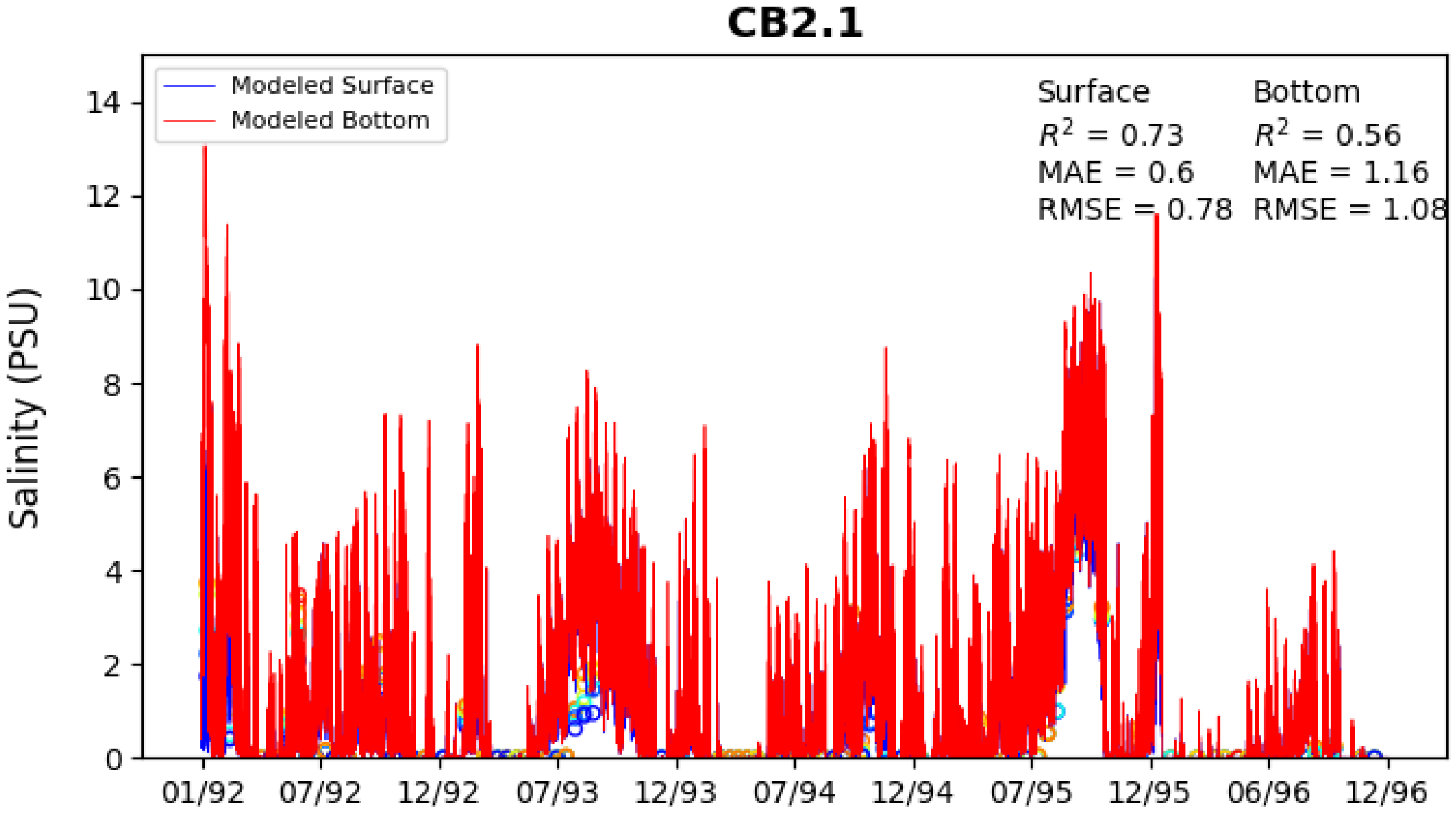
** anything shallower than **12m** is not plotted

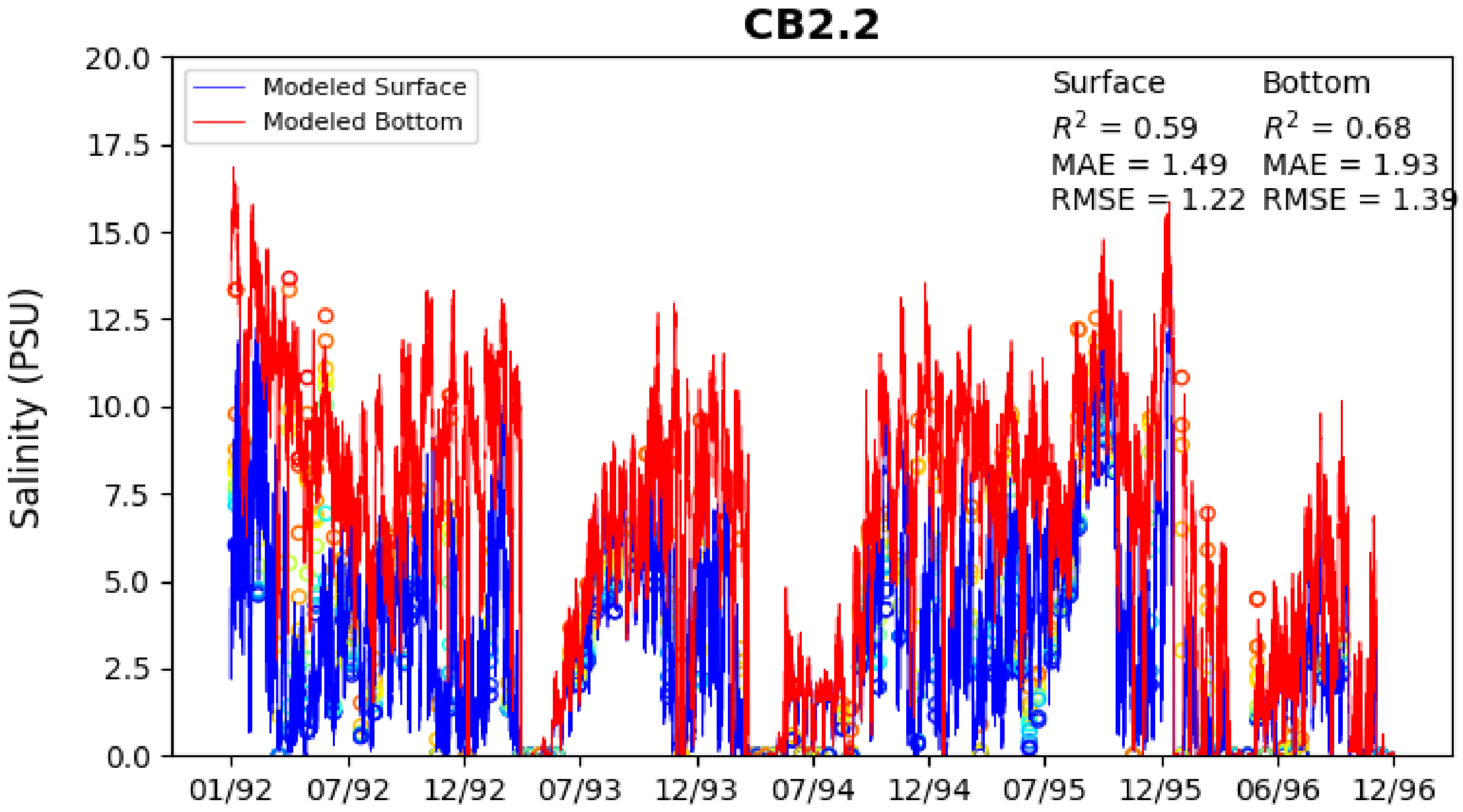
The updated long-term verification of temperature and salinity (1991-1996)

