# Quarterly Progress report on the Patapsco-Back MTM


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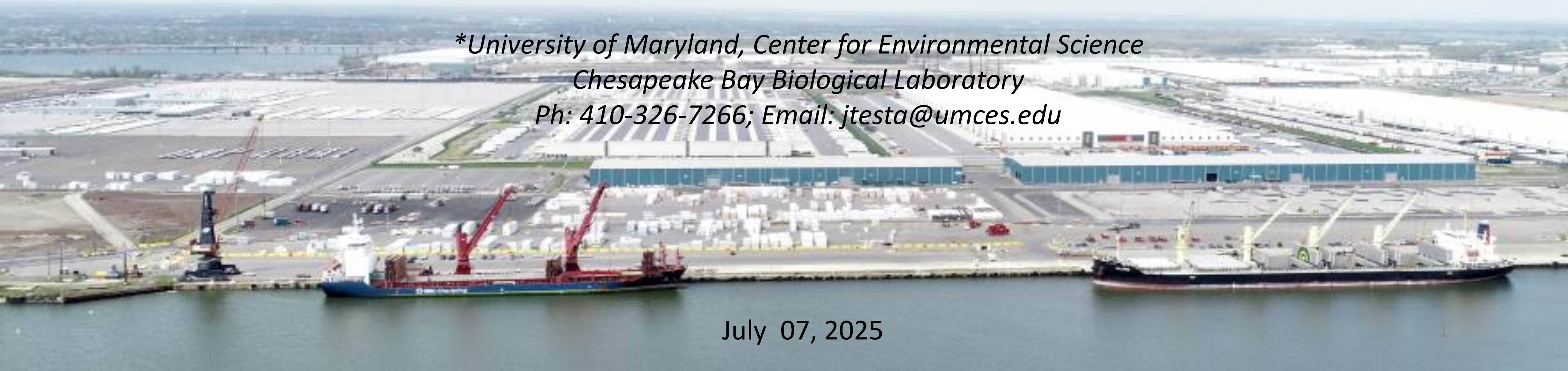


July  07, 2025

# Outline:

I. Characterization of non-point source loading

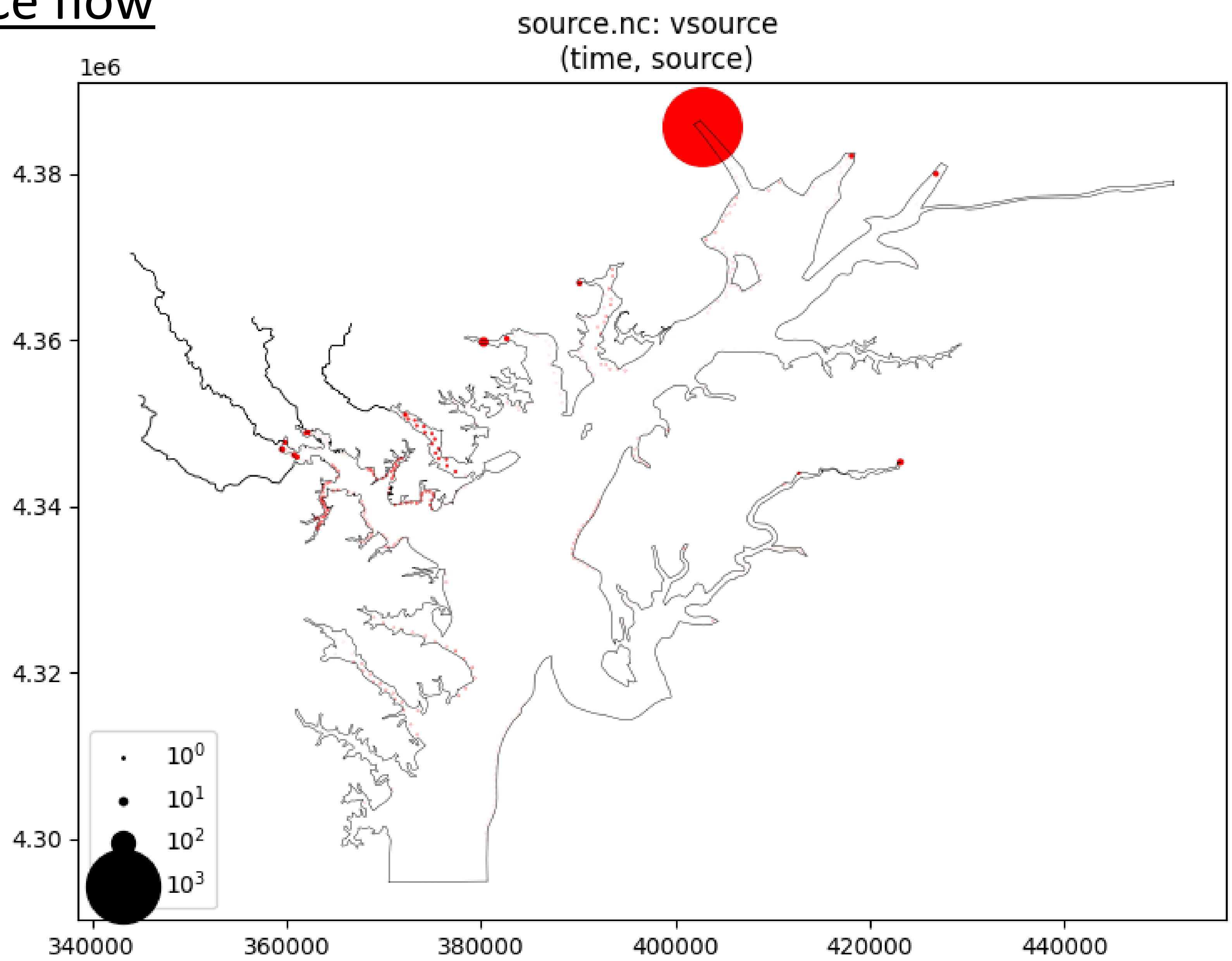
II. Directly-coupled SCHISM-ICM water quality modeling results

III. Discussion - off-line set up for water quality run

IV. Summary

# I. Characterization of Phase6/7 Hybrid Non-point Source Loading

## Non-point source flow



# Non-point sources for water quality variables

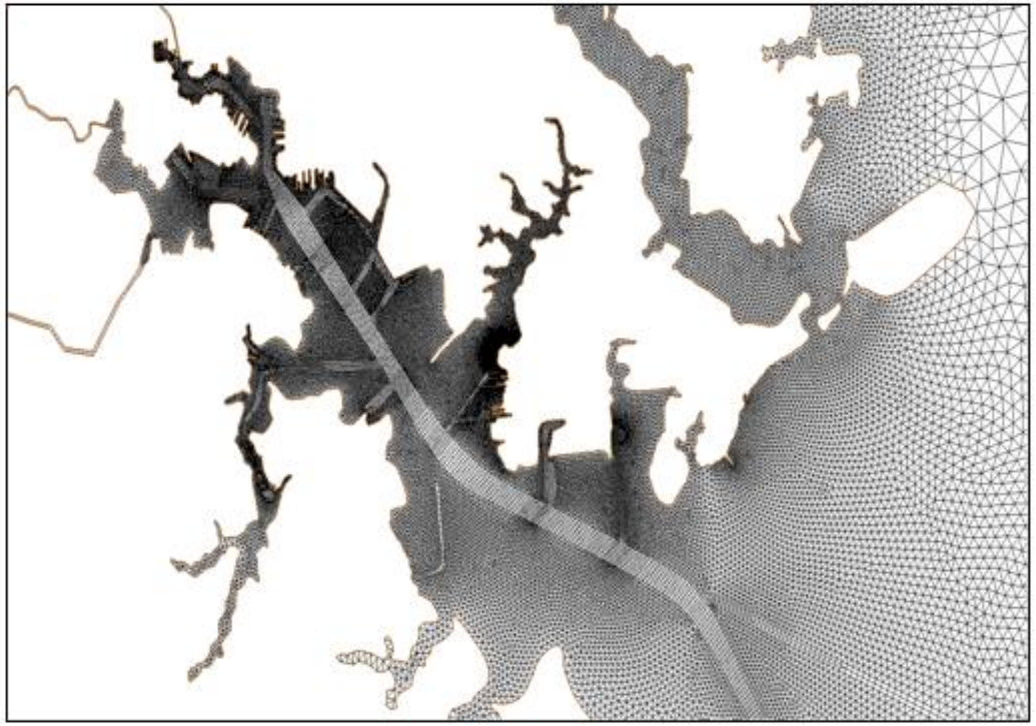
Within the source.nc input file, msource specify concentration for 23 variables:

1. Temperature
2. Salinity
3. PB1 (Diatom)
4. PB2 (Green Algae)
5. PB3 (Cyanobacteria)
6. RPOC (Refractory Particulate Organic Carbon)
7. LPOC (Labile Particulate Organic Carbon)
8. DOC (Dissolved Organic Carbon)
9. RPON (Refractory Particulate Organic Nitrogen)
10. LPON (Labile Particulate Organic Nitrogen)
11. DON (Dissolved Organic Nitrogen)
12. NH4 (Ammonium Nitrogen)
13. NO3 (Nitrate Nitrogen)
14. RPOP (Refractory Particulate Organic Phosphorus)
15. LPOP (Labile Particulate Organic Phosphorus)
16. DOP (Dissolved Organic Phosphorus)
17. PO4 (Total Phosphate)
18. COD (Chemical Oxygen Demand)
19. DOX (Dissolved Oxygen)
20. SRPOC (Slow Refractory Particulate Organic Carbon)
21. SRPON (Slow Refractory Particulate Organic Nitrogen)
22. SRPOP (Slow Refractory Particulate Organic Phosphorus)
23. PIP (Particulate Inorganic Phosphate)

# II. Directly-coupled SCHISM-ICM Water quality modeling results

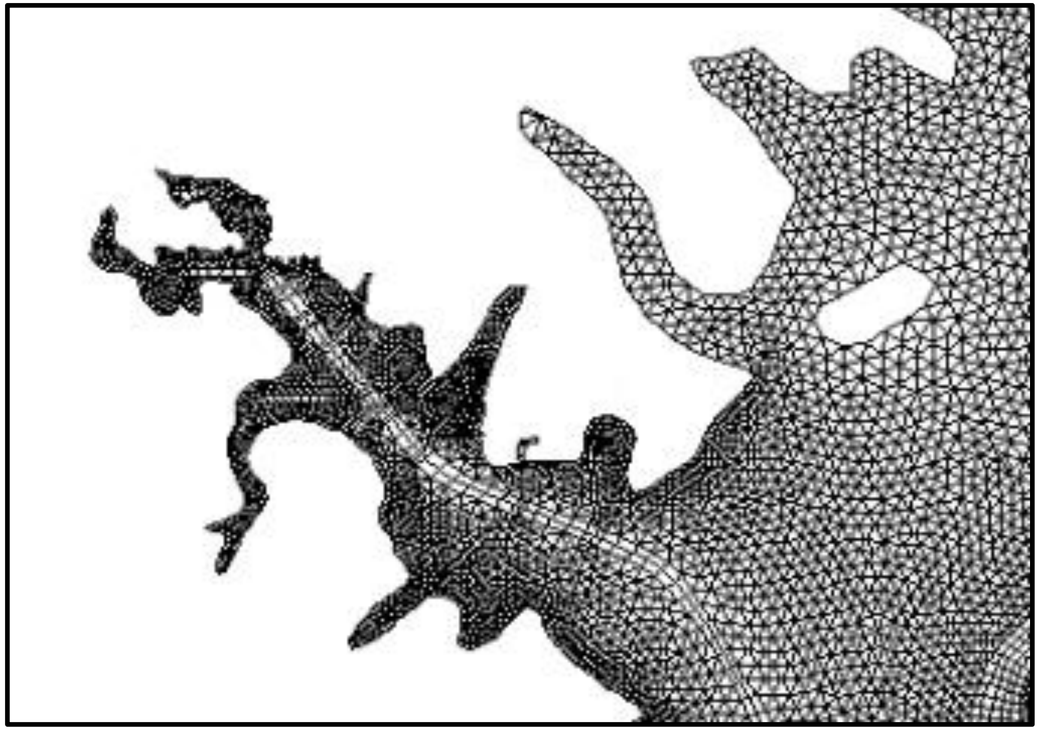
Directly coupled hydrodynamic model SCHISM and ICM water quality modeling run - without including wind wave model are presented.

