The Triblet Connection

Nodal Point Pollutant Sources South and Severn River Estuaries

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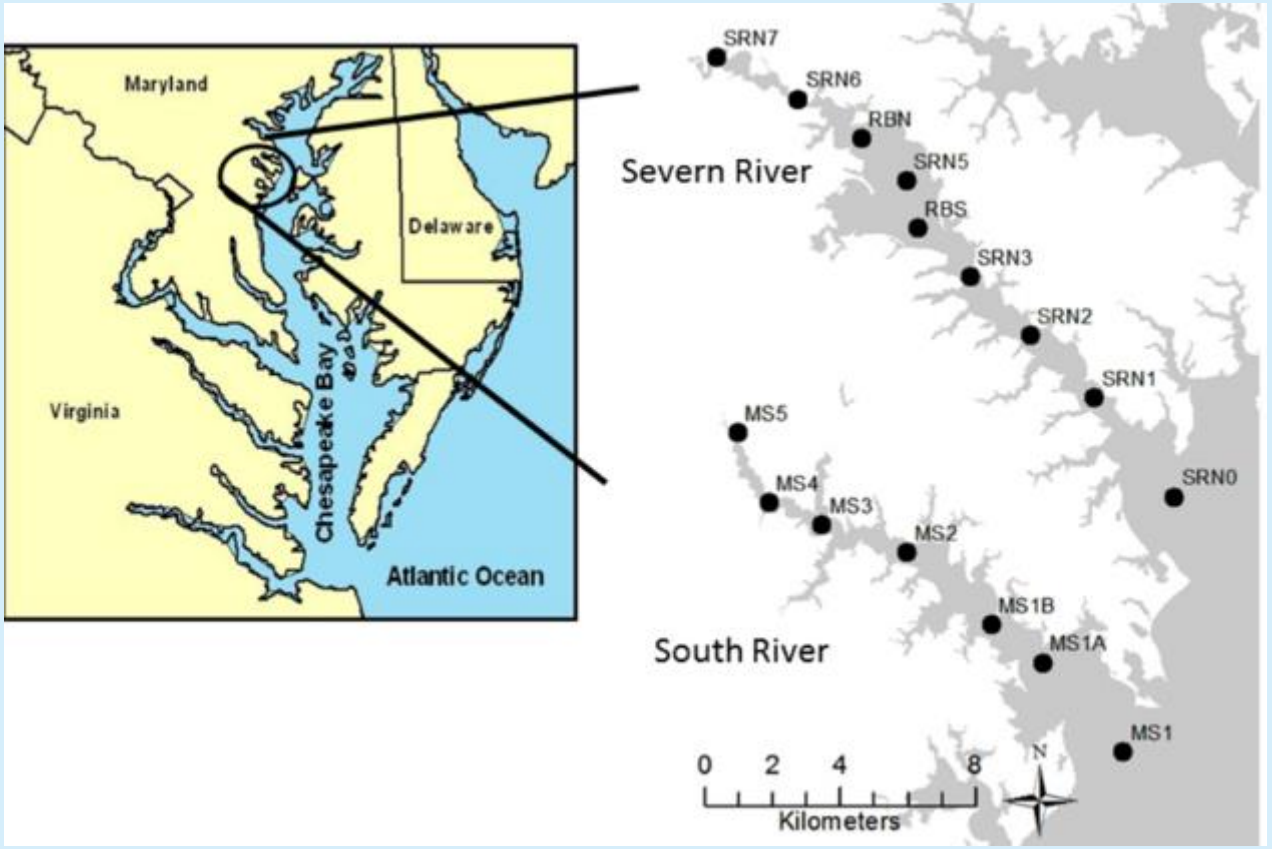
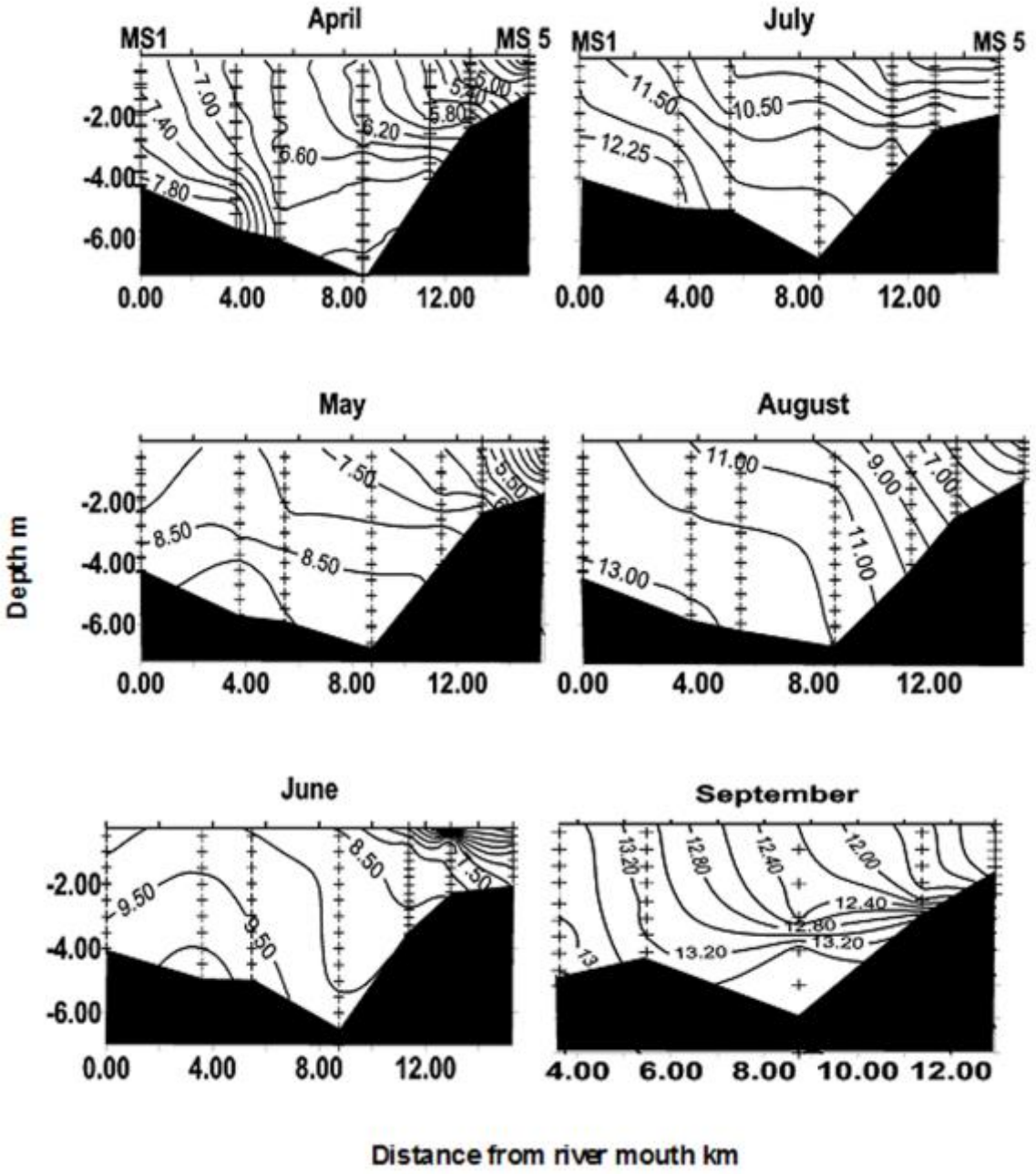
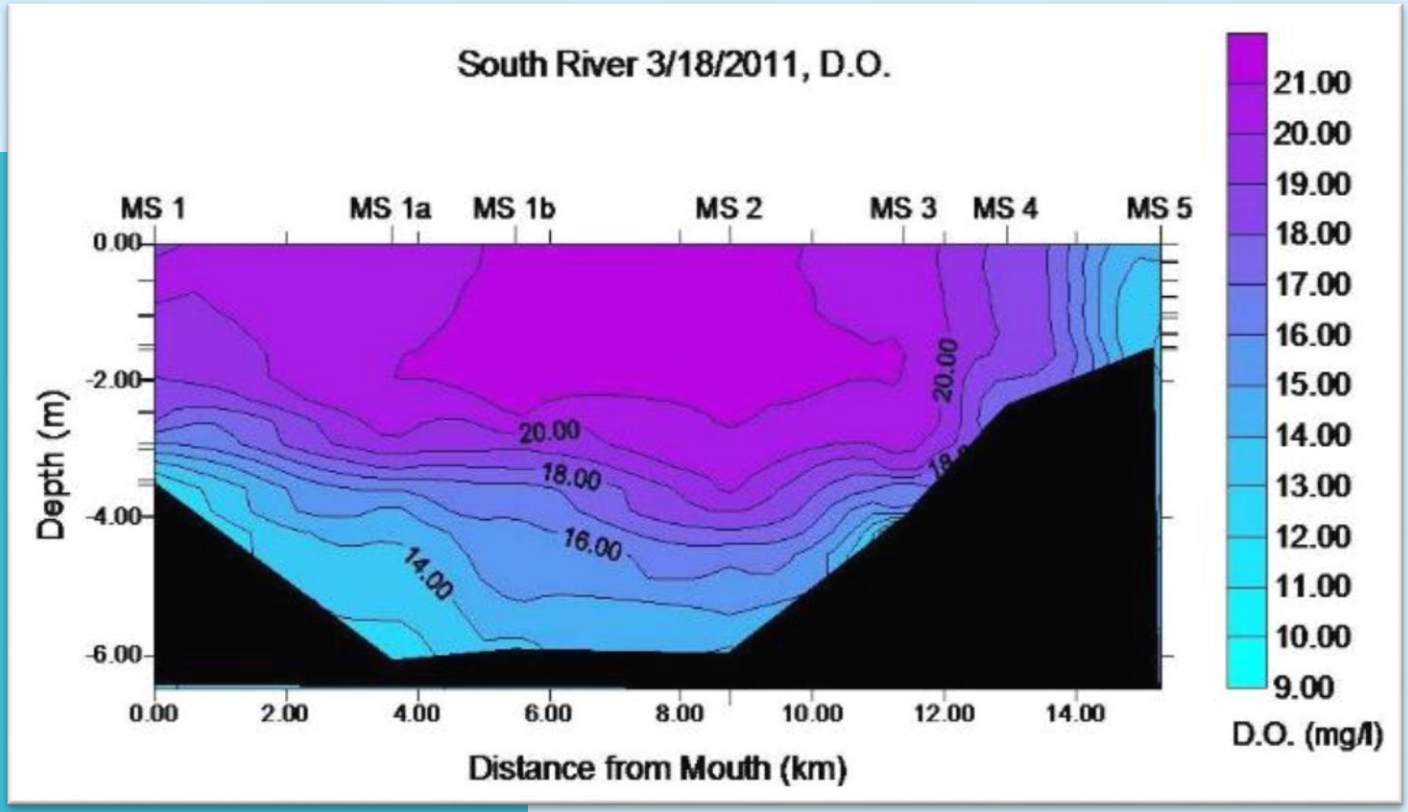
Location and Stations



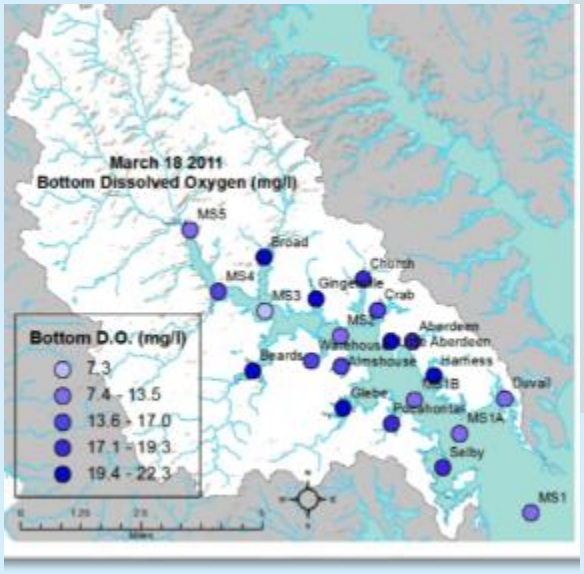
Median Monthly Salinity distribution in the South River, MD.

