Chesapeake Bay Program
Scientific and Technical Advisory Committee

Tidal Sediments Workshop Report

May 28-29, 2009

STAC Publication 10-001

About the Scientific and Technical Advisory Committee

The Scientific and Technical Advisory Committee (STAC) provides scientific and technical guidance to the Chesapeake Bay Program on measures to restore and protect the Chesapeake Bay. As an advisory committee, STAC reports periodically to the Implementation Committee and annually to the Executive Council. Since it's creation in December 1984, STAC has worked to enhance scientific communication and outreach throughout the Chesapeake Bay watershed and beyond. STAC provides scientific and technical advice in various ways, including (1) technical reports and papers, (2) discussion groups, (3) assistance in organizing merit reviews of CBP programs and projects, (4) technical conferences and workshops, and (5) service by STAC members on CBP subcommittees and workgroups. In addition, STAC has the mechanisms in place that will allow STAC to hold meetings, workshops, and reviews in rapid response to CBP subcommittee and workgroup requests for scientific and technical input. This will allow STAC to provide the CBP subcommittees and workgroups with information and support needed as specific issues arise while working towards meeting the goals outlined in the *Chesapeake 2000* agreement. STAC also acts proactively to bring the most recent scientific information to the Bay Program and its partners. For additional information about STAC, please visit the STAC website at www.chesapeake.org/stac.

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Cover photo of sediment plumes on the South River, Maryland provided by Jane Thomas, Integration and Application Network (http://ian.umces.edu/).

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Tidal Sediments Workshop Report

Introduction

A small group of Chesapeake Bay regional experts on sediments, water clarity, and submerged aquatic vegetation (SAV), along with federal and state modelers and managers, met at the Doubletree Hotel in Annapolis, MD for 1.5 days on May 28-29, 2009. The meeting was sponsored by the Chesapeake Bay Program (CBP) Scientific and Technical Advisory Committee (STAC). The immediate purpose of the meeting was to discuss CBP Water Quality and Sediment Transport Model (WQSTM) suspended sediment, water clarity, and SAV predictions based on scenarios run to date, in the context of available data and understanding. The ultimate purpose was to help keep the CBP on track towards the goal of making defensible recommendations for tidal sediment allocations by 2010. The meeting was also intended to help identify areas in which additional or alternate information should be used for TMDL development, rather than relying solely on model predictions.

Attendees

Rich Batiuk, EPA-CBPO
Peter Bergstrom, NOAA-CBO
Steve Bieber, WashCOG
[S]Carl Cerco, USACE
Lee Currey, MDE
[S]Carl Friedrichs, VIMS
Chuck Gallegos, SERC
[S]Jeff Halka, MD DNR
Courtney Harris, VIMS
[S]Scott Hardaway, VIMS
Julie Herman, VIMS
Lee Karrh, MD DNR
[S] Steering Committee Member

[*]Michael Kemp, UMCES-HPL
Evamaria Koch, UMCES-HPL
[S]Lewis Linker, EPA-CBPO
Nancy Rybicki, USGS
[*S]Larry Sanford, UMCES-HPL
Chris Spaur, USACE
Peter Tango, USGS-CBPO
Mark Trice, MD DNR
Liz Van Dolah, CRC-STAC
Alexey Voinov, CRC
Patricia Wiberg, UVA

[*] STAC representative

Agenda

Day 1, May 28 –
Morning (10-12:45)
Introduction and Call to Order (Sanford)
Developing the Management Strategies to Achieve the Clarity/SAV Water Quality Standard (Linker)
Long-term Changes in Suspended Sediment Properties Inferred from Transparency and Attenuation Measurements (Gallegos)
Relations between SAV and Water Clarity in Lower Choptank (1984 -2007) (Kemp)
Other interactions between SAV and sediments (Koch)

Discussion

Afternoon (1:30-5:00)

Remarks on sediment-SAV relationships in the Potomac River (Karrh)

Marginal Sediments: Characteristics at the Edges of the Chesapeake Bay (Halka)

Shoreline erosion estimates in Virginia (Hardaway)