**MTM**



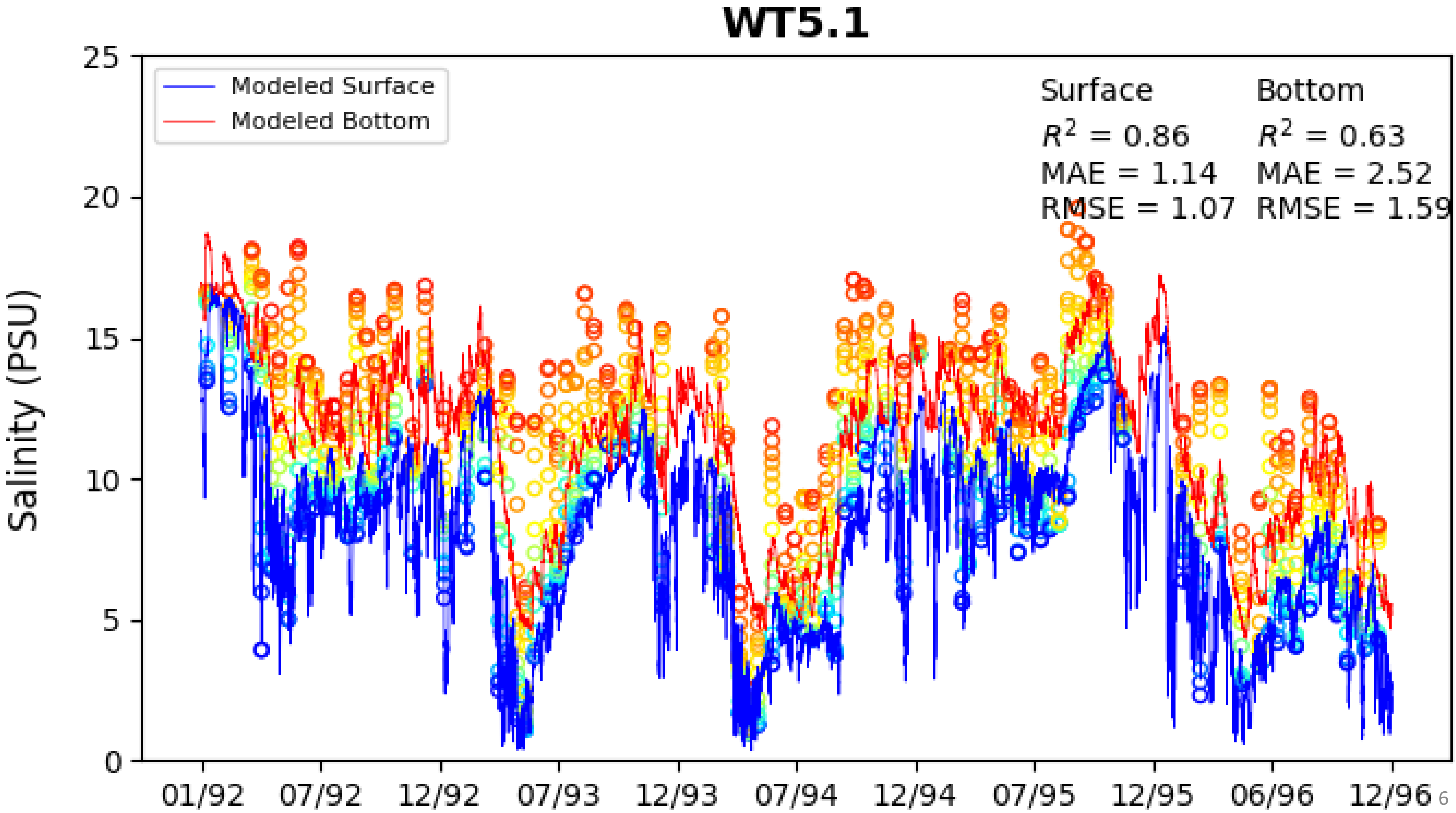
Overall resolution 50-100 m

**MBM**

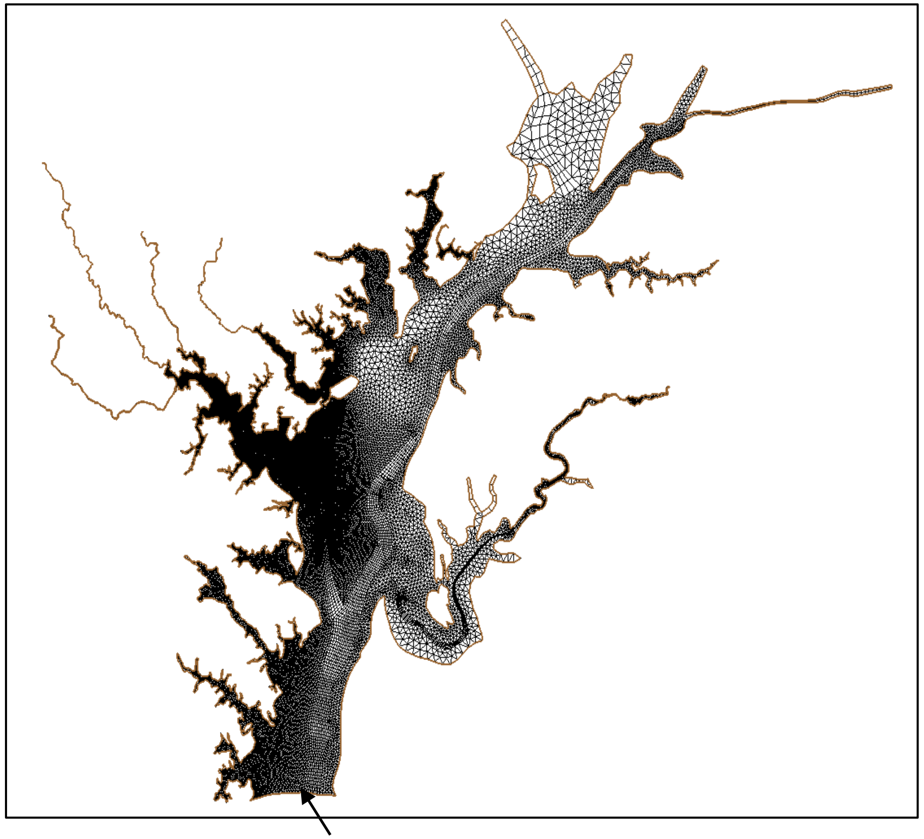


Overall resolution 200-500 m

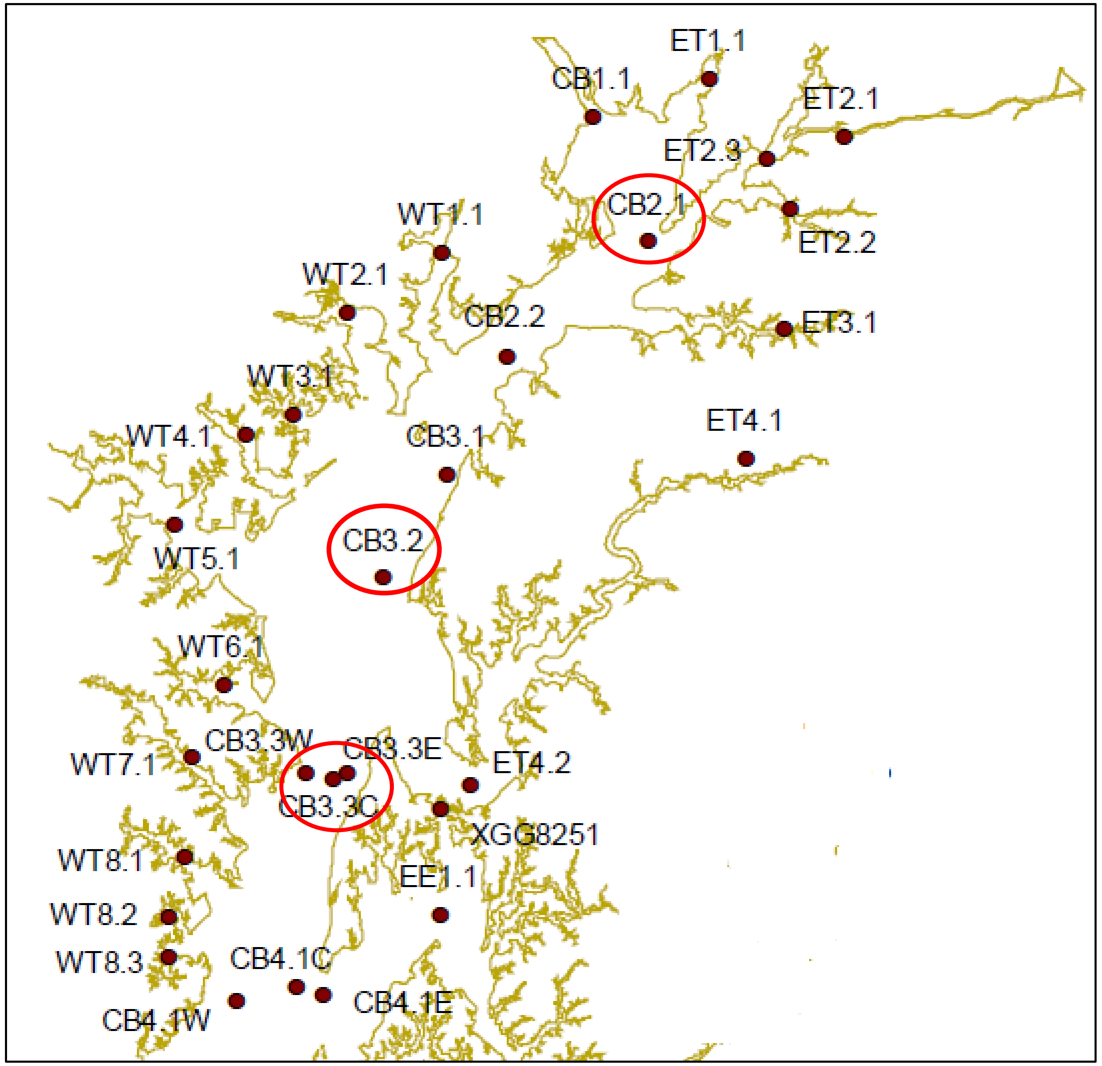
# Salinity calibration



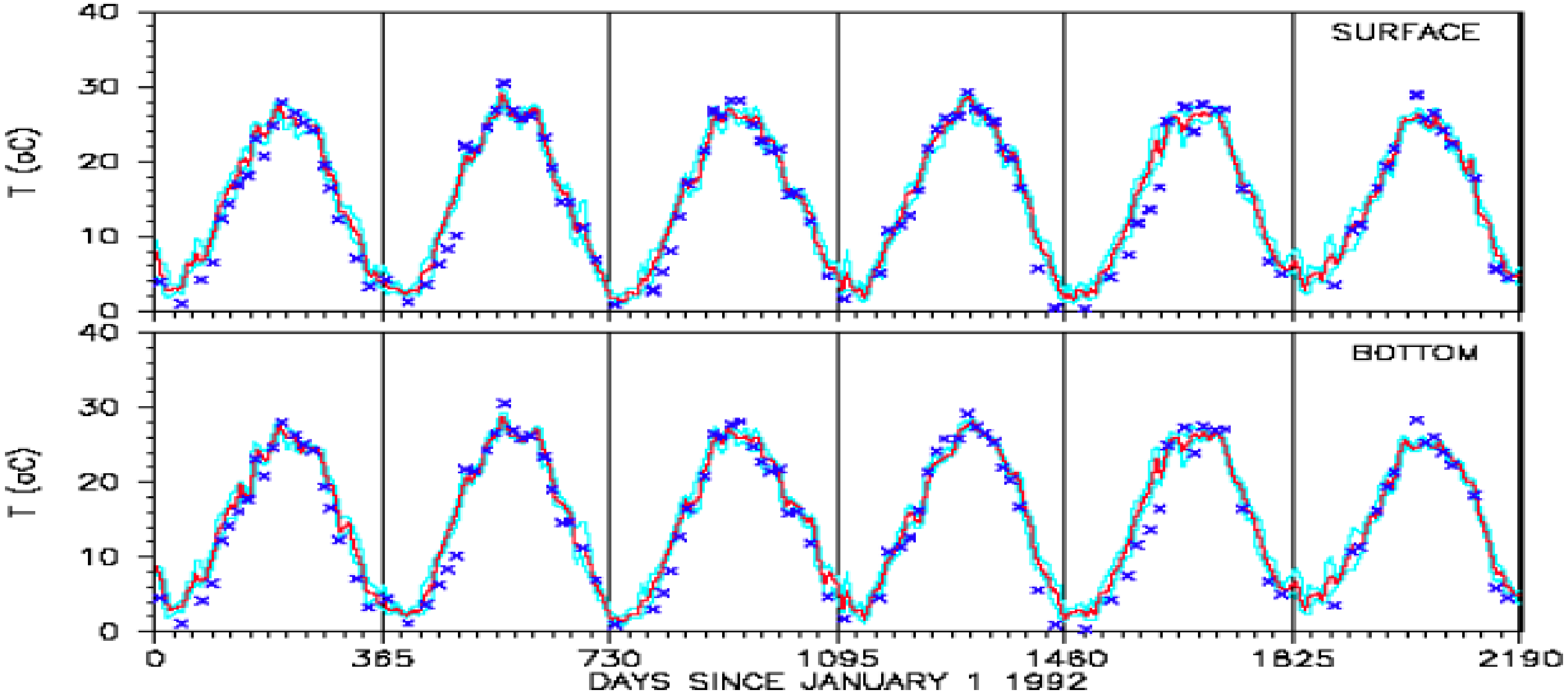
# Monitoring stations used for calibration in the Upper Bay



Open boundary condition



# CB2.1



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BOTTOM
T (oC)
DAYS SINCE JANUARY 1 1992
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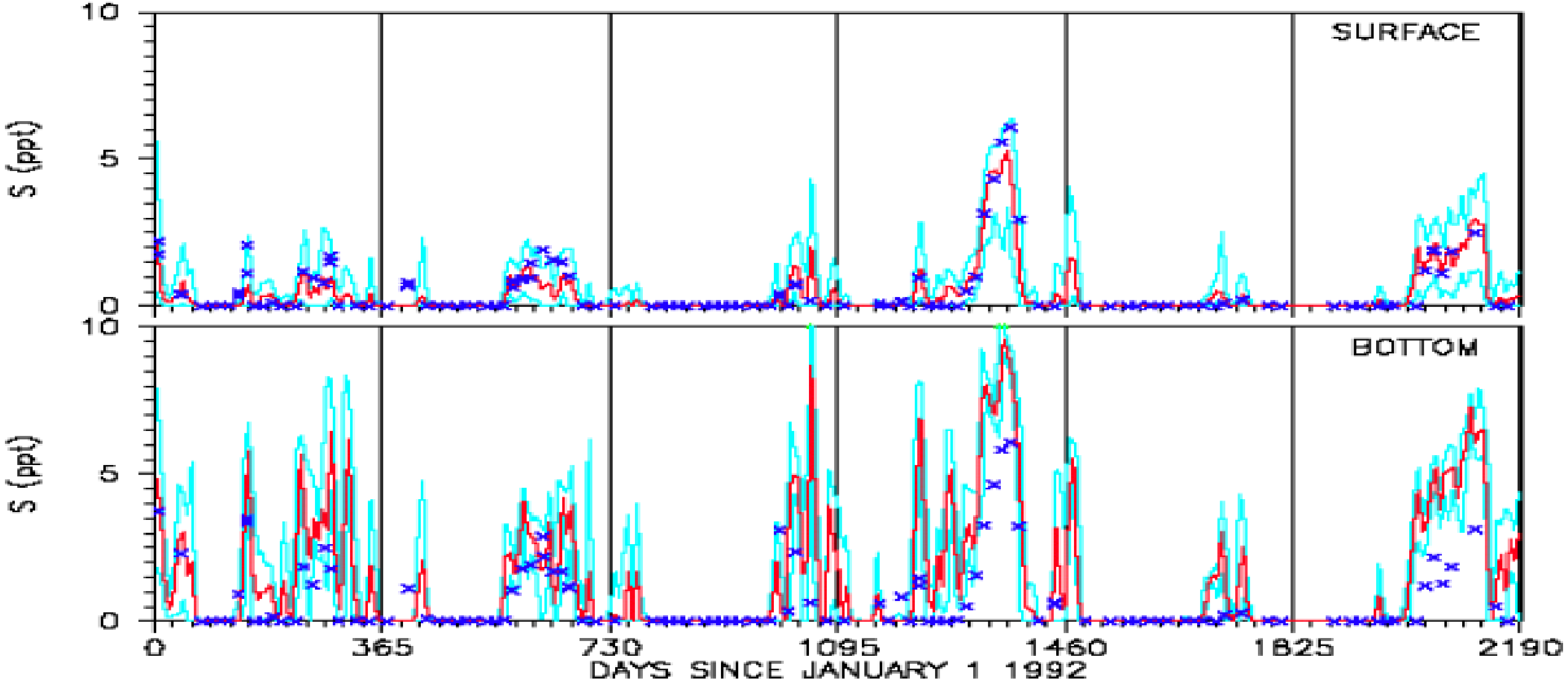
730
1095
1460
1825
2190

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BOTTOM
S (ppt)
DAYS SINCE JANUARY 1 1992
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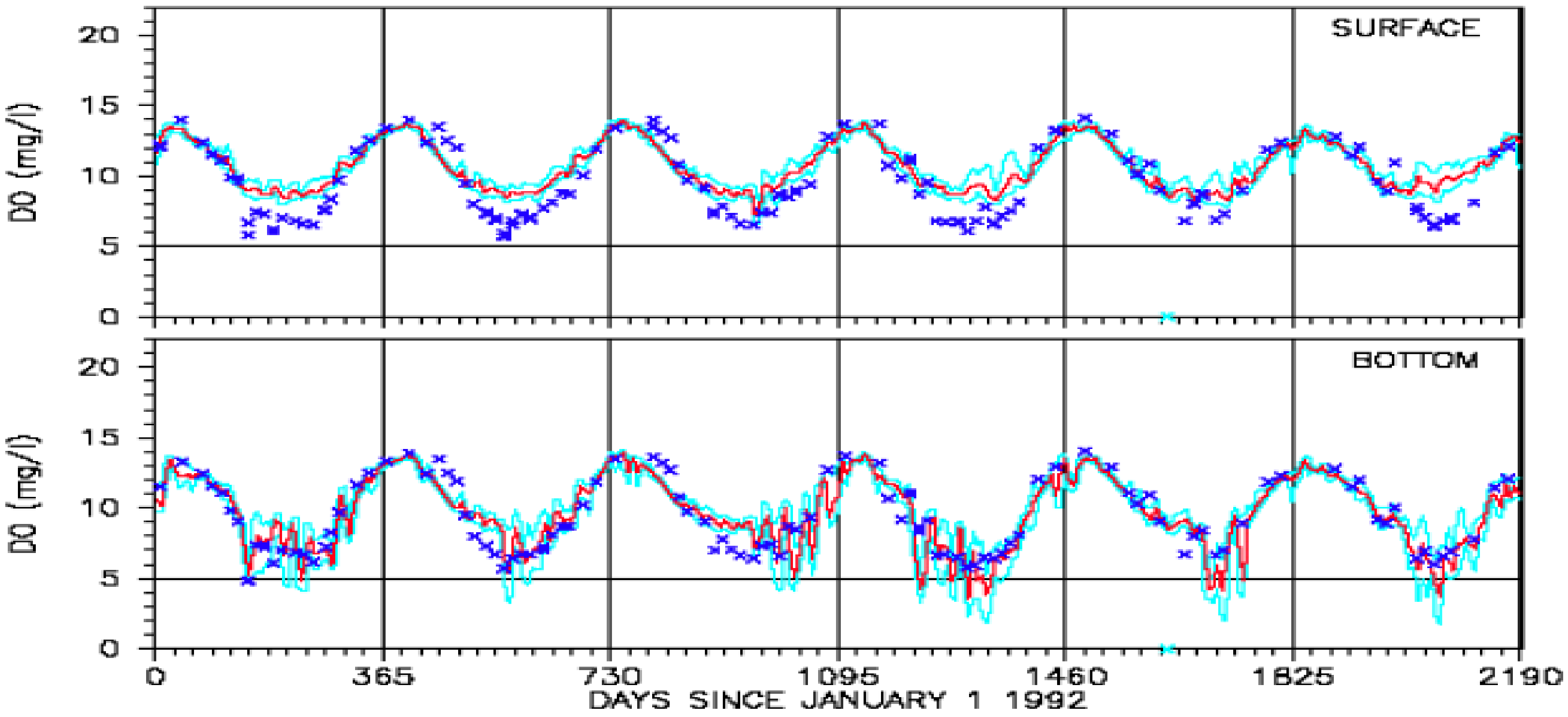
730
1095
1460
1825
2190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DO (mg/l)
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0
BOTTOM
DO (mg/l)
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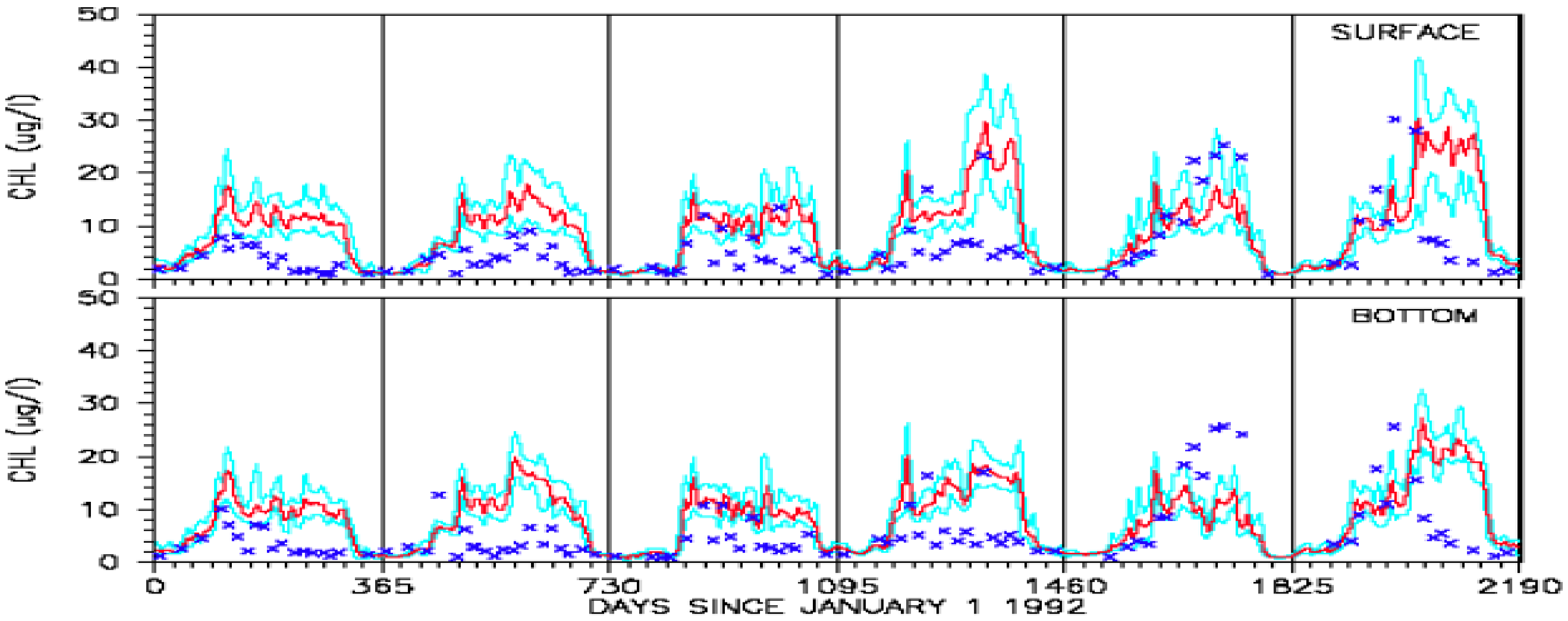
1460
1825
2190
DAYS SINCE JANUARY 1 1992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BOTTOM
CHL (ug/l)
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1460
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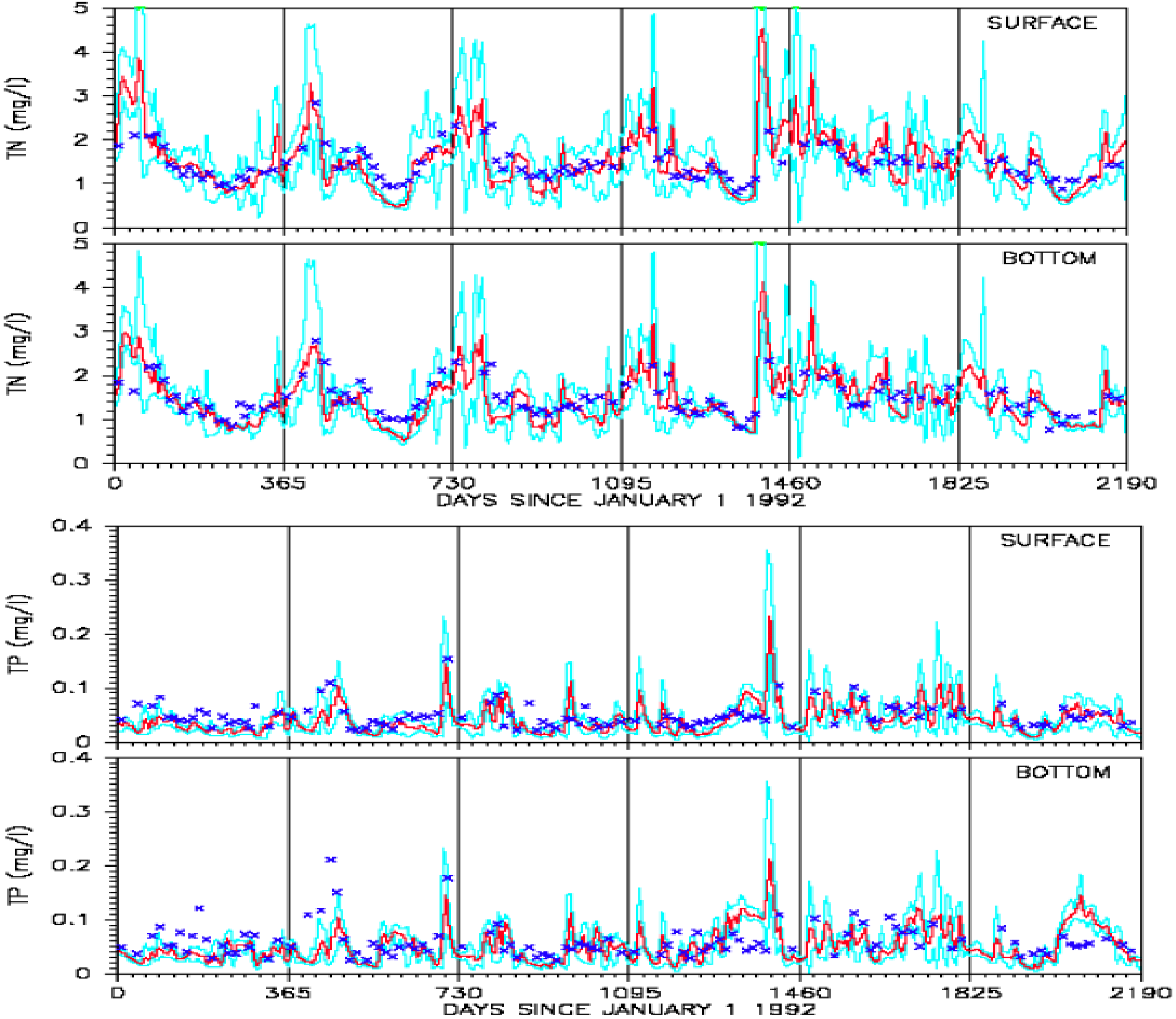
DAYS SINCE JANUARY 1 1992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BOTTOM
TN (mg/l)
DAYS SINCE JANUARY 1 1992
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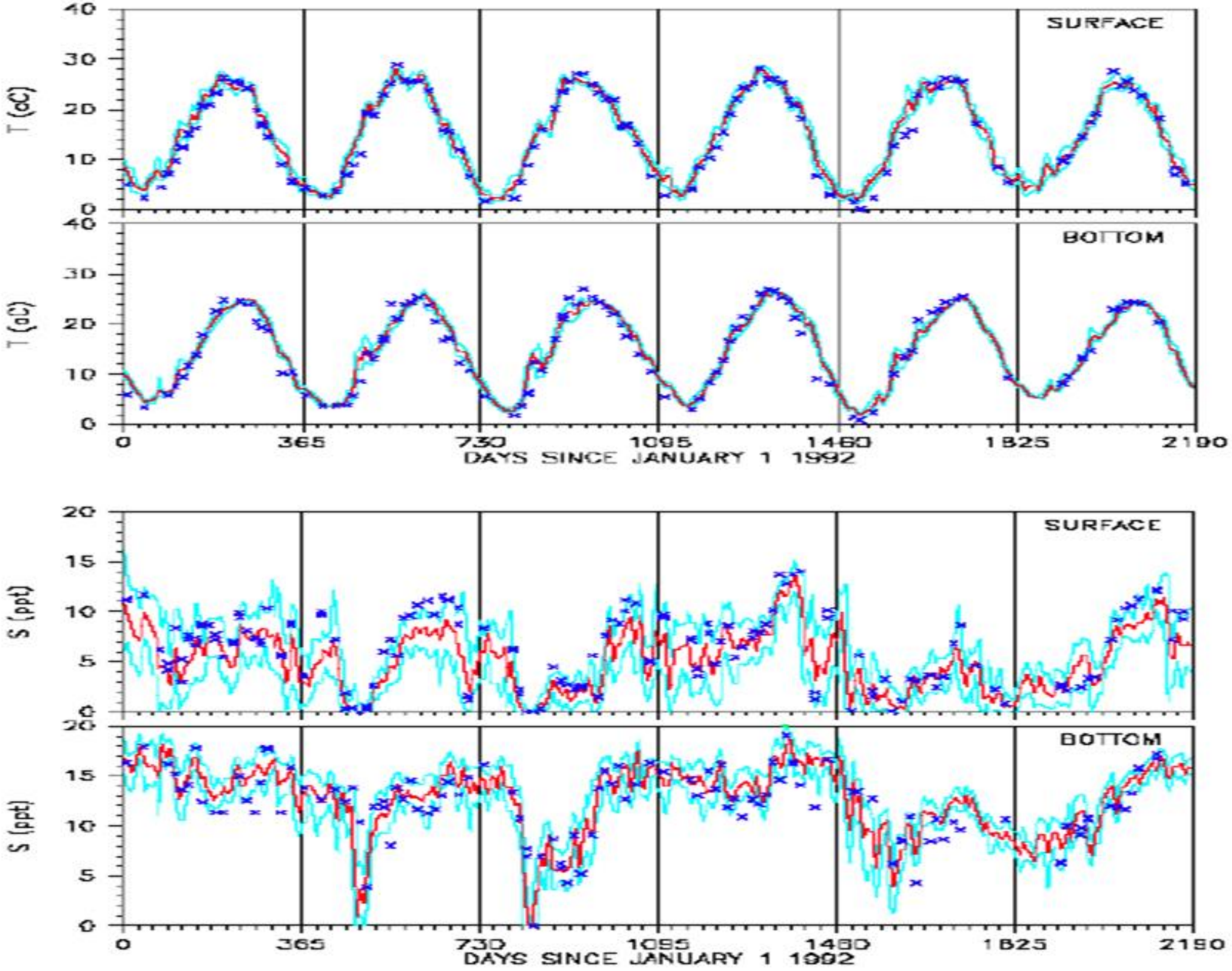
1460
1825
2190
SURFACE
BOTTOM
TP (mg/l)
DAYS SINCE JANUARY 1 1992

