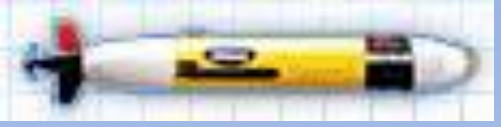

Spatio-Temporal Evolution of Hypoxia in Sub-Estuaries of the Chesapeake Bay

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U.S. Naval Academy

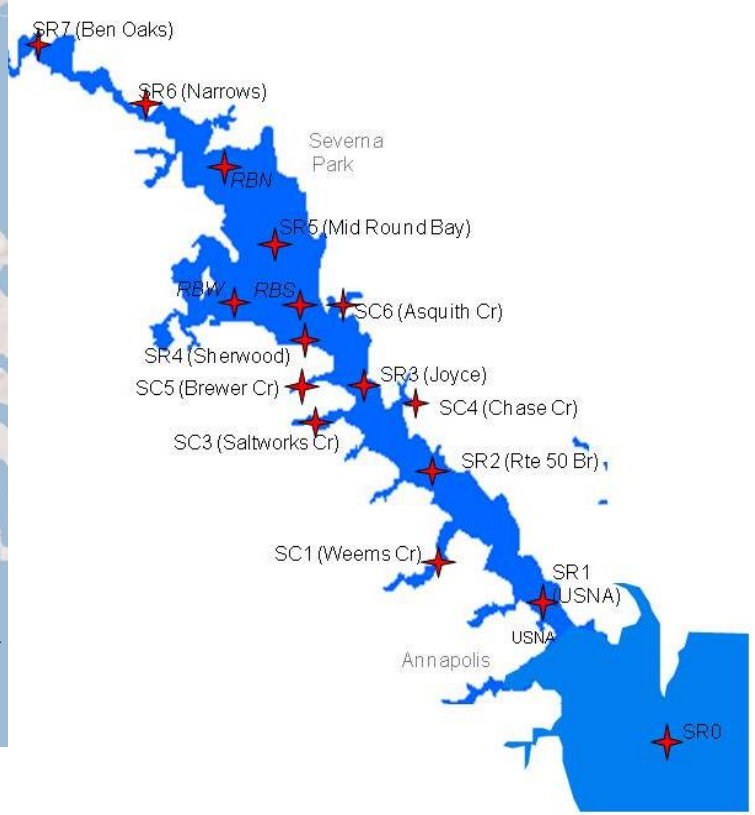
South River Federation

Spatial Variability vs. Temporal Variability

- In any monitoring program or research Endeavour to understand the bio-physical process that dominate ecological systems we must sacrifice either the spatial or temporal components.

- Spatial intensive – lower temporal resolution
- Temporal intensive – lower horiz. spatial resolution
    - May loose vertical dimension

