Determining the “Best” Model for Explaining Water Clarity Variation during SAV Seasons within the Tidal Tributary Rivers of the Chesapeake Bay Watershed

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SUMMARY and DISCUSSION

Appropriate water clarity, expressed in terms of percent light through the water column, is known to be one of the primary characteristics necessary for the restoration and retention of submersed aquatic vegetation (SAV) in the tidal Chesapeake Bay (CB) system. Of particular concern is maintenance of appropriate light conditions during the SAV growing season, and consequently, determining which variables most influence the variation in clarity at this time. The US EPA (2003) has recently published ambient water quality criteria for water clarity, in which percent light through the water column are determined from Secchi depth measurements. In this work I examine the variation of Secchi depth and explanatory variables in samples take in several major CB tributary tidal river systems from 1985 through 2000. (See Figure 1. Data available from the USGS and Chesapeake Bay Program.) The rivers include the James and its tributary Appomattox, the York including the Pamunkey and the Mattaponi, the Rappahannock, the Potomac, the Patuxent, the Susquehanna, the Choptank, the Nanticoke and the Pocomoke. Although the samples are from the main channel, they are considered to be indicative of seasonal conditions for SAV in more shallow areas. (Batiuk et al, 2000).

Primary factors influencing water clarity are thought to be suspended sediment and chlorophyll-a in the water column (Batiuk, et al, 2000; Cerco et al, 2004). Sediment loads in the non-tidal portion of the tributary rivers are known to correlate with flow conditions (Langland et al, 2001). Consequently, I applied all-possible-regression analysis to the available long-term quasi-monthly data for Secchi depth in the central channel versus the primary physical explanatory variables of chlorophyll-a and total suspended sediments at the top and bottom of the water column, salinity (as an index of low flow conditions), and nontidal river discharge into the estuarine portion, as well as time variables, including year, subseason, and day-of-year fraction. Because most of the samples came from the tidal fresh, oligohaline or mesohaline salinity zones, I adopted the definition of the SAV growing season in these salinity zones, namely the months of April through October. I also considered the early and late portions of the growing season separately (April through June, July through August); for completeness, I also examined Secchi depth during the time of winter senescence (November through March) and over the entire year. Figure 2a shows an example of the data available for the Potomac River.

Analysis determined which one characteristic best explained Secchi depth variation. In almost all cases, that is over all 67 sites in all nine river systems and during all 5 seasonal groupings, the primary explanatory variable (statistically significant at $p \leq 0.05$) was total suspended sediments at the top of the water column, either in real or log units. However, the adjusted R^2 ranged from 0.72 to 0.04, with most values between 0.20 and 0.45. Chlorophyll-a either at the top or the bottom of the water column was the primary variable in a very few locations in the mesohaline salinity regime. This is consistent with the observation by Buiteveld (2003) that suspended sediment is a more important determinant than algae or yellow substance in water for Secchi depth < 1m.

Analysis also showed how much more variation could be explained with a more complex model linear model. Total suspended sediments at the top of the water column, either in real or log units, was a component of each model; frequently, flow and chlorophyll-a also were included. The adjusted R^2 of the more complex models (statistically significant $p \leq 0.05$) ranged from 0.80 through 0.06, indicating some but not large gain in introducing more complexity. Figures 2b and 2c illustrate the results for the Potomac River for the SAV growing and senescing seasons. Table 1 gives AMJJASO models results.

CONCLUSION

Although the amount of variation in Secchi Depth that can be explained differs between locations in the same river and between different seasons at the same location, the primary explanatory variable for water clarity in this system, measured as Secchi depth, is the variation in total suspended sediment.