**CB3.2**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BOTTOM
T (oC)
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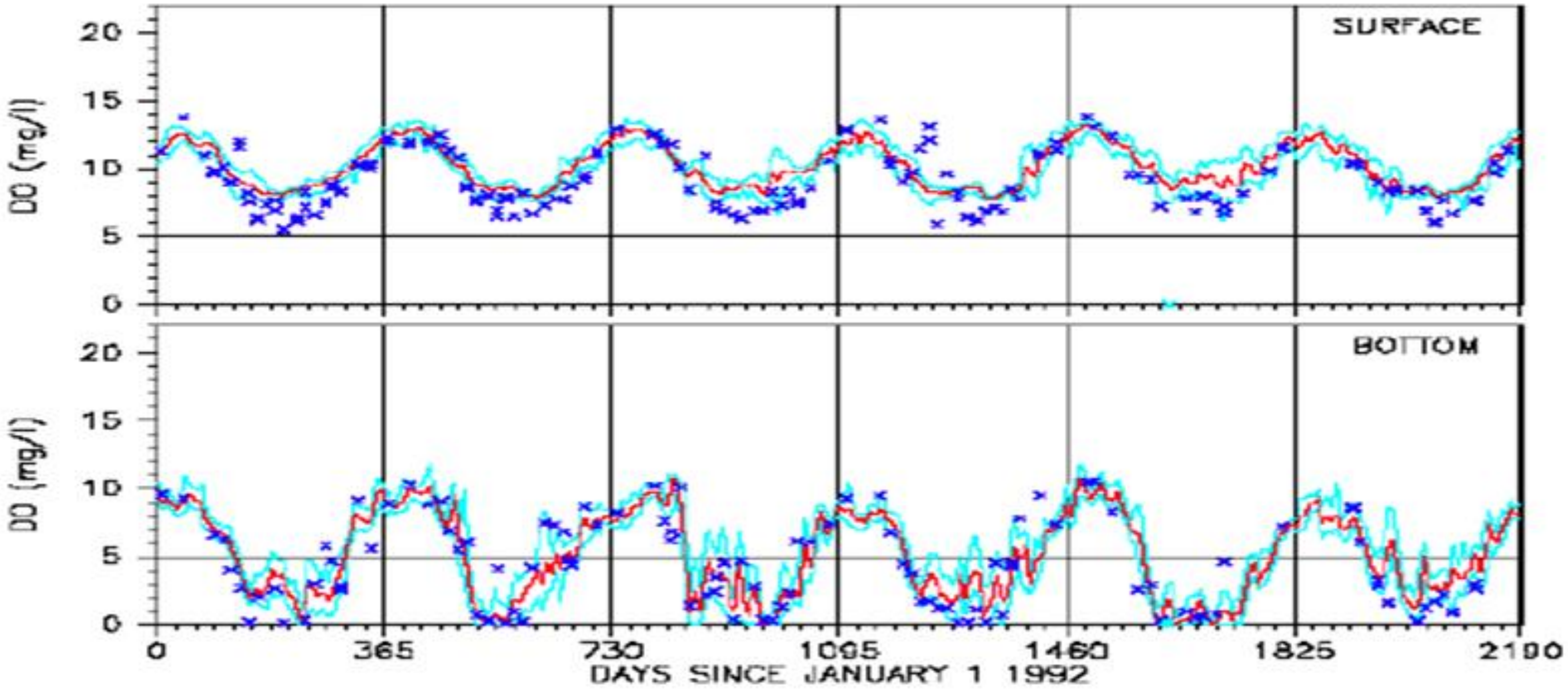
10
20
30
40
0
365
730
1095
1460
1825
2190
DAYS SINCE JANUARY 1 1992
SURFACE
BOTTOM
S (ppt)
0
5
10
15
20
0
365
730
1095
1460
1825
2190
DAYS SINCE JANUARY 1 1992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BOTTOM
DO (mg/l)
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10
5
0
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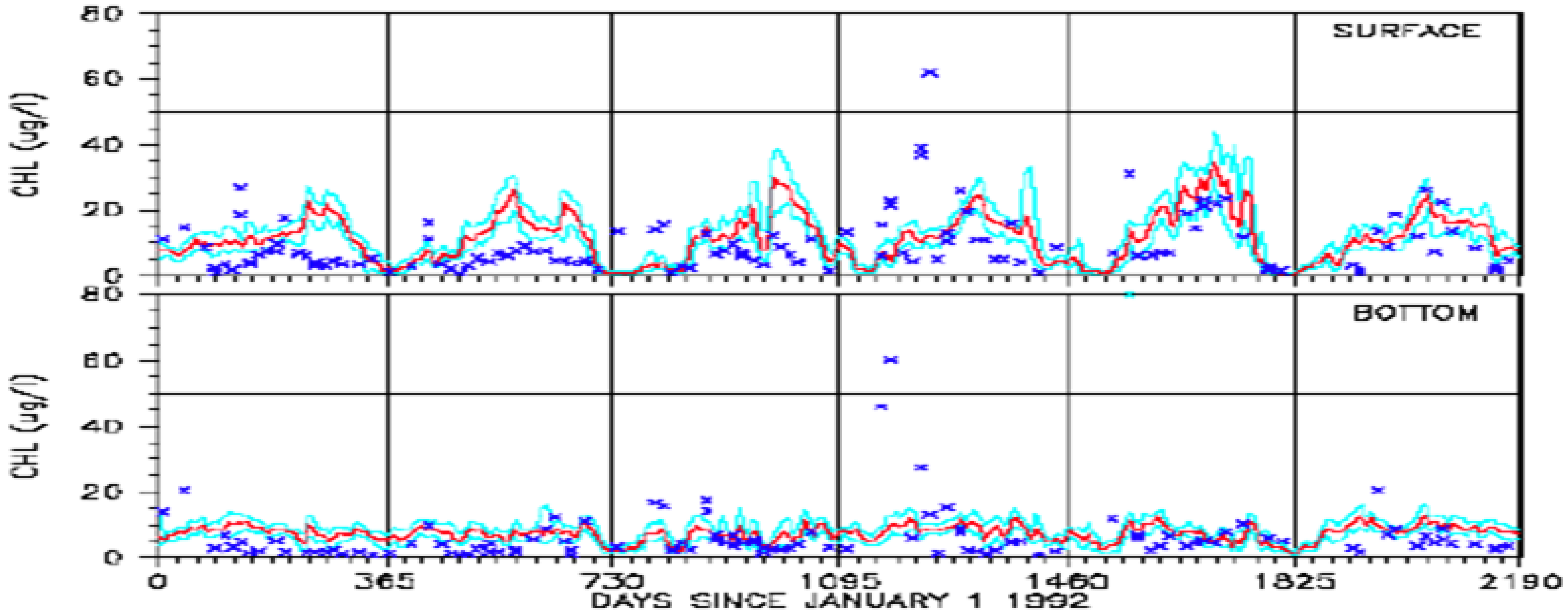
365
730
1095
1460
1825
2190
DAYS SINCE JANUARY 1 1992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BOTTOM
CHL (ug/l)
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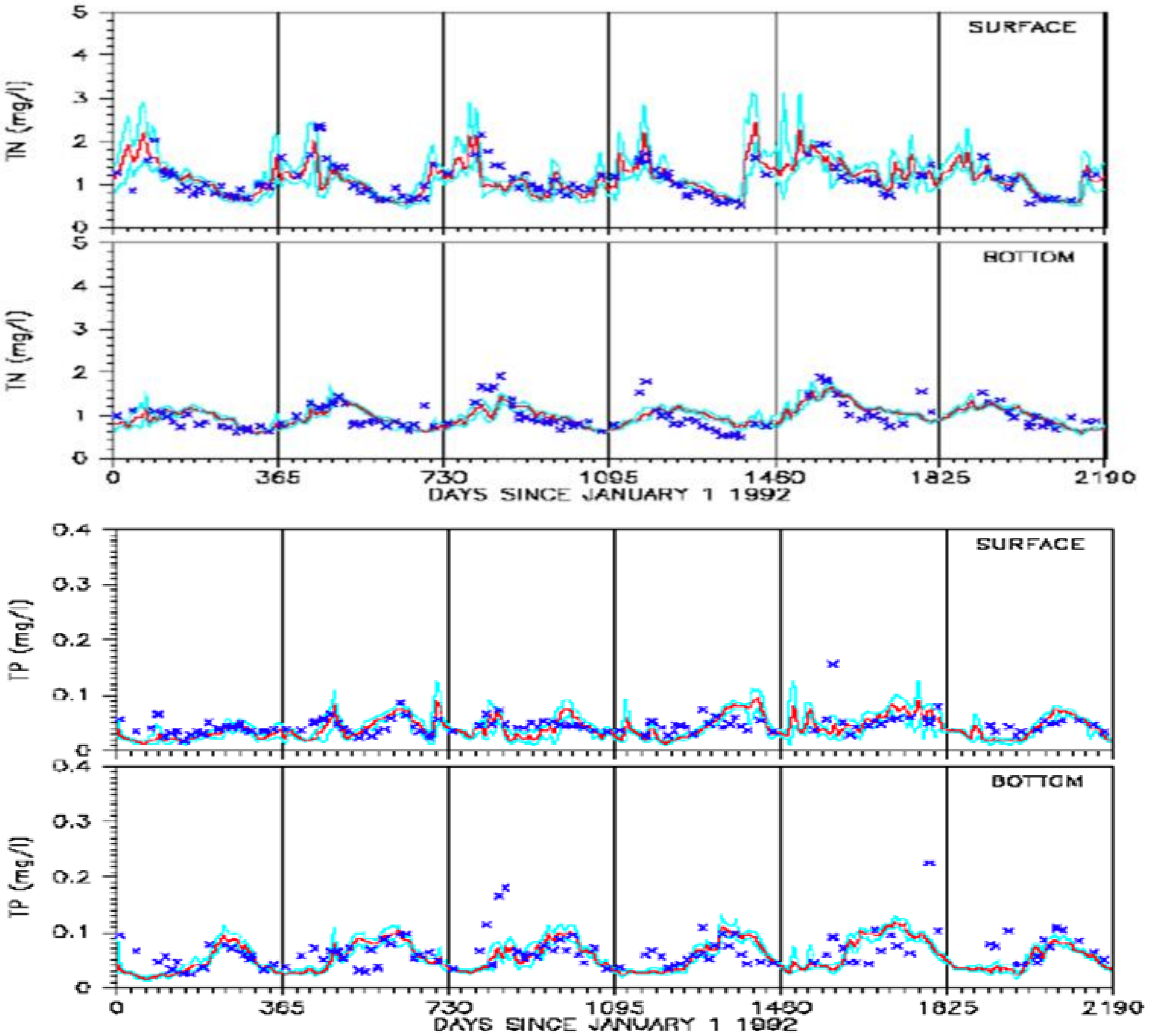
1460
1825
2190
DAYS SINCE JANUARY 1 1992


SURFACE
BOTTOM
TN (mg/l)
TP (mg/l)
DAYS SINCE JANUARY 1 1992
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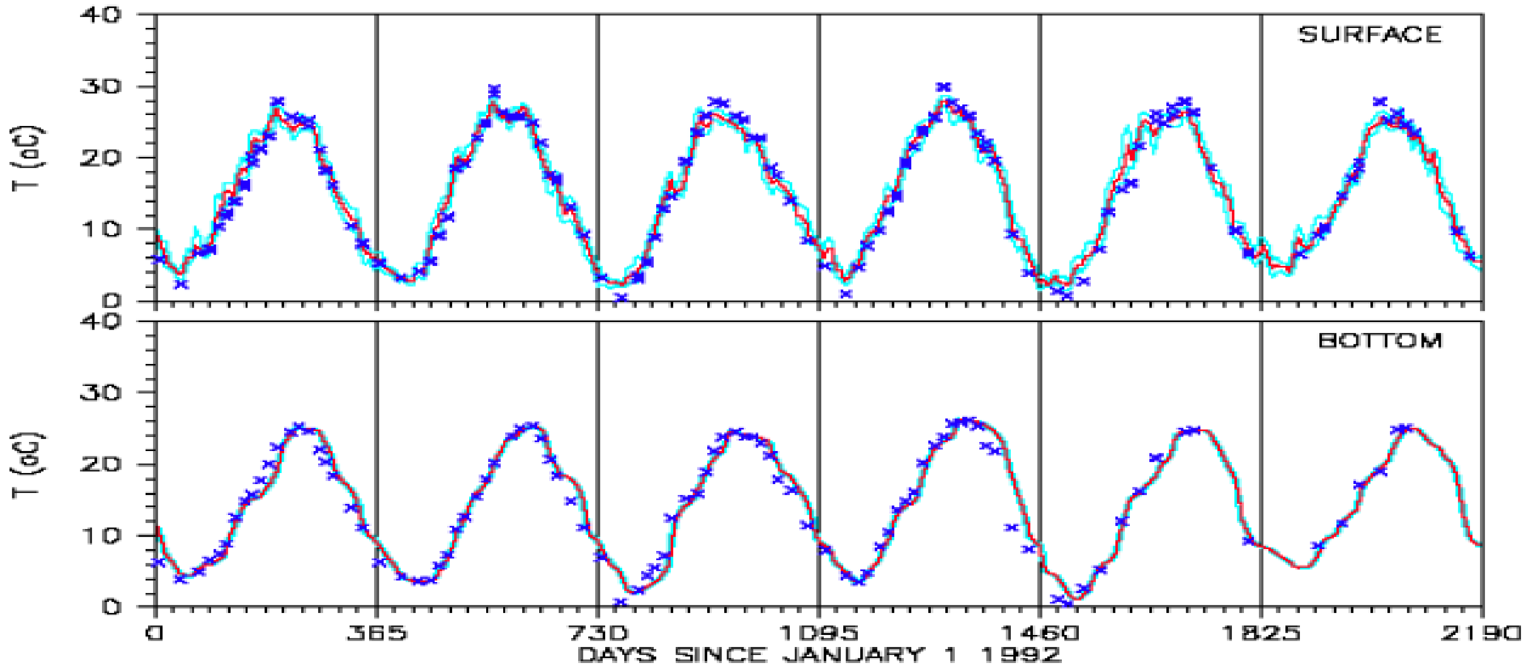
730
1095
1460
1825
2190