Resolving the Spatio-Temporal dilemma



South and Severn River stations

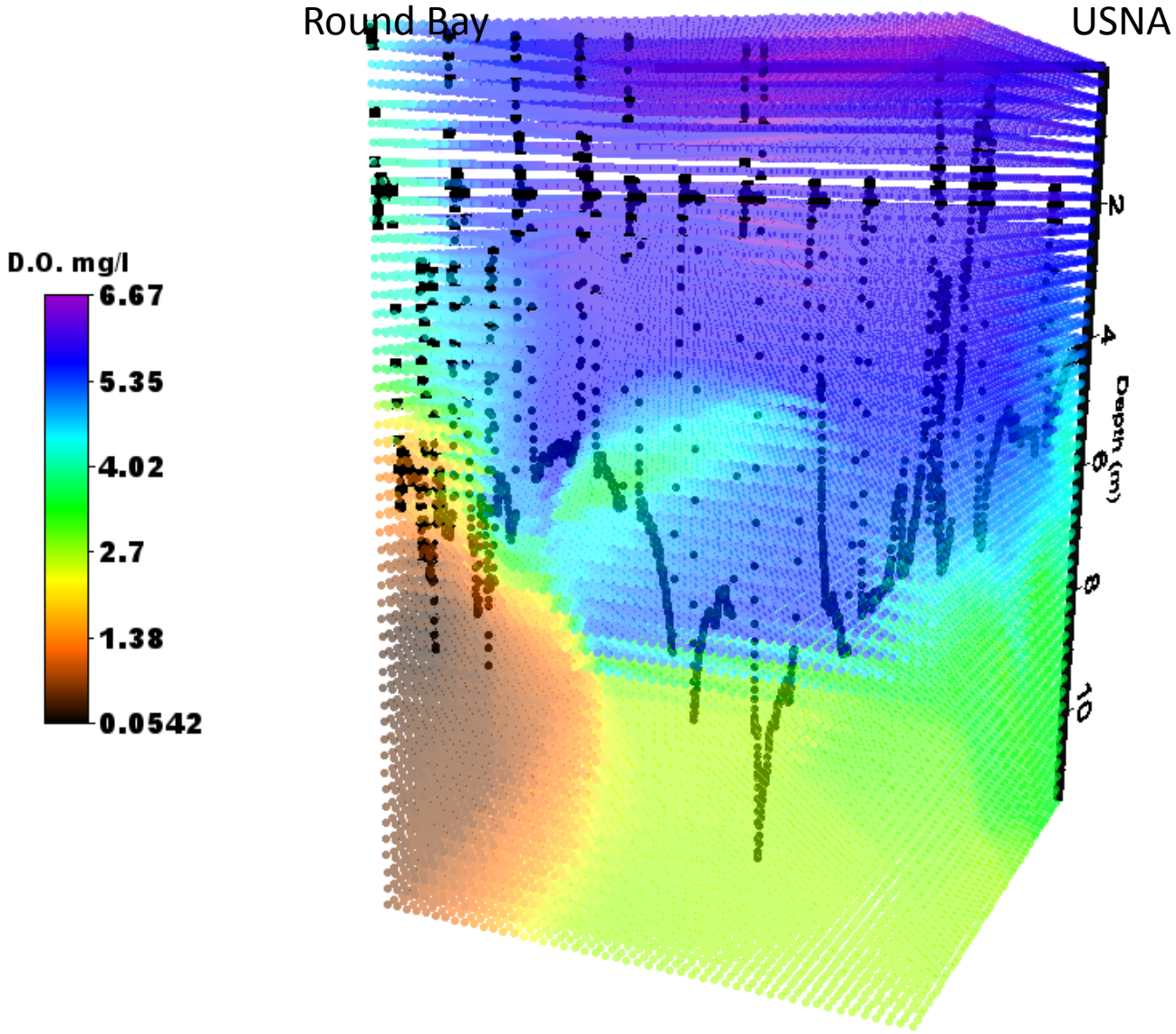
Resolving the Spatio-Temporal dilemma