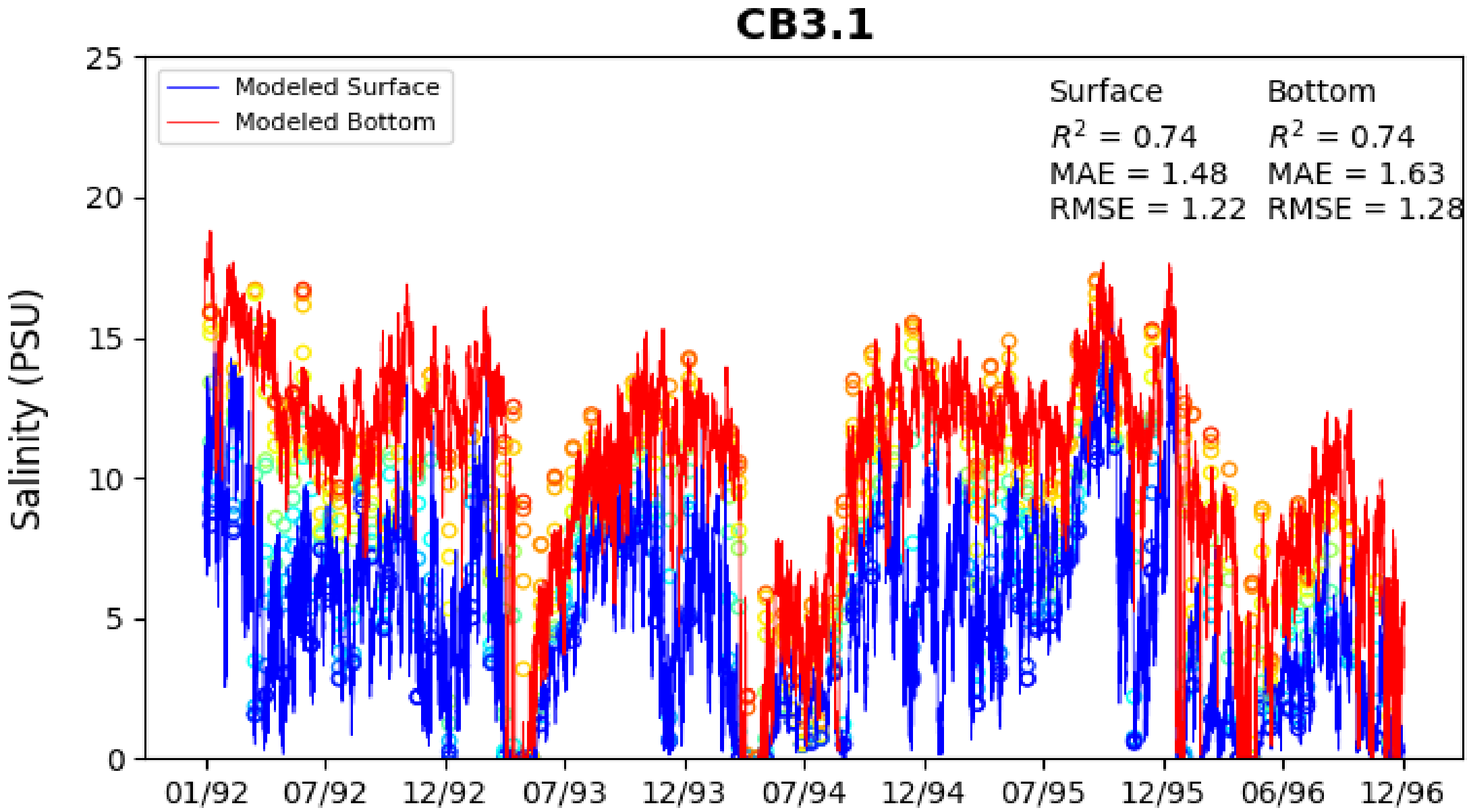


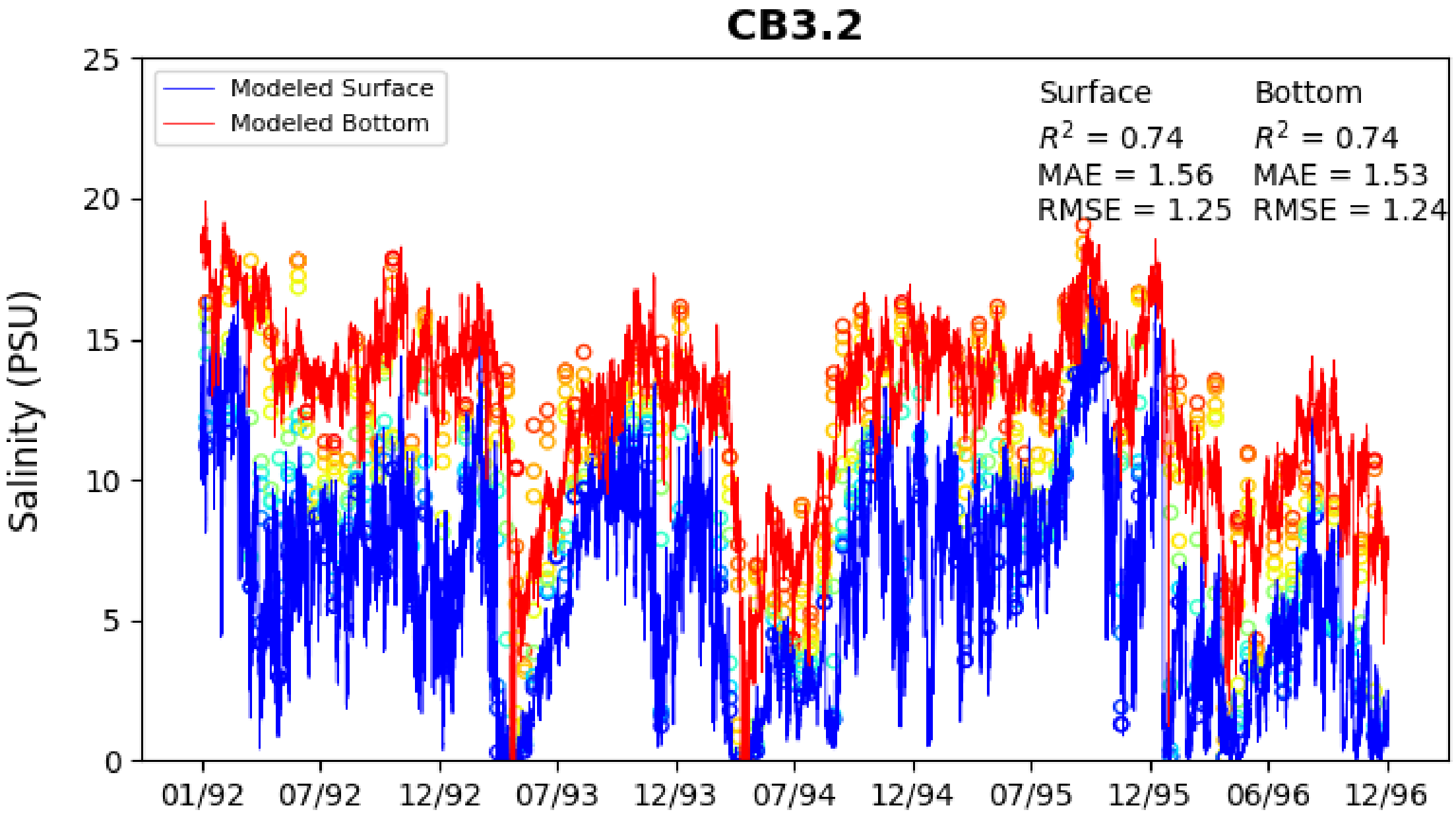
Station	surface R2	surface MAE	surface RMSE
CB1.1	0.941	1.999	1.414
CB2.1	0.970	1.413	1.189
CB2.2	0.984	0.848	0.921
CB3.1	0.988	0.728	0.853
CB3.2	0.989	0.800	0.894
CB3.3C	0.988	0.796	0.892
CB3.3E	0.977	0.845	0.919
CB3.3W	0.985	0.825	0.908
WT5.1	0.985	1.295	1.138