**CB3.3C**



SURFACE
BOTTOM
T (oC)
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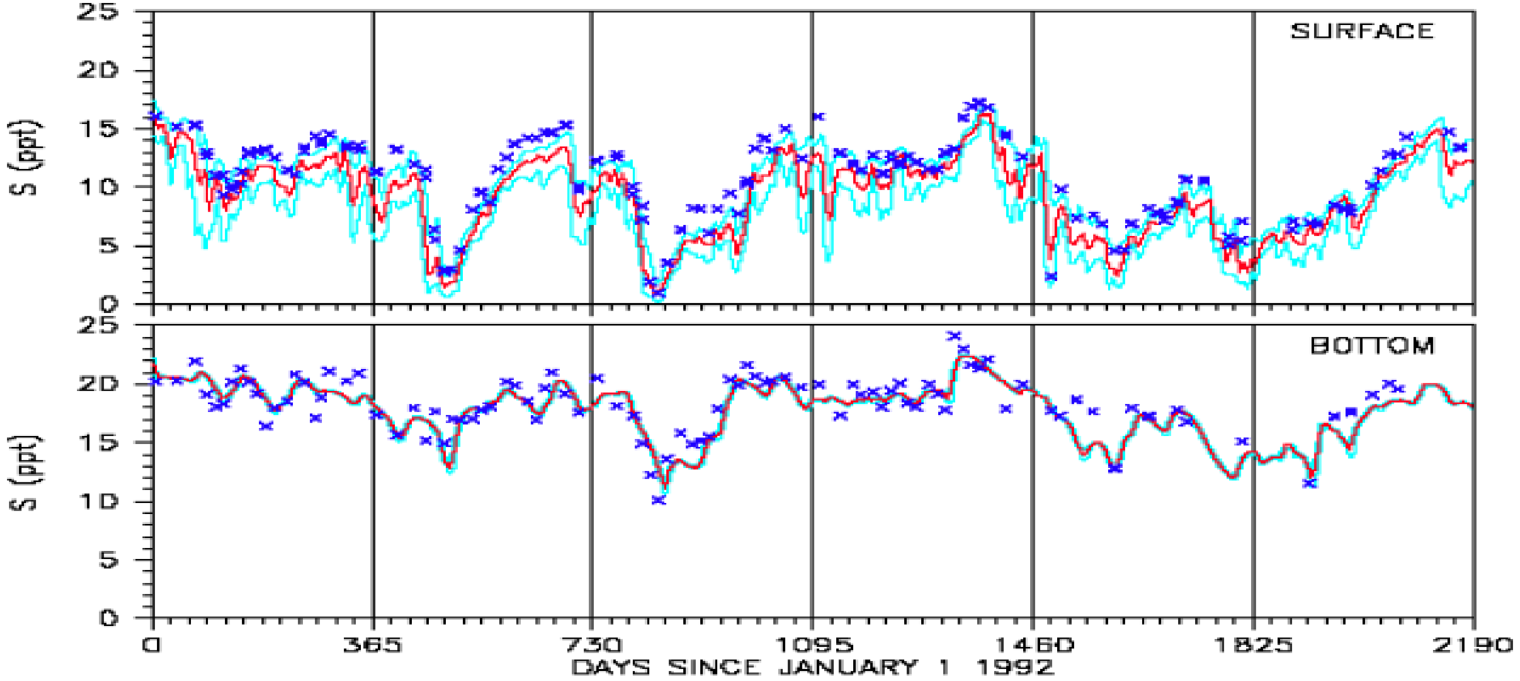
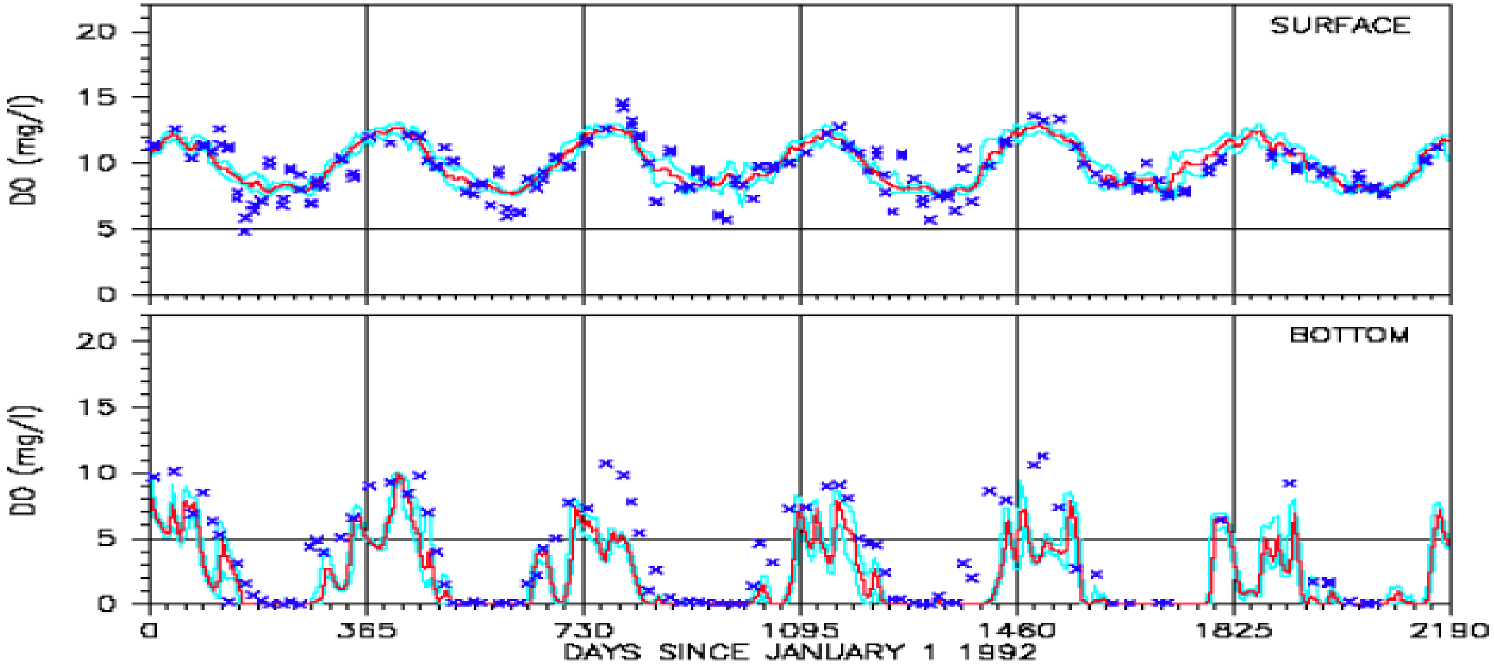
10
20
30
40
0
365
730
1095
1460
1825
2190
DAYS SINCE JANUARY 1 1992

SURFACE
BOTTOM
S (ppt)
0
5
10
15
20
25
0
365
730
1095
1460
1825
2190
DAYS SINCE JANUARY 1 1992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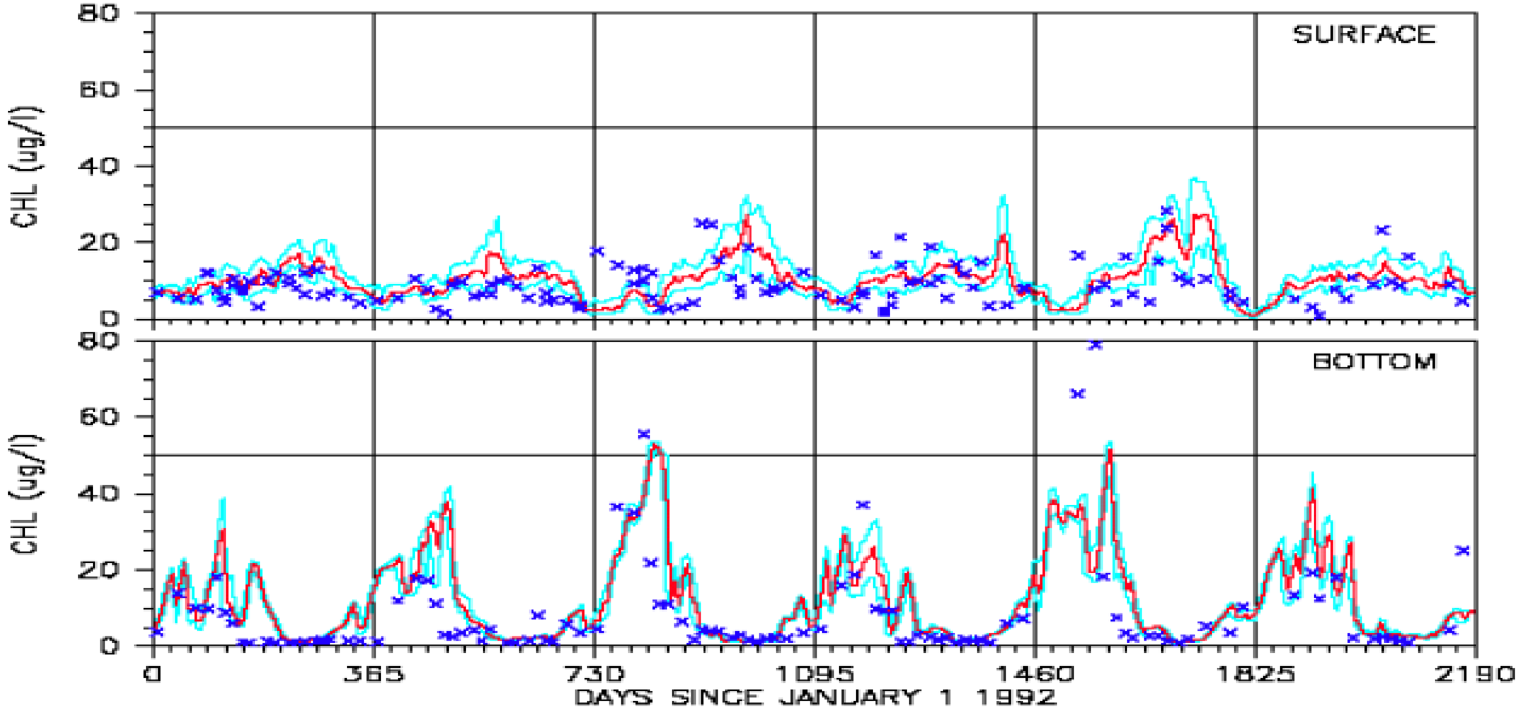
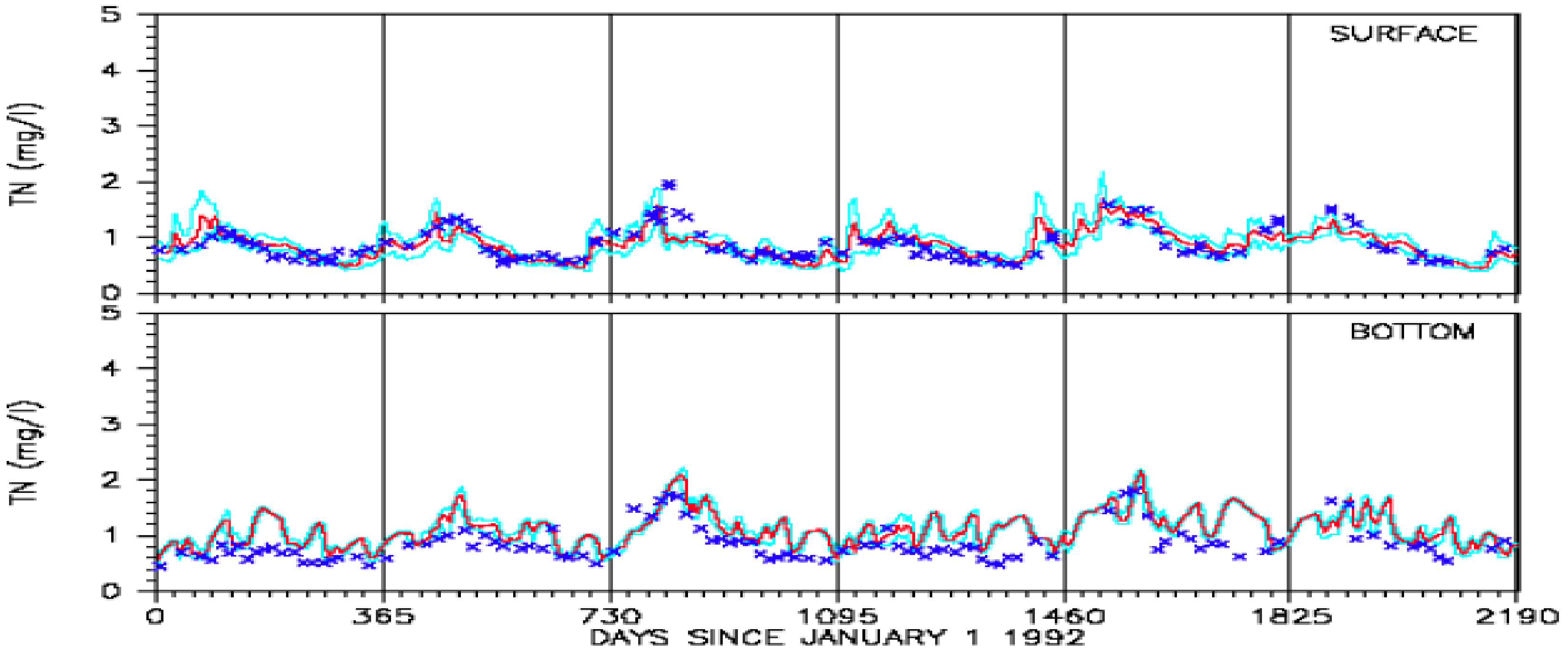
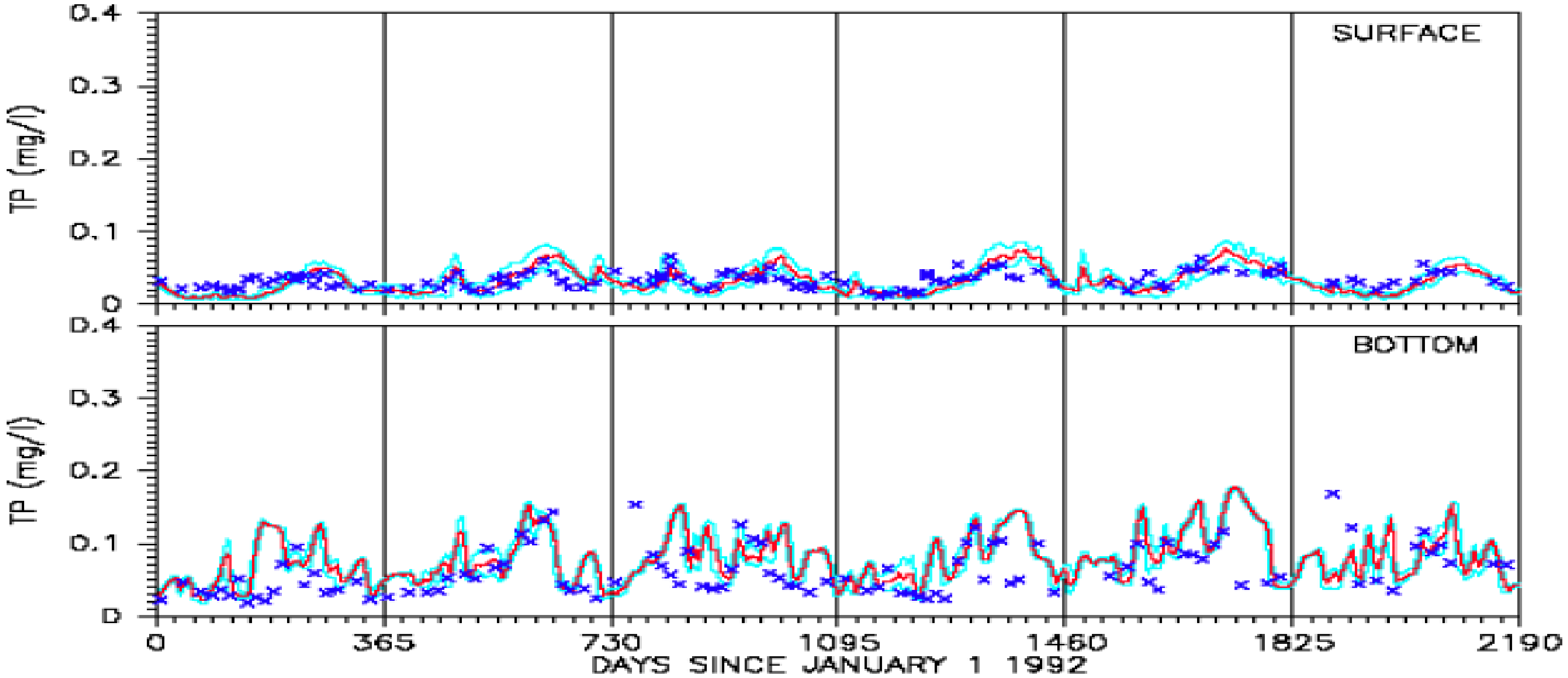
DO (mg/l)
BOTTOM
DO (mg/l)
DAYS SINCE JANUARY 1 1992