- REMUS 100

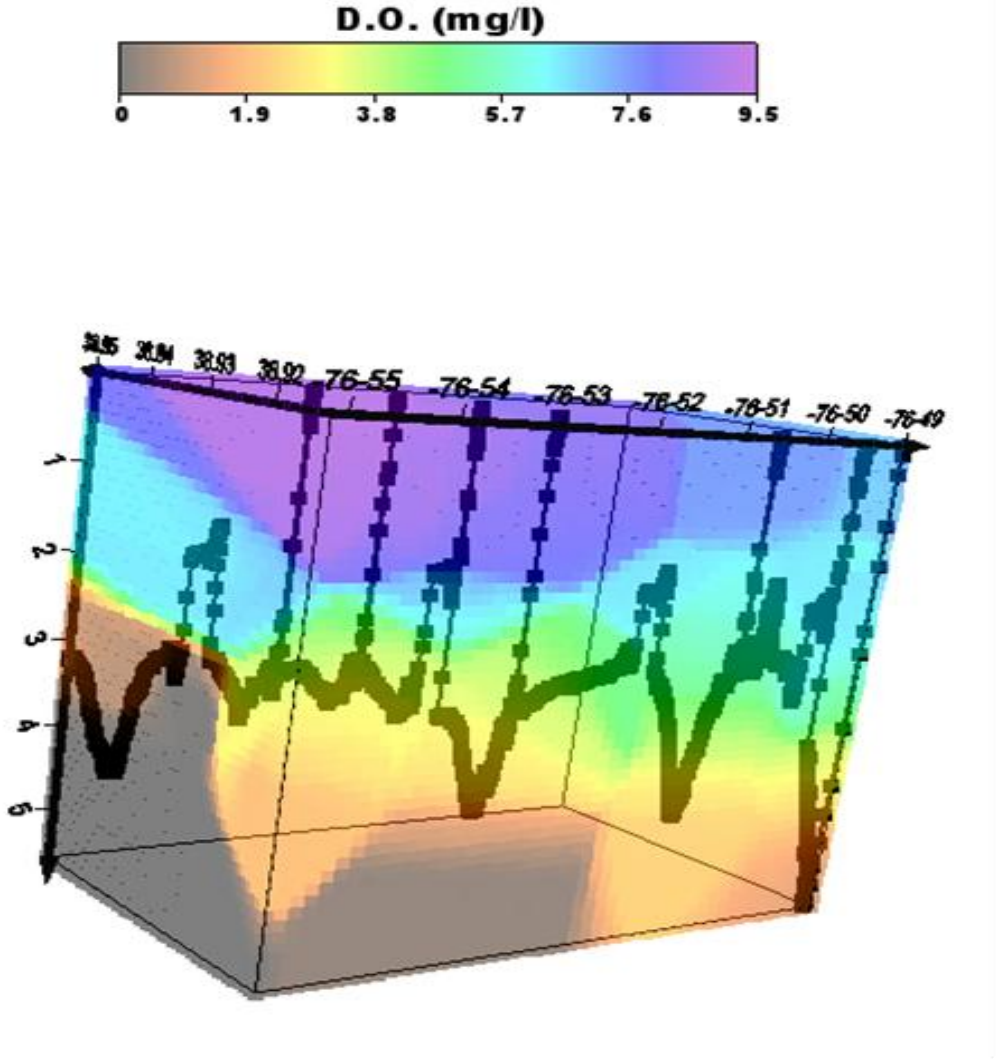
- HydroLab DS 5

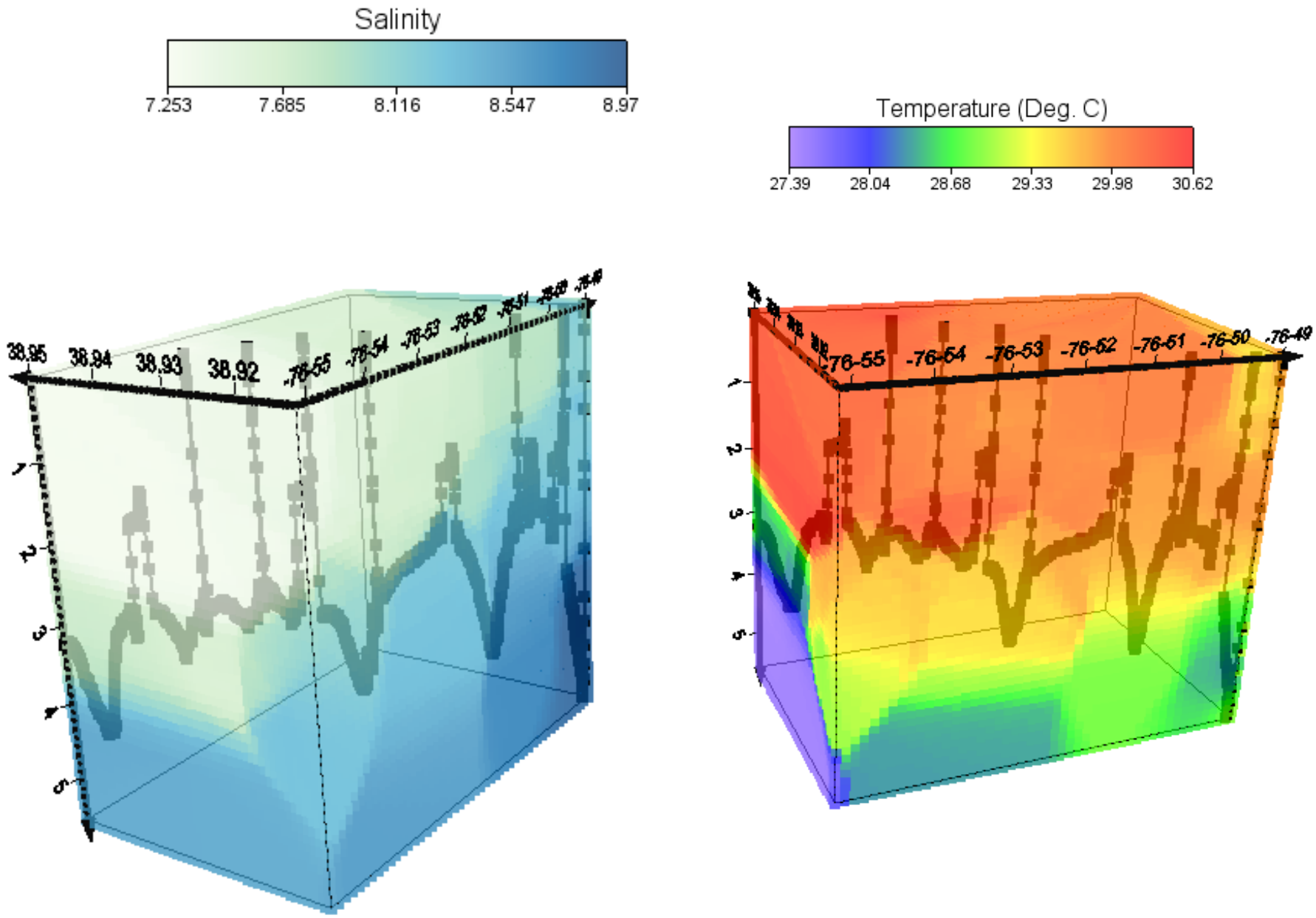
- NOAA Annapolis Buoy

Severn River 6-15-2011