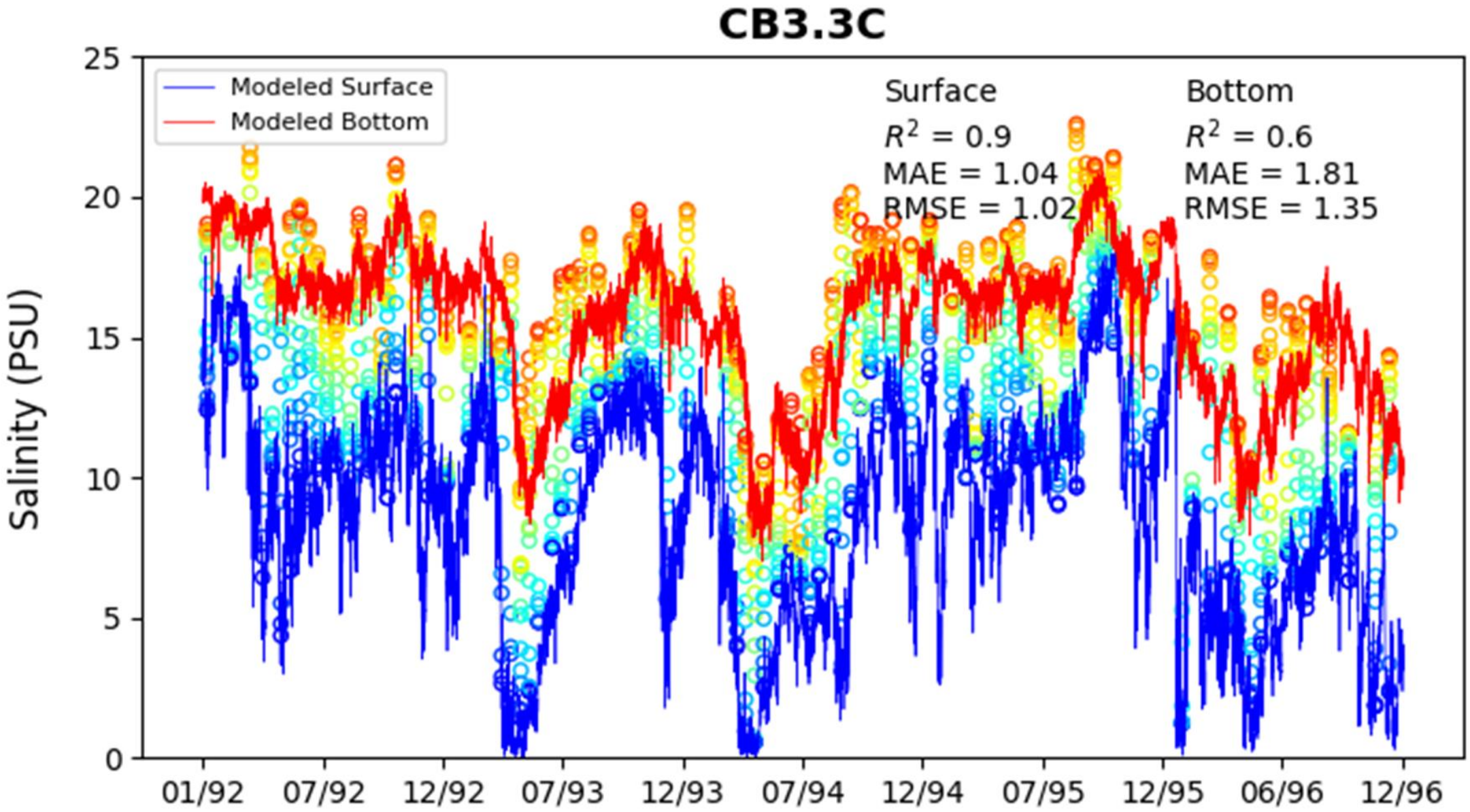

CB1.1
Modeled Surface
Modeled Bottom
Surface
R^2 = 0.0
MAE = 0.0
RMSE = 0.06
Bottom
R^2 = 0.32
MAE = 0.01
RMSE = 0.08
Salinity (PSU)
0
1
2
3
4
5
6
7
8
01/92
07/92
12/92
07/93
12/93
07/94
12/94
07/95
12/95
06/96
12/96