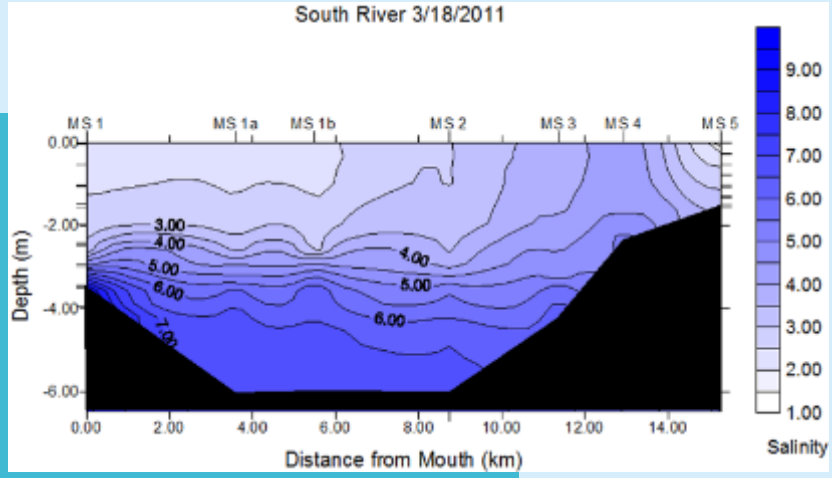


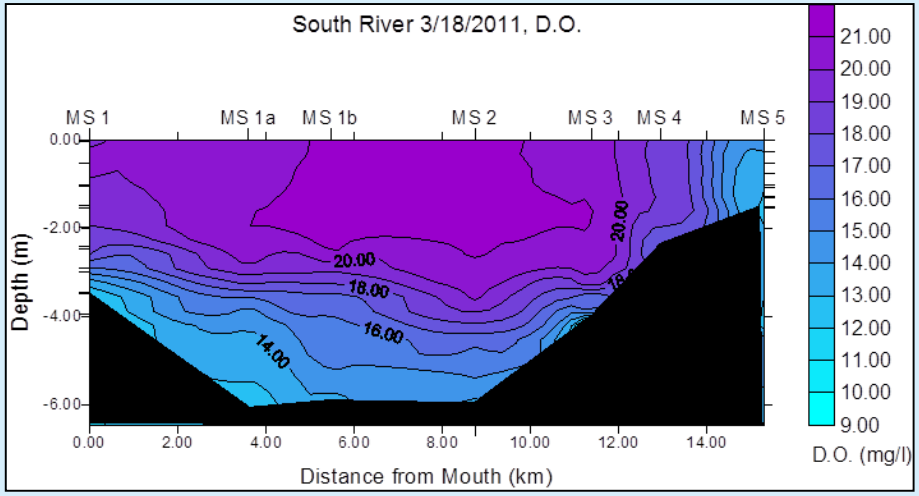


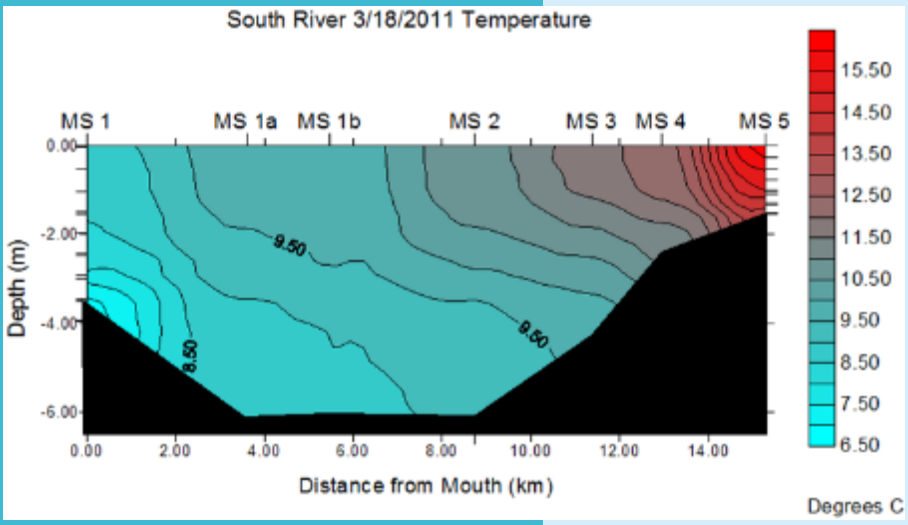
Release of Conowingo Dam

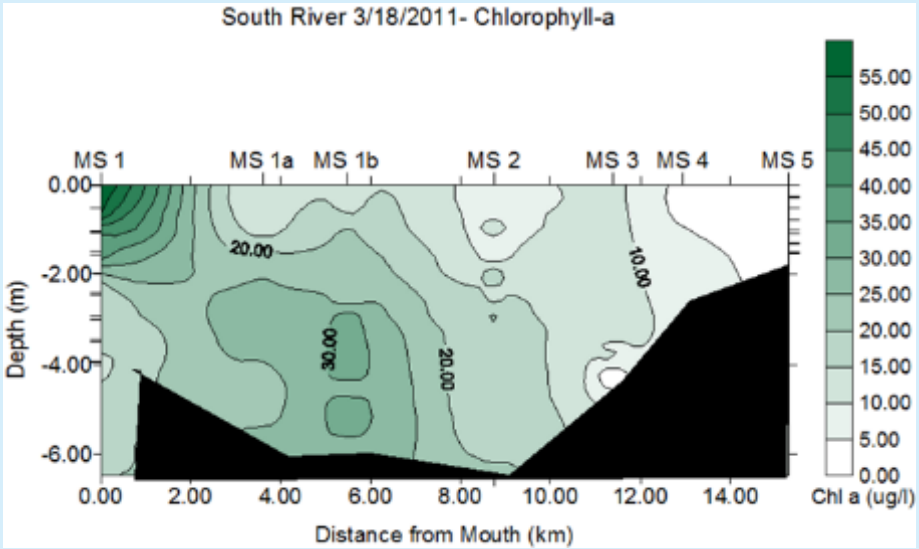
26 of 50 gates opened



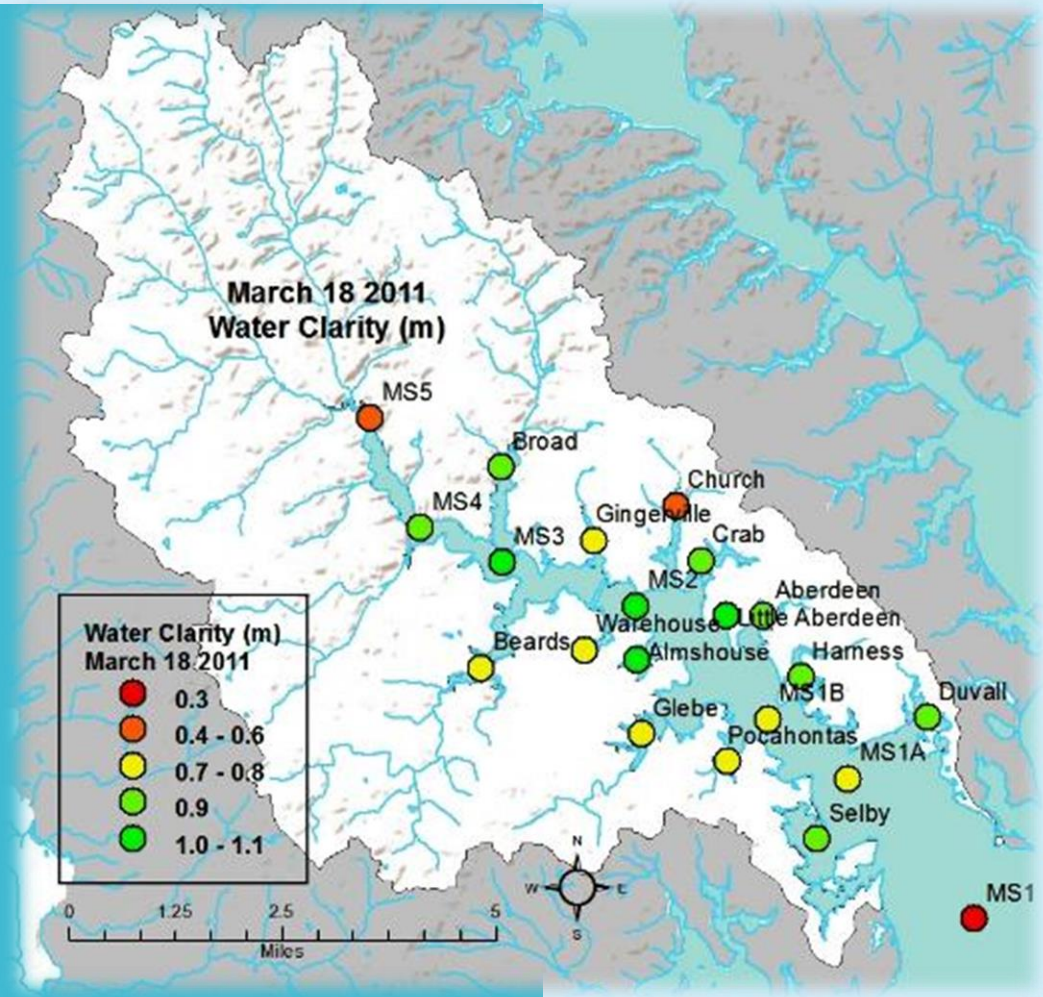

South River 3/18/2011
MS 1
MS 1a
MS 1b
MS 2
MS 3
MS 4
MS 5
Depth (m)
Distance from Mouth (km)
Salinity


South River 3/18/2011, D.O.
MS 1
MS 1a
MS 1b
MS 2
MS 3
MS 4
MS 5
Depth (m)
Distance from Mouth (km)
D.O. (mg/l)

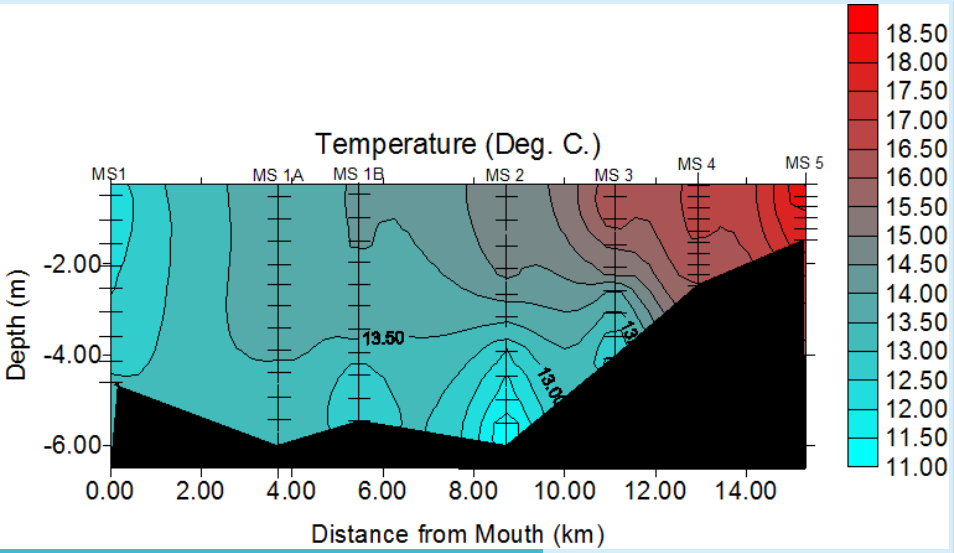

South River 3/18/2011 Temperature
MS 1
MS 1a
MS 1b
MS 2
MS 3
MS 4
MS 5
Depth (m)
Distance from Mouth (km)
Degrees C

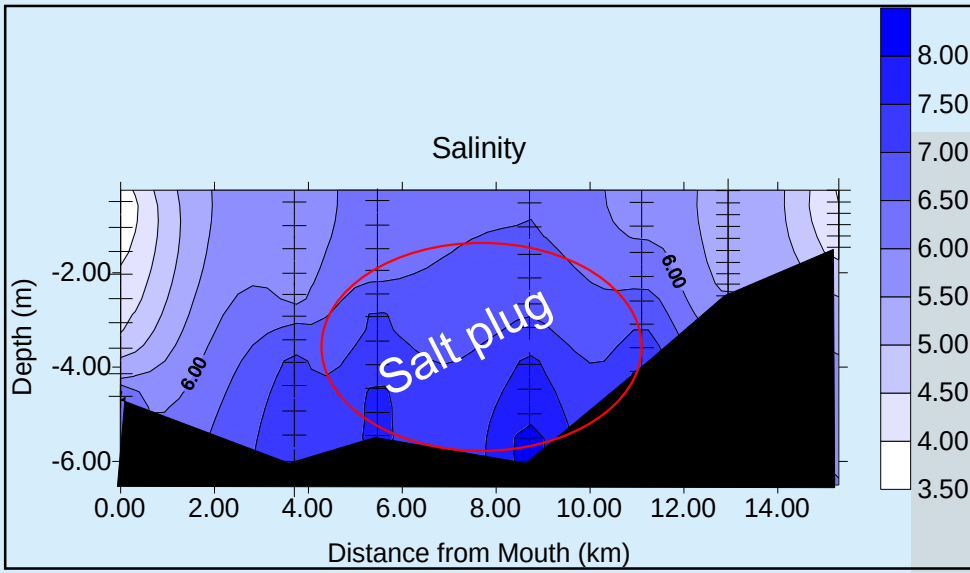

South River 3/18/2011- Chlorophyll-a
MS 1
MS 1a
MS 1b
MS 2
MS 3
MS 4
MS 5
Depth (m)
Distance from Mouth (km)
Chl a (ug/l)

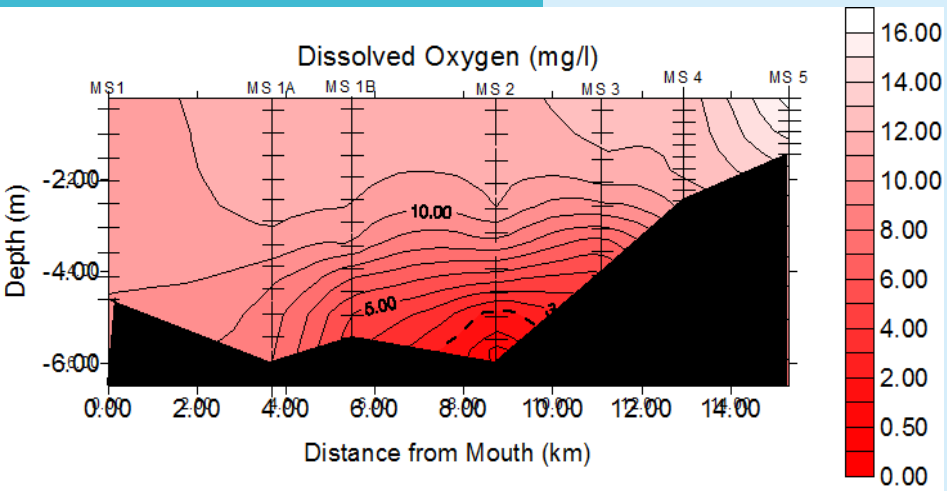
First release of the Conowingo Dam, March 18 2011

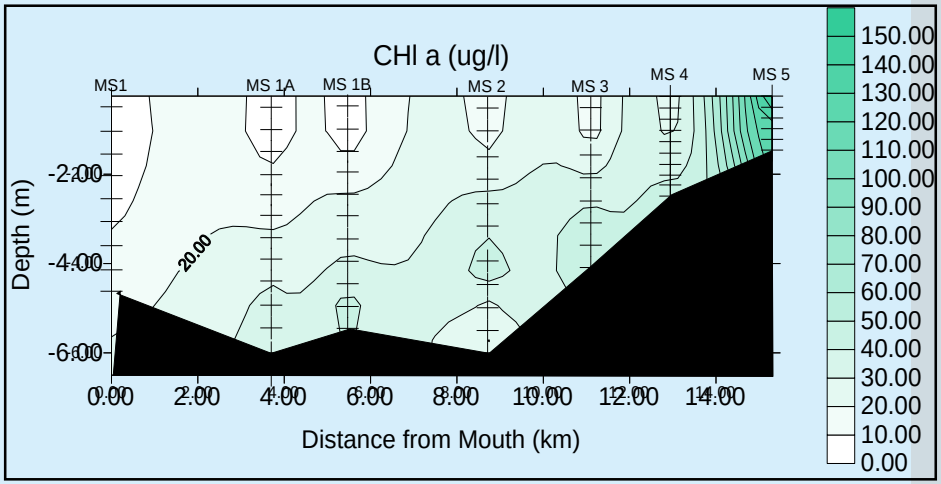


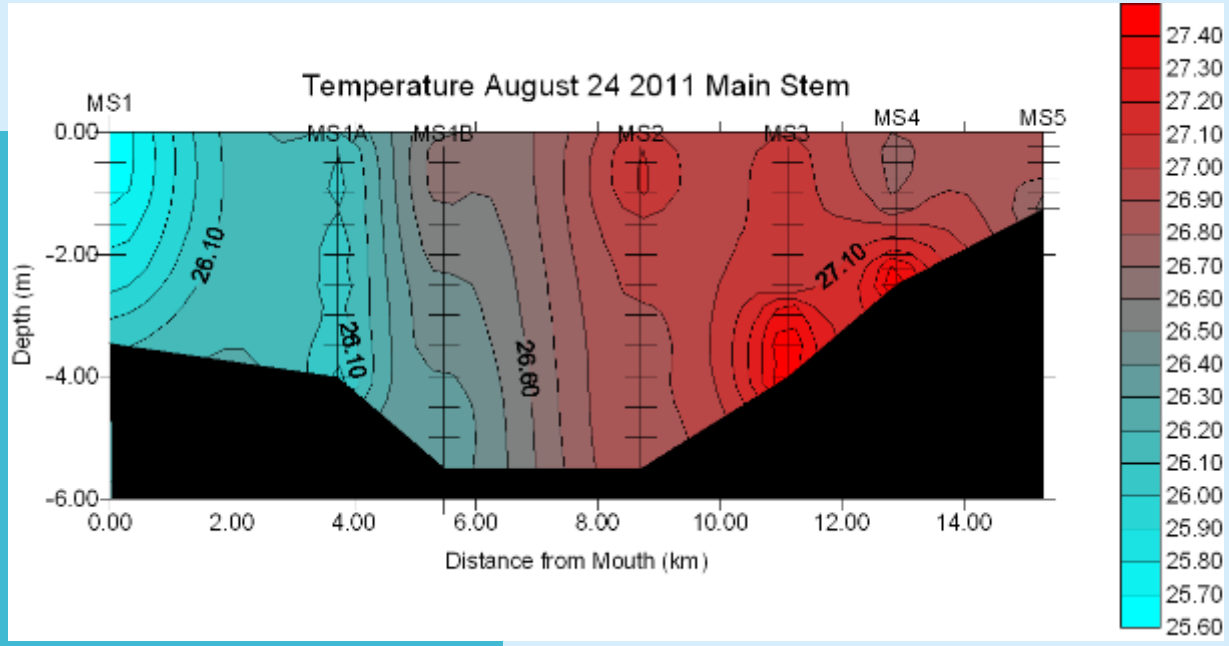
Rethinking how the Mid-Chesapeake Bay and South River Function

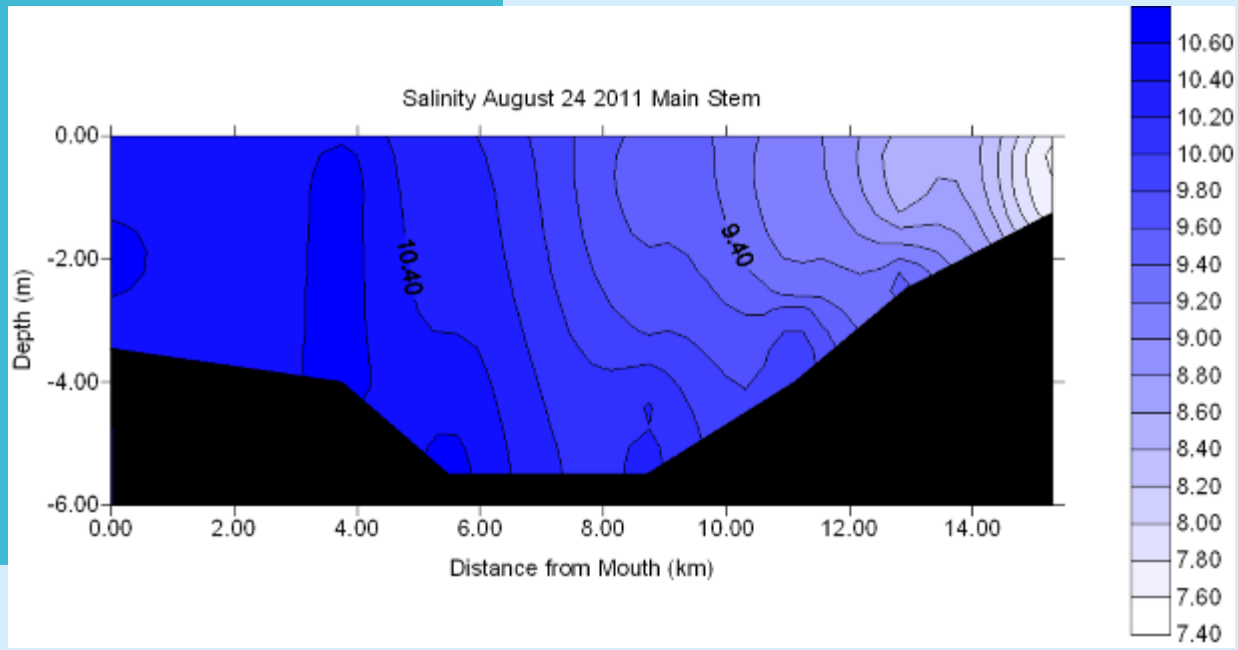

Temperature (Deg. C.)
MS1
MS 1A
MS 1B
MS 2
MS 3
MS 4
MS 5
Depth (m)
-2.00
-4.00
-6.00
13.50
13.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
Distance from Mouth (km)
18.50
18.00
17.50
17.00
16.50
16.00
15.50
15.00
14.50
14.00
13.50
13.00
12.50
12.00
11.50
11.00


Salinity
Depth (m)
-2.00
-4.00
-6.00
6.00
6.00
Salt plug
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
Distance from Mouth (km)
8.00
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
3.50