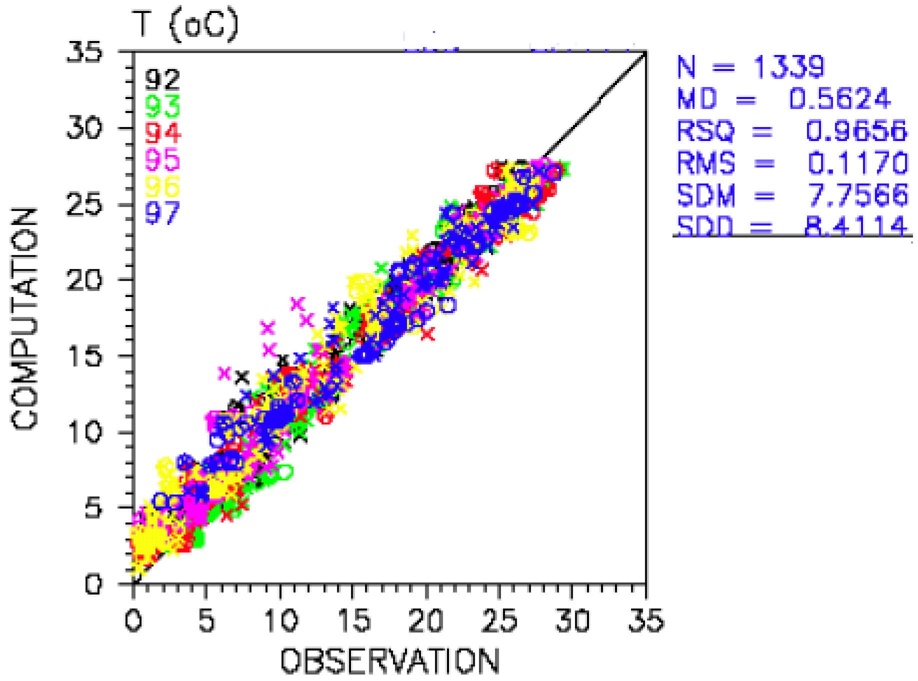

SURFACE
CHL (ug/l)
BOTTOM
CHL (ug/l)
DAYS SINCE JANUARY 1 1992

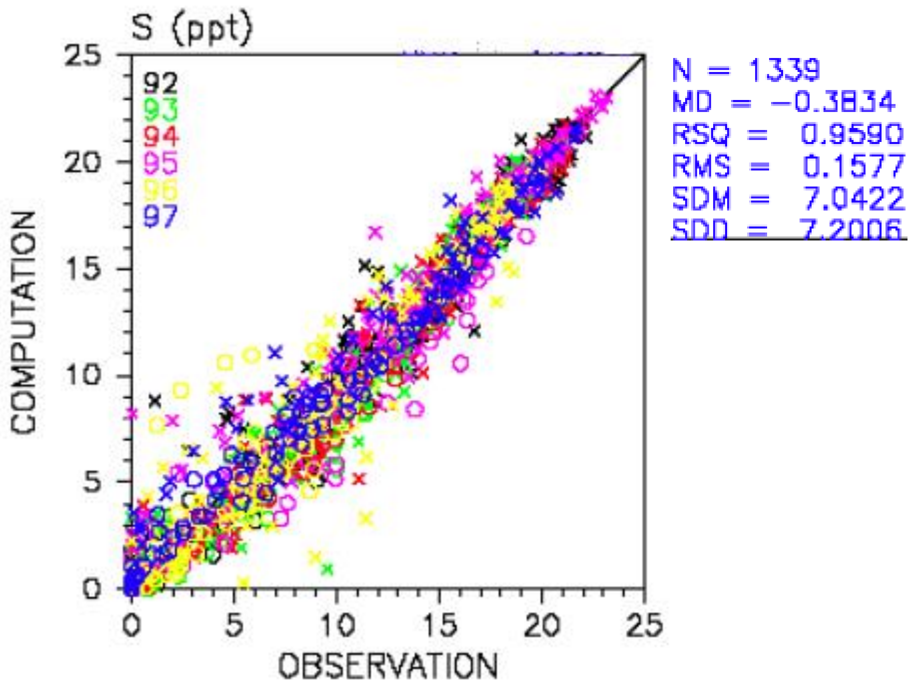

SURFACE
BOTTOM
TN (mg/l)
DAYS SINCE JANUARY 1 1992

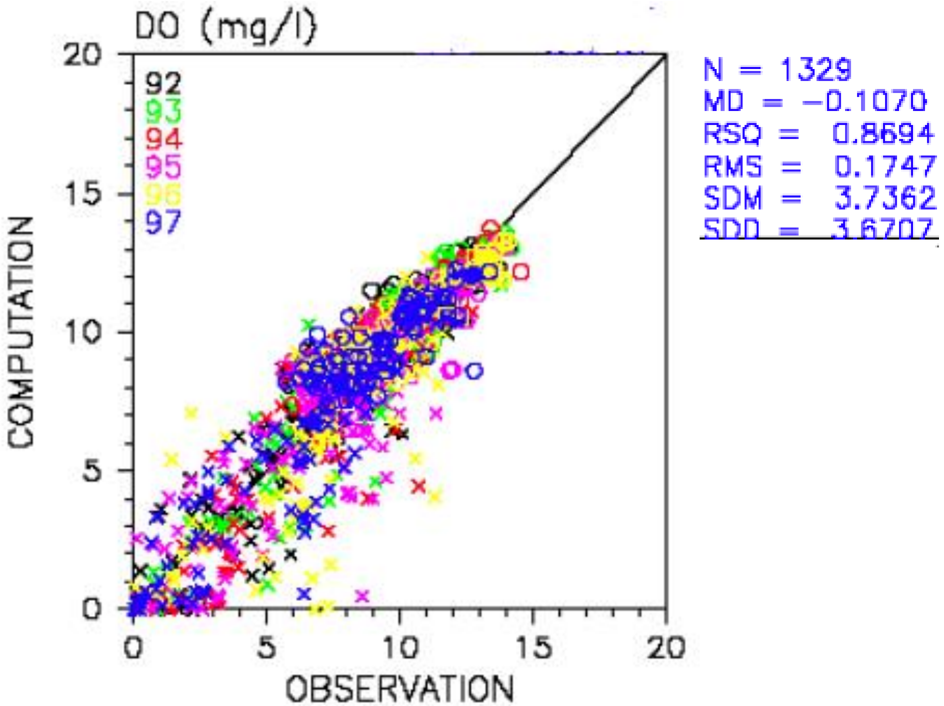

SURFACE
BOTTOM
TP (mg/l)
DAYS SINCE JANUARY 1 1992

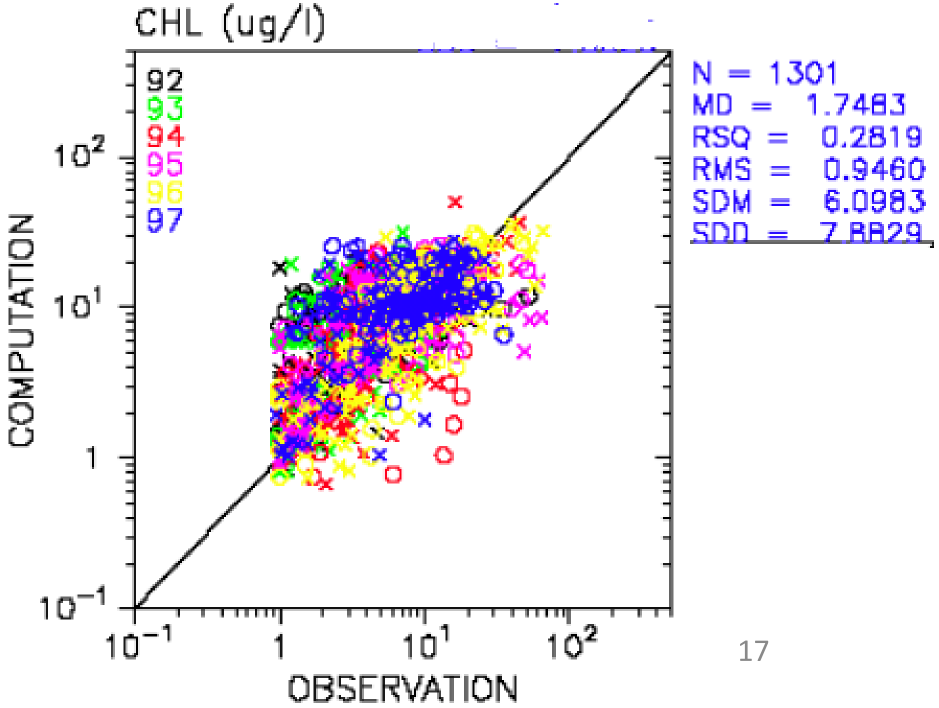
# Performance Statistics for Upper Bay stations

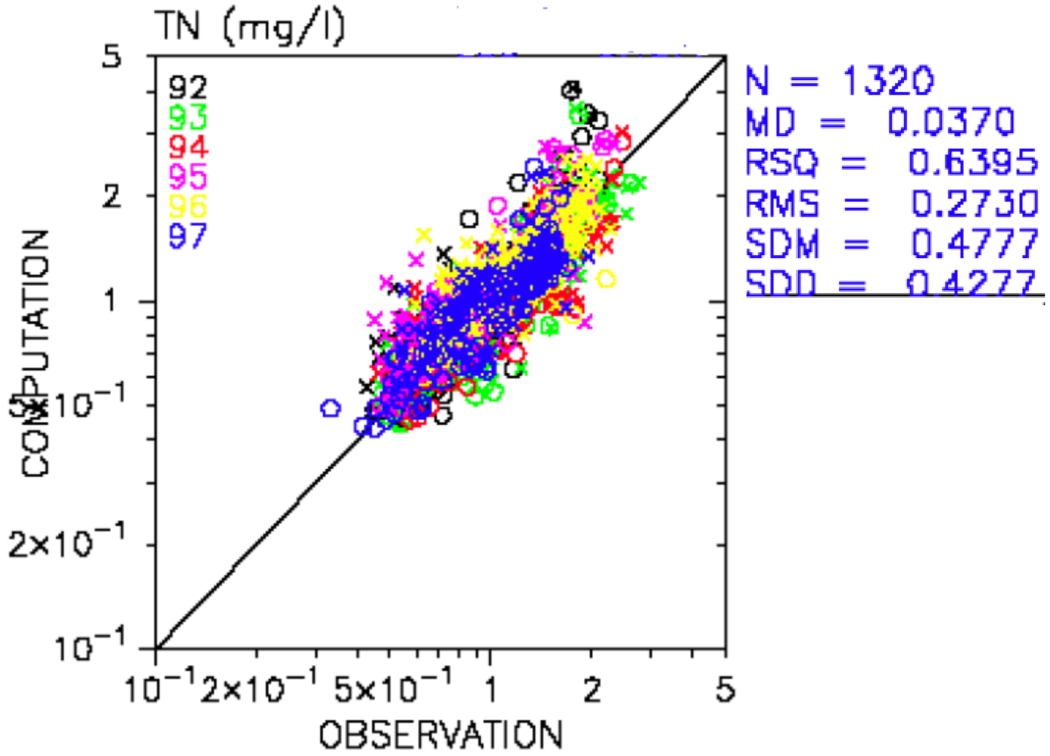
MD: Mean difference
RSQ: R-square; coefficient of determination
RMS: Root-mean-square
SDM: Standard deviation of the mean
SDD: Sum of squared deviation

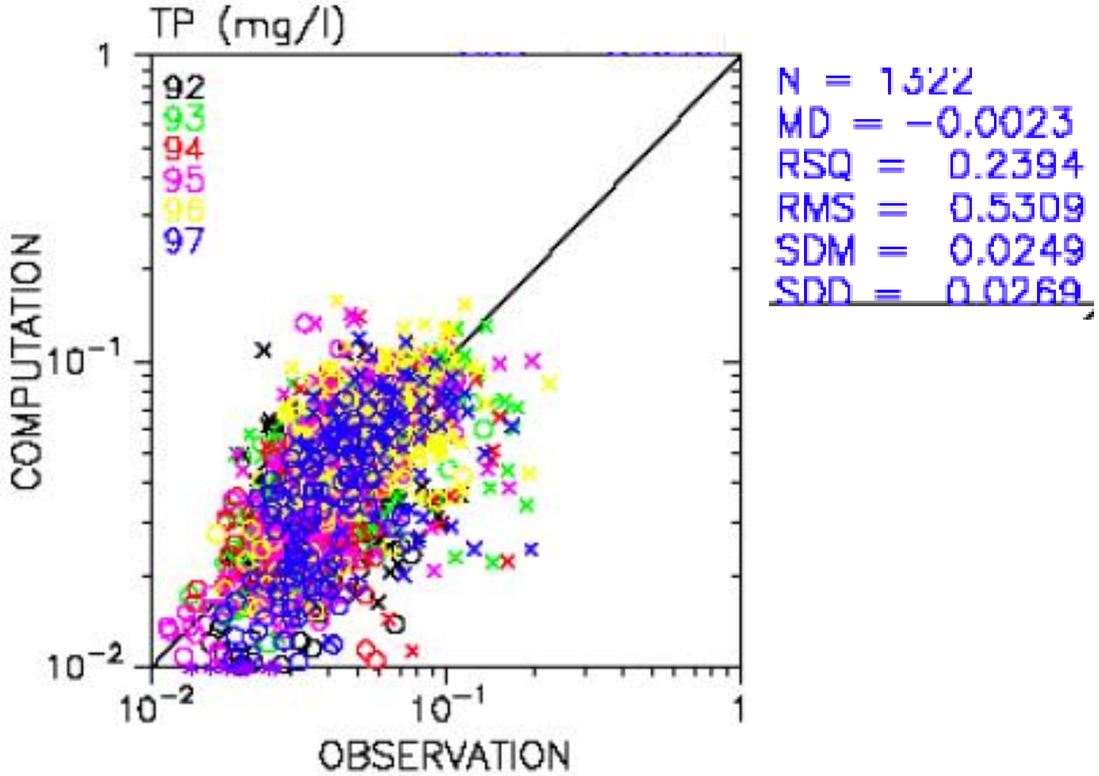


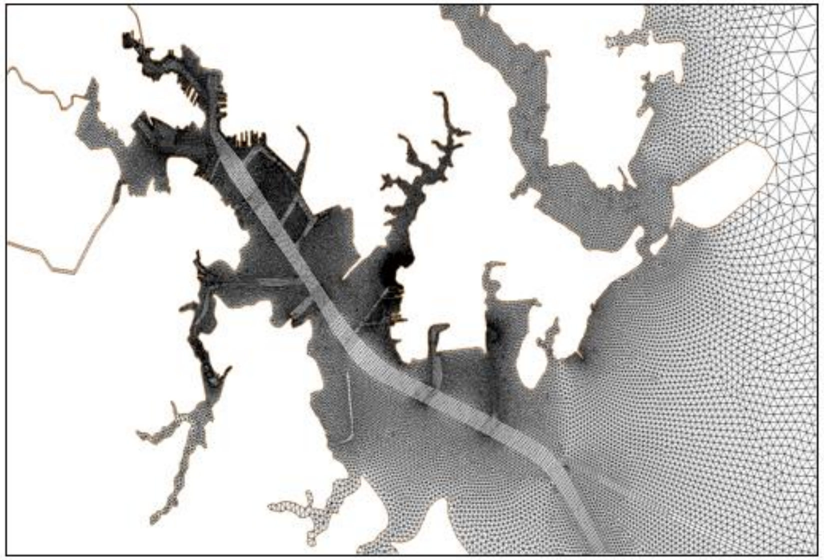



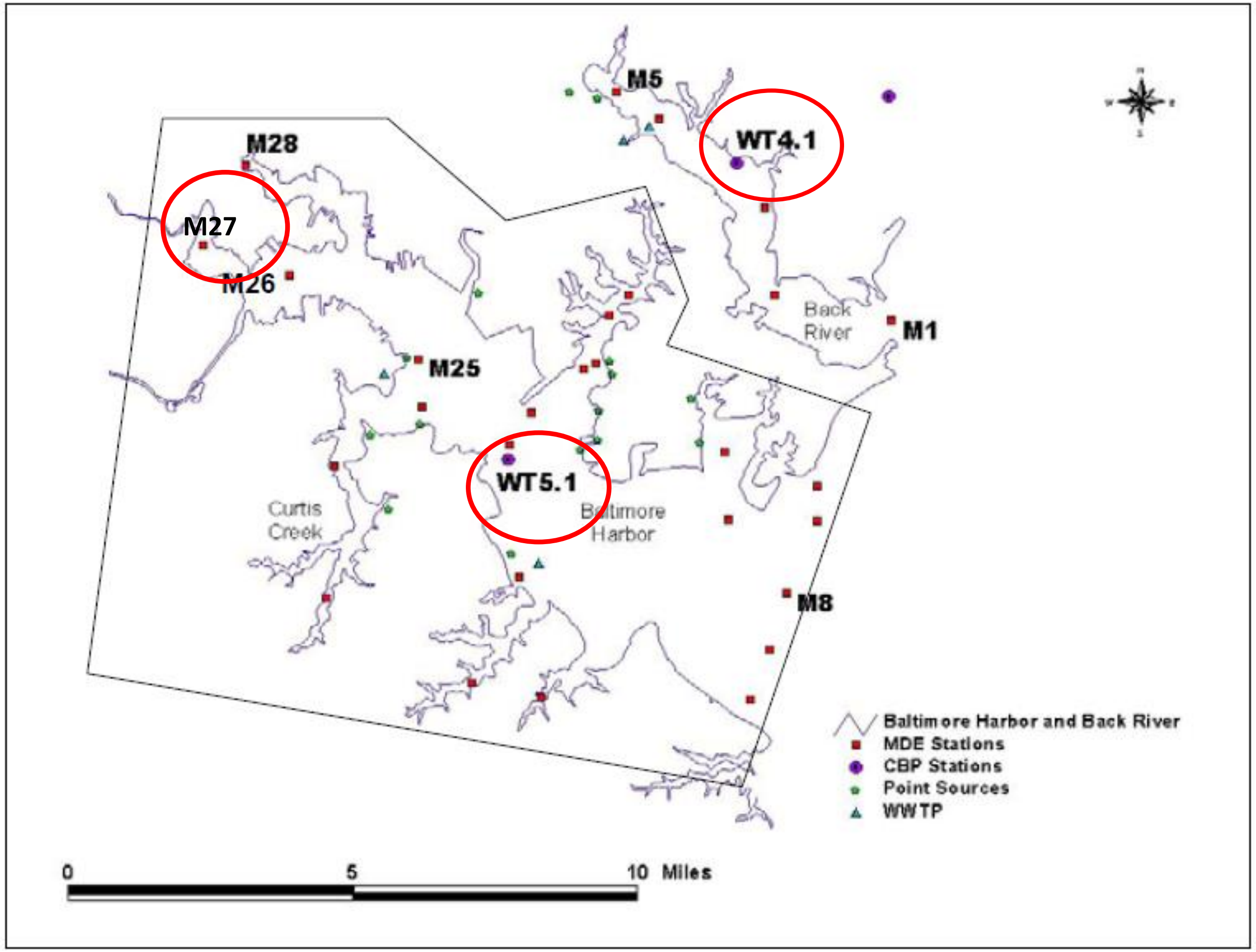




TN (mg/l)
92
93
94
95
96
97
N = 1320
MD = 0.0370
RSQ = 0.6395
RMS = 0.2730
SDM = 0.4777
SDD = 0.4277
COMPUTATION
OBSERVATION


TP (mg/l)
92
93
94
95
96
97
N = 1322
MD = −0.0023
RSQ = 0.2394
RMS = 0.5309
SDM = 0.0249
SDD = 0.0269
COMPUTATION
OBSERVATION

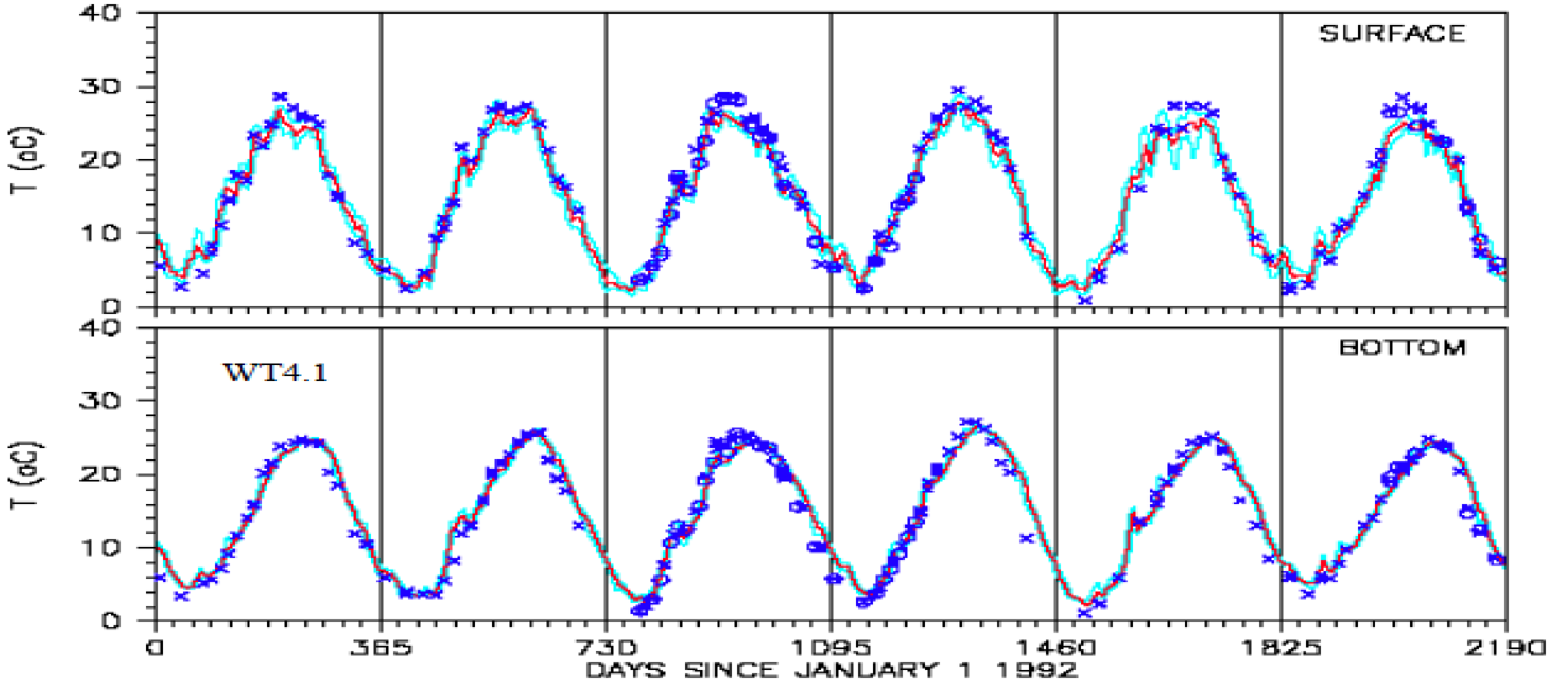
# Monitoring stations used for calibration in the Patapsco and Back River