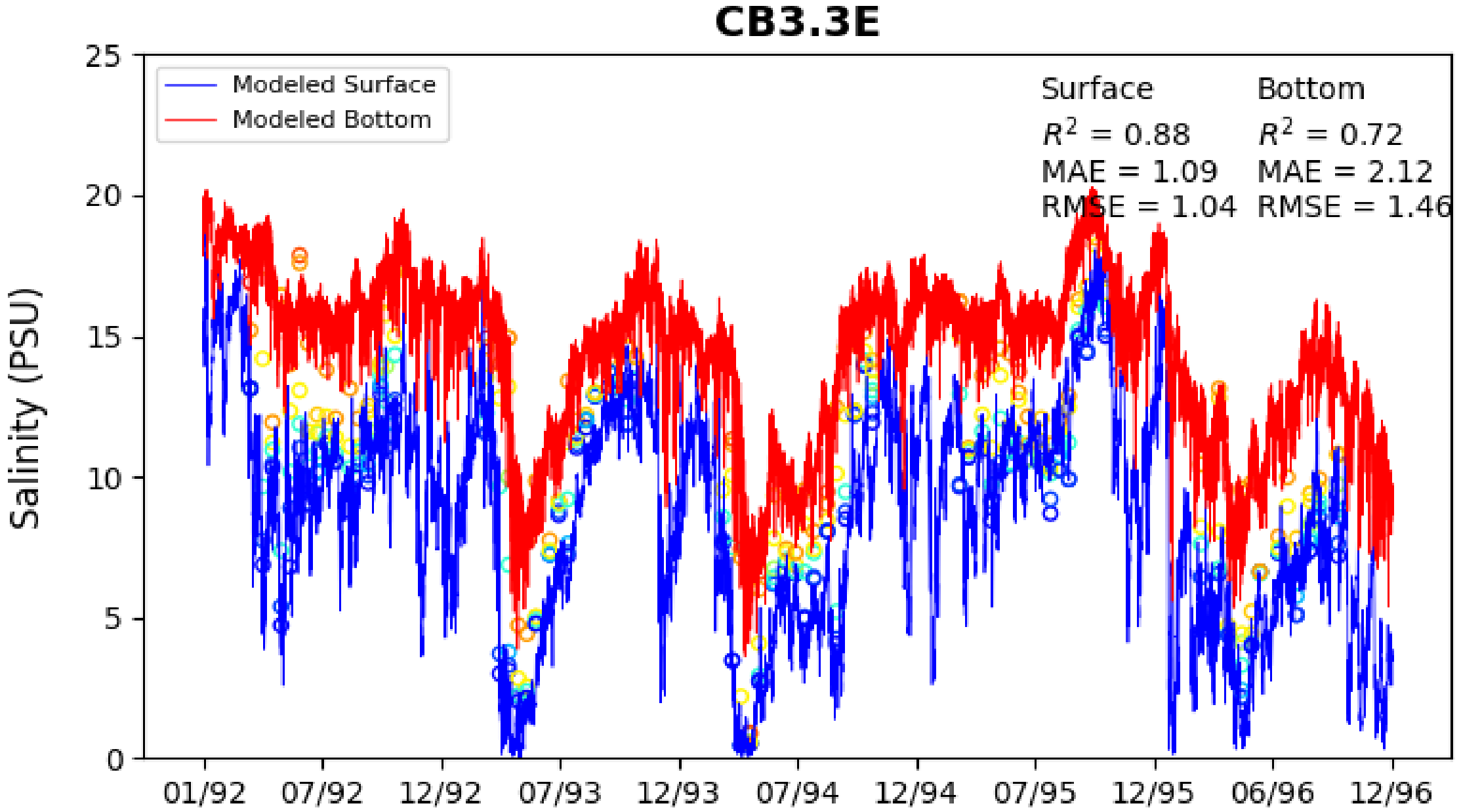

CB2.1
Modeled Surface
Modeled Bottom
Surface
R^2 = 0.73
MAE = 0.6
RMSE = 0.78
Bottom
R^2 = 0.56
MAE = 1.16
RMSE = 1.08
Salinity (PSU)
0
2
4
6
8
10
12
14
01/92
07/92
12/92
07/93
12/93
07/94
12/94
07/95
12/95
06/96
12/96