Dissolved Oxygen (mg/l)
MS1
MS 1A
MS 1B
MS 2
MS 3
MS 4
MS 5
Depth (m)
-2.00
-4.00
-6.00
10.00
6.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
Distance from Mouth (km)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.50
0.00


CHl a (ug/l)
MS1
MS 1A
MS 1B
MS 2
MS 3
MS 4
MS 5
Depth (m)
-2.00
-4.00
-6.00
20.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
Distance from Mouth (km)
150.00
140.00
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00

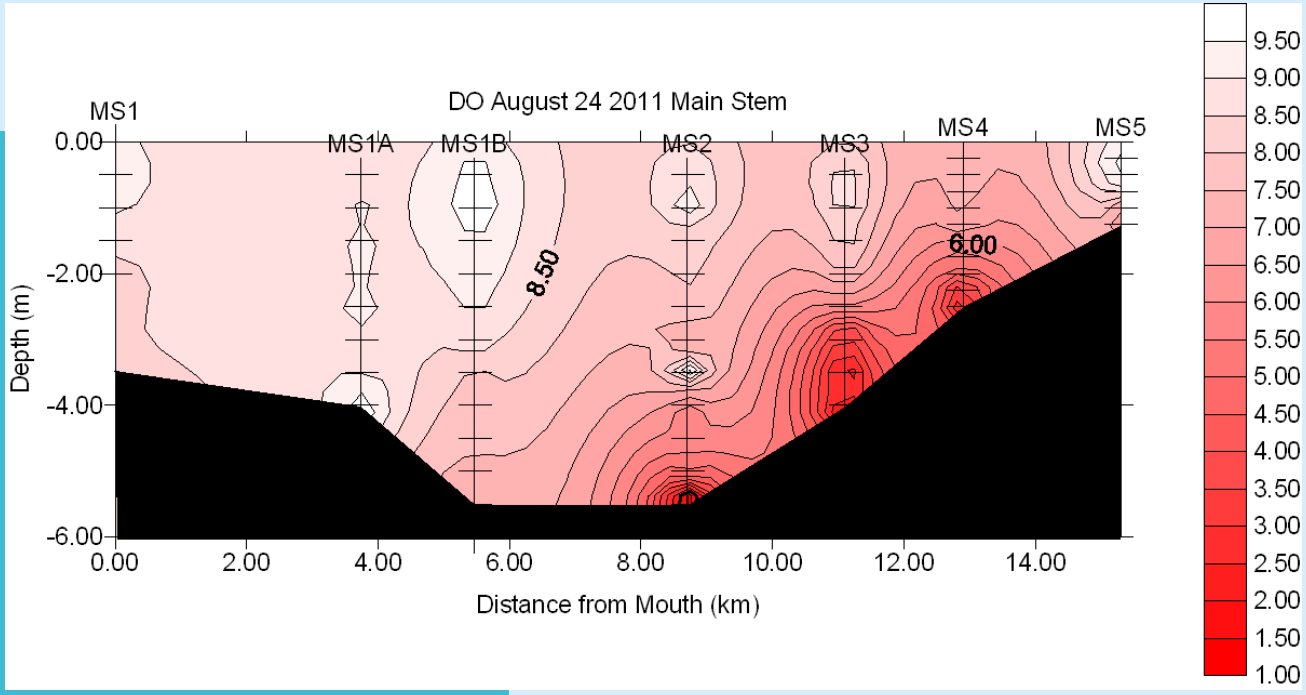


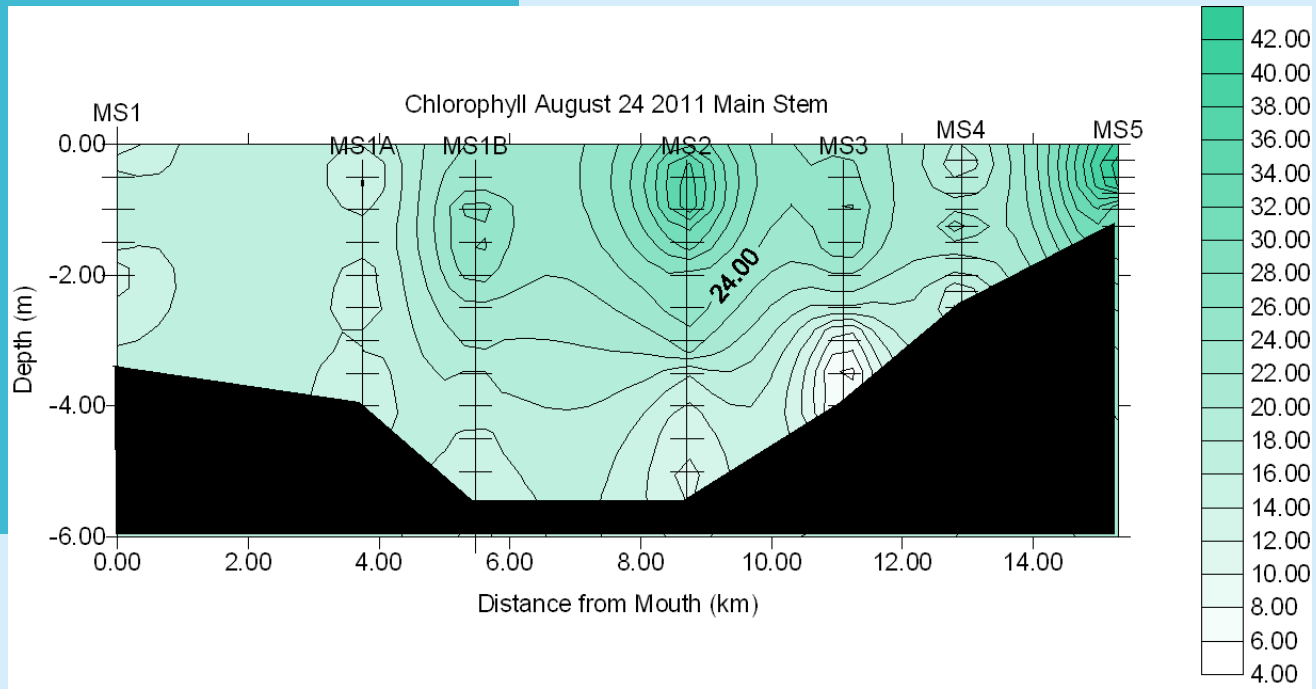


Beginning of Hurricane Irene

No thermocline

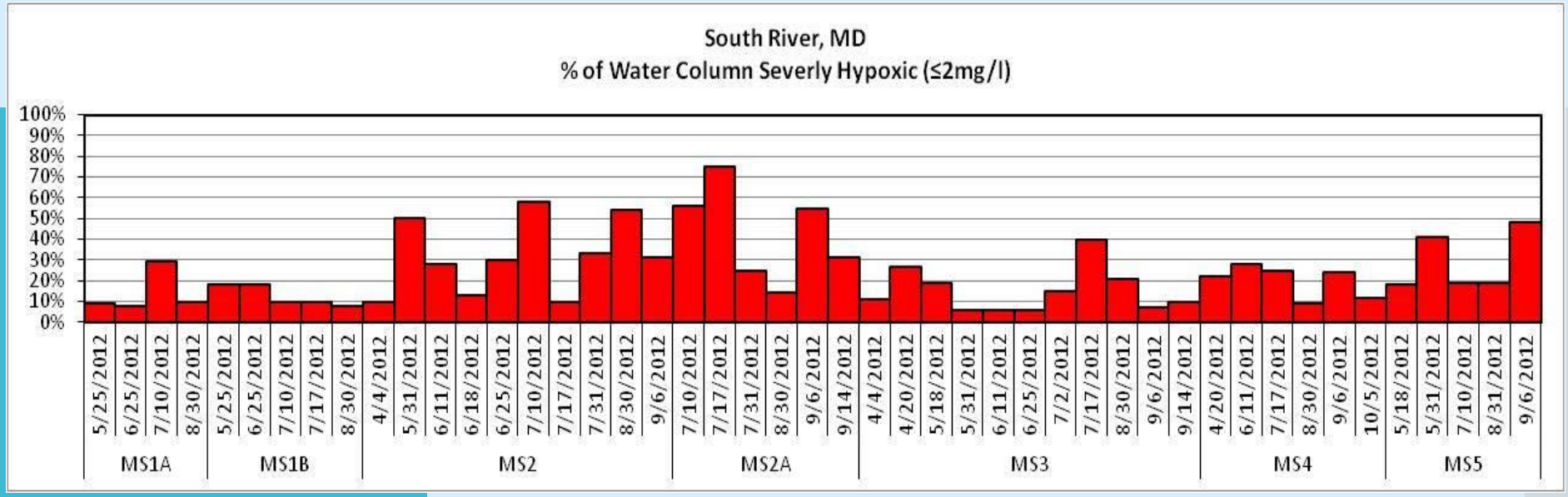
No halocline

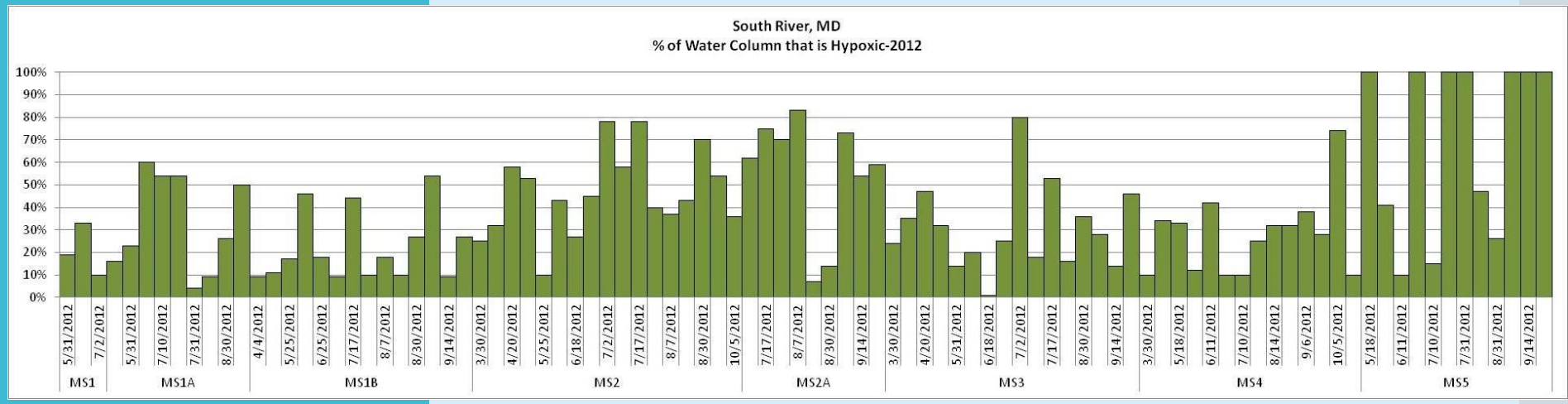




Low Dissolved Oxygen w/out pycnocline

Chl a “hot spot”


South River, MD
% of Water Column Severly Hypoxic (≤2mg/l)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
5/25/2012
6/25/2012
7/10/2012
8/30/2012
5/25/2012
6/25/2012
7/10/2012
7/17/2012
8/30/2012
4/4/2012
5/31/2012
6/11/2012
6/18/2012
6/25/2012
7/10/2012
7/17/2012
7/31/2012
8/30/2012
9/6/2012
7/10/2012
7/17/2012
7/31/2012
8/30/2012
9/6/2012
9/14/2012
4/4/2012
4/20/2012
5/18/2012
5/31/2012
6/11/2012
6/25/2012
7/2/2012
7/17/2012
8/30/2012
9/6/2012
9/14/2012
4/20/2012
6/11/2012
7/17/2012
8/30/2012
9/6/2012
10/5/2012
5/18/2012
5/31/2012
7/10/2012
8/31/2012
9/6/2012
MS1A
MS1B
MS2
MS2A
MS3
MS4
MS5

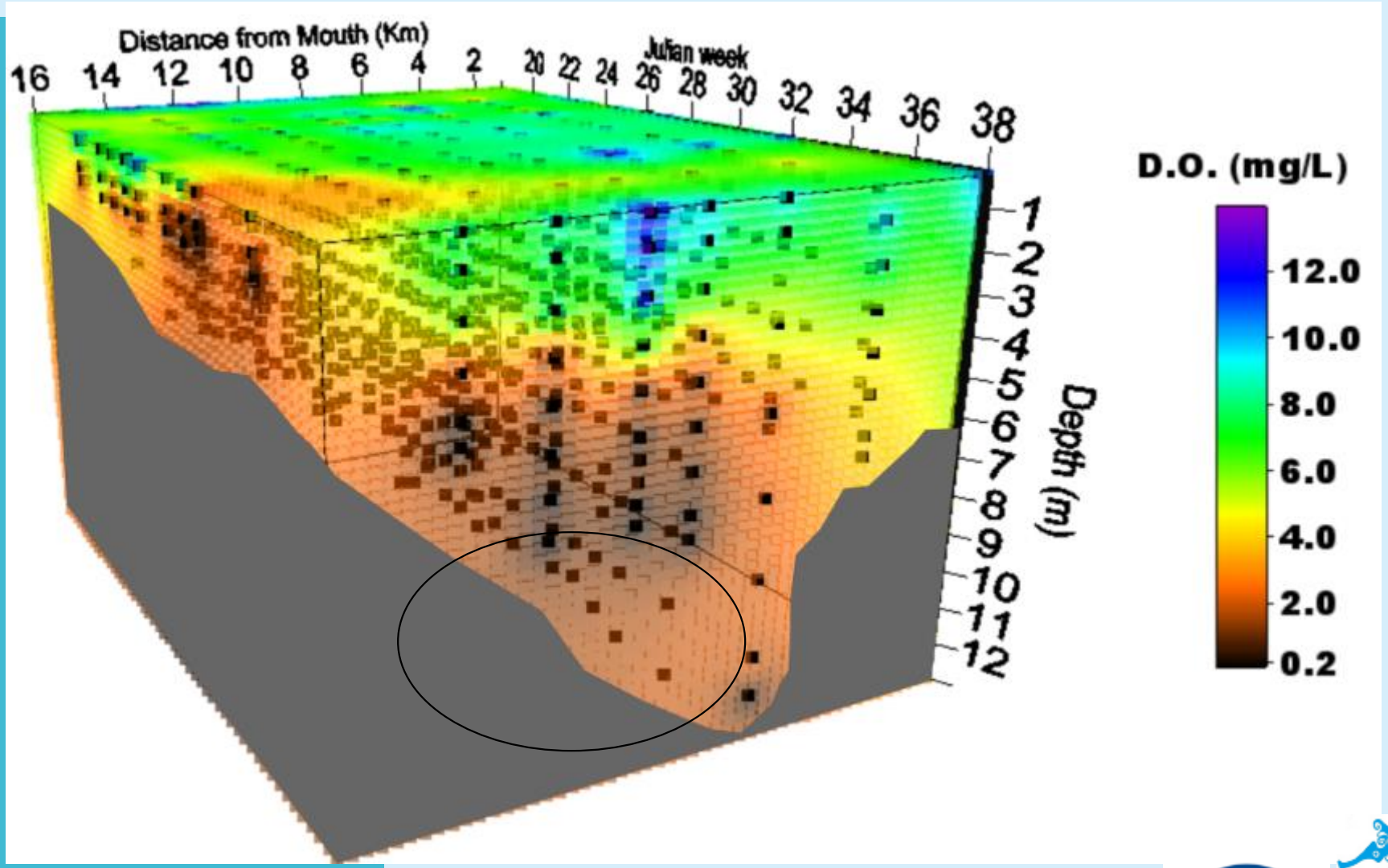

South River, MD
% of Water Column that is Hypoxic-2012
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
5/31/2012
7/2/2012
5/31/2012
7/10/2012
7/31/2012
8/30/2012
4/4/2012
5/25/2012
6/25/2012
7/17/2012
8/7/2012
8/30/2012
9/14/2012
3/30/2012
4/20/2012
5/25/2012
6/18/2012
7/2/2012
7/17/2012
8/7/2012
8/30/2012
10/5/2012
7/17/2012
8/7/2012
8/30/2012
9/14/2012
3/30/2012
4/20/2012
5/31/2012
6/18/2012
7/2/2012
7/17/2012
8/30/2012
9/14/2012
3/30/2012
5/18/2012
6/11/2012
7/10/2012
8/14/2012
9/6/2012
10/5/2012
5/18/2012
6/11/2012
7/10/2012
7/31/2012
8/31/2012
9/14/2012
MS1
MS1A
MS1B
MS2
MS2A
MS3
MS4
MS5