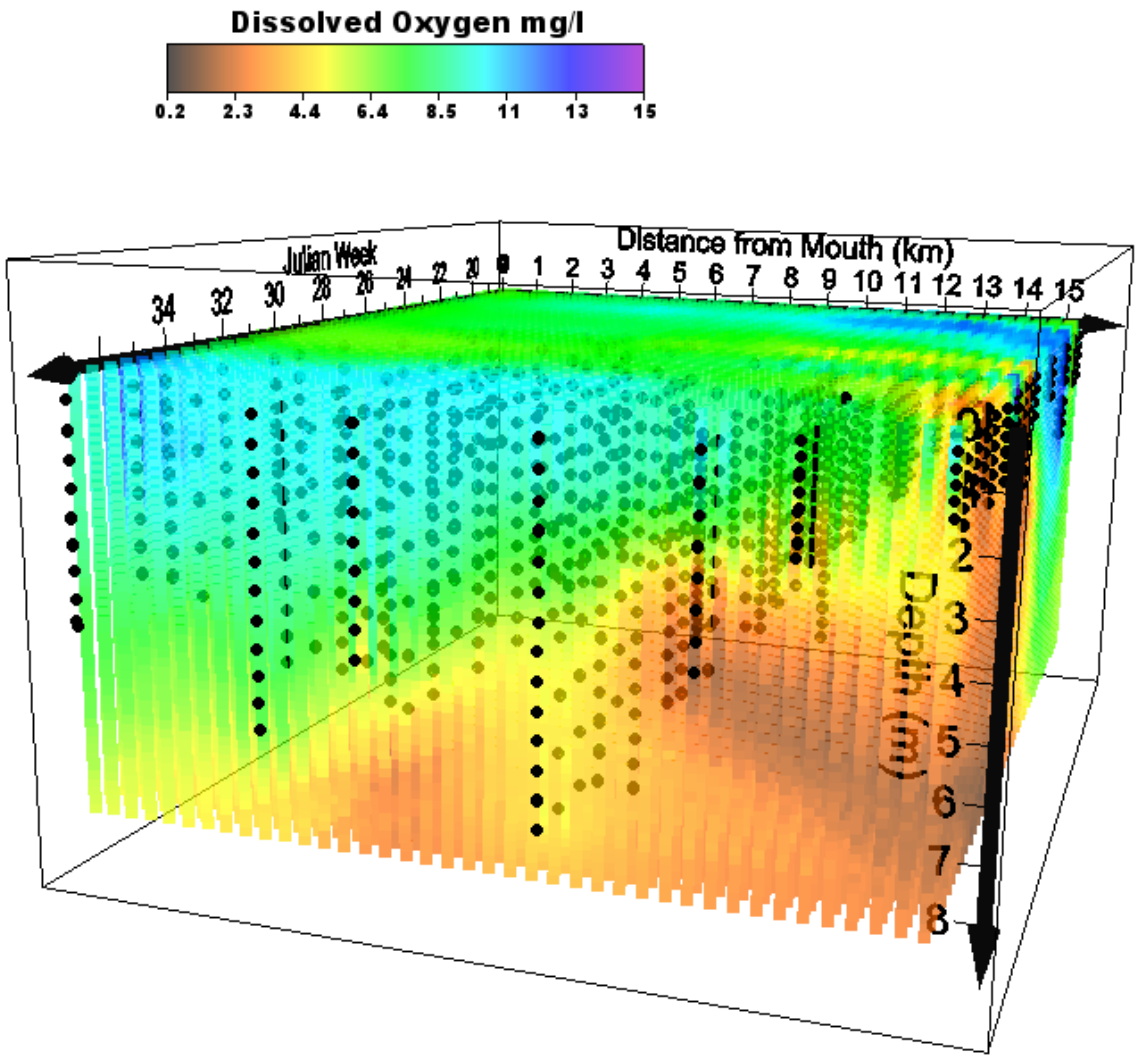


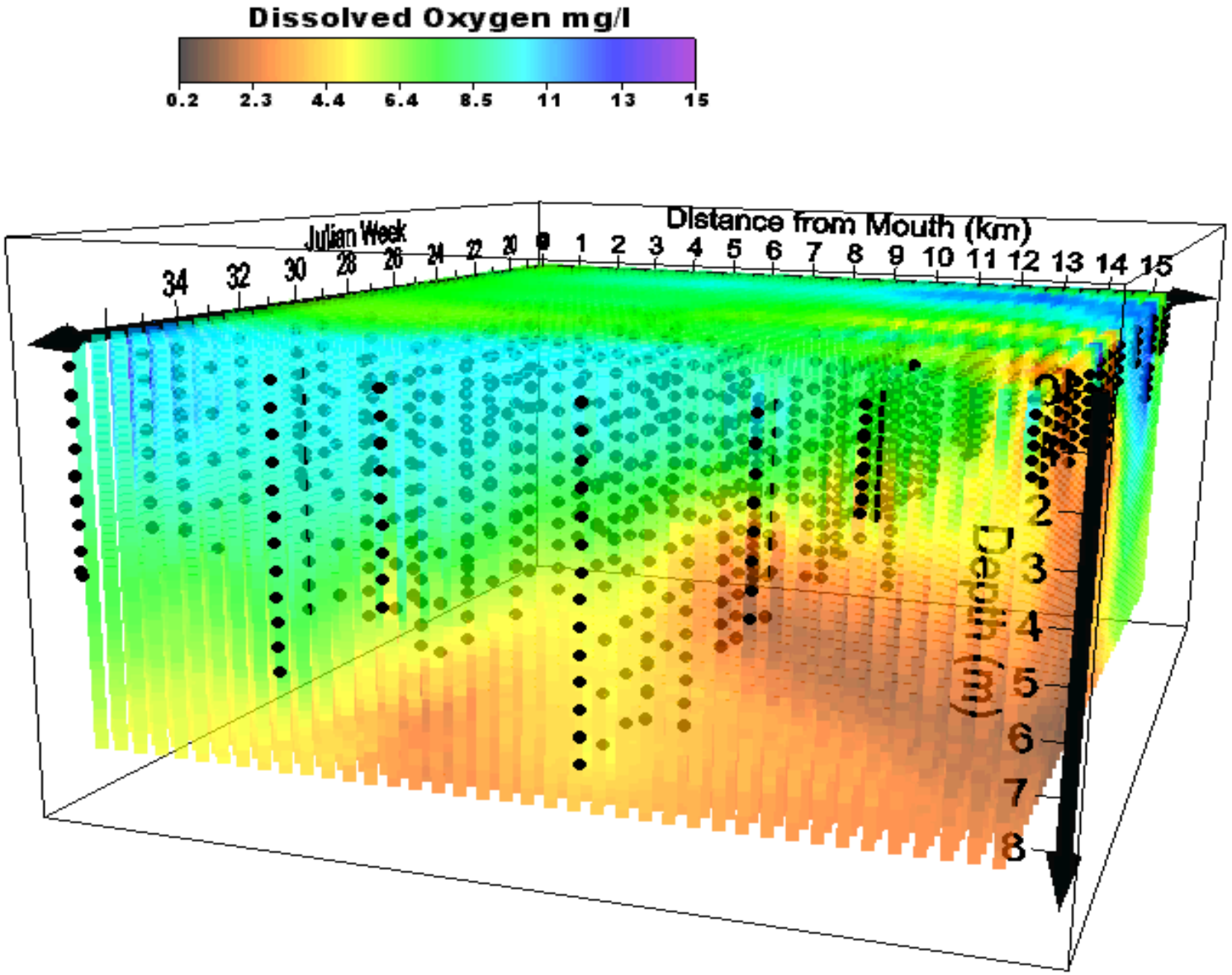
South River 7-22-11



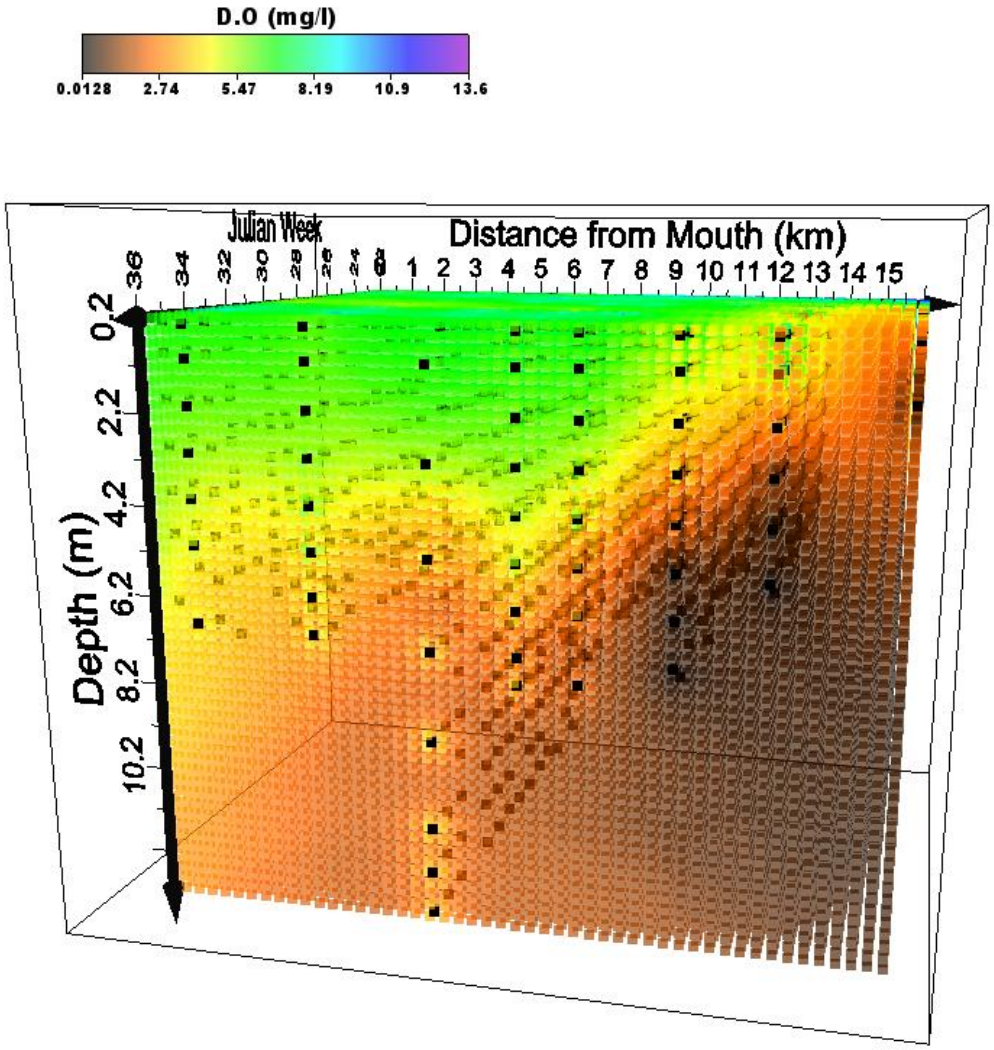

Salinity
7.253
7.685
8.116
8.547
8.97
Temperature (Deg. C)
27.39
28.04
28.68
29.33
29.98
30.62
38.95
38.94
38.93
38.92
-76-55
-76-54
-76-53
-76-52
-76-51
-76-50
-76-49