Factors affecting shallow water suspended sediments in Chesapeake Bay (Sanford)

Sediment/Clarity Data Available from Maryland's Monitoring Efforts (Trice)

Discussion

Suspended Sediment, Water Clarity and SAV in the WQSTM – Formulations, Scenarios and Description of the WQSTM and predictions to date (Cerco)

Discussion

Day 2, May 29 –

Morning

Summary of Day 1 Presentations and Discussions (Friedrichs)

Discussion of workshop recommendations

Key points of presentations

There were many good points made in the various presentations, the ensuing discussions, and the discussions leading up to the recommendations below. Most of the presentations may be viewed in their entirety on the meeting website at www.chesapeake.org/stac/tidalsediment.html. Key points are summarized here.

After Larry Sanford called the meeting to order and explained its specific purposes, Lewis Linker presented CBPO perspectives and requirements. He explained the duality of the regulations for water clarity: either a specified area within each Bay segment must meet specified water clarity goals during the SAV growing season, or SAV must be present in a (generally smaller) area within each segment, based upon previously observed SAV acreage. Predictions of SAV acreage are preferable, since SAV recovery is the ultimate goal, but at present the WQSTM SAV predictions have significant problems. He also stated that the CBP is compelled to deliver an assessment by spring 2010 of the actions required to achieve the clarity/SAV water quality standard. They need to provide the best estimate possible using available tools during June/July 2009 to be able to meet the 2010 deadlines. The purpose of this workshop is to provide guidance to the CBPO as to how to best achieve their goals.

Chuck Gallegos presented some very interesting data and analysis on long-term changes in optical properties of Bay waters. He showed that, in much of the Bay, K_dZ_{SD} (the product of attenuation coefficient and secchi depth) is decreasing (figure 1). Under equilibrium conditions, this product is thought to be a constant. In most of the cases presented, secchi depth appears to be changing more than attenuation coefficient. The trend in K_dZ_{SD} implies an approximately twofold increase in the scattering-to-absorption ratio, with an increase in the specific-scattering coefficient of suspended solids the most likely cause. This could be due to an increasing fraction of organic suspended solids, smaller particle-size distributions, or other unknown factors. The net result is that the calibration of the light attenuation model is drifting. More importantly, the implications of this change are largely unknown.