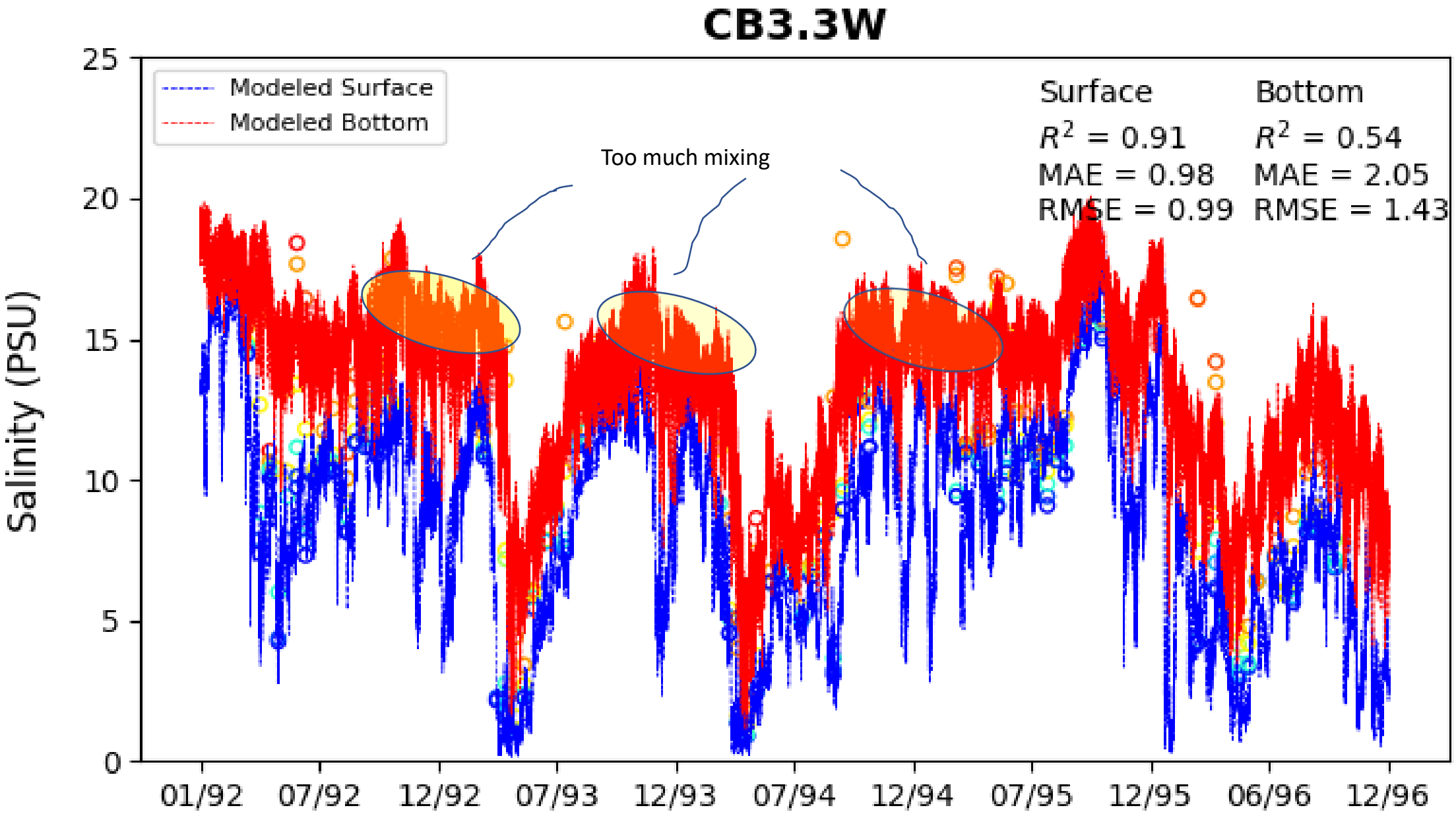

CB2.2
Modeled Surface
Modeled Bottom
Surface
Bottom
R^2 = 0.59
MAE = 1.49
RMSE = 1.22
R^2 = 0.68
MAE = 1.93
RMSE = 1.39
Salinity (PSU)
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
01/92
07/92
12/92
07/93
12/93
07/94
12/94
07/95
12/95
06/96
12/96