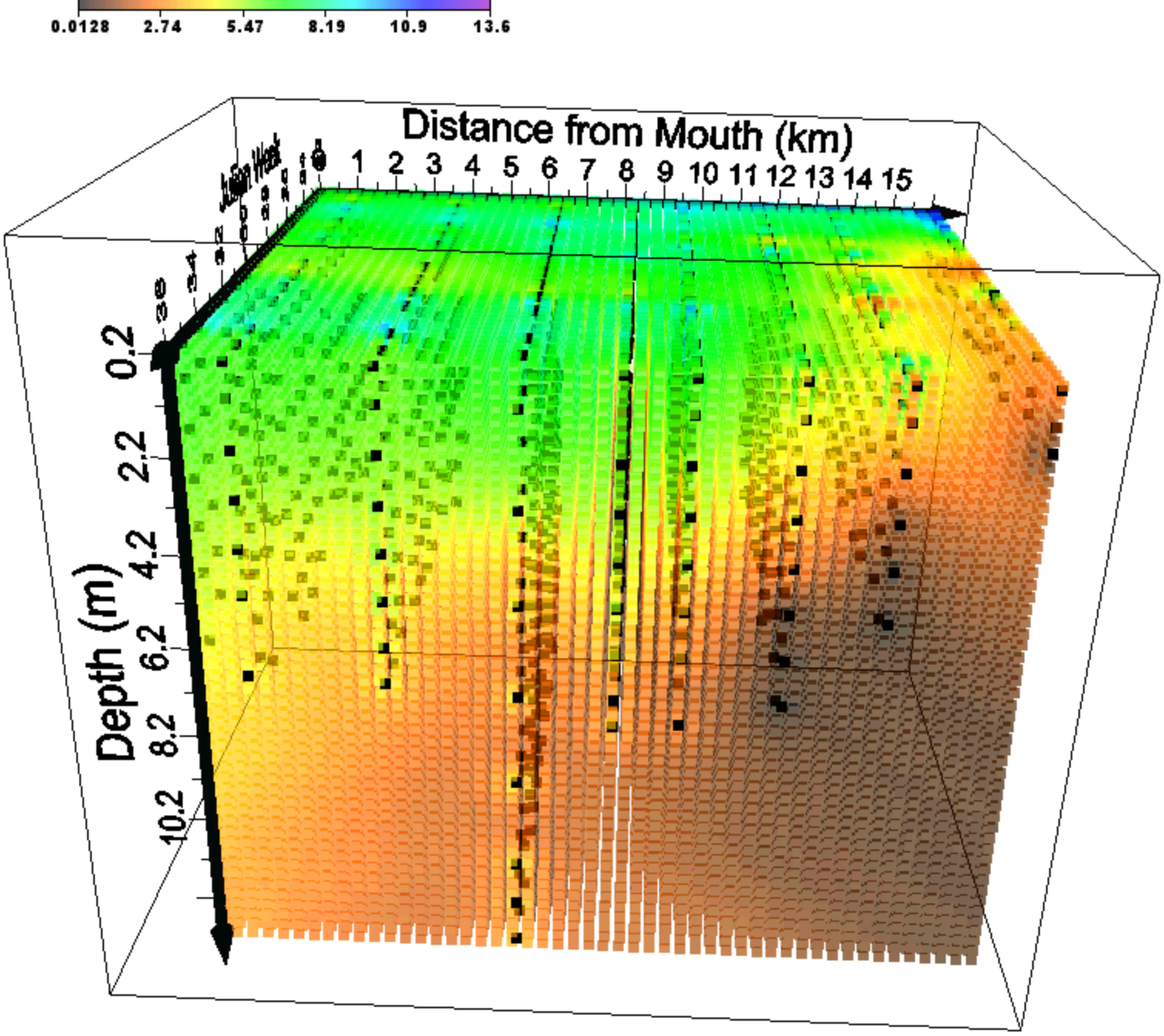
South River D.O.

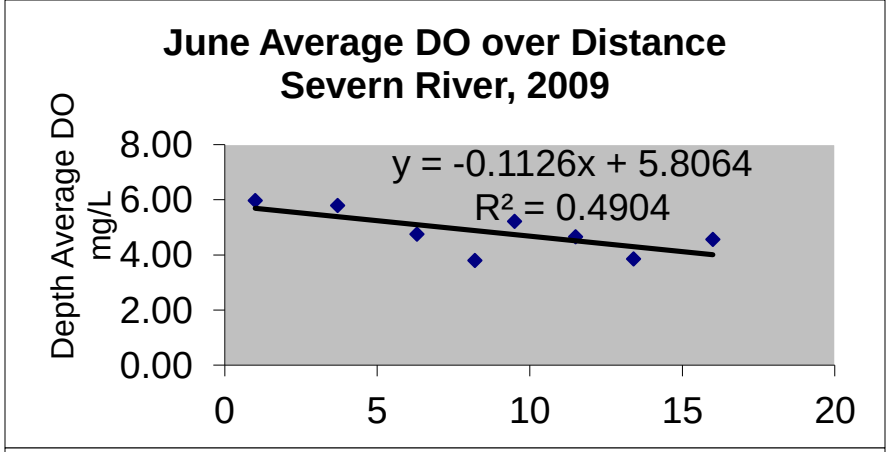


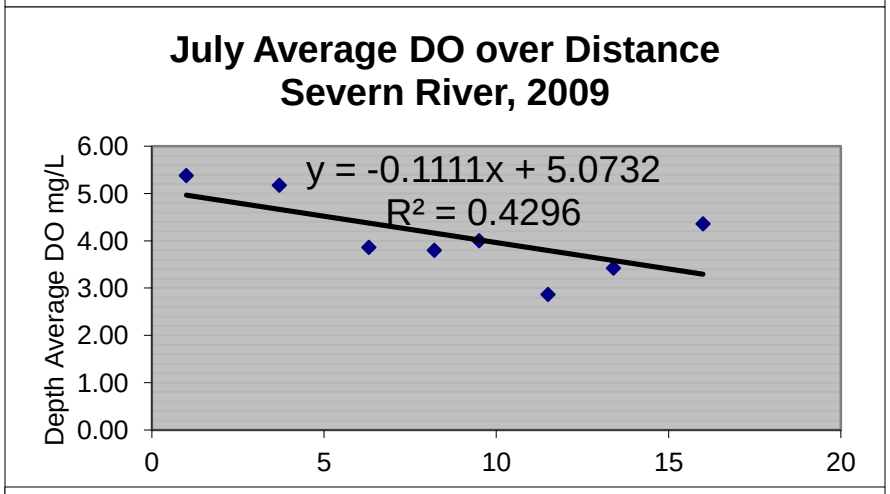

Dissolved Oxygen mg/l
0.2
2.3
4.4
6.4
8.5
11
13
15
Julian Week
34
32
30
28
26
24
22
20
Distance from Mouth (km)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Depth (m)
1
2
3
4
5
6
7
8

