Past, Present and Future Monitoring and Modeling of the Severn River, MD.

Andrew C. Muller, PhD.
Associate Professor
Oceanography Department
United States Naval Academy
Spatial Variability vs. Temporal Variability

- In any monitoring program or research endeavor to understand the bio-physical processes that dominate ecological systems we face the spatio-temporal dilemma, we can be

- Spatial intensive – lower temporal resolution
  – or
- Temporal intensive – lower spatial resolution
  • May loose vertical dimension

- But, water quality parameters exist in the spatiotemporal domain
Resolving the Spatio-Temporal dilemma

- REMUS 100
- HydroLab DS 5, YSI EXO 1 and 2
- NOAA Annapolis Buoy
- YP 686
- Mids on an Edgewater
Severn River D.O. 2010
Severn River 2011
Severn 2011 Spatiotemporal Volume

4.1% ≥ 28 deg. C

27% ≤ 2 mg/L - Volume
REMUS 100
Remote Autonomous Environmental Units

Physical Specs:
Manufacturer: Hydroid
Body Type: Torpedo
Size (LxWxH): 1.60m x 0.19m x 0.19m Body Size (LxWxH): 1.60m x 0.19m x 0.19m
Hull Material: Aluminum
Weight: 37.00kg
Maximum Depth: 100.00 m
Self-Righting: Yes
Obstacle Avoidance: No
Endurance (nominal load): 22 hours -
Mission: Round Bay, Severn River

hypoxia
Round Bay July 28, 2015
Mission: Severn River
June, 15 2011 - Round Bay to College Creek

D.O. (mg/l)

0.054  1.7  3.4  5  6.7

REMUS (6-8 AM)  SRK weekly monitoring (8 AM – 2 PM)
Mission: South River
July 22, 2011
Mission South River
July 22, 2011

Salinity

Temp (deg. C)

27.4 28.2 29 29.8 30.6
South River Creeks-DO

Data below this line is NOT valid
South River Nutrients

Nutrient Criteria Guidance exceedance:
TN: 0.65 mg/l
TP: 0.037 mg/l
Winchester Lump

DO at Winchester Lump
Increasing the importance and relevance of buoy data and AUVs, building the network

What if you could extract buoy information and cat it throughout the rest of a small tributary.

Theoretical Approach: Slice up the tributary into 1 meter sections.
Consider well mixed within a section; stratification occurs between sections.
As a result conservative properties may be modeled as Gaussian distribution.

**Statistical Methods:**

\[
T(x) = (T_R - T_M)(e^{-\frac{x^2}{2\sigma^2}}) + T_M
\]
\[
S(x) = (S_M - S_R)(e^{-\frac{x^2}{2\sigma^2}}) + S_R
\]
Severn River Temp Gaussian
1 August 2012

Predicted vs. Actual Temperature

- Surface Predicted
- 2 Meter Predicted
- 4 Meter Predicted
- 6 Meter Predicted
- Surface Actual
- 2 Meter Actual
- 4 Meter Actual
- 6 Meter Actual

Station: SR0, SR1, SR2, SR3, RBS, SR5, RBN, SR6, SR7
1 August 2012
Predicted vs. Actual Salinity

[Graph showing predicted and actual salinity values at different stations for the date of 1 August 2012. The graph includes lines for predicted salinity at surface, 2 meters, 4 meters, and 6 meters, as well as actual salinity values at these depths. The stations are labeled as SR0 to SR7.]
Husband-and-wife scientists take on black muck clogging Chesapeake Bay

https://www.washingtonpost.com/national/health-science/husband-and-wife-scientists-take-on-black-muck-clogging-chesapeake-bay/2015/05/11/abc97194-e784-11e4-aae1-d642717d8afa_story.html
USNA and UDEL
USNA and UDEL
\[ y = -0.058x + 6.091 \]

\[ R^2 = 0.33 \]

Backscatter Amplitude (average)
USNA and UDEL

\[ \text{Phi} (\phi) = -\log_2 D_{(mm)} \]
The Future

USNA-NECOS Concept
Secure, Adhoc, Semi-Mobile, Environmental Monitoring Network

Naval Estuarine and Coastal Ocean Observation System
Conclusion

- It is important to understand the complete system when attempting to make important policy decisions regarding restoration.
- Physics dominates and controls the system, no coriolis and no sloshing of water in and out by tides,
- Hypoxia and anoxia are locally controlled (it’s the creeks!!!)
- Susquehanna River is NOT the main polluter to Severn and South Rivers.
- Thermal inversion induced mixing (fall overturn) is largely a myth, wind is much more efficient than thermal cooling or tidal mixing.
- Use of technology like REMUS, CONMONS, and a more complete observing system will allow for better modeling, and therefore better policy decisions.
- Focused research should include downstream benefits of upland restoration in tidal sections (does this really work for TMDL issues?)
- Can we use in-situ biogeochemistry to deal with bottom muck
- What are the true water quality trends?