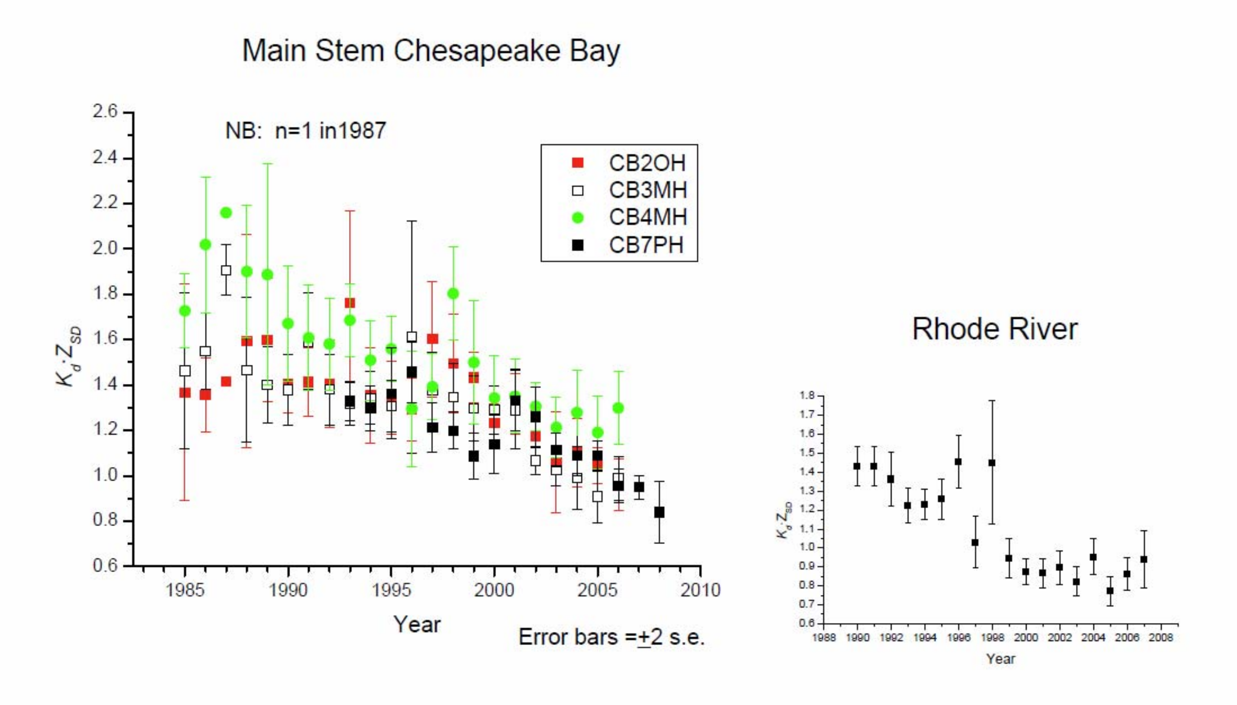


Figure 1 - Trends in optical depth in Chesapeake Bay

Mike Kemp then presented data on relationships between K_d, Z_{SD}, SAV cover, and environmental conditions in the Lower Choptank from 1985 through 2007. He showed a significant decline in Z_{SD}, with insufficient data to detect a K_d trend. Interannual variations in water clarity were directly related to river flow. SAV cover (predominantly *Ruppia maritima*) has been increasing, but highly variable since 1990. SAV cover has varied with changes in Z_{SD} since 1996 (but not before). The relationship $K_d \sim \alpha/Z_{SD}$ appears to be significant for the Lower Choptank, but the value for α has recently changed from 1.6 to 1.0.

Evamaria Koch talked about the interacting effects of light requirements and bottom sediment quality. She showed that sunlight at the leaf surface is more than a nutrient effect, but that the spatial and temporal variability of turbidity needs to be considered as well. This may be because epiphytes may play a major role in light attenuation in SAV exposed to high TSS levels, i.e. along eroding shorelines, as the suspended sediments are incorporated into the epiphyte matrix. She also showed that the bottom sediment quality must be considered, distinguishing between “bad” (mud) and “good” (sand) sediment. There is a seagrass sediment habitat requirement of <35% silt + clay in the Coastal Bays (*Zostera marina* and *Ruppia maritima*). It is likely that there is a similar habitat requirement for SAV in Chesapeake Bay, though it has not yet been sufficiently quantified. Lee Karrh presented preliminary data from the

Potomac River that suggests that SAV need <32% mud in the bottom sediments. He also pointed out that SAV beds in the Potomac tend to occur adjacent to naturally stable shorelines.

Jeff Halka discussed the characteristics of nearshore bottom sediments in the Bay, focusing on Maryland waters (Figure 2). While it is generally true that nearshore sediments of the lower part of the Maryland mainstem are sandy, there are a number of exceptions to this rule and very nearshore sediments are more heterogeneous. The nearshore sediments of the upper Bay are much muddier, reflecting their proximity to the Susquehanna River and the turbidity maximum. Virginia nearshore sediments are more uniformly sandy. In both states, however, there remain large portions of tributaries and some parts of the Bay where the bottom sediments are essentially unmapped. Summarizing his talk, Halka said that nearshore sediments are not uniformly sand sized; that eroding banks and nearshore areas have spatially variable sediment composition; that the fastland (above mean tide) contribution to nearshore erosion is not constant, although it is approximated as such for Maryland waters in the WQSTM; that many locations in the Bay are characterized by a variably thick layer of mobile sand overlying compacted finer grained sediments; that equilibrium depth profiles characterize eroding shores, but the factors influencing the profile shapes are as yet uncertain; and that variable sand thickness influences SAV distributions relative to underlying compacted sediments.