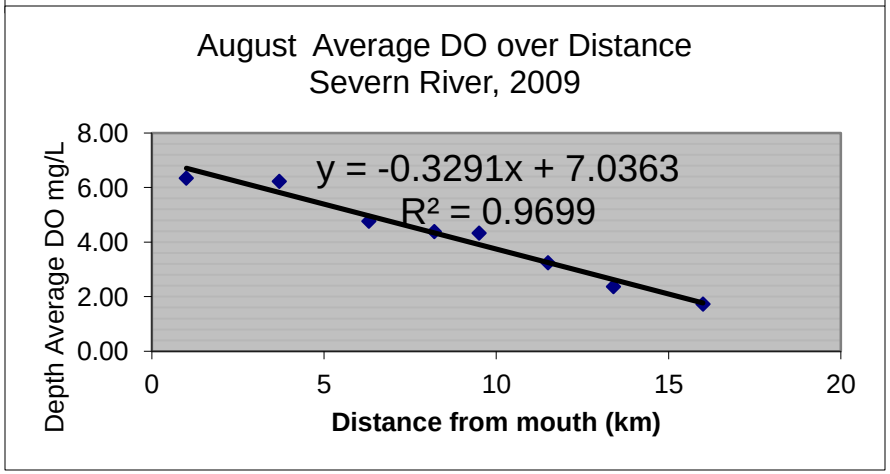
Severn River D.O.



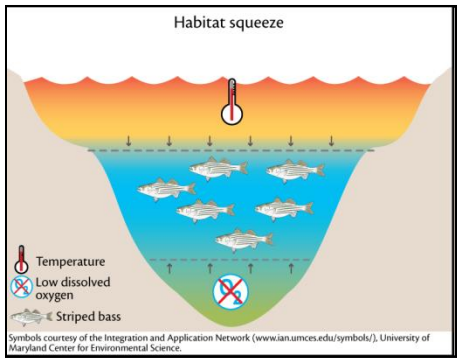

0.0128
2.74
5.47
8.19
10.9
13.6
Distance from Mouth (km)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Depth (m)
0.2
2.2
4.2
6.2
8.2
10.2


June Average DO over Distance
Severn River, 2009
Depth Average DO mg/L
8.00
6.00
4.00
2.00
0.00
0
5
10
15
20
y = -0.1126x + 5.8064
R² = 0.4904


July Average DO over Distance
Severn River, 2009
Depth Average DO mg/L
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0
5
10
15
20
y = -0.1111x + 5.0732
R² = 0.4296

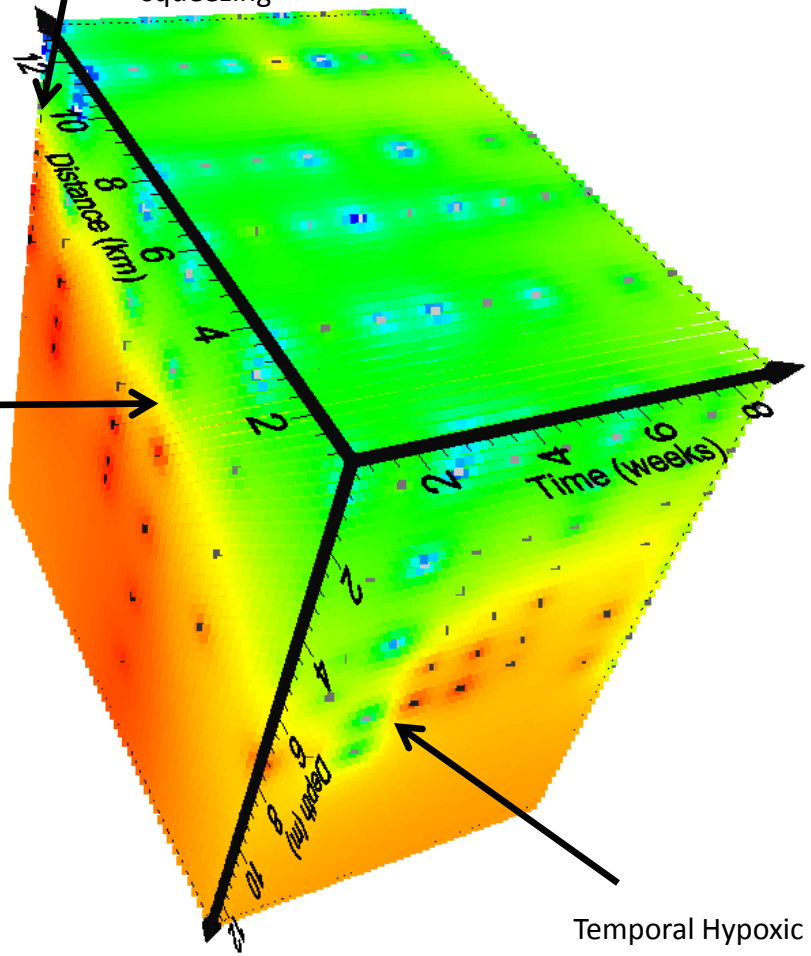

August Average DO over Distance
Severn River, 2009
Depth Average DO mg/L
8.00
6.00
4.00
2.00
0.00
0
5
10
15
20
y = -0.3291x + 7.0363
R² = 0.9699
Distance from mouth (km)