MS1
MS1A
MS1B
MS2, WT8.1
MS3
MS4
MS5

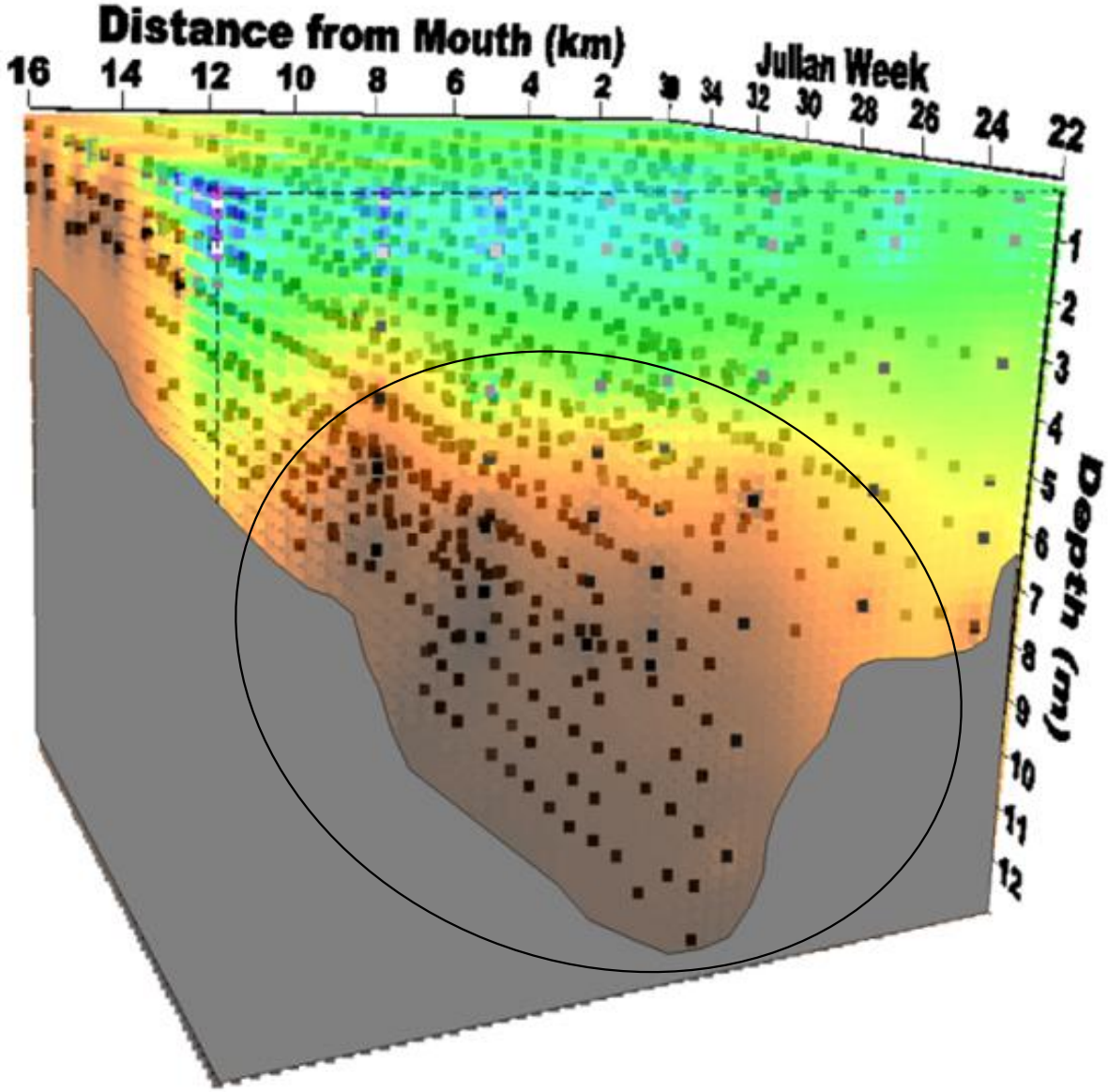
The monthly averaged stratification numbers for each station suggest that haloclines exist in the upper portion of the river (MS3 – MS5) from April through August. Weak haloclines exist in the central portion of the South River during July and August. Station MS1 appears to be well mixed throughout the entire sampling season. Monthly composite temperature profiles of the main channel indicate slightly cooler water temperatures at the mouth of the South River, with increasing temperatures toward the headwaters (MS5). Overwhelmingly, during the summer, the entire water column in the South River approaches 28°C, from surface to bottom. The plots also reveal very weak layering to mixed conditions with rare localized thermoclines. This leads to a very weak circulation in the South River with the dominate physical processes being the competition between thermal stratification and wind mixing coupled with weak tidal flows. The most important result from constructing these monthly salinity patterns is the realization that unlike the Chesapeake Bay proper, these small sub-estuaries do not have spatially or temporally extensive haloclines or pycnoclines.

Station	April	May	June	July	August	September
MS1	0.06	0.07	0.08	0.07	0.04	0.03
MS 1A	0.17	0.01	0.02	0.13	0.17	0.03
MS 1B	0.06	0.02	0.02	0.02	0.13	0.13
MS 2	0.14	0.11	0.01	0.02	0.17	0.11
MS 3	0.22	0.22	0.01	0.23	0.36	0.15
MS 4	0.22	0.31	0.07	0.27	0.43	0.10
MS 5	0.35	0.35	0.54	0.22	0.49	0.11

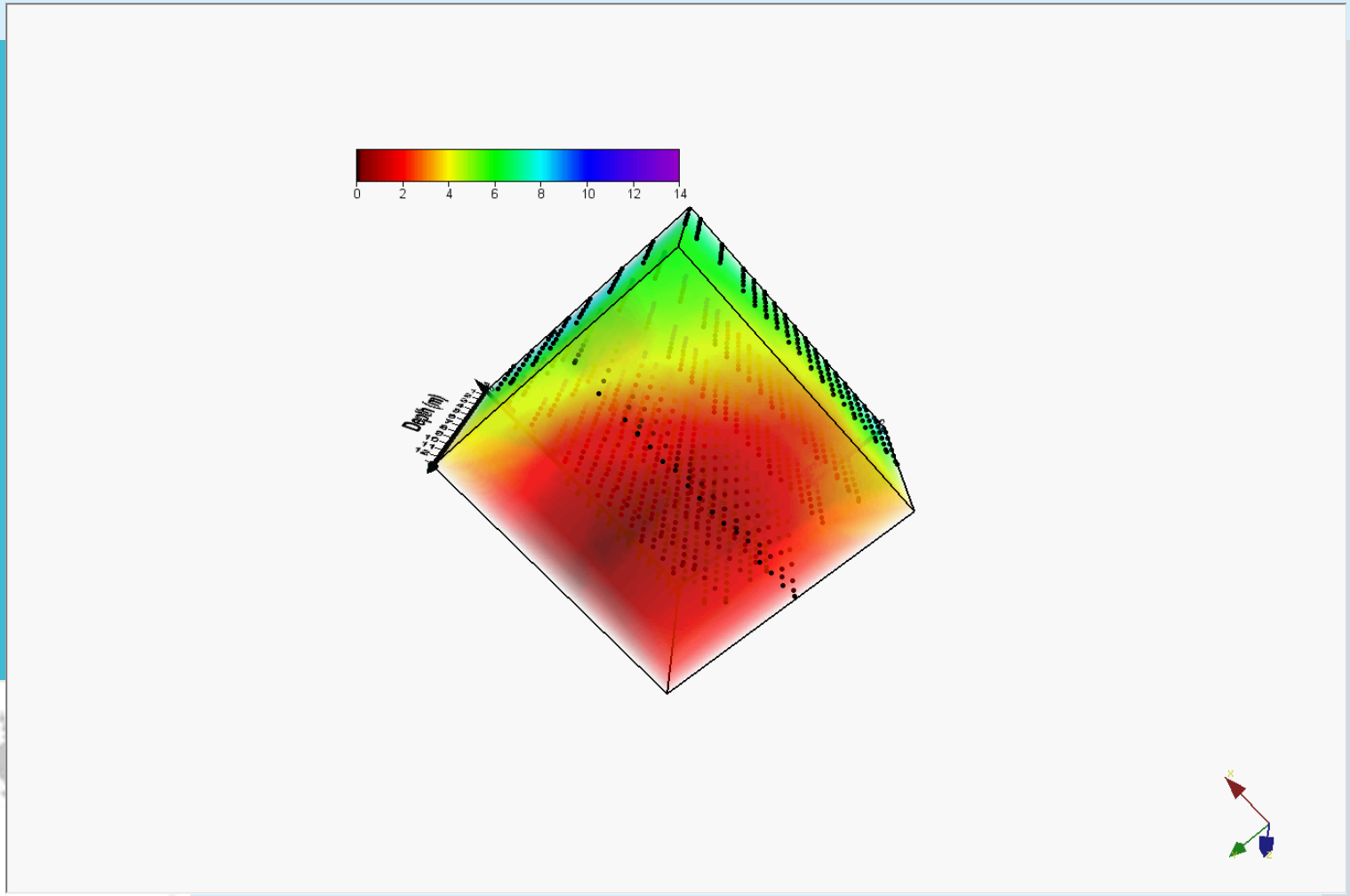
Severn River DO Model 2009



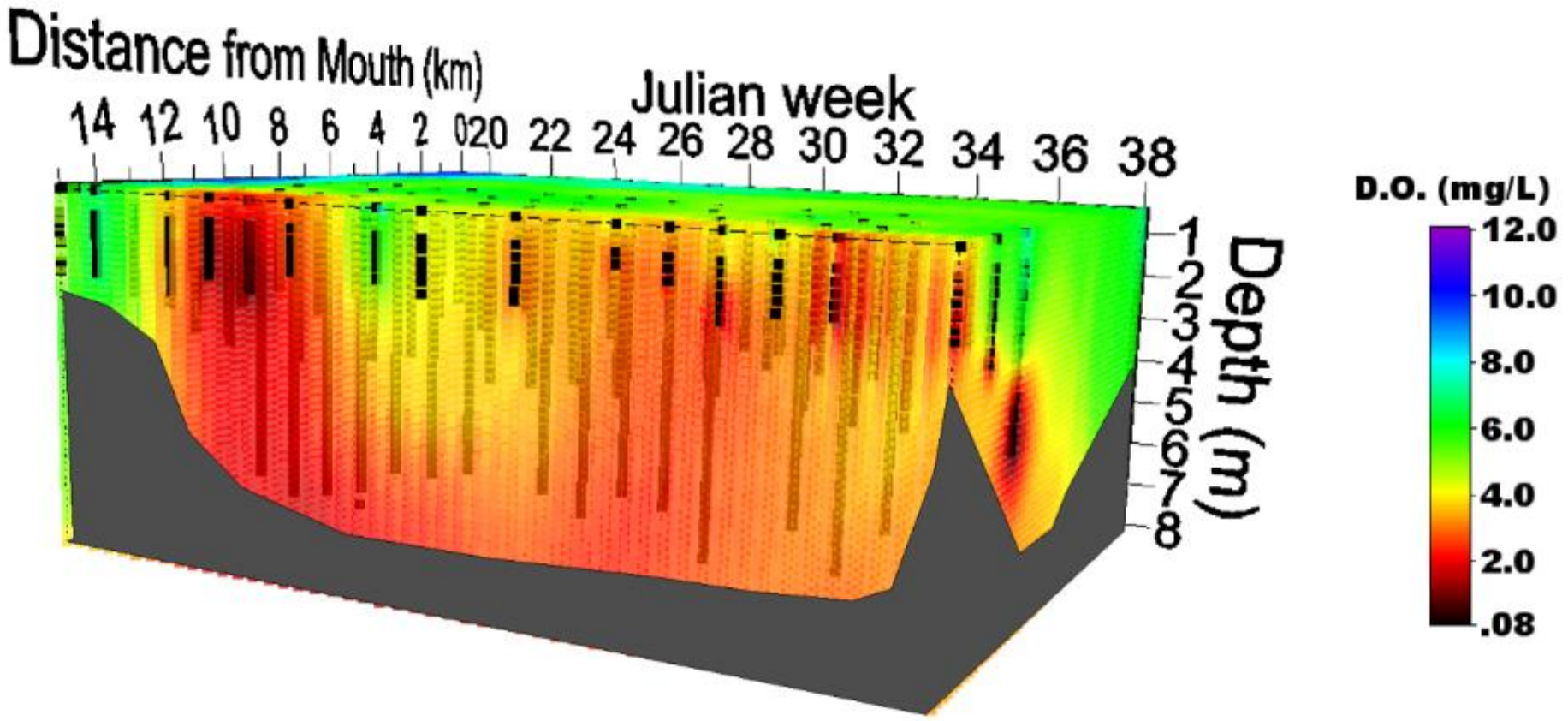
Severn River Model 2010



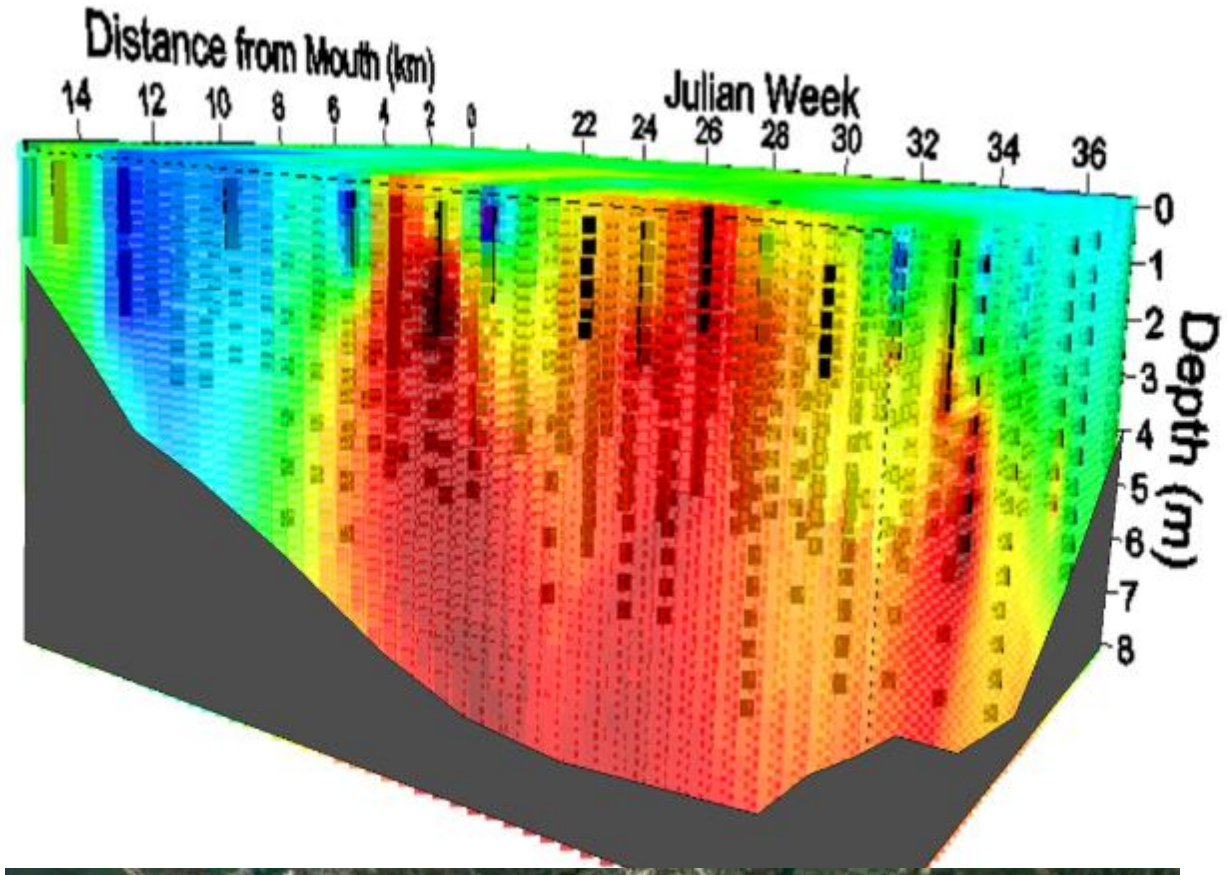
2011 Severn River, Dissolved Oxygen, Voxler Modeled data-movie