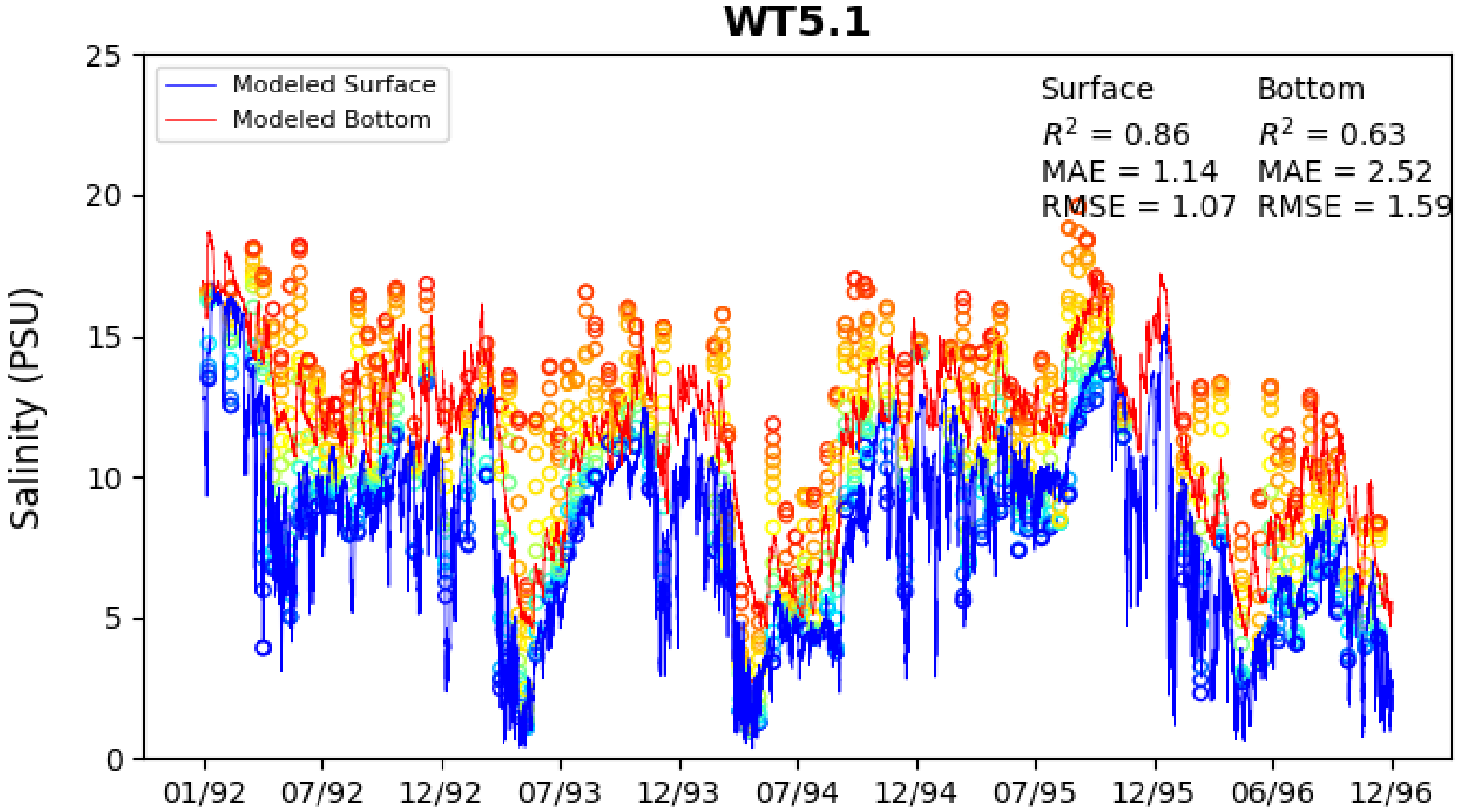

CB3.1
Modeled Surface
Modeled Bottom
Surface
Bottom
R^2 = 0.74
MAE = 1.48
RMSE = 1.22
R^2 = 0.74
MAE = 1.63
RMSE = 1.28
Salinity (PSU)
25
20
15
10
5
0
01/92
07/92
12/92
07/93
12/93
07/94
12/94
07/95
12/95
06/96
12/96


CB3.2
Modeled Surface
Modeled Bottom
Surface
R^2 = 0.74
MAE = 1.56
RMSE = 1.25
Bottom
R^2 = 0.74
MAE = 1.53
RMSE = 1.24
Salinity (PSU)
25
20
15
10
5
0
01/92
07/92
12/92
07/93
12/93
07/94
12/94
07/95
12/95
06/96
12/96


CB3.3C
Modeled Surface
Modeled Bottom
Surface
R^2 = 0.9
MAE = 1.04
RMSE = 1.02
Bottom
R^2 = 0.6
MAE = 1.81
RMSE = 1.35
Salinity (PSU)
25
20
15
10
5
0
01/92
07/92
12/92
07/93
12/93
07/94
12/94
07/95
12/95
06/96
12/96

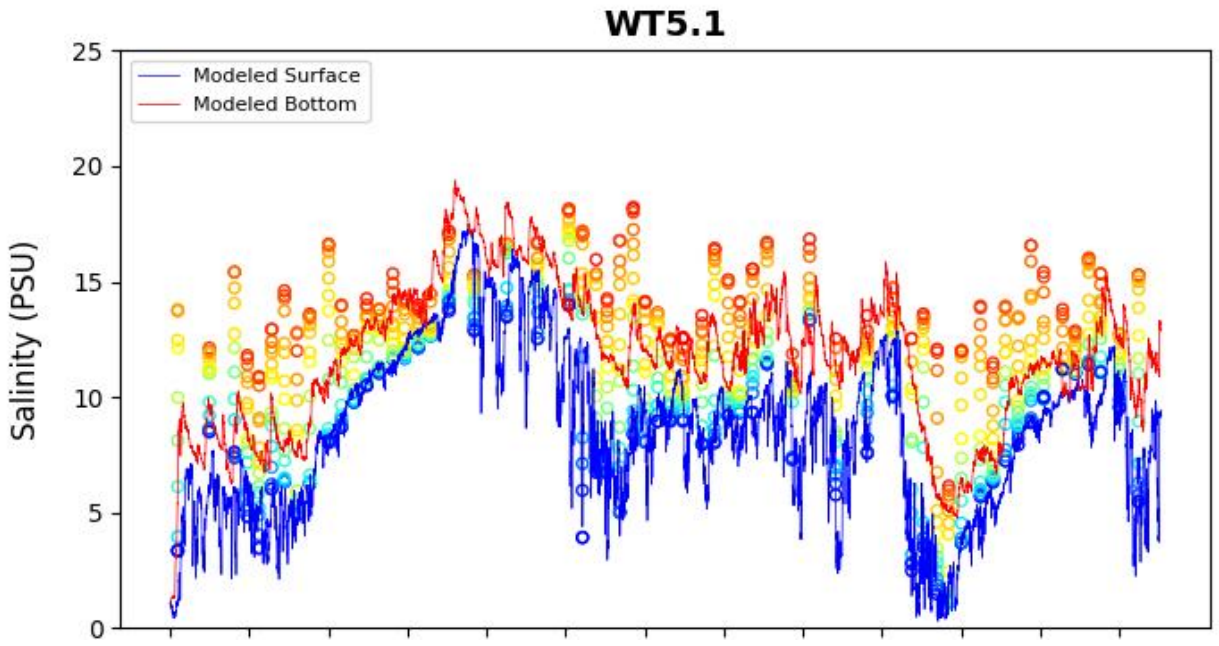

CB3.3E
Modeled Surface
Modeled Bottom
Surface
R^2 = 0.88
MAE = 1.09
RMSE = 1.04
Bottom
R^2 = 0.72
MAE = 2.12
RMSE = 1.46
Salinity (PSU)
25
20
15
10
5
0
01/92
07/92
12/92
07/93
12/93
07/94
12/94
07/95
12/95
06/96
12/96


CB3.3W
Modeled Surface
Modeled Bottom
Too much mixing
Surface
R^2 = 0.91
MAE = 0.98
RMSE = 0.99
Bottom
R^2 = 0.54
MAE = 2.05
RMSE = 1.43
Salinity (PSU)
25
20
15
10
5
0
01/92
07/92
12/92
07/93
12/93
07/94
12/94
07/95
12/95
06/96
12/96