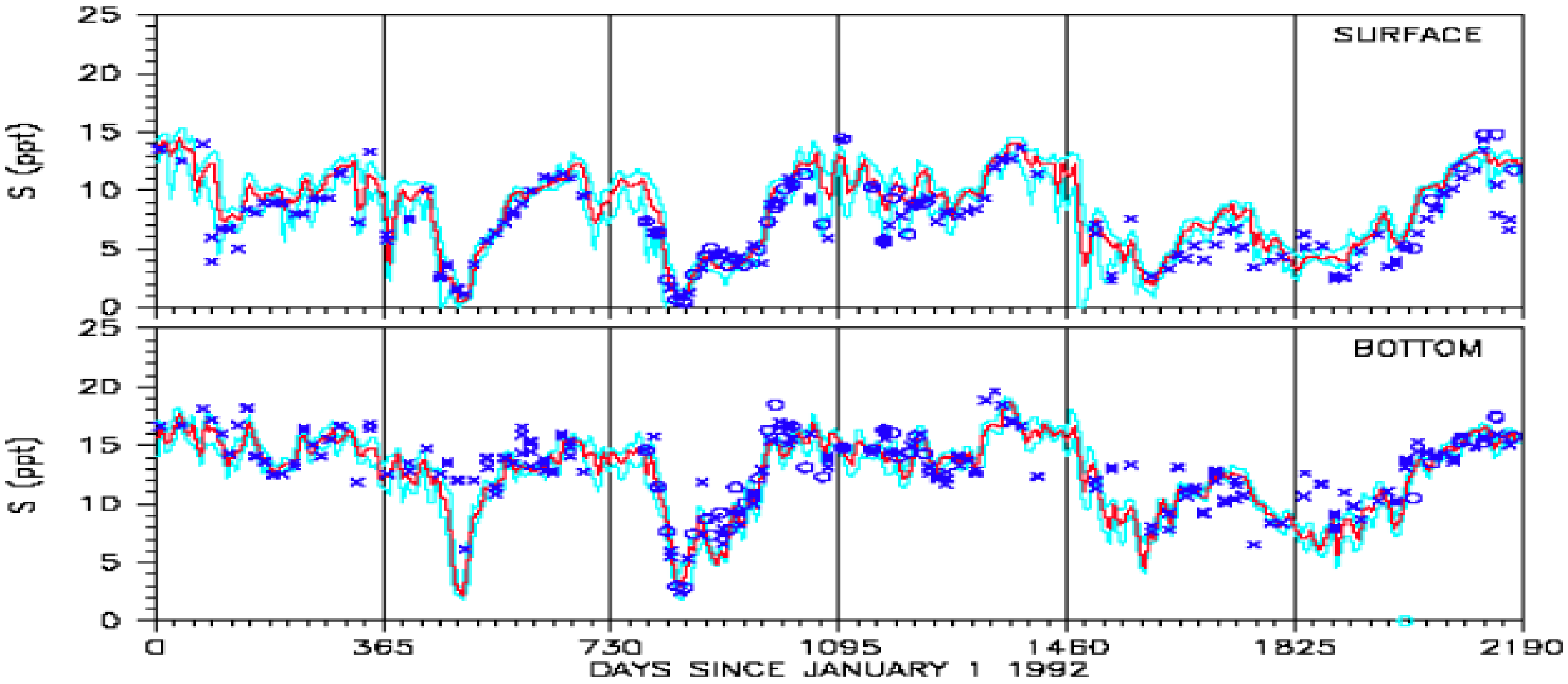


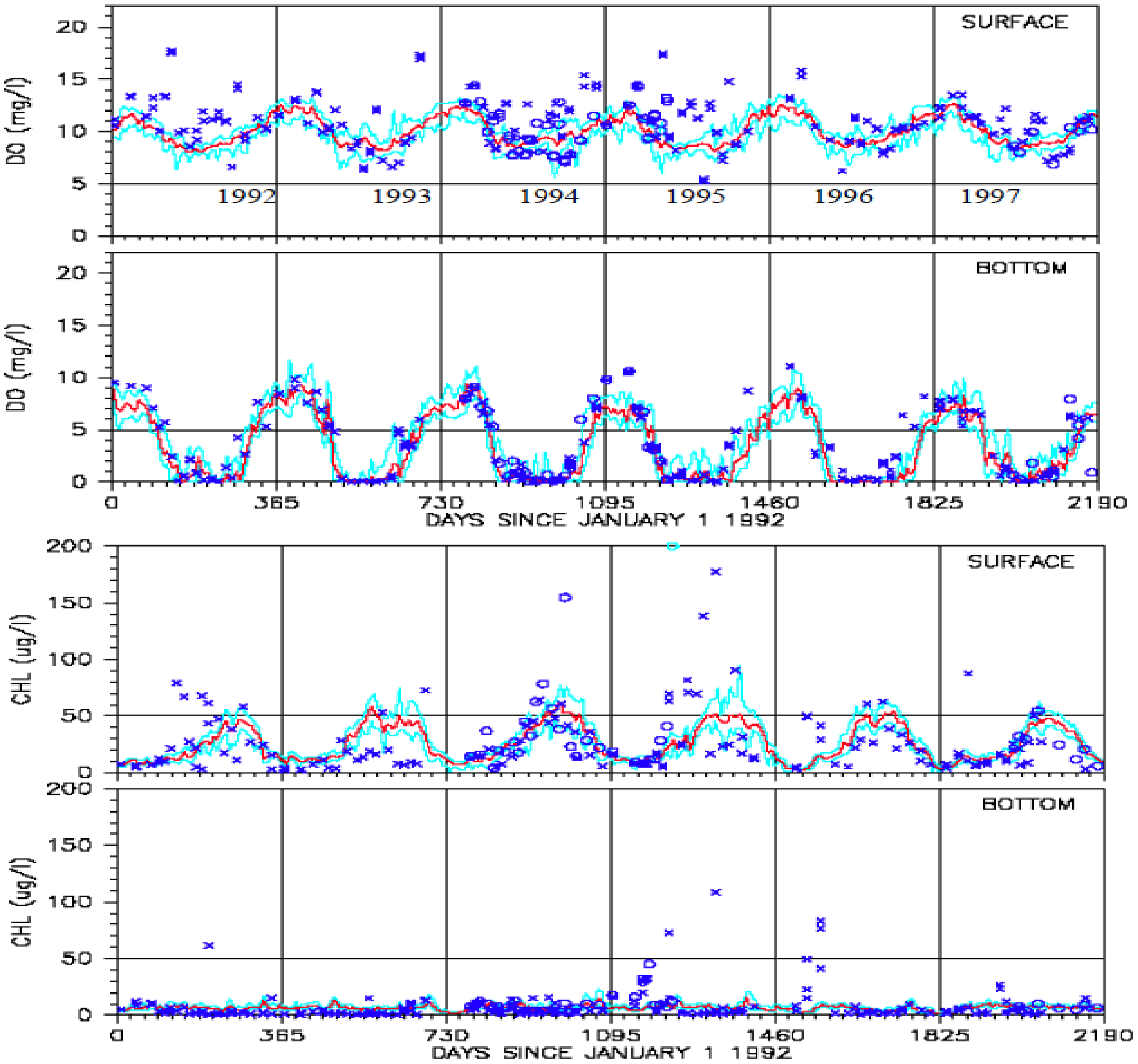


# WT5.1

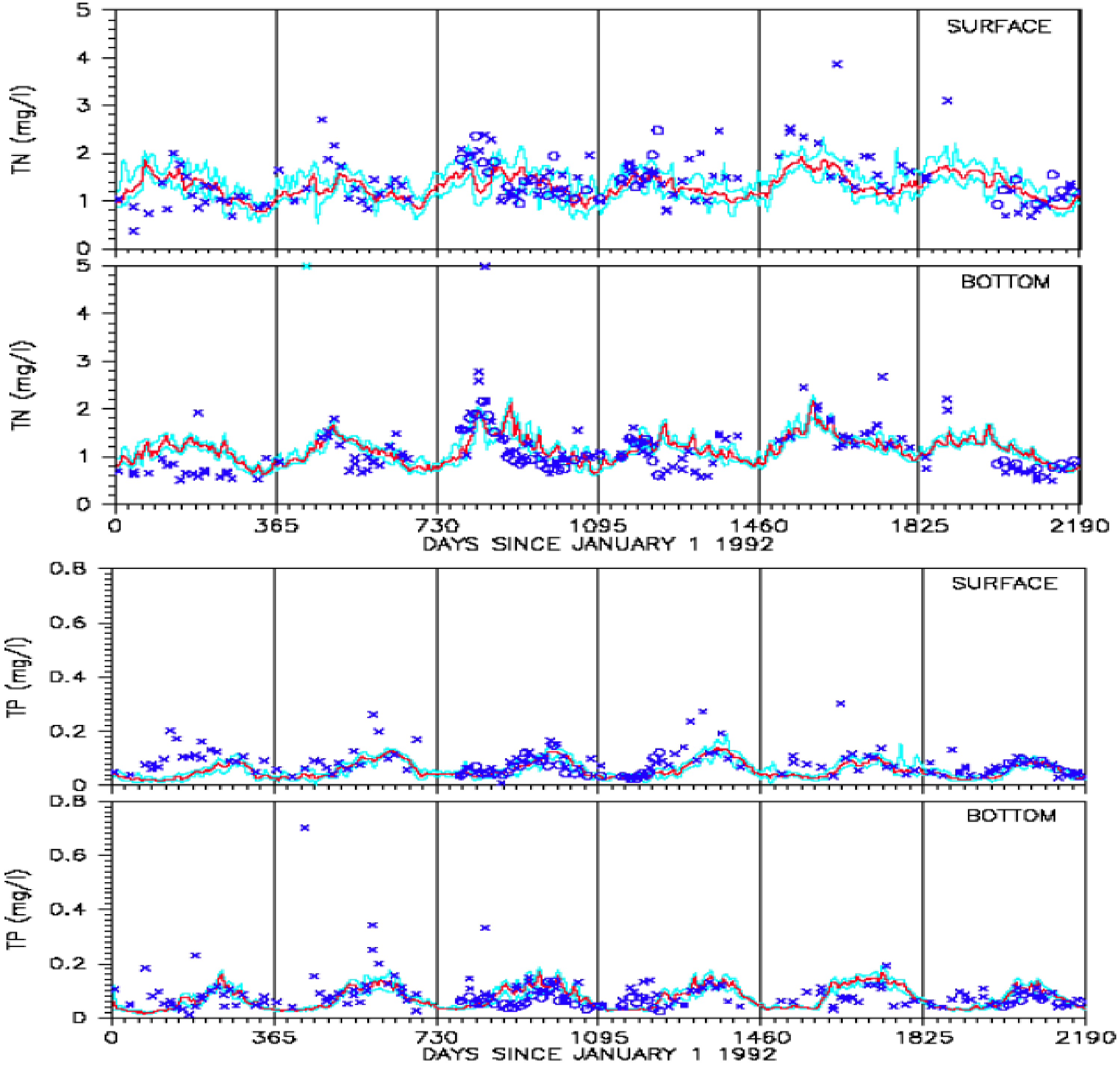
(Patapsco River)