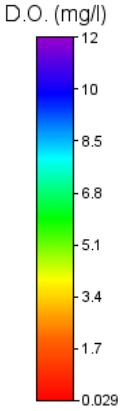
Feeling the Hypoxic Squeeze in 3-D



Vertical Hypoxic squeezing

Lateral hypoxic squeezing





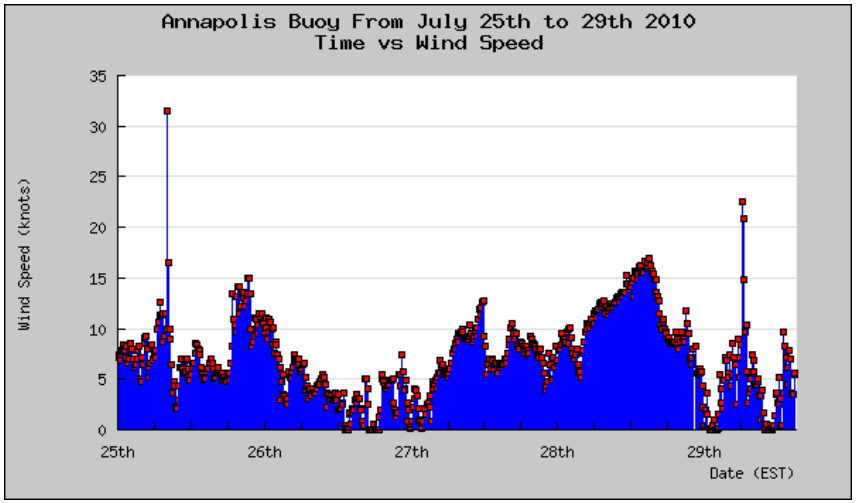
Temporal Hypoxic squeezing

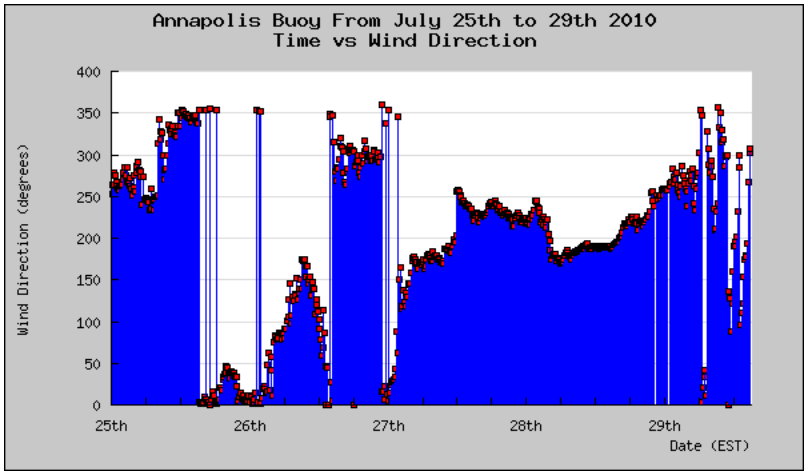
Hypoxic Squeeze Index

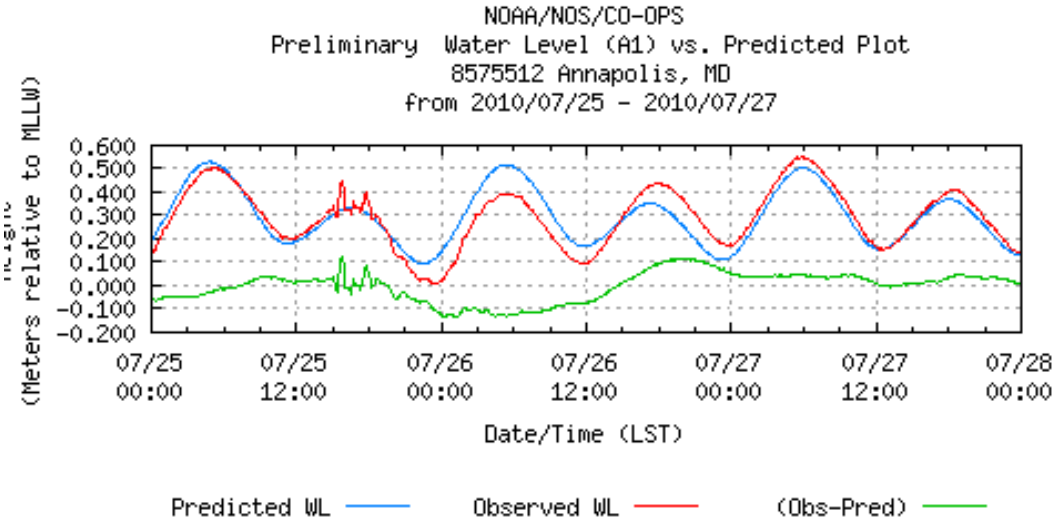
- How do we calculate how much squeezing has occurred and what is the threshold for fish kills?

$$\left(\frac{\left| DO_{surface} - DO_{Bottom} \right|}{DepthAvg.DO} \right)$$

Cause of Severn River Fish Kill
26 July 2010







Conclusions

- It is possible to map bio-physical process in the spatio-temporal domain by intensive multiplatform monitoring
- Fleet of REMUS 100's may be the future
- The South and Severn Rivers have similarities and differences related to timing and strength of stratification leading to different emergent D.O structures

- Hypoxic squeezing is realized in both spatial and temporal domains- leading to a better understanding of fish kill prediction
- Combining buoy data at the mouth with weekly intensive monitoring and REMUS runs may allow us to hindcast environmental conditions throughout the sub-estuary from just the buoy alone!