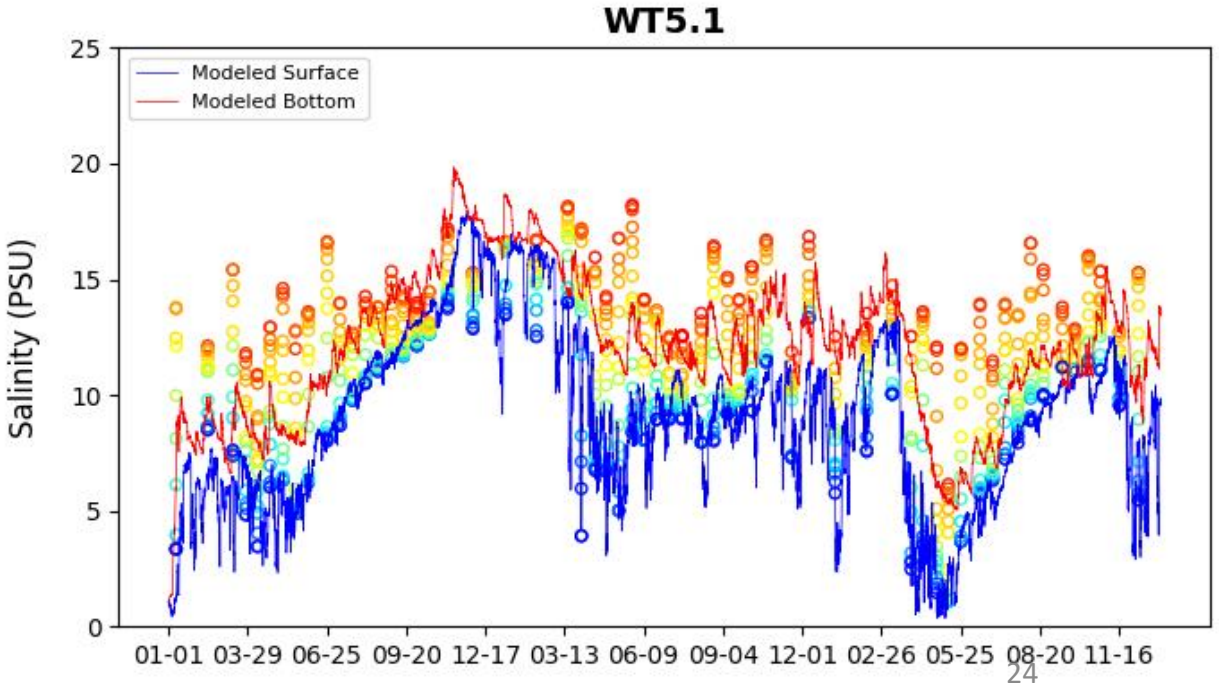

WT5.1
Modeled Surface
Modeled Bottom
Surface
Bottom
R^2 = 0.86
R^2 = 0.63
MAE = 1.14
MAE = 2.52
RMSE = 1.07
RMSE = 1.59
Salinity (PSU)
25
20
15
10
5
0
01/92
07/92
12/92
07/93
12/93
07/94
12/94
07/95
12/95
06/96
12/96

Compare WT5.1 station to previous version

Previous Result ->
Mean bottom salinity =
11.747 PSU

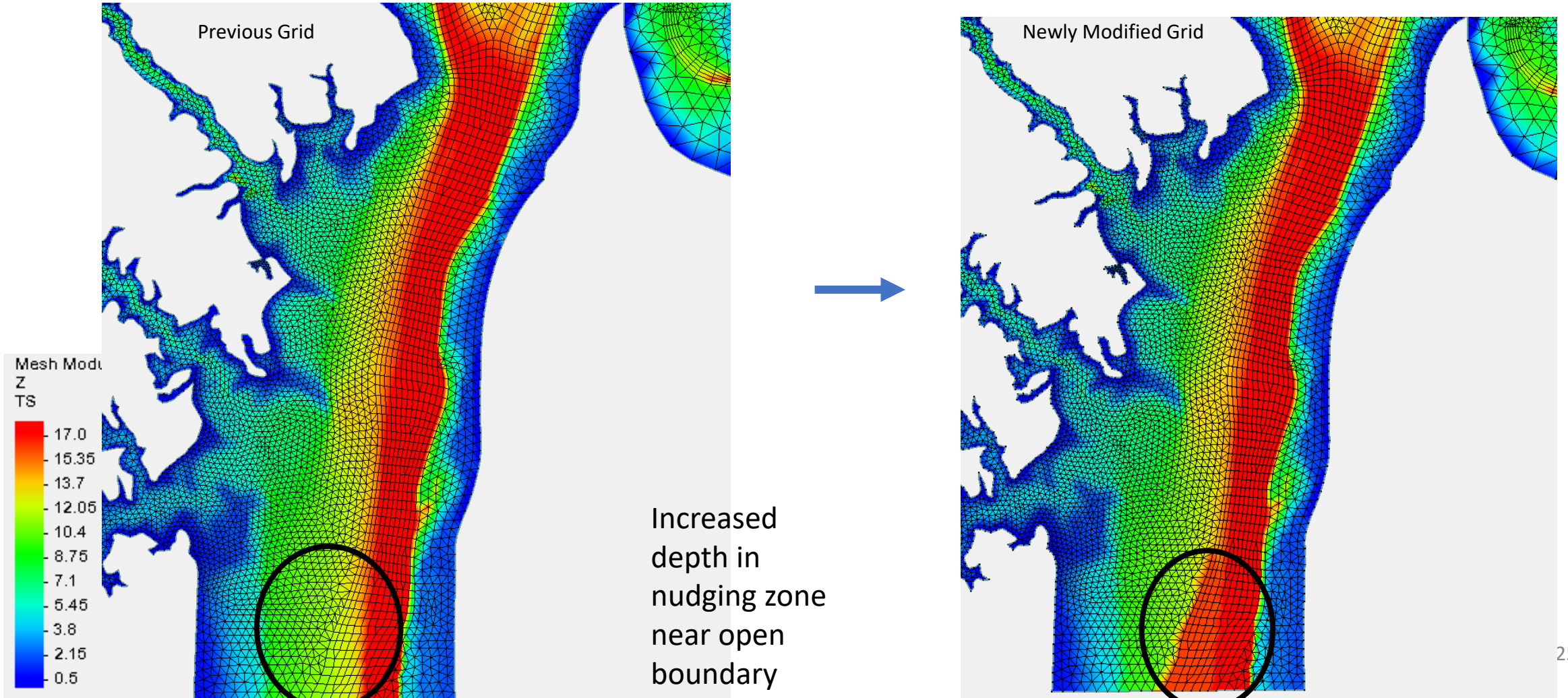


New Result ->
Mean bottom salinity =
12.203 PSU



Further improvement by modifying configuration in the nudging zone at the open boundary condition

Too much mixing at CB3.3W, leads to insufficient exchange flow between Upper Bay and Baltimore Harbor channel. The cause of not enough stratification at CB3.3W is traced back to the skewed channel at the nudging zone of the open boundary condition. The bathymetry on the west side of the channel was shored up disparately. It is now corrected by deepening uniformly.