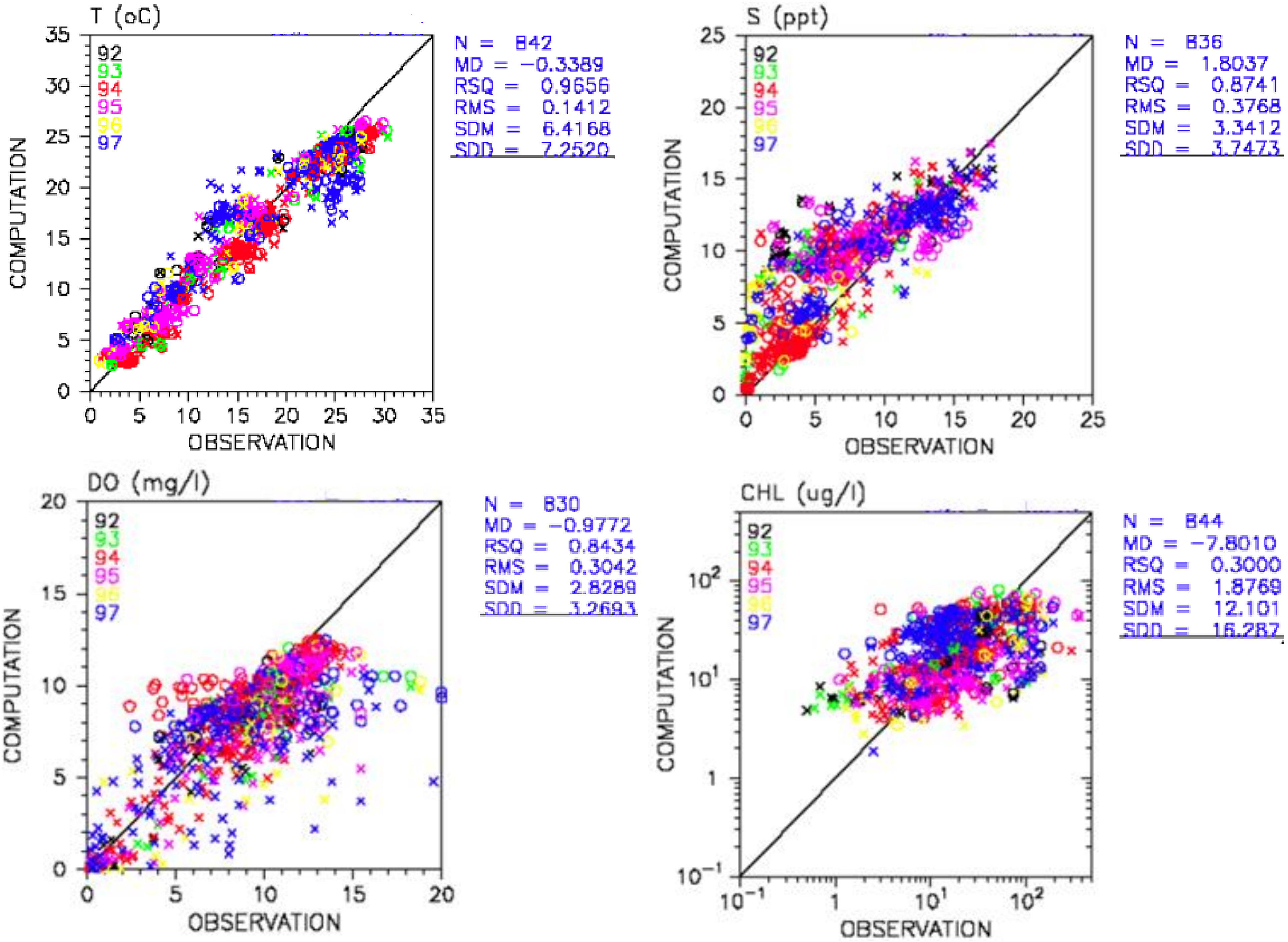



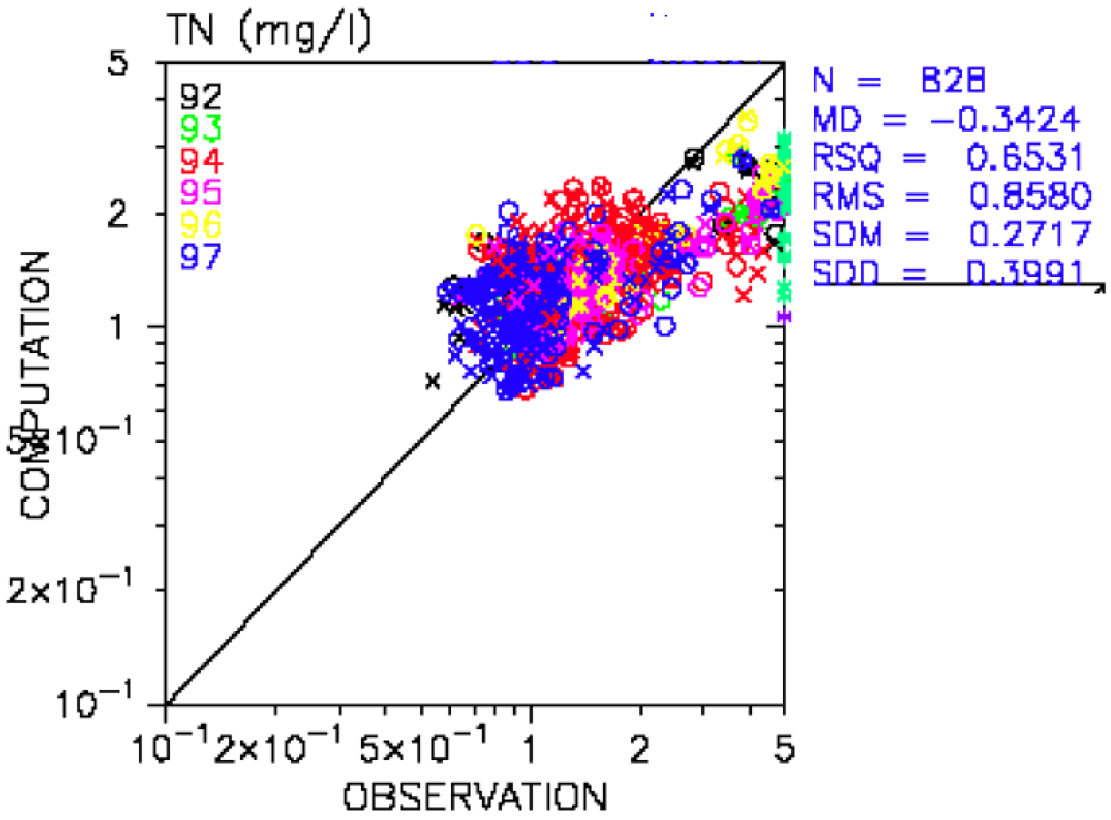


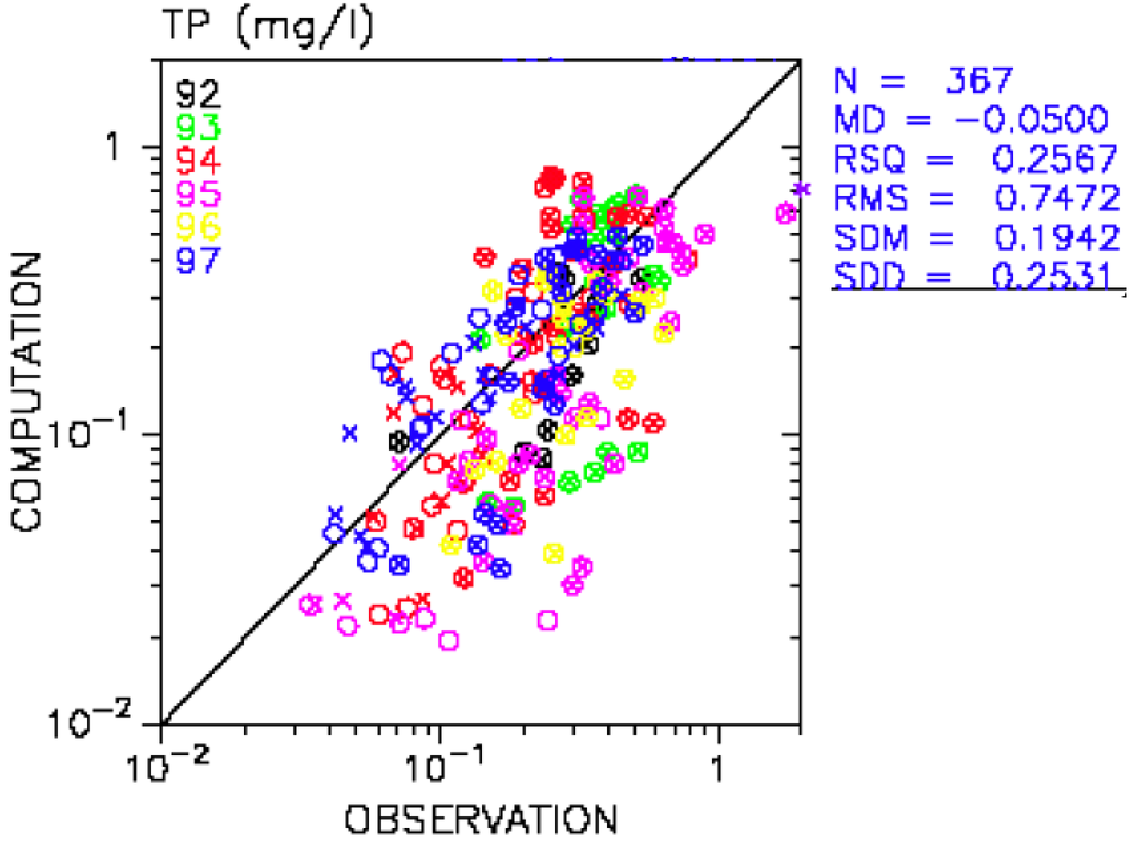
SURFACE
DO (mg/l)
1992
1993
1994
1995
1996
1997
BOTTOM
DO (mg/l)
DAYS SINCE JANUARY 1 1992
SURFACE
CHL (ug/l)
BOTTOM
CHL (ug/l)
DAYS SINCE JANUARY 1 1992



SURFACE
BOTTOM
TN (mg/l)
DAYS SINCE JANUARY 1 1992
TP (mg/l)
0
365
730
1095
1460
1825
2190

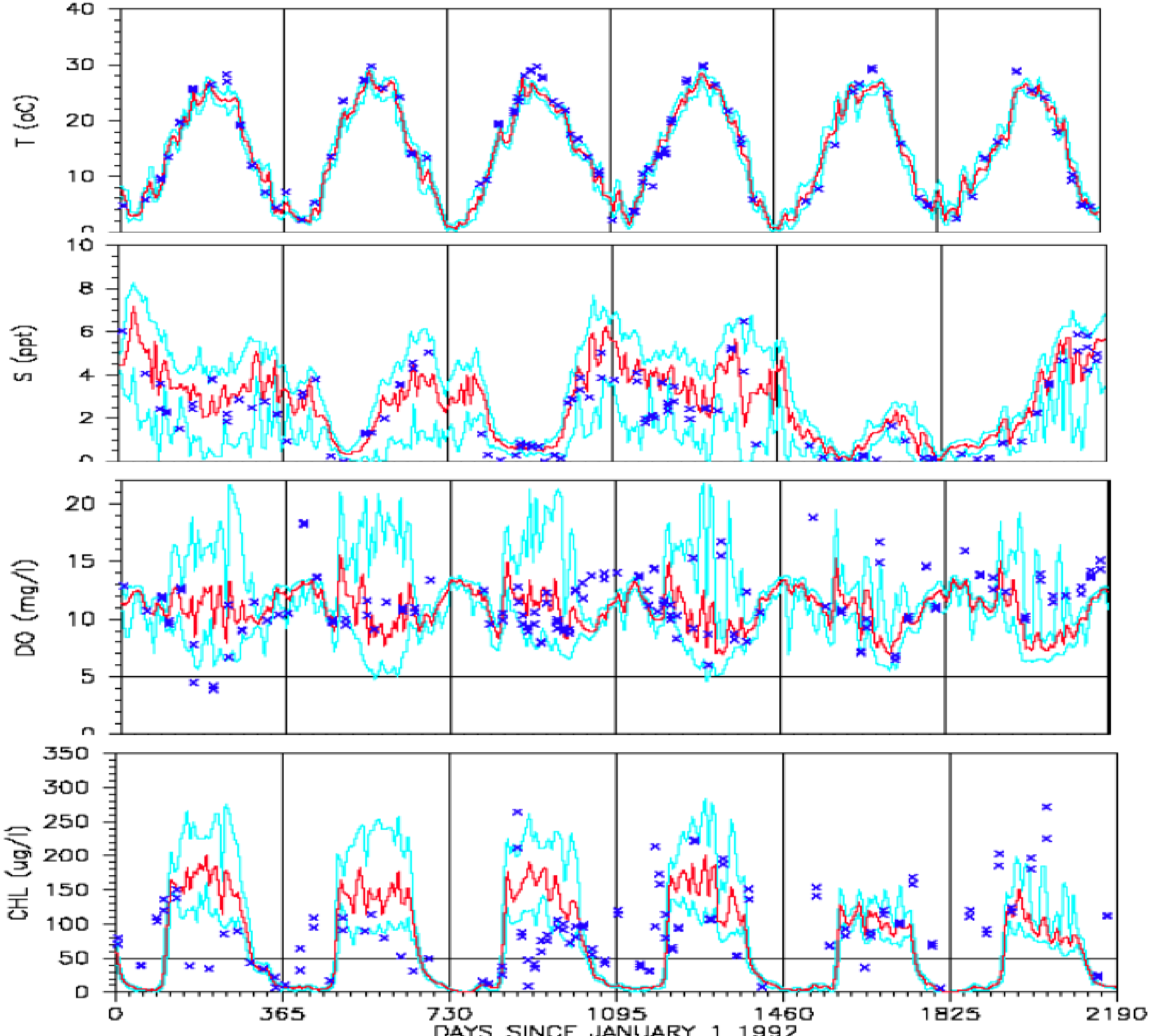

T (oC)
N = 842
MD = -0.3389
RSQ = 0.9656
RMS = 0.1412
SDM = 6.4168
SDD = 7.2520
S (ppt)
N = 836
MD = 1.8037
RSQ = 0.8741
RMS = 0.3768
SDM = 3.3412
SDD = 3.7473
DO (mg/l)
N = 830
MD = -0.9772
RSQ = 0.8434
RMS = 0.3042
SDM = 2.8289
SDD = 3.2693
CHL (ug/l)
N = 844
MD = -7.8010
RSQ = 0.3000
RMS = 1.8769
SDM = 12.101
SDD = 16.287
92
93
94
95
96
97
COMPUTATION
OBSERVATION

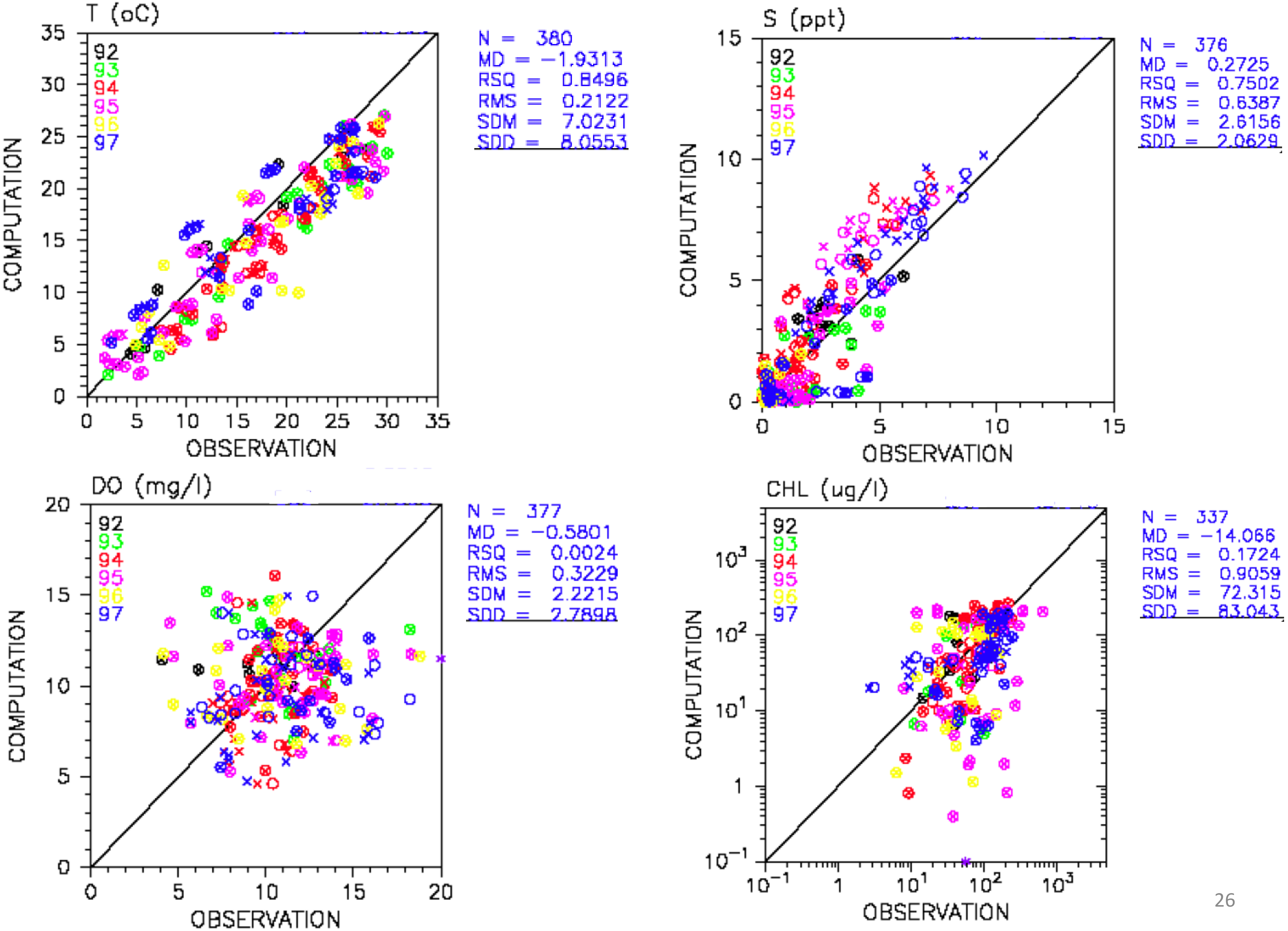

TN (mg/l)
92
93
94
95
96
97
N = 828
MD = −0.3424
RSQ = 0.6531
RMS = 0.8580
SDM = 0.2717
SDD = 0.3991
COMPUTATION
OBSERVATION

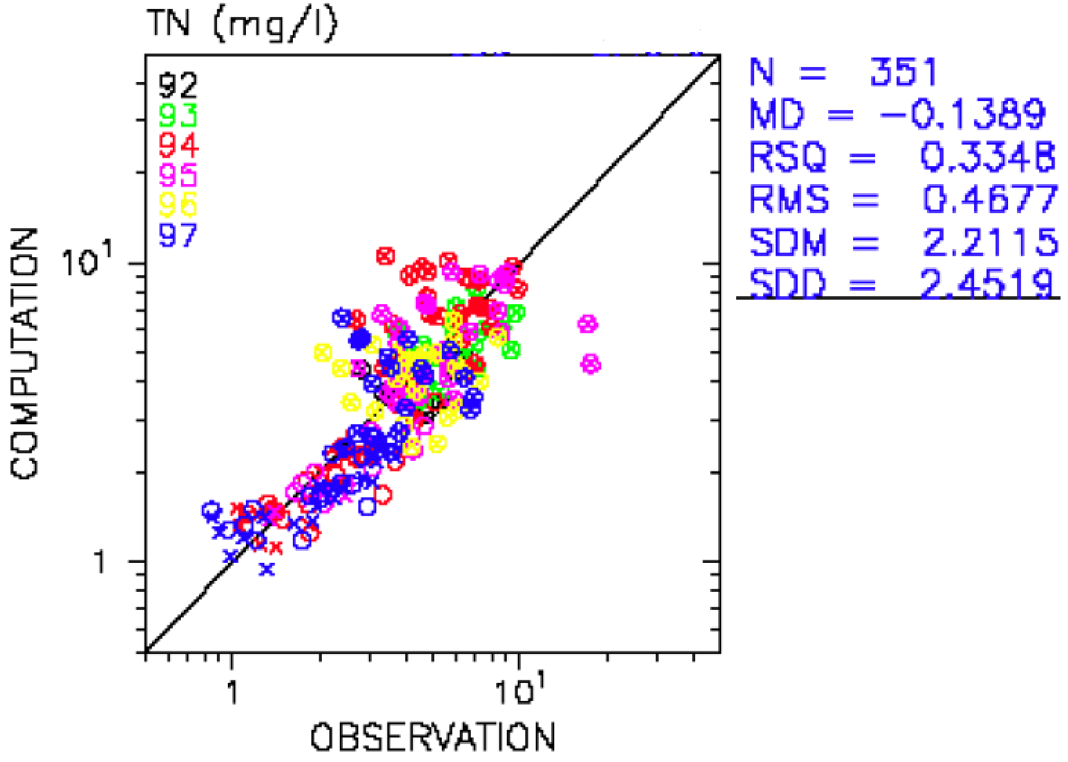

TP (mg/l)
92
93
94
95
96
97
N = 367
MD = −0.0500
RSQ = 0.2567
RMS = 0.7472
SDM = 0.1942
SDD = 0.2531
COMPUTATION
OBSERVATION

**WT4.1**

(Back River)




T (oC)
N = 380
MD = −1.9313
RSQ = 0.8496
RMS = 0.2122
SDM = 7.0231
SDD = 8.0553
S (ppt)
N = 376
MD = 0.2725
RSQ = 0.7502
RMS = 0.6387
SDM = 2.6156
SDD = 2.0629
DO (mg/l)
N = 377
MD = −0.5801
RSQ = 0.0024
RMS = 0.3229
SDM = 2.2215
SDD = 2.7898
CHL (ug/l)
N = 337
MD = −14.066
RSQ = 0.1724
RMS = 0.9059
SDM = 72.315
SDD = 83.043
92
93
94
95
96
97
COMPUTATION
OBSERVATION



TN (mg/l)
92
93
94
95
96
97
COMPUTATION
OBSERVATION
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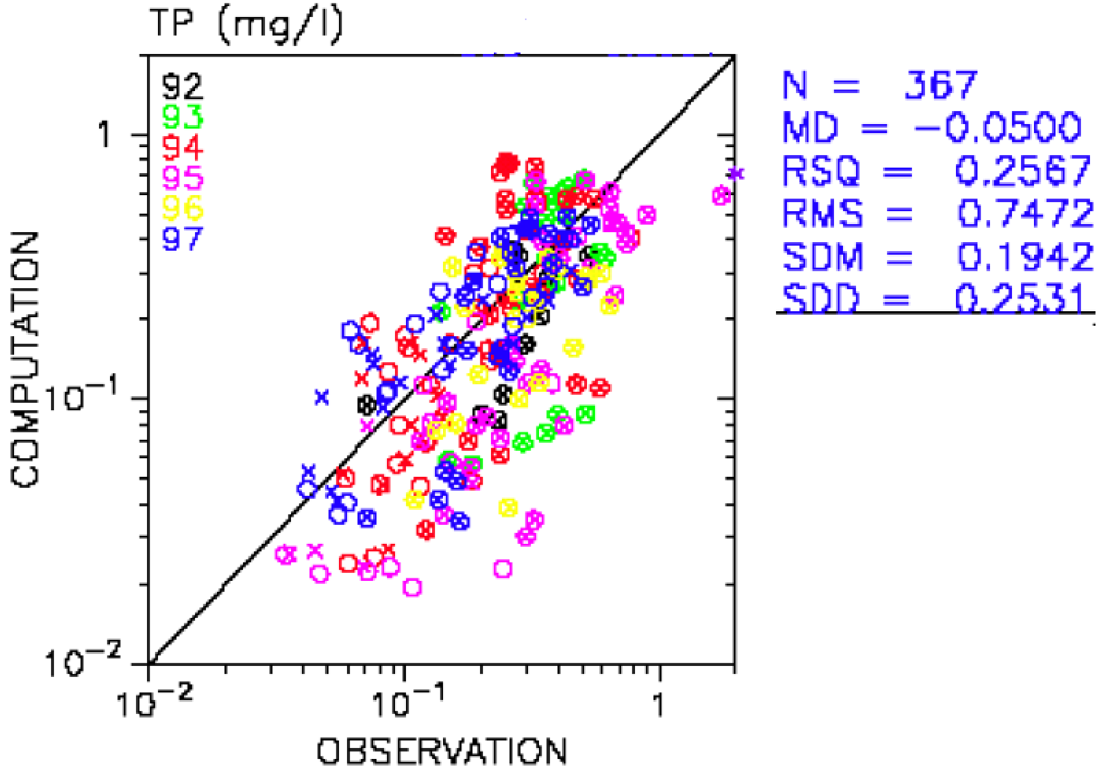
SDM = 2.2115
SDD = 2.4519