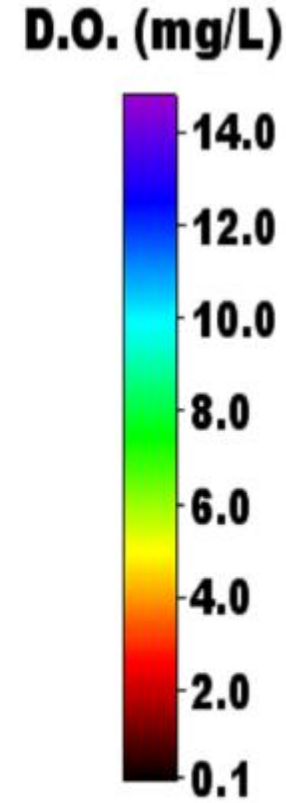


South River 2009 Dissolved Oxygen, Voxler Model

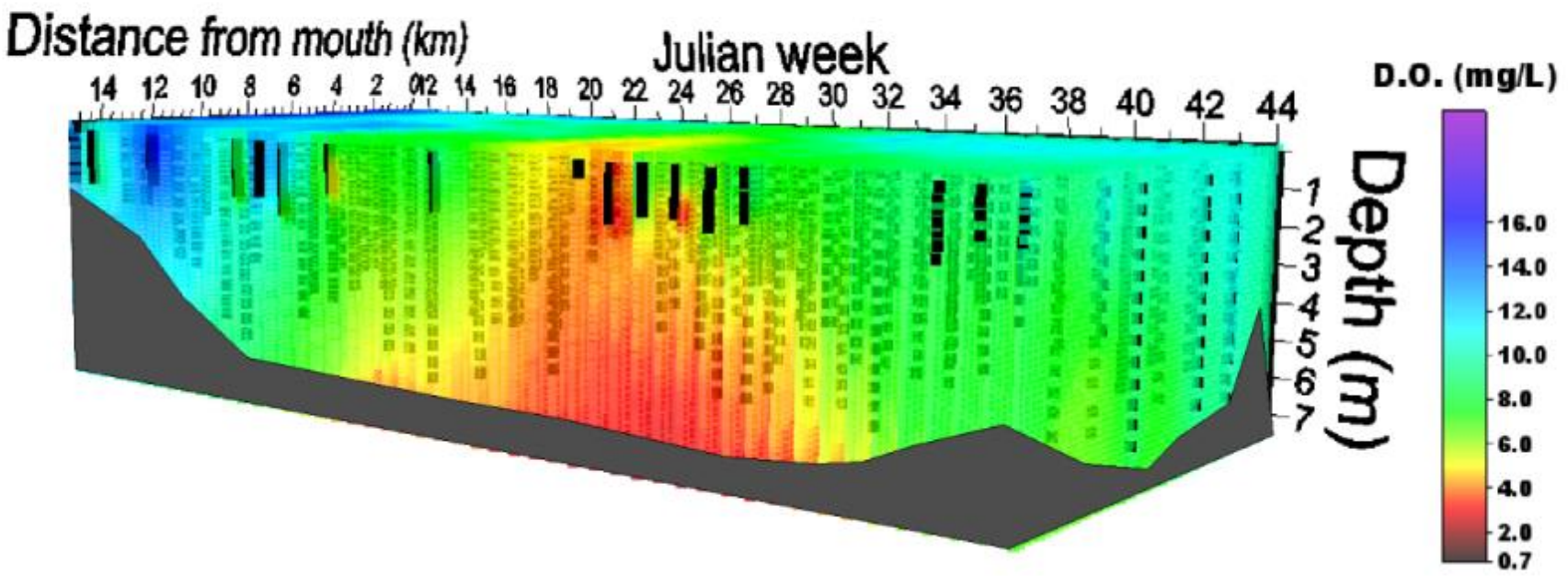


South River 2010 Dissolved Oxygen, Voxler Model



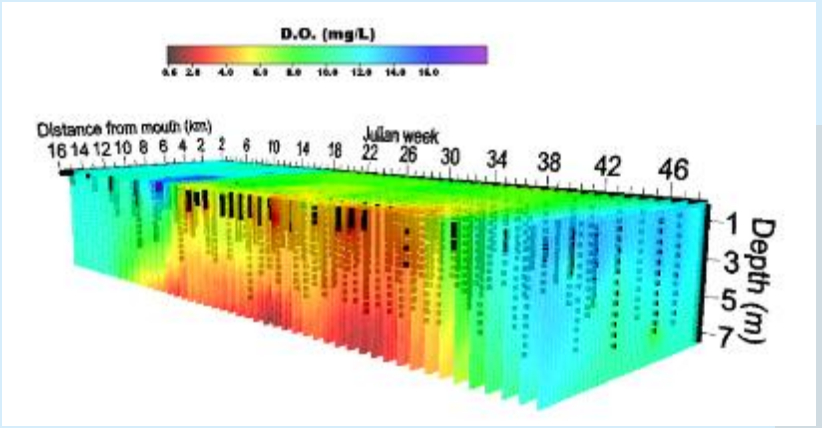


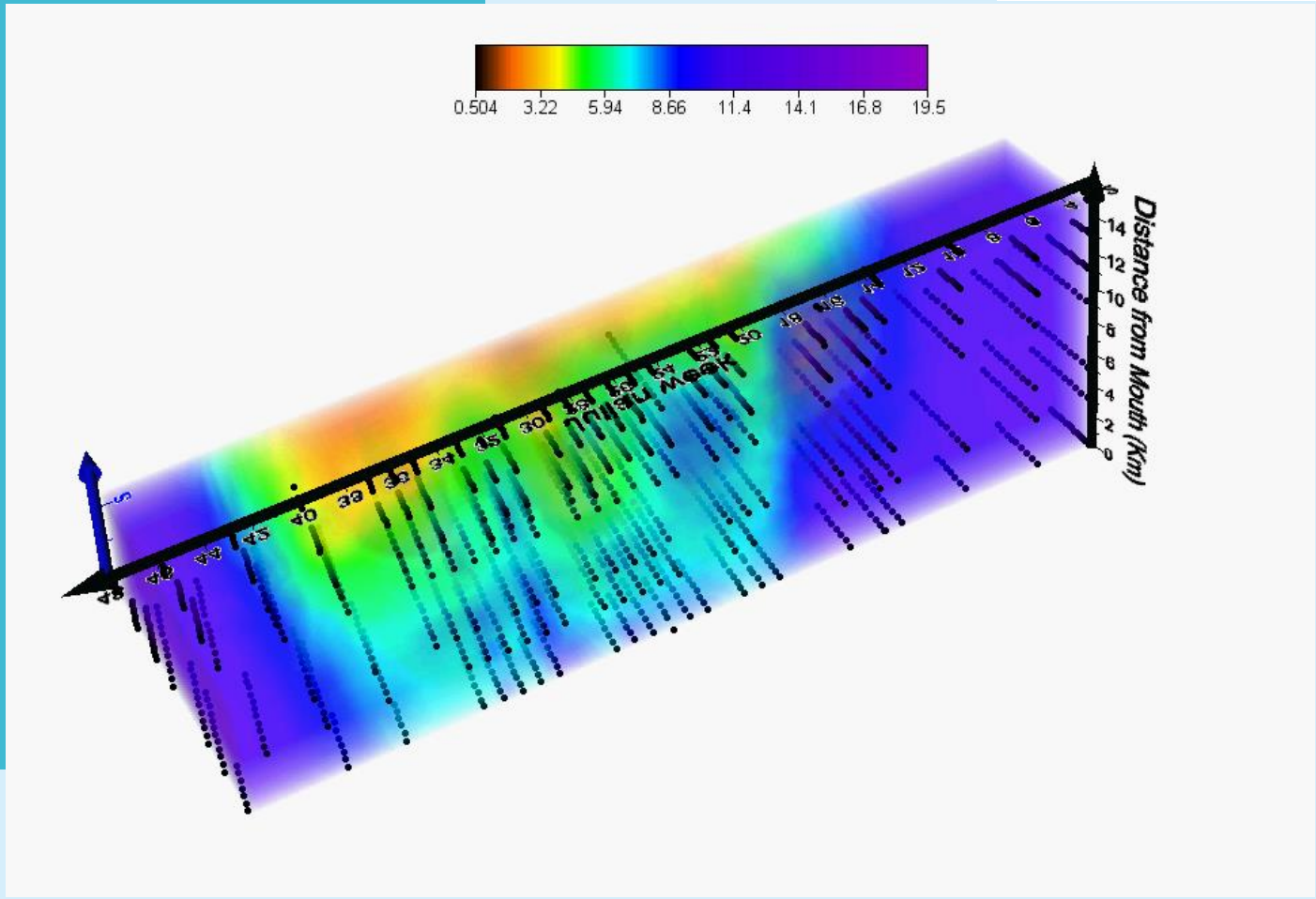
South River 2011 Dissolved Oxygen, Voxler Model



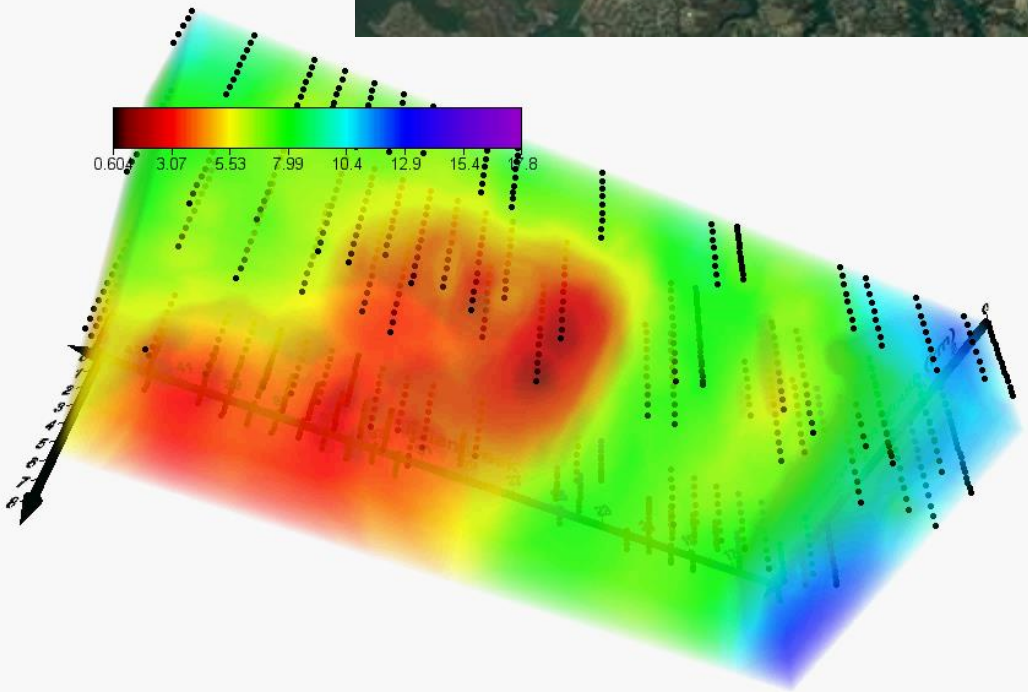
2012 South River, Dissolved Oxygen, Modeled Voxler

Data-movie

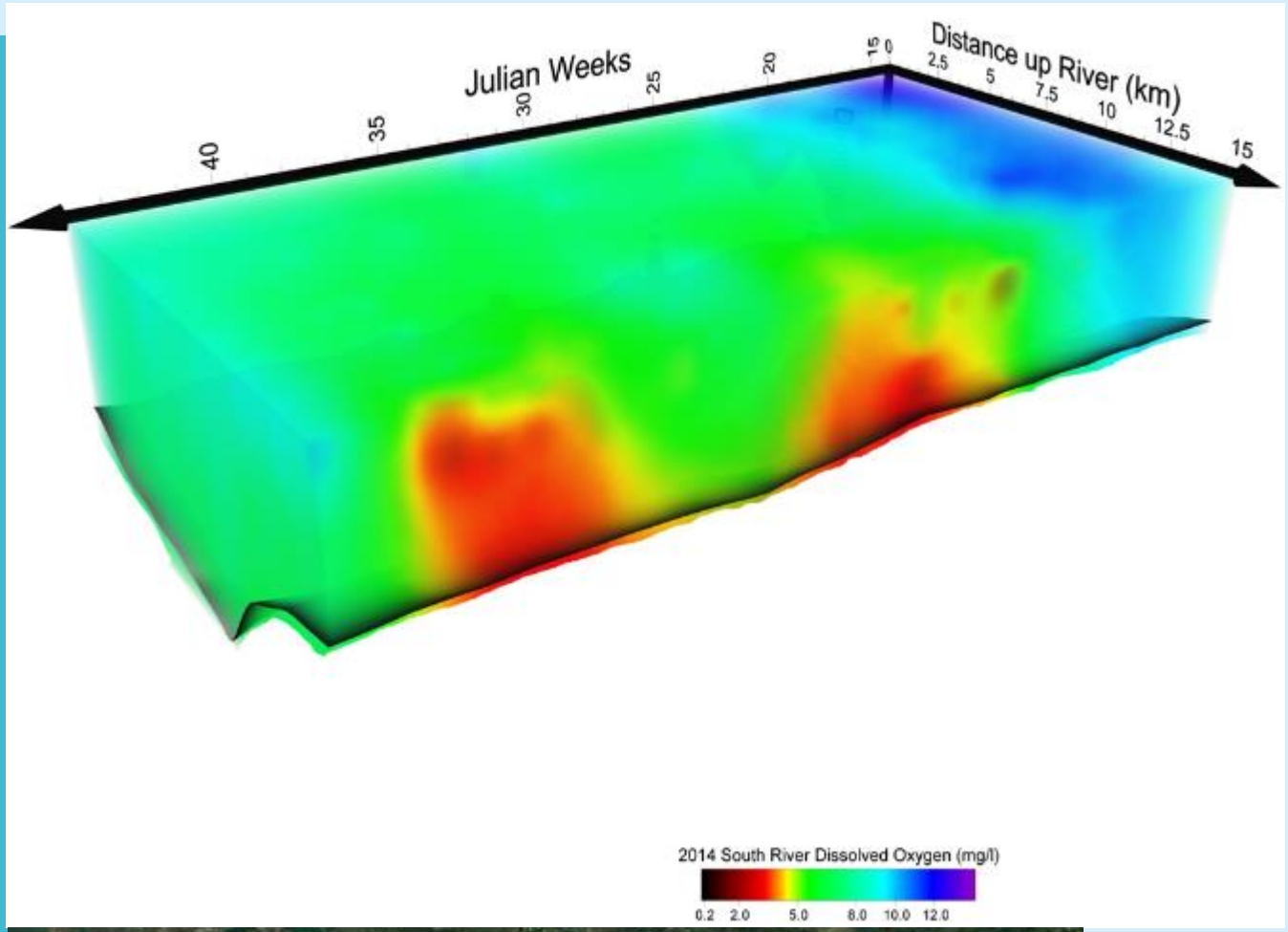




2013 South River, Dissolved Oxygen, Modeled Voxler movie

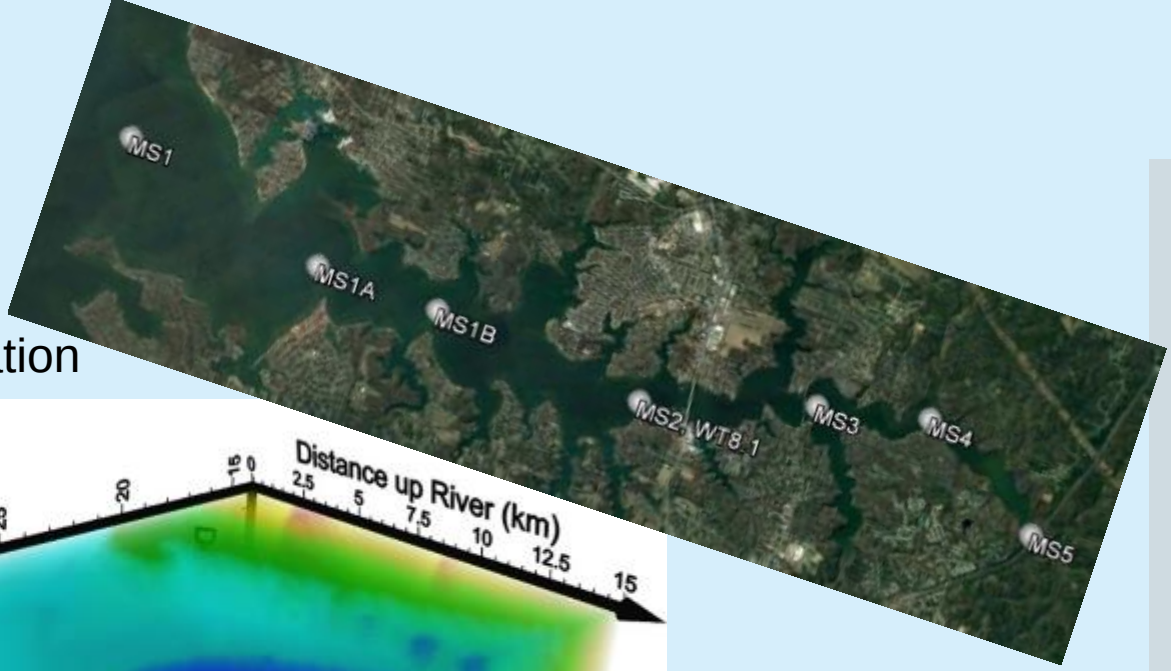


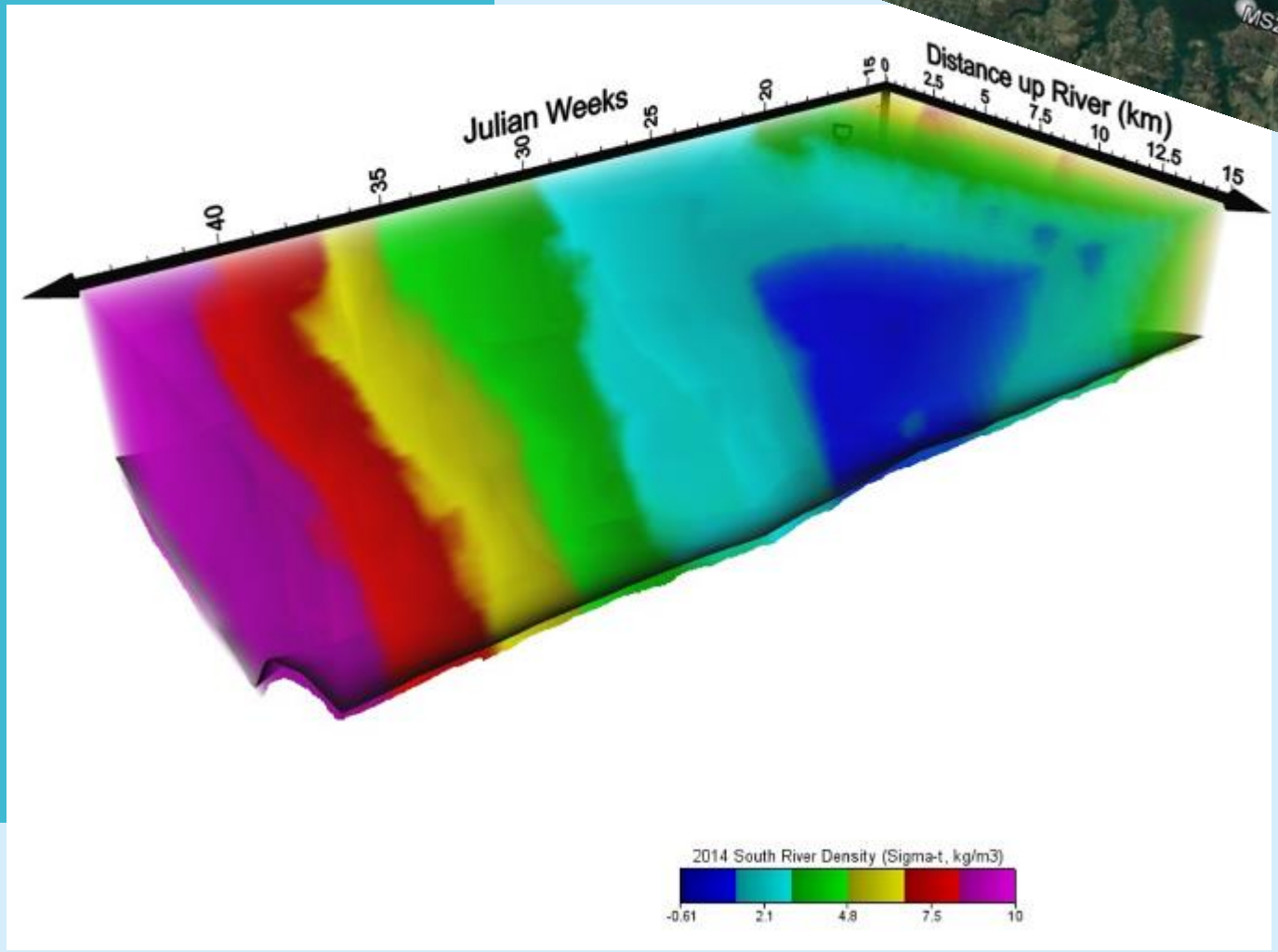
2014 South River Dissolved Oxygen Modeled Voxler