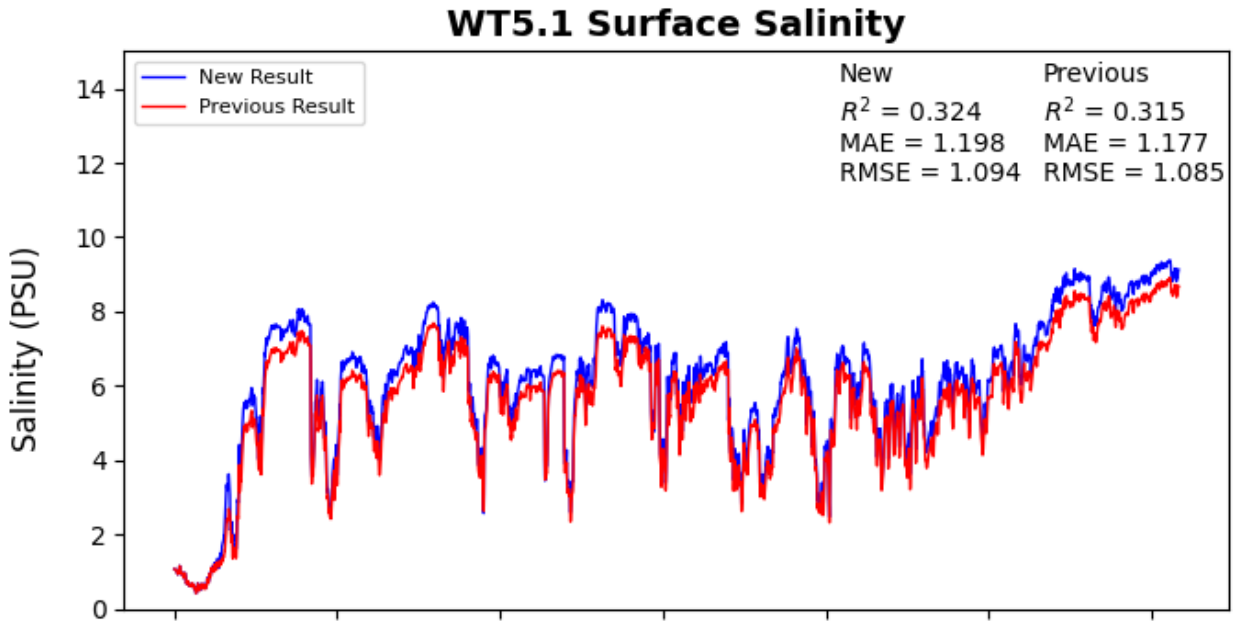


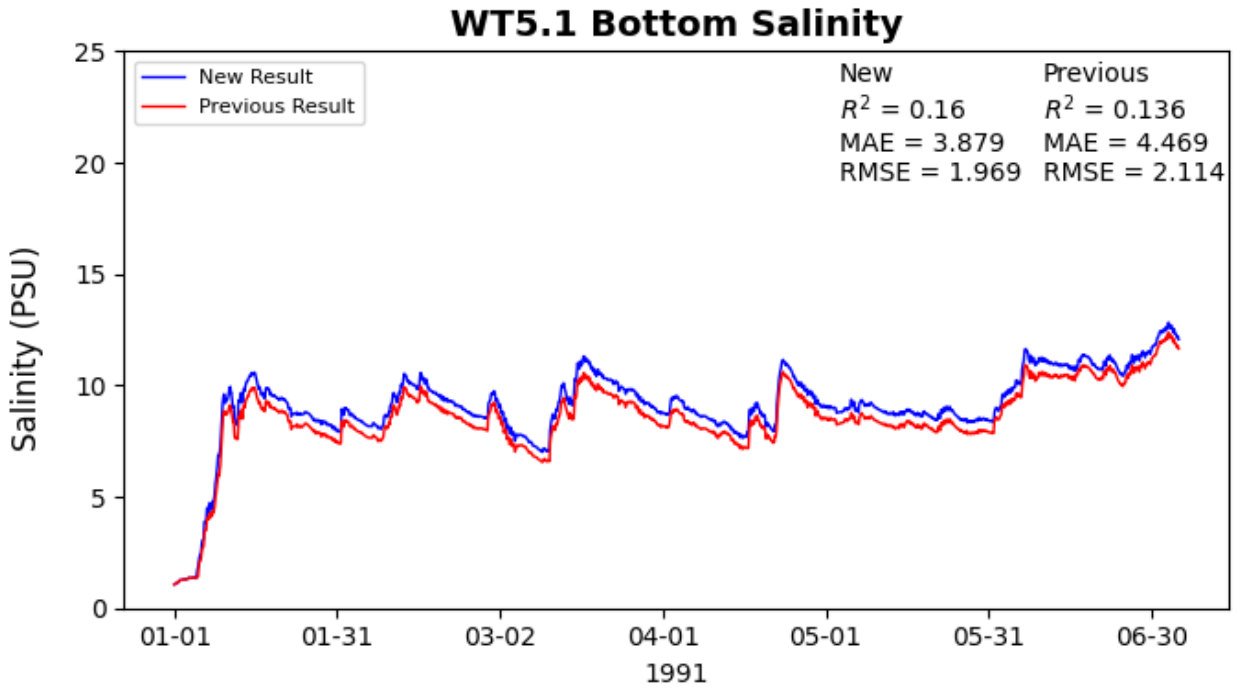
Most updated !!!

Compare surface and bottom salinity at WT5.1 between new preliminary results and previous results.

We now see an appreciable increase in salinity at WT5.1.

I plan to present the full results on 1/13/2025.





V. Summary:

1. The long-term (1991-1997) calibration for Patapsco/Back River focusing on temperature and salinity was conducted.

2. The real-time Baltimore Harbor freshwater discharges and the C&D canal boundary condition were set up. They add minor variabilities locally but do not drastically affect the overall salinity and temperature comparisons.

3. The comparison over 9 stations shows that salinity and temperature in the Upper Chesapeake Bay are reasonably well calibrated and verified to the observation data with the statistical skills comparable to MBM results.

4. However, we have found that the salinity comparison inside the Harbor at WT5.1 still needs the improvement after the channel configuration was streamlined.

5. Further work over the nudging zone near the open boundary.

Future action:
Present the full results on 1/13/2025.