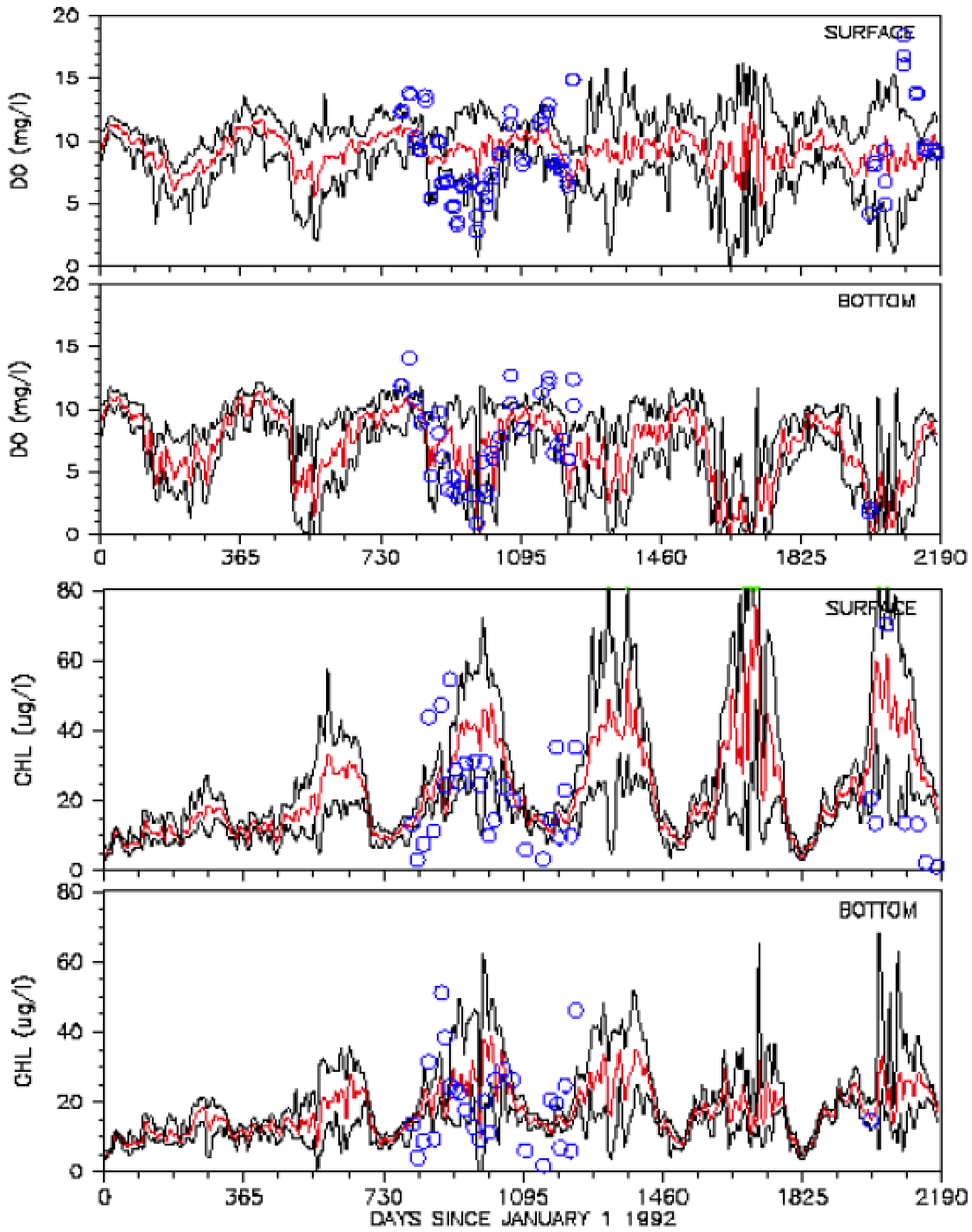



TP (mg/l)
92
93
94
95
96
97
COMPUTATION
OBSERVATION
N = 367
MD = −0.0500
RSQ = 0.2567
RMS = 0.7472
SDM = 0.1942
SDD = 0.2531

**Calibration for MDE stations**

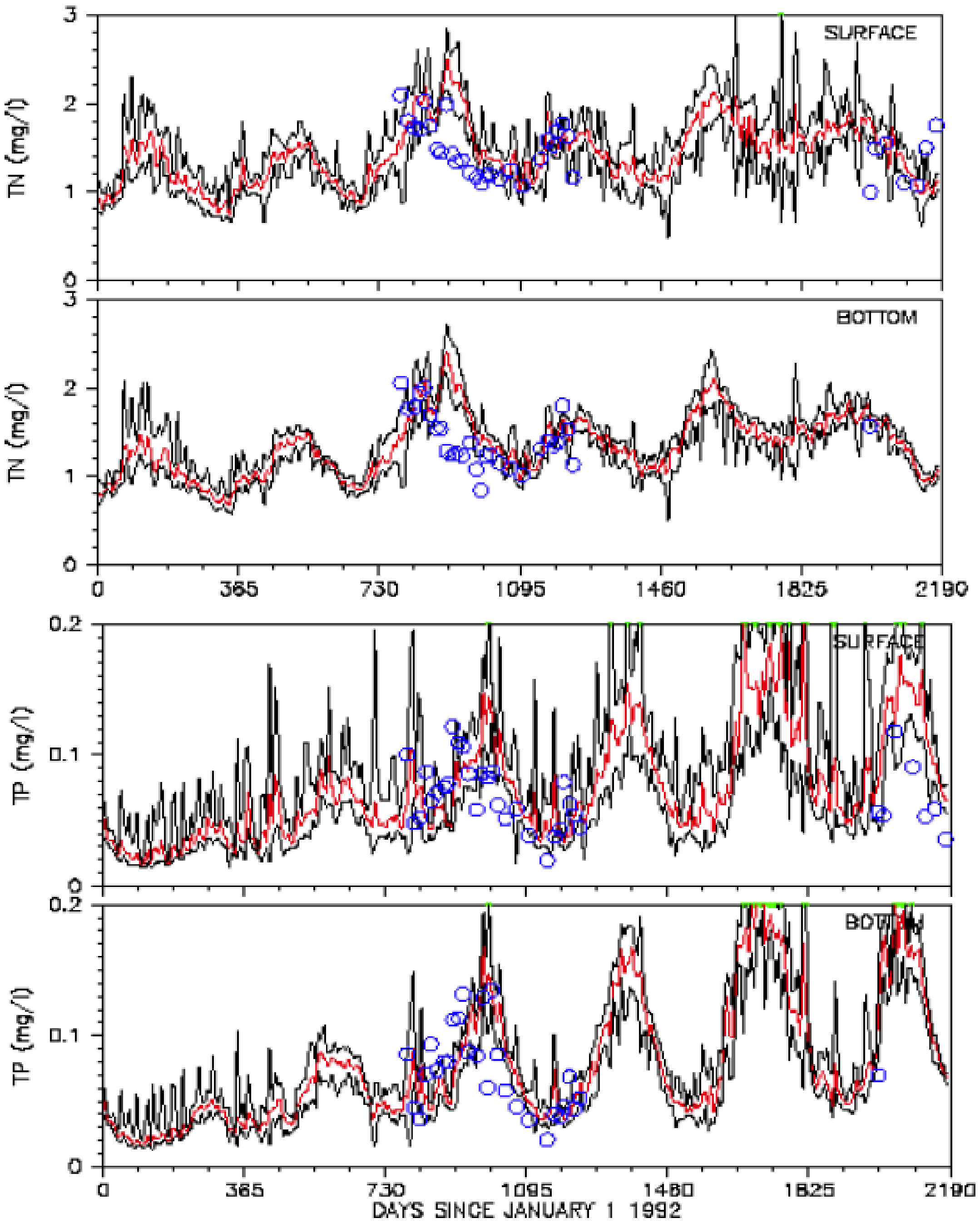
**M27**

(Mouth of Gwynns Falls)



**M27**

(Mouth of Gwynns Falls)



# III. Indirect-coupling (Off-line) setup for water quality run

## Issued encountered and being pondered:

A. Choice of DT (delta T) under Lagrangian-Eulerian scheme
B. How small the friction can be reduced (due to mud) and the model is still stable?
C. The role of WWM model in modulating vertical mixing. Which turbulence scheme should be used? (GLS or Gotm)
D. Use of high-order non-oscillatory WENO scheme (switching stencil) for advection-diffusion equation.

**Question:**

A. SCHISM is semi-implicit, so it allows larger time steps than purely explicit models, especially for the free surface and barotropic modes. However, when you increase grid resolution, small elements can still enforce stricter limits due to local CFL constraints, especially in shallow or fast-flow regions. For MTM should DT reduced by 3 times for hydrodynamic model? How about DT for wind wave model and for the sediment model (Are they finite volume-base)?

B. In deep channel, the friction is adjust to be low in part due to mud and enhance salt intrusion (WenFan). Does this lead to instability in the momentum calculation?

C. When WWM is added, the wave current interaction occurred at the bottom boundary. For example, wave dispersion relation with current: $\omega = \omega_0 + \vec{k} \cdot \vec{U}$
Does the current turbulence models handle the wave-induced process? Does the wind wave affect the vertical mixing?

D. What is the best way to handle high-order WENO? It is notoriously become unstable at corner point. Should it be used or not recommended?

# IV. Summary

1. The coupled hydrodynamic SCHISM and water quality ICM model was successfully executed in direct-coupling mode, without linking to the wind wave module.

2. Model–observation comparisons of key water quality variables—dissolved oxygen (DO), chlorophyll-a, total nitrogen (TN), and total phosphorus (TP)—were performed for stations in the Upper Chesapeake Bay, Patapsco River, and Back River. These variables showed reasonable agreement with observed data based on statistical performance metrics. (Additional comparisons for nutrient species were conducted but are not showed here.)

3. We also attempted an indirect-coupling approach by saving the hydrodynamic results to drive the water quality model offline. However, this approach introduced unexpected issues, especially when the hydrodynamic model was linked with sediment transport and wind wave modules. The salinity stratification was decimated.

   Key challenges included:
   (A) Determining the appropriate time step (DT) when using a grid resolution three times finer,
   (B) Evaluating the performance of the WENO high-order advection-diffusion scheme, and
   (C) Selecting an appropriate turbulence closure model.

**Future Steps:**
Resolve the above issues (working with Zhengui Wang and Joseph Zheng with indirectly-coupling and execuate for 10-year simulation periods.

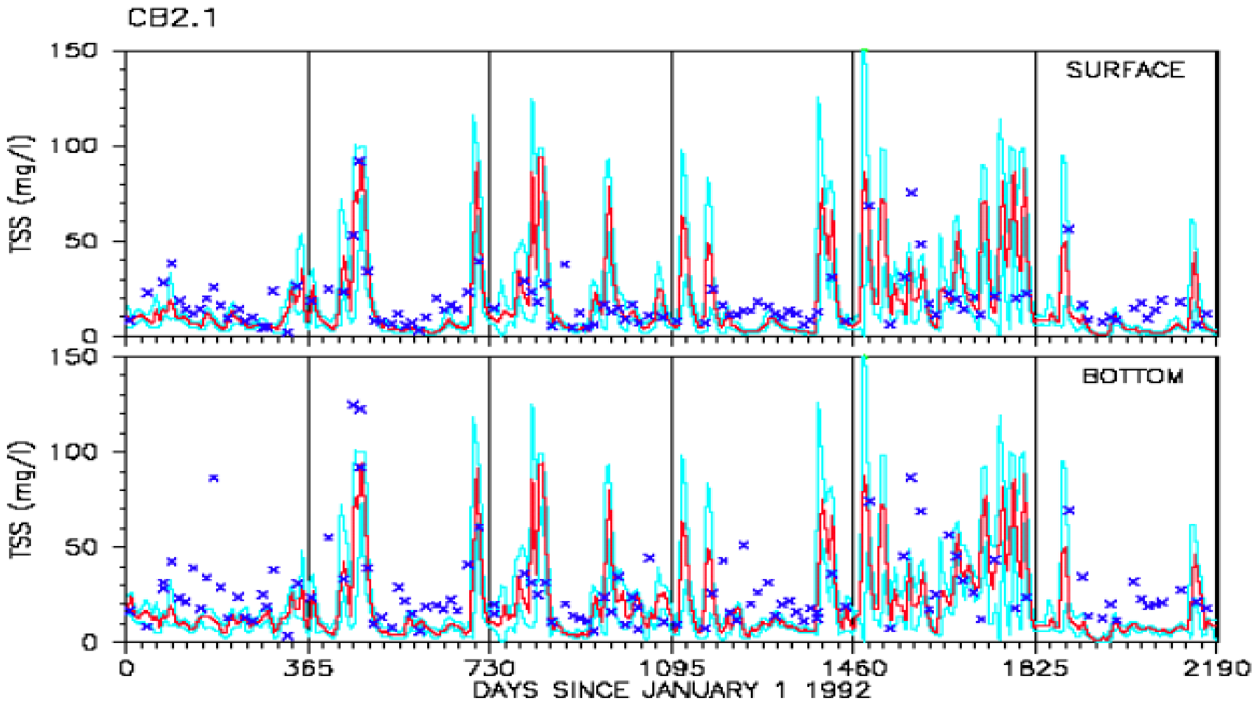
# Additional slide for reference:

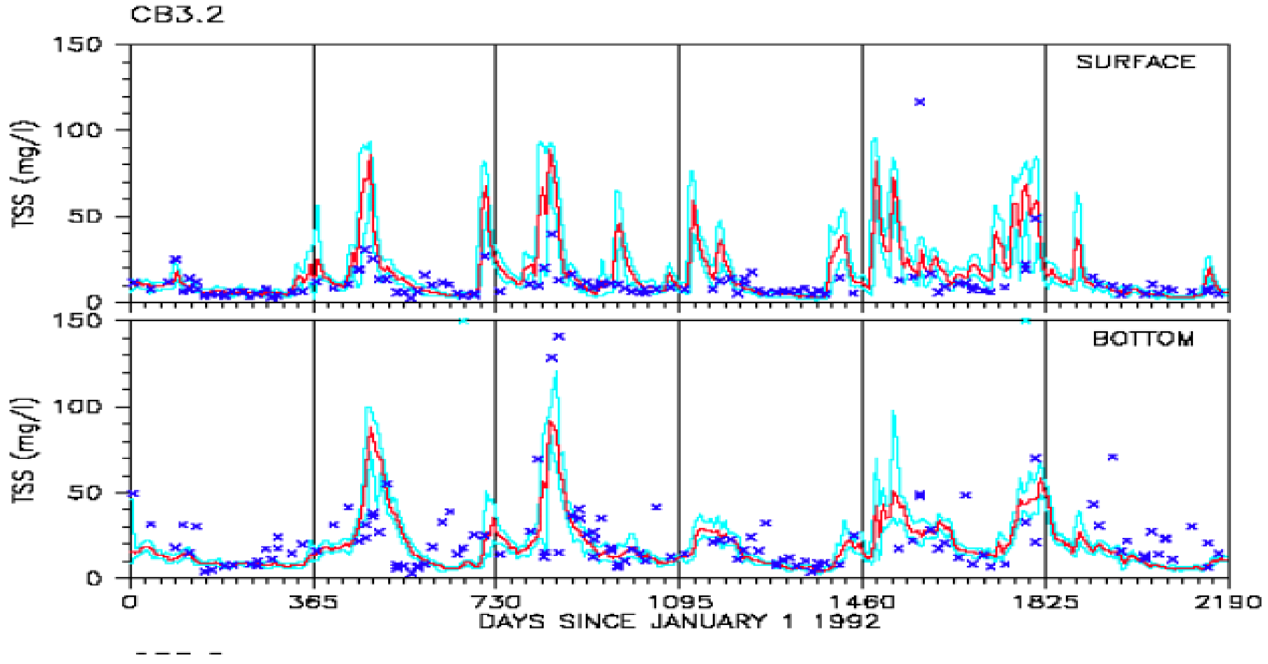
**Sediment profile was determined by**:

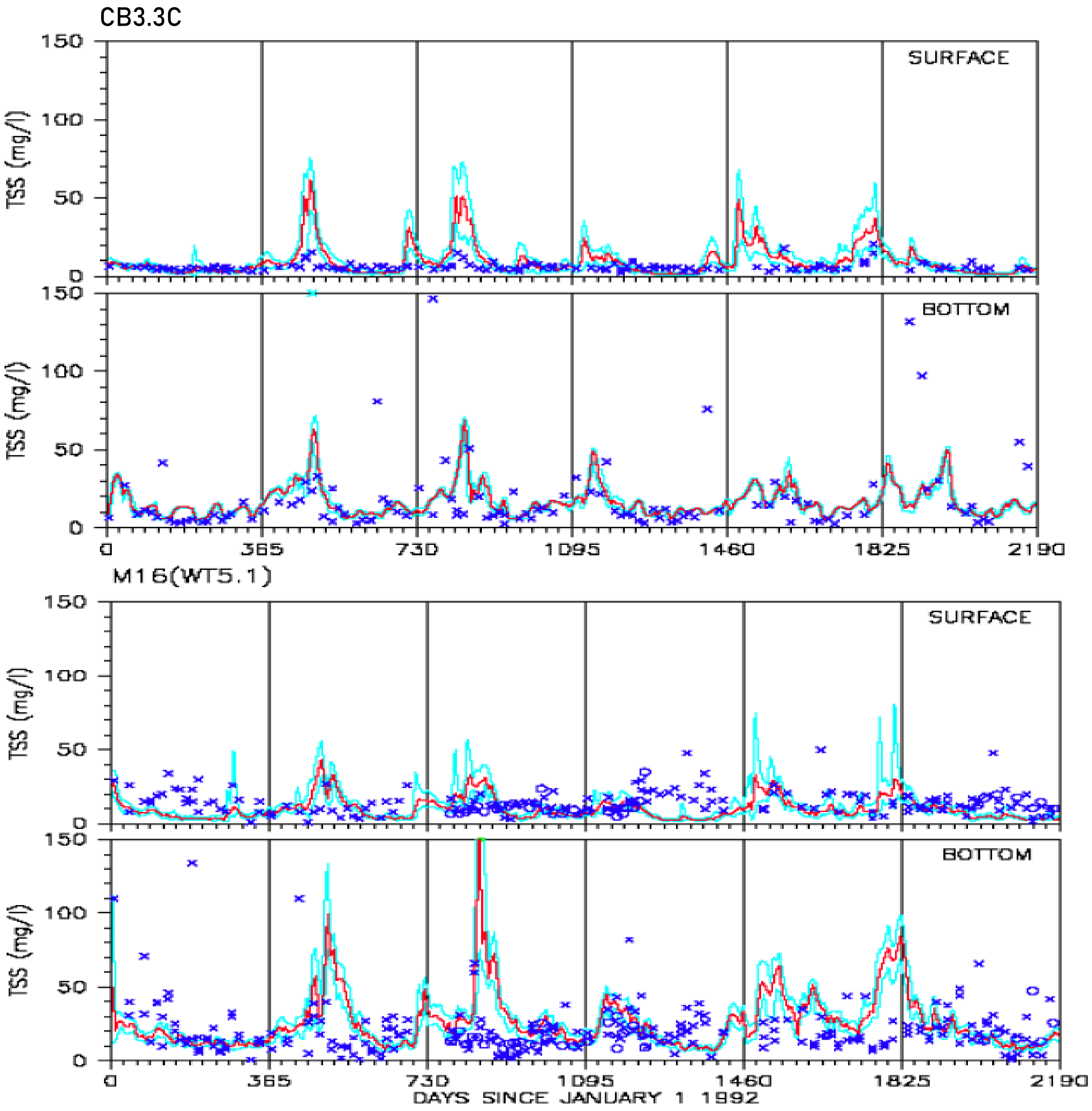
```
TSS = tss2c * POC
```

- **TSS** = Total Suspended Solids (mg/L): The total concentration of particulate matter (organic + inorganic) suspended in water.
- **POC** = Particulate Organic Carbon (mg C/L): The portion of total organic carbon that is in particulate form.
- **tss2c** = Conversion factor (unit: mg TSS / mg C): A constant representing the ratio of TSS to POC, which accounts for both organic and inorganic components associated with organic carbon particles.

| Environment / Reference | tss2c Value (mg TSS / mg C) |
| --- | --- |
| ICM Model Defaults (EPA/CE-QUAL) often used in Chesapeake Bay and other systems | 2.0 – 4.0 |





CB3.3C
SURFACE
BOTTOM
TSS (mg/l)
150
100
50
0
365
730
1095
1460
1825
2190
M16(WT5.1)
SURFACE
BOTTOM
DAYS SINCE JANUARY 1 1992