REFERENCES

- Batiuk, R., et al, 2000, Chesapeake Bay Submerged Aquatic Vegetation Water Quality and Habitat-Based Requirements and Restoration Targets: A Second Technical Synthesis, CBP/TRS 245/00, EPA 903-R-00-014, 217pp.
- Buiteveld, H., 2003, A Model for Calculation of Diffuse Light Attenuation (PAR) and Secchi Depth, Freshwater Biology, 48(1):55-65.
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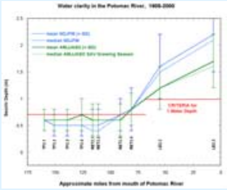
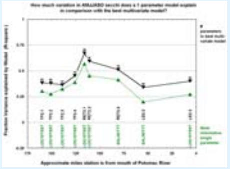
- Langland, M., R. Edwards, L. Sprague, and S.Yochum, 2001, Summary of Trends and Status Analysis for Flow, Nutrients, and Sediments at Selected Nontidal Sites, Chesapeake Bay Basin, 1985-99, U.S.Geological Survey Open File Report 01-73, 49pp.
- United States Environmental Protection Agency, 2003, Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries, EPA 903-R-03-002, 231pp (plus appendices).

Figure 1. Chesapeake Bay Program long term water quality monitoring stations.

Source: www.chesapeakebay.net/wqual.htm

Figure 2 : Potomac





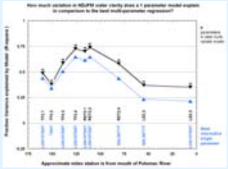


Table1. BEST AMJJASO Model

Station	N	Adjusted R2	Model #	Variables for BEST AMJASO model
JAMES				
TF5.2A	105	0.60	5	LOG10TSST LOG10TSSB TRMSAVYR TRMSAVFRAC SEASNUM
TF5.3	108	0.49	5	LOG10TSST LOG10TSSB TRMSAVFRAC SEASNUM SALINITYT
TF5.4	100	0.28	3	LOG10TSST FLOW CHLAT
TF5.5	103	0.24	3	FLOW LOG10FLOW CHLAT
TF5.5A	109	0.31	5	LOG10TSST TRMSAVYR TRMSAVFRAC FLOW CHLAT
TF5.6	111	0.20	2	LOG10TSST FLOW
RET5.1A	111	0.21	3	TSST TSSB LOG10TSSB
RET5.2	115	0.58	3	LOG10TSST LOG10TSSB SALINITYT
LE5.1	113	0.71	3	TSST LOG10TSST SALINITYT
LE5.2	118	0.70	4	LOG10TSST TRMSAVYR TRMSAVFRAC SALINITYT
LE5.3	113	0.41	4	LOG10TSST TRMSAVYR TRMSAVFRAC SALINITYT
LE5.4	112	0.52	5	TSST LOG10TSST TRMSAVYR TRMSAVFRAC SALINITYT
LE5.5	177	0.55	5	TSST LOG10TSST TRMSAVYR SALINITYT CHLAT
YORK				
TF4.2	101	0.12	2	TSST FLOW
RET4.1	112	0.41	2	LOG10TSST SALINITYT
TF4.4	87	0.36	4	LOG10TSSB TRMSAVFRAC SALINITYTFLOW
RET4.2	92	0.34	2	LOG10TSST SALINITYT
RET4.3	96	0.46	2	LOG10TSST SALINITYT
LE4.1	97	0.55	4	LOG10TSST TRMSAVYR TRMSAVFRAC SALINITYT
LE4.2	100	0.43	3	LOG10TSST TRMSAVYR TRMSAVFRAC
LE4.3	98	0.30	3	TSST LOG10TSST TRMSAVFRAC
WE4.2	162	0.29	6	TSST LOG10TSST TRMSAVFRAC SEASNUM SALINITYT CHLAT
RAPPAHANNOCK				
TF3.1E	47	0.24	1	TSSB
TF3.1B	65	0.30	3	TSST LOG10TSSB TRMSAVYR