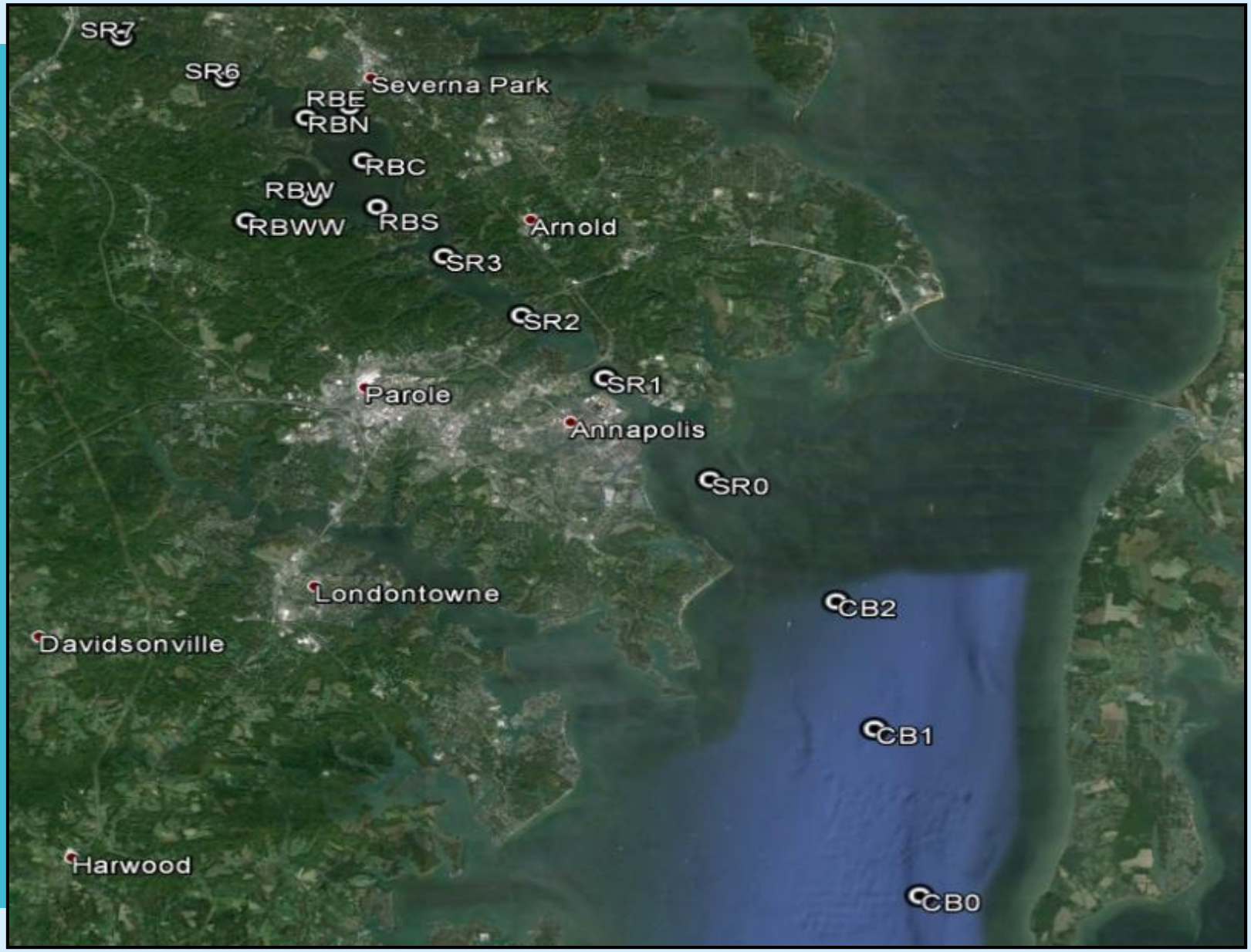
Density in South River
Lateral not vertical

DO problems seem to be
Temp related not due to stratification

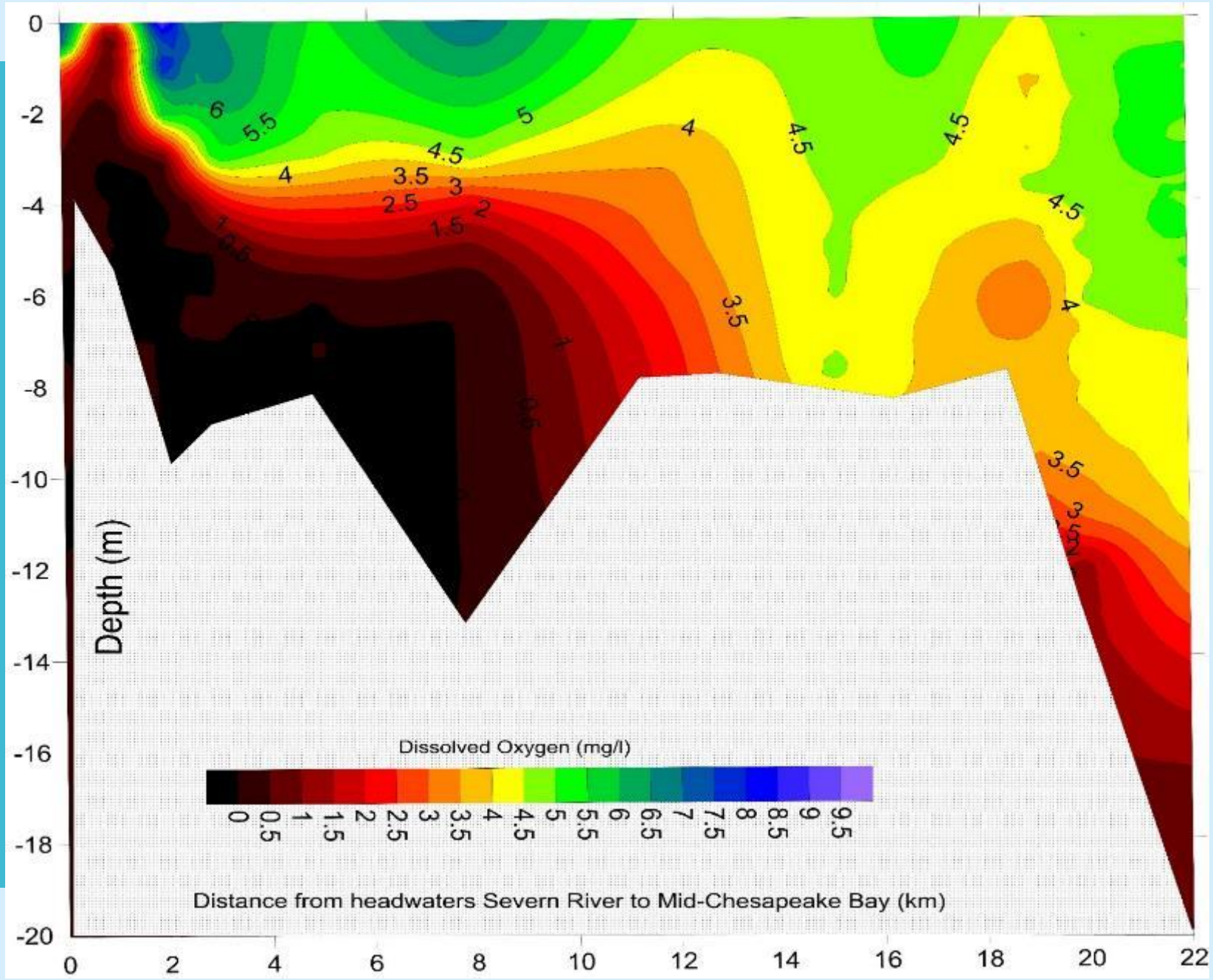




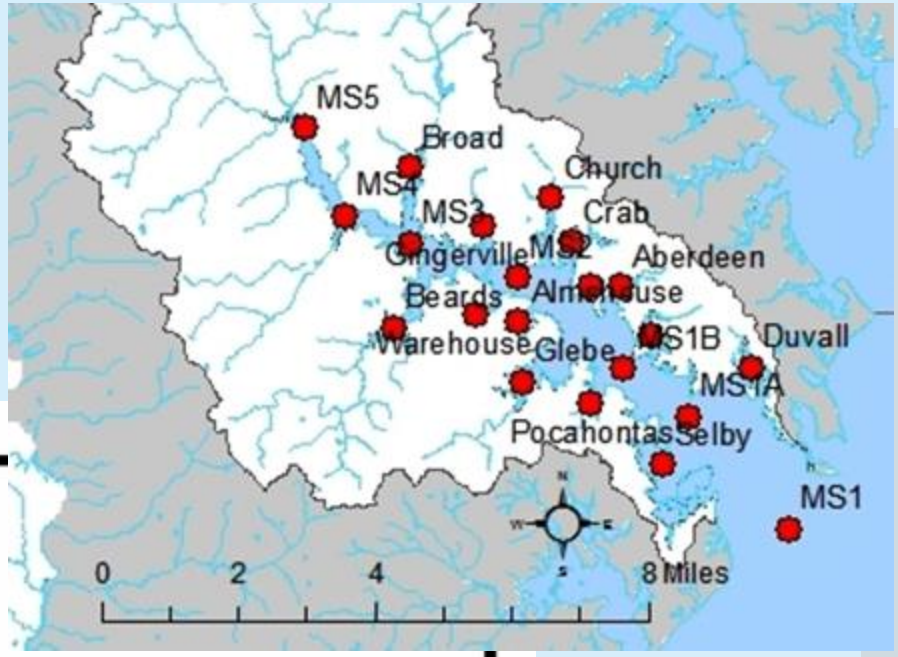
Severn River, Md, USNA transect 2015

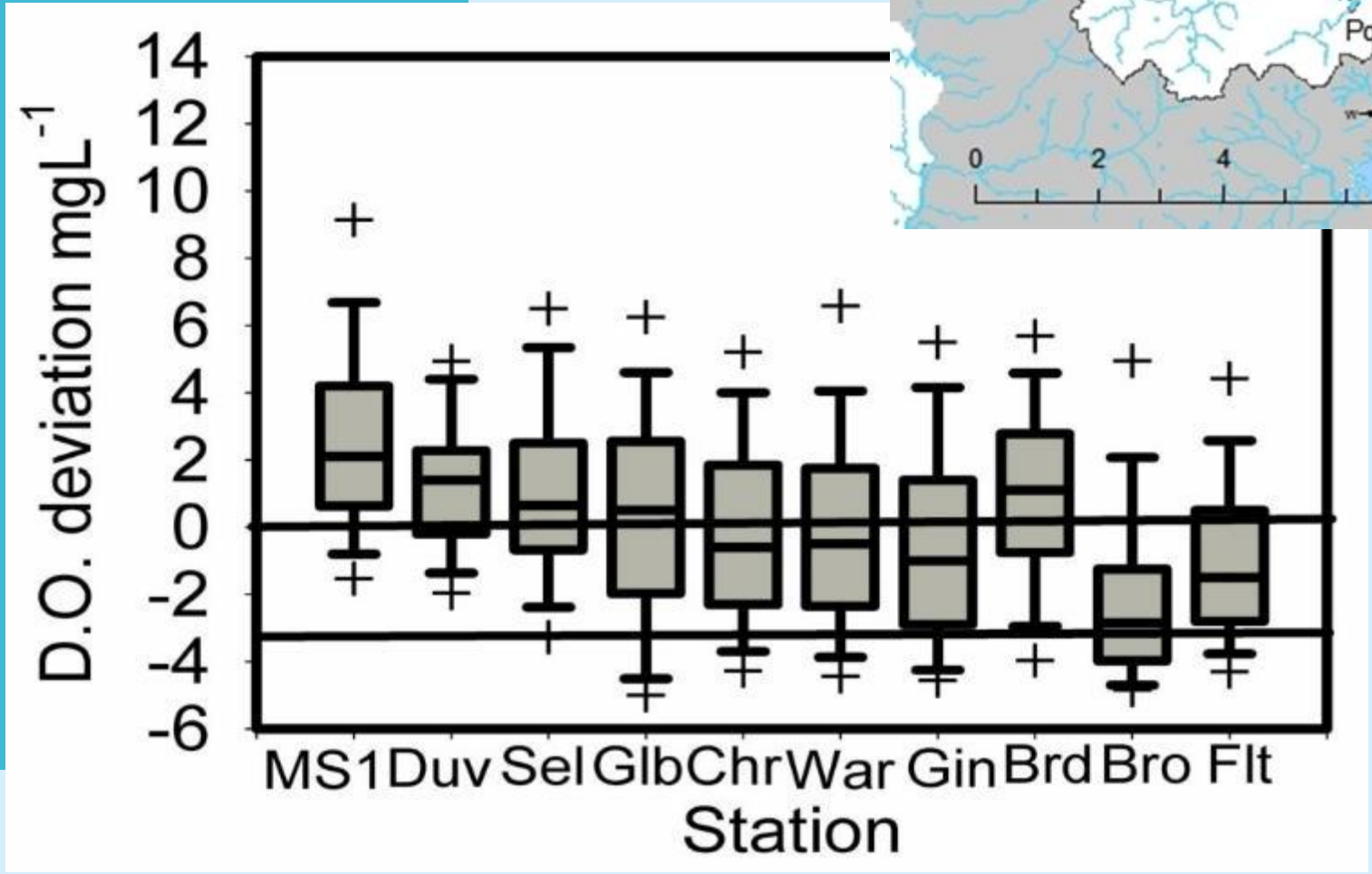


Cross section profile Round Bay, Severn River to mid-channel of Chesapeake Bay

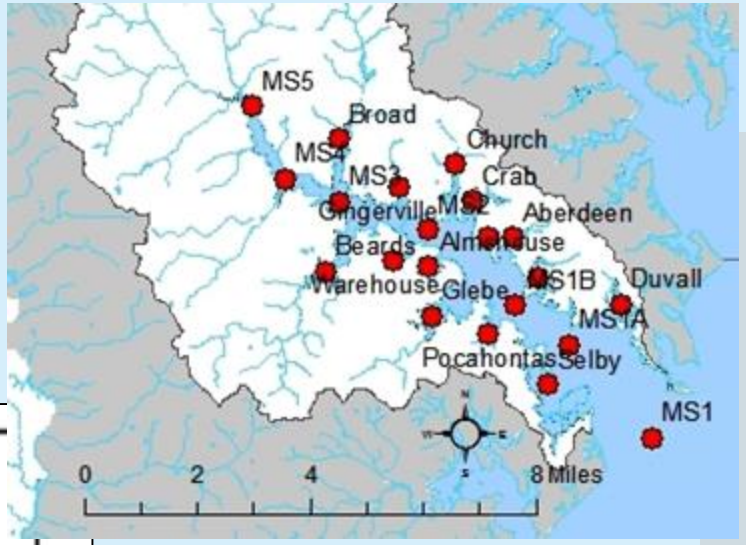


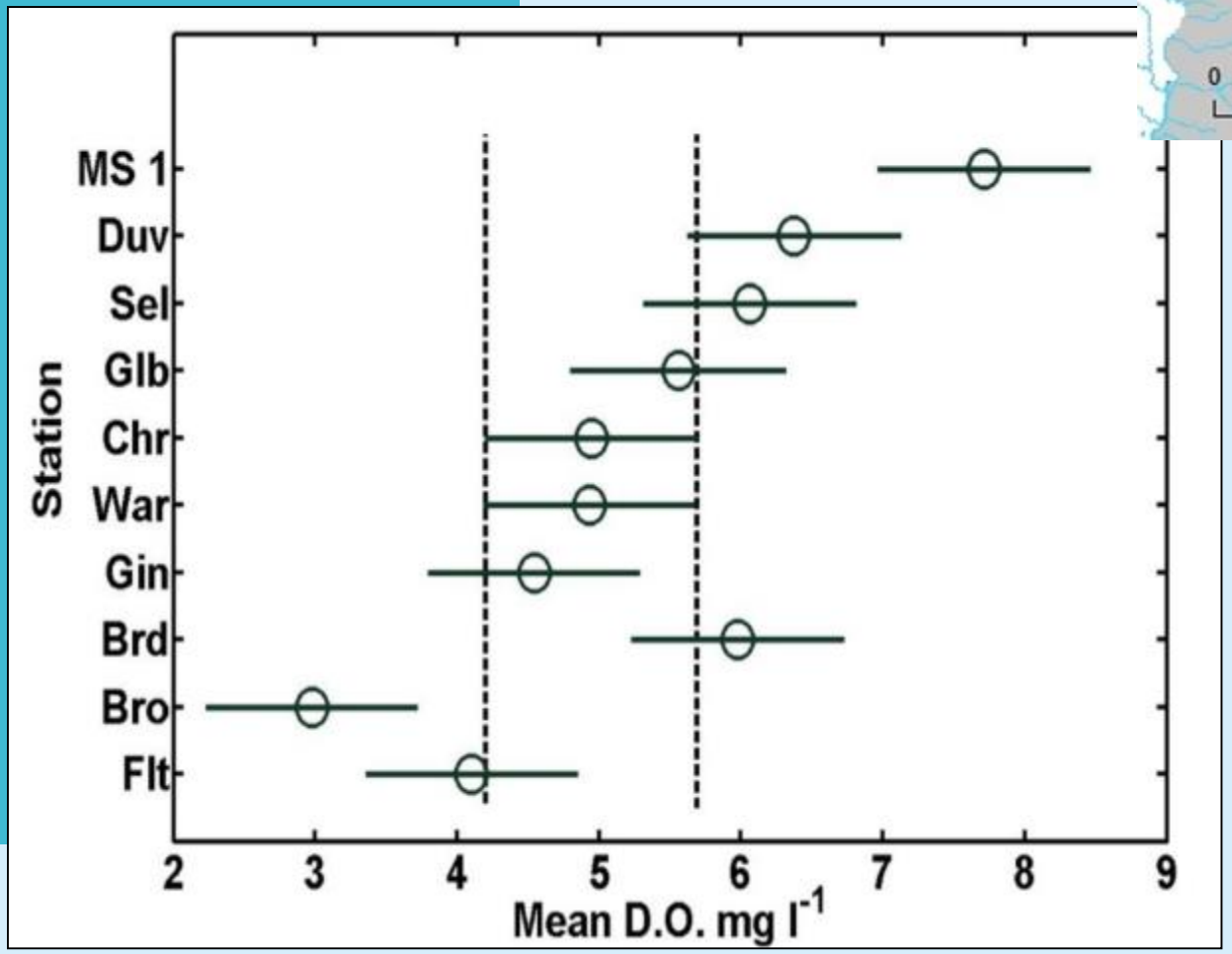
South River Creeks
anova of tidal creeks
6 years of data weekly, Bottom D.O





South River Creeks
Tukey-Kramer Means comparison test
For bottom dissolved oxygen (2004-2009)





South River water bottom temperature, as illustrated in the box plots, ranges from a low of 5 to a high of 33°C, and median values are between 22 and 25°C. The ANOVA results of bottom temperature in the tidal creeks showed that the within creek variability is much larger than the between creek variability. Both the box plots and the results of the one-way ANOVA test indicate that there is no significant difference between individual creeks with respect to bottom temperature, and therefore the null hypothesis is accepted.

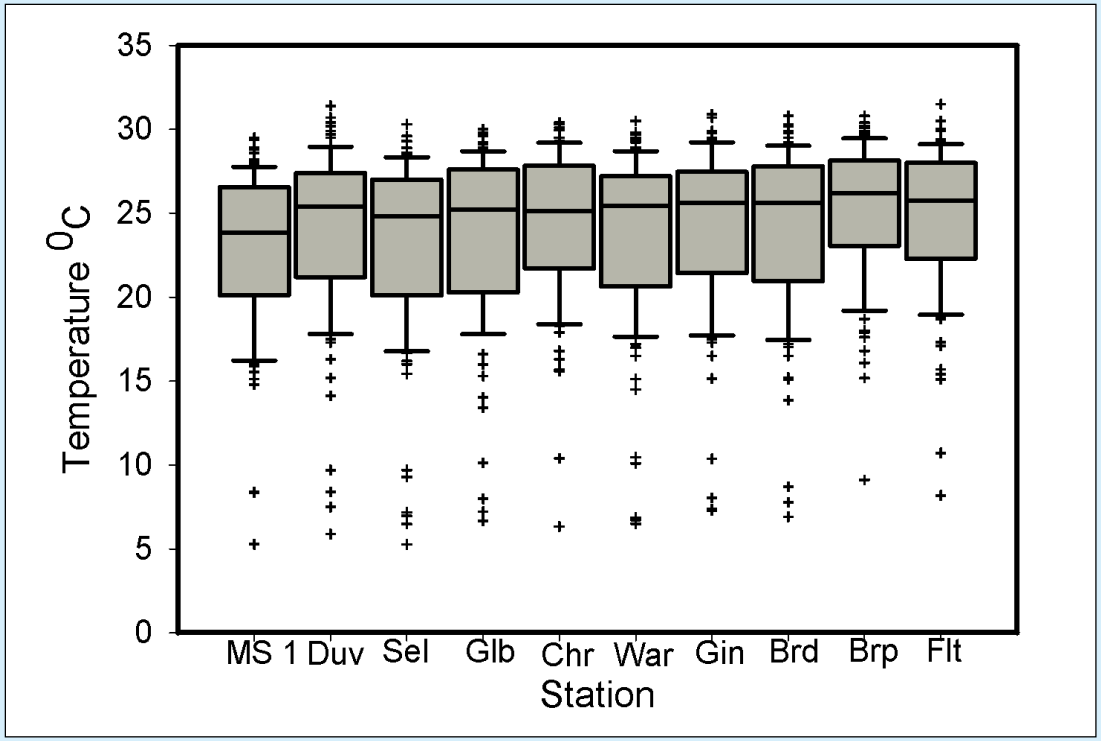


Table 4 Kruskal-Wallis ANOVA of bottom temperature for individual tidal creeks

Source	*SS*	*df*	*MS*	*Chi-sq*	*Prob>Chi-sq*
Between	$1.44 * 10^6$	9	159819.6	16.71	0.0535
Within	$8.60 * 10^7$	1006	85441.3		
Total	$8.73 * 10^7$	1015			

pH Variability

pH is a leading variable important to the health of all fresh and marine ecosystems [62]. Mean bottom pH values range from a high of 7.8 at MS1 to a low of 7.43 at station Bro. Box and whisker plots reveal large variability within each of the creeks. Individual pH measurements range from a low of 5.60 in War to a maximum of 9.5 in Glb and Flt. Several creeks have pH measurements above 9.0, whereas most sites have minimum values around 6.3 (Fig. 8).

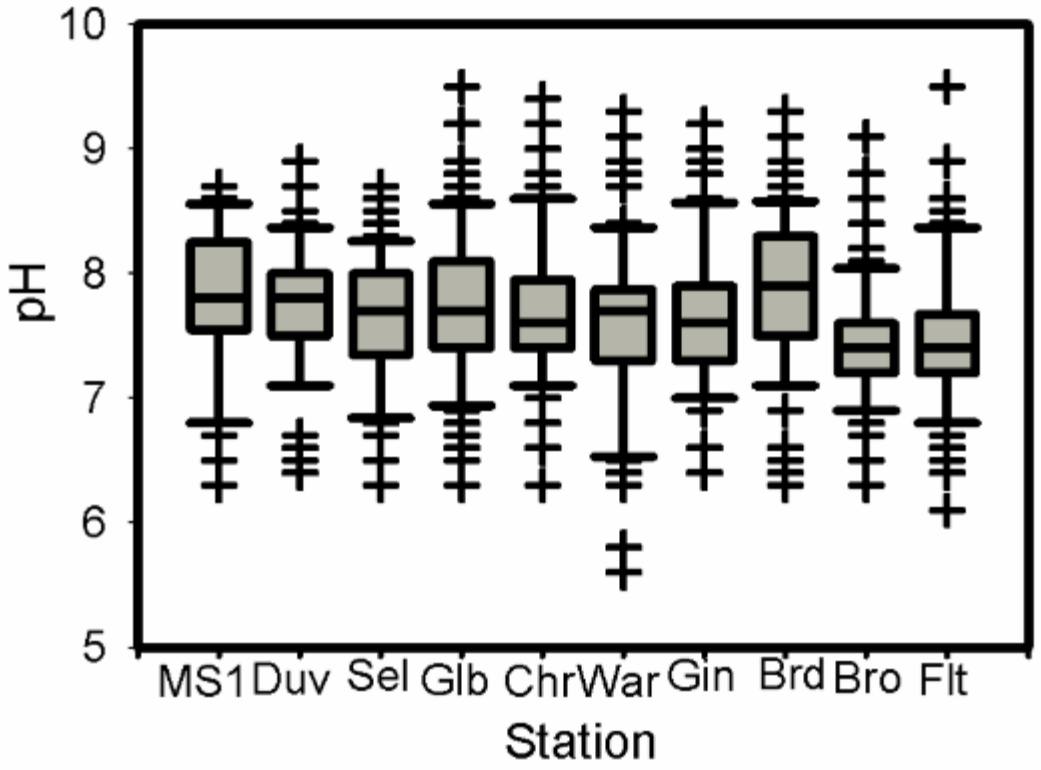
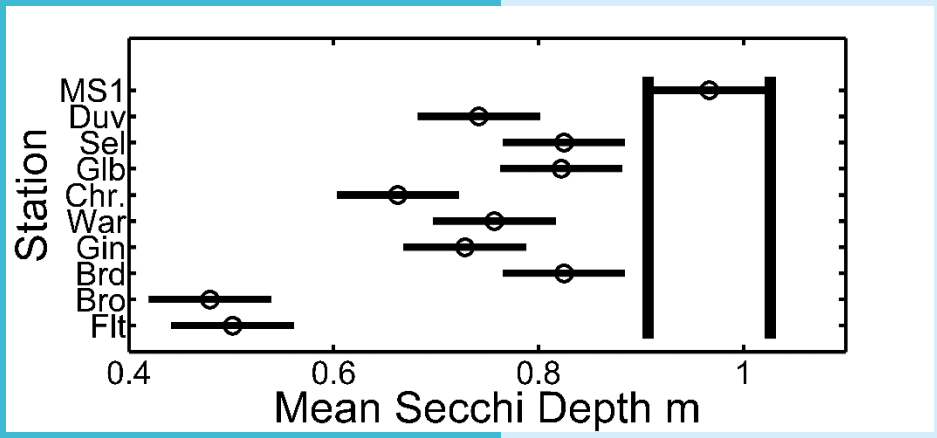


Table 8 Kruskal-Wallis ANOVA of bottom pH for individual tidal creeks

Source	*SS*	*df*	*MS*	*Chi-sq*	*Prob>Chi-sq*
Between	$2.54 * 10$	9	$2.82 * 10^{5}$	58.63	<0.0001
Within	$2.87 * 10^{7}$	712	$4.03 * 10^{4}$		
Total	$3.12 * 10^{7}$	721			

Table 10 Results of the Tukey-Kramer means comparison test for water clarity

Station	Stations that are statistically different
MS1	Duv, Sel, Glb, Chr, War, Gin, Brd, Bro, Flt
Duv	MS1, Bro, Flt
Sel	S1, Chr, Bro, Flt
Glb	MS1, Chr, Bro, Flt
Chr	MS1, Sel, Slb, Brd, Bro, Flt
War	MS1, Bro, Flt
Gin	MS1, Bro, Flt
Brd	MS1, Chr, Bro, Flt
Bro	MS1, Duv, Sel, Glb, Chr, War, Gin, Brd
Flt	MS1, Duv, Sel, Glb, Chr, War, Gin, Brd



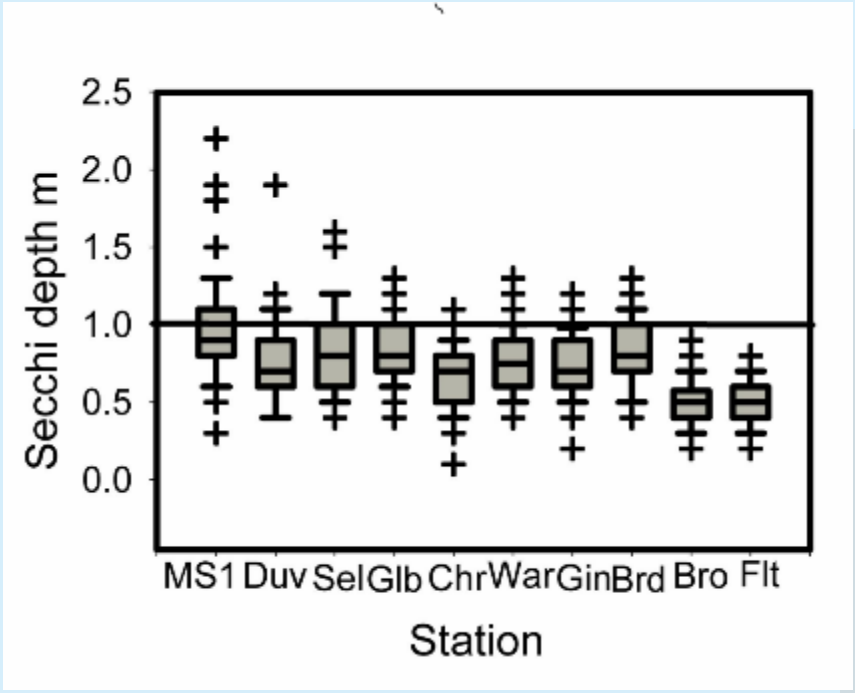
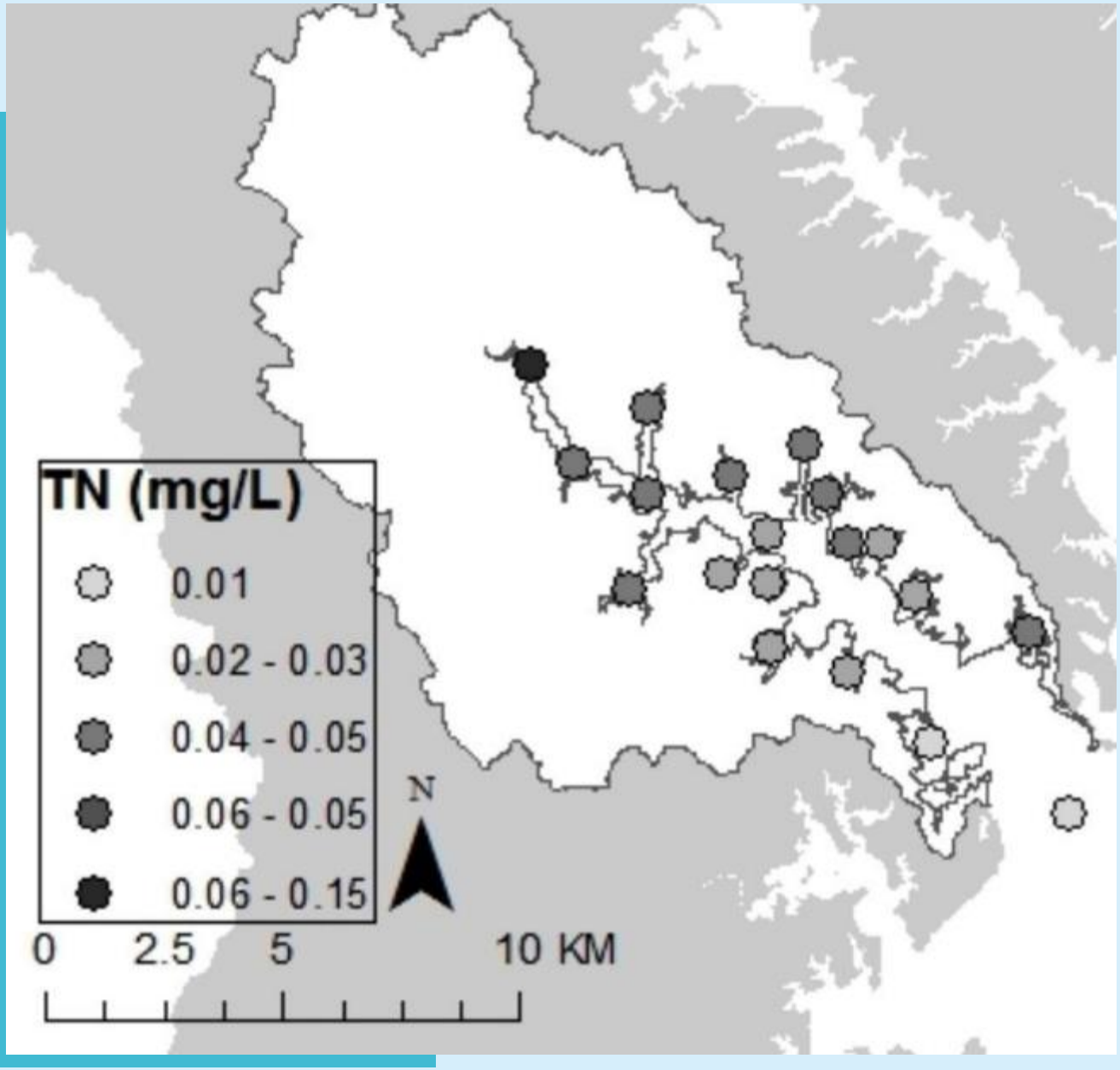
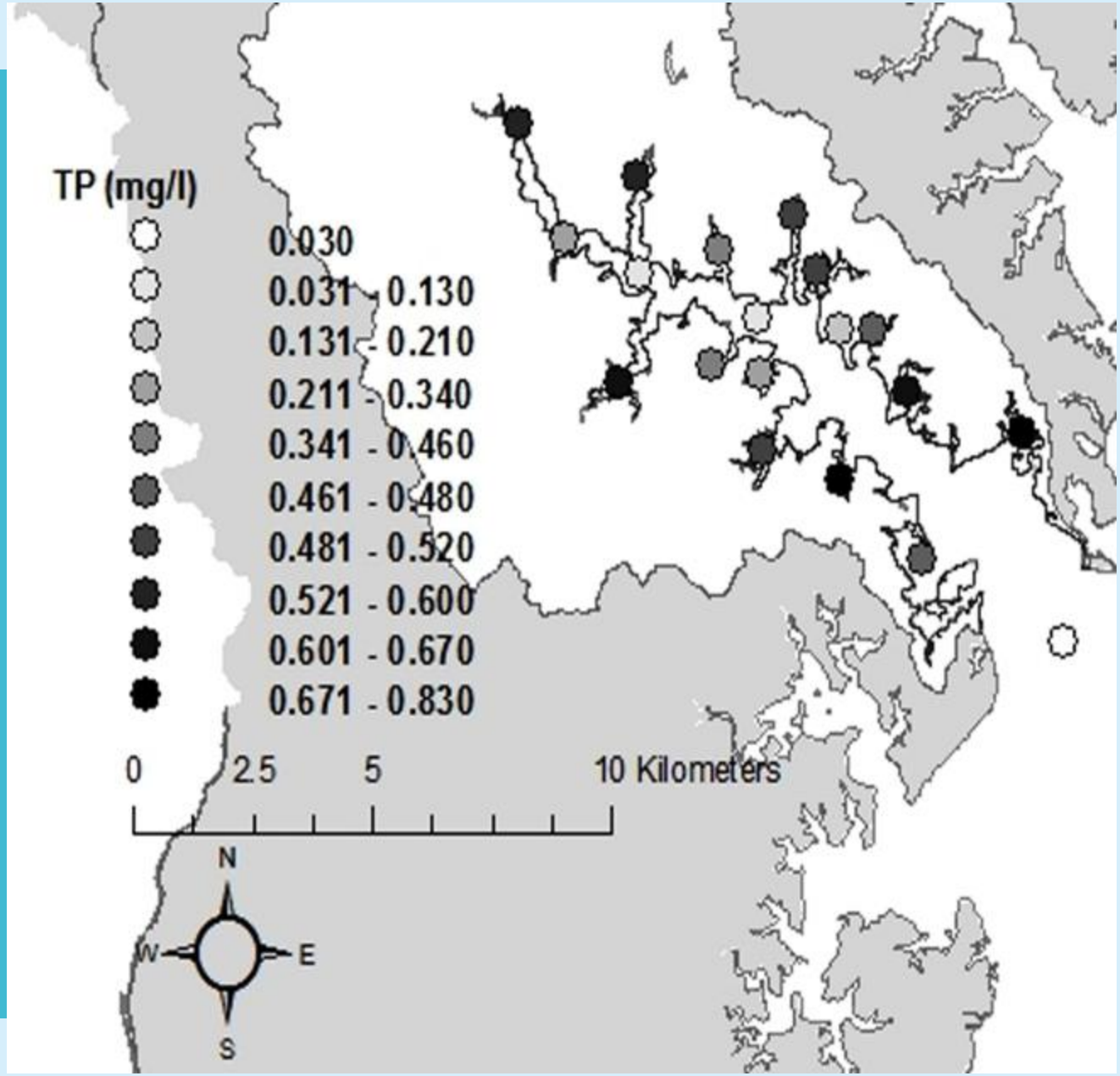