TF3.2	90	0.30	2	TSST CHLAT
TF3.2A	38	0.55	3	LOG10TSST TRMSAVFRAC CHLAT
TF3.3	106	0.32	3	LOG10TSST TSSB LOG10FLOW
RET3.1	113	0.55	3	TSST SALINITYT FLOW
RET3.2	110	0.14	5	TSSB TRMSAVYR SEASNUM SALINITYTLOG10FLOW
LE3.1	115	0.29	4	TSST SALINITYT FLOW LOG10FLOW
LE3.2	118	0.32	3	SALINITYT LOG10FLOW CHLAT
LE3.3	118	0.27	4	LOG10TSSB SALINITYT LOG10FLOW CHLAT
LE3.4	114	0.36	6	LOG10TSST TRMSAVFRAC SEASNUM SALINITYT FLOW CHLAT
LE3.6	186	0.39	6	LOG10TSSB TRMSAVYR SEASNUM SALINITYT LOG10FLOW CHLAT
POTOMAC				
TF2.1	201	0.38	5	LOG10TSST TSSB LOG10TSSB FLOW CHLAB
TF2.2	195	0.38	6	TSST LOG10TSST TRMSAVYR TRMSAVFRAC FLOW CHLAB
TF2.3	214	0.36	5	LOG10TSST TSSB LOG10TSSB SEASNUM FLOW
TF2.4	200	0.45	3	LOG10TSST TRMSAVYR LOG10FLOW
MAT0016	207	0.22	7	LOG10TSST TRMSAVYR TRMSAVFRAC SEASNUM FLOW LOG10FLOW CHLAT
RET2.1	192	0.68	8	LOG10TSST TSSB LOG10TSSB SALINITYT TSST FLOW LOG10FLOW CHLAB
RET2.2	220	0.60	4	TSST LOG10TSST SEASNUM SALINITYT
RET2.4	198	0.54	4	TSST TRMSAVYR TRMSAVFRAC SALINITYT
LE2.2	206	0.39	6	LOG10TSST TRMSAVYR TRMSAVFRAC SEASNUM SALINITYT CHLAT
LE2.3	200	0.44	5	LOG10TSST LOG10TSSB TRMSAVFRAC SALINITYT CHLAT
PATUXENT				
WXT0001	116	0.62	3	TSST LOG10TSST CHLAT
TF1.4	204	0.48	5	LOG10TSST TRMSAVYR TRMSAVFRAC FLOW LOG10FLOW
TF1.5	202	0.17	4	TSST TRMSAVYR SALINITYT FLOW
TF1.6	202	0.21	2	LOG10TSST FLOW
TF1.7	204	0.39	5	TSST LOG10TSST SALINITYT FLOW CHLAT
RET1.1	203	0.33	6	TSST TRMSAVYR TRMSAVFRAC SEASNUM SALINITYT LOG10FLOW
LE1.1	186	0.27	6	LOG10TSST TRMSAVYR TRMSAVFRAC SEASNUM SALINITYT LOG10FLOW
LE1.2	203	0.43	7	LOG10TSST TRMSAVYR TRMSAVFRAC SEASNUM SALINITYT LOG10FLOW CHLAT
LE1.3	203	0.44	8	LOG10TSST TRMSAVYR TRMSAVFRAC SEASNUM SALINITYT LOG10FLOW CHLAT CHLAB
LE1.4	203	0.35	5	TSST LOG10TSST SEASNUM SALINITYT CHLAT
SUSQUEHANNA				
CB1.1	200	0.75	4	LOG10TSST LOG10TSSB TRMSAVFRAC LOG10FLOW
CHOPTANK				
ET5.1	209	0.09	3	LOG10TSSB TRMSAVFRAC FLOW
ET5.2	217	0.49	7	LOG10TSST TSSB LOG10TSSB SALINITYT FLOW LOG10FLOW CHLAT
EE2.1	200	0.31	6	LOG10TSST TRMSAVYR TRMSAVFRAC SALINITYT LOG10FLOW CHLAT
EE2.2	178	0.42	5	LOG10TSSB TRMSAVFRAC LOG10FLOW CHLAT CHLAB
NANTICOKE				
ET6.1	101	0.17	1	SEASNUM
ET6.2	93	0.41	5	TSST TRMSAVYR TRMSAVFRAC SEASNUM SALINITYT
POCOMOKE				
ET10.1	96	0.14	2	TSST LOG10FLOW
EE3.3	176	0.43	4	LOG10TSSB TRMSAVFRAC LOG10FLOW CHLAB

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