Table 9 Kruskal-Wallis ANOVA results for water clarity of individual creeks

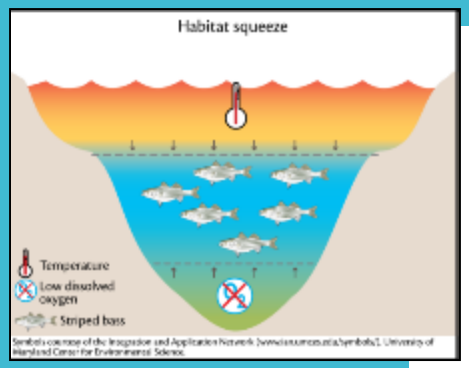
Source	*SS*	*df*	*MS*	*Chi-sq*	*Prob>Chi-sq*
Between	$9.23 * 10^6$	9	$1.02 * 10^6$	217	<0.0001
Within	$2.12 * 10^7$	708	$2.99 * 10^4$		
Total	$3.04 * 10^7$	717			

The water clarity results in stations Chr, Gin, War, Bro and Flt are extremely poor in relation to the other sites, further demonstrating the importance of statistically characterizing the variability of individual tidal creeks. The means comparison test also confirms the up-estuarine degrading pattern in water clarity.


TN (mg/L)
0.01
0.02 - 0.03
0.04 - 0.05
0.06 - 0.05
0.06 - 0.15
N
0
2.5
5
10 KM


TP (mg/l)
0.030
0.031 - 0.130
0.131 - 0.210
0.211 - 0.340
0.341 - 0.460
0.461 - 0.480
0.481 - 0.520
0.521 - 0.600
0.601 - 0.670
0.671 - 0.830
0
2.5
5
10 Kilometers
N
W
E
S

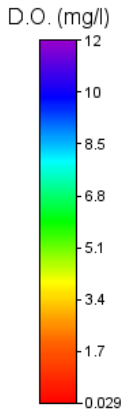
Feeling the Hypoxic Squeeze in 3-D

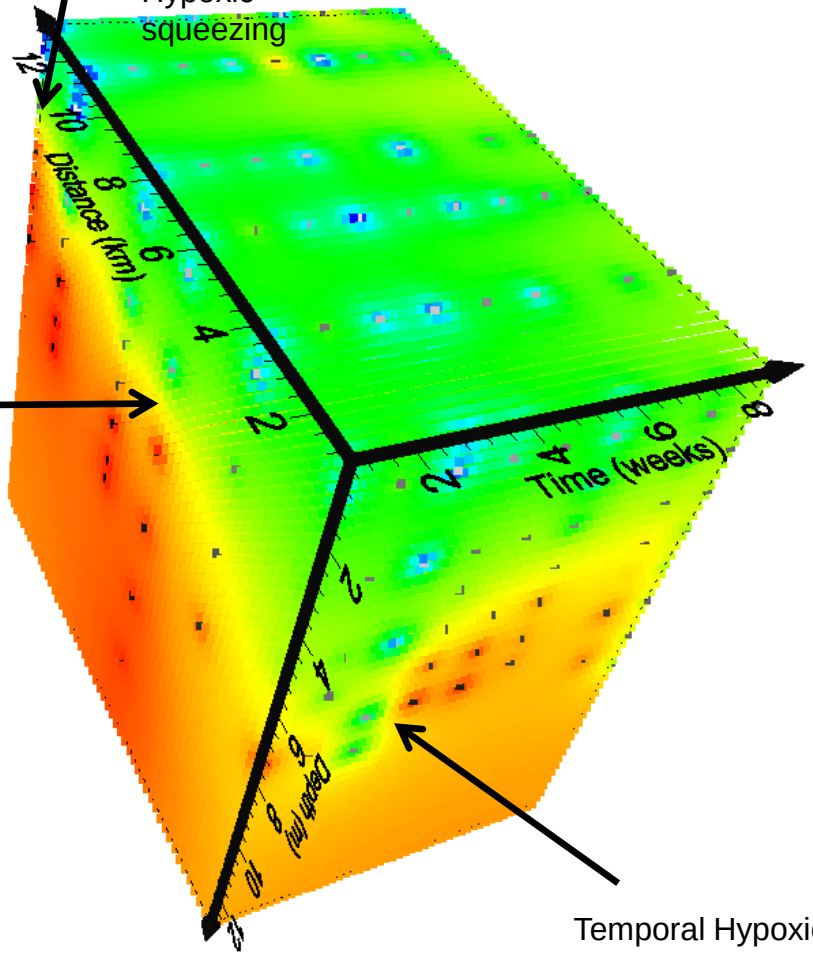


Vertical Hypoxic squeezing

Lateral hypoxic squeezing

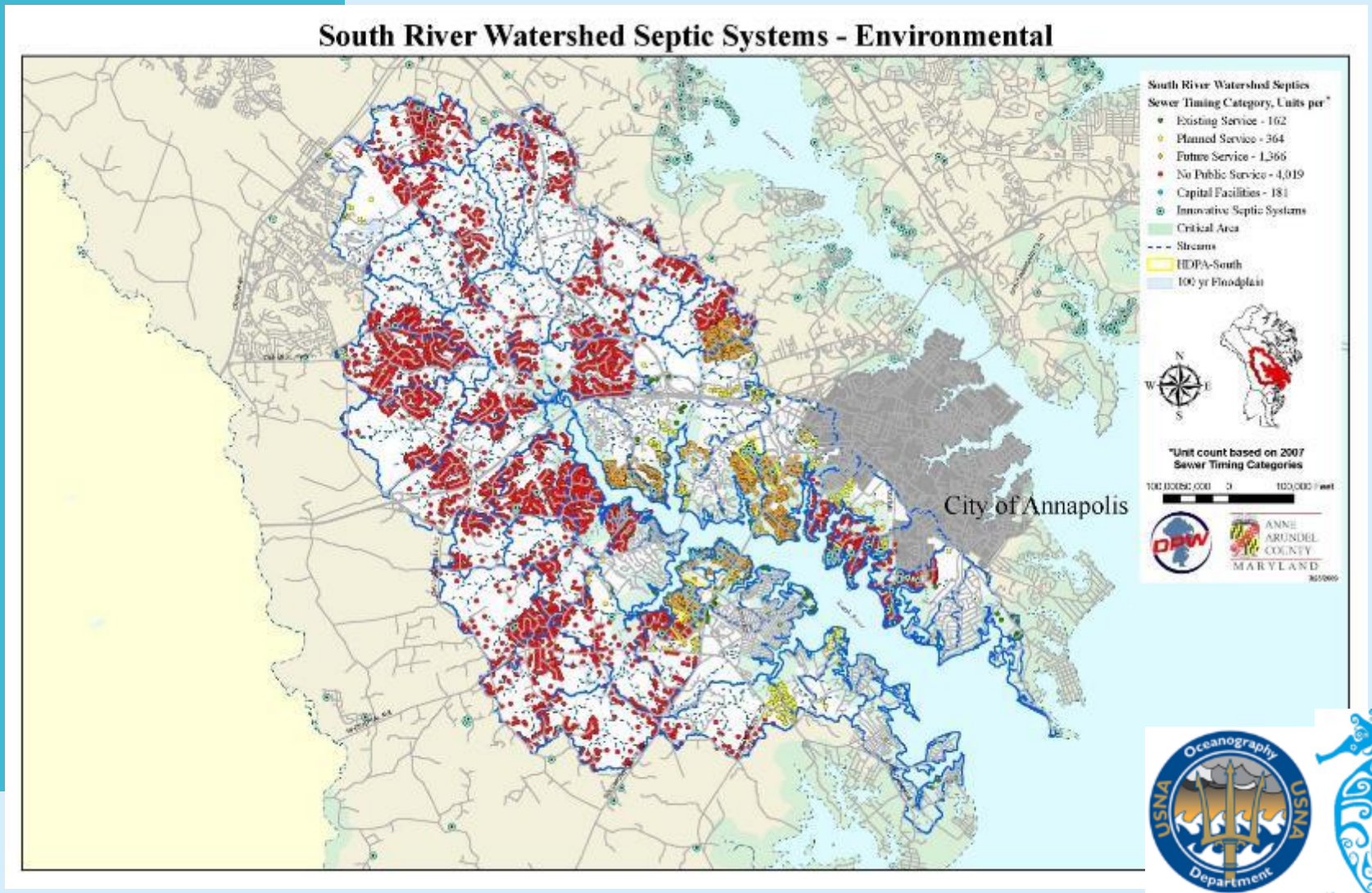
Temporal Hypoxic squeezing





South River Triblet: Land-Water Connection

*They are a poster Child for Urban/sub-urban watershed, 66,ooo residents each, both have
*over 6ooo septic systems each, storm water, and antiquated sewer systems.
*Severely incised non-tidal streams
*A growing population of people that want to live near the Bay



Gingerville Creek, South River, MD

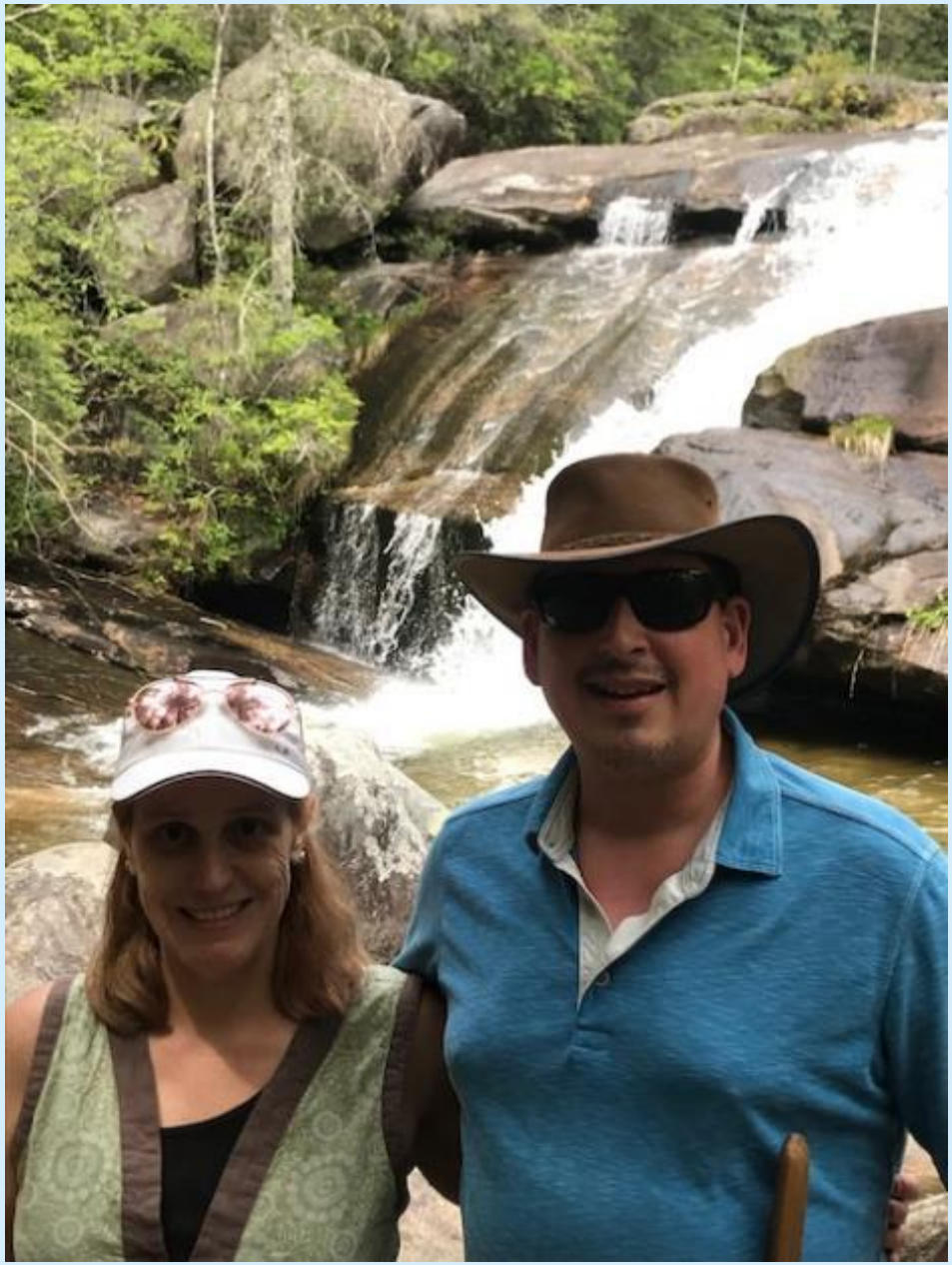
WHAT WE NEED TO DO

*Ground Truthing: Walk, Hike, Bike, Boat, Kayak, or Fly the watershed yourself

Fill in Data Gaps: Spatio-Temporal

Main Stem Modeling vs Triblet Modeling

Thank you



Diana and Andrew Muller