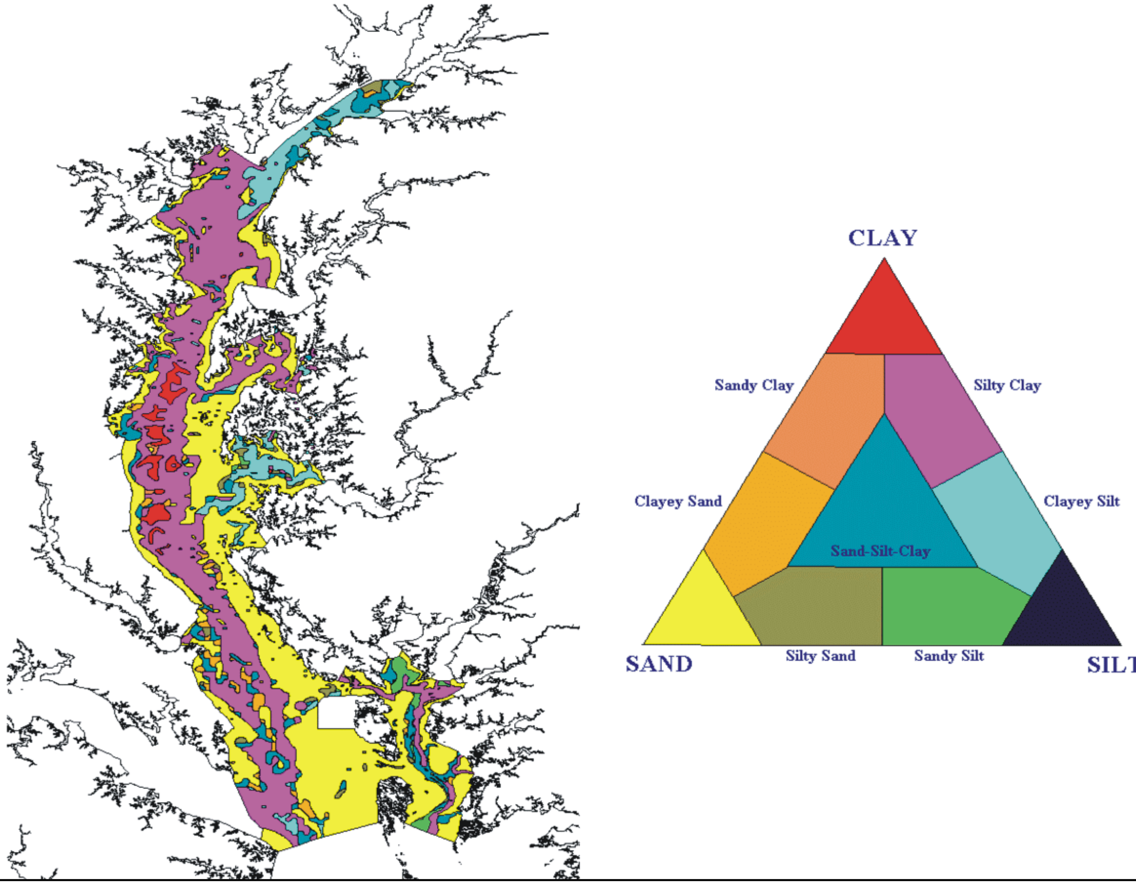


Figure 2 - Map of bottom sediment distribution in the Maryland Chesapeake Bay, from Kerhin et al. (1988).

Scott Hardaway then discussed the Maryland and Virginia methods by which sediment loadings from shore erosion are calculated as input to the WQSTM. Both methods are empirically based and built on the best available data, and both start with long term segment specific shore erosion rates calculated as the difference between successive shoreline surveys divided by the time between the surveys. The most recent historical shorelines (~50 yrs) are used, and currently hardened shoreline segments are not included. Fastland erosion rates are estimated for the unprotected remaining transects to determine shore elevation from topographic quads and separating bank/bluff from marsh shorelines. The methods diverge when accounting for the relative contributions of fastland to nearshore erosion and estimating the eroded sediment grain sizes. Both methods are reasonable based on regional differences in geomorphological characteristics and available data, but both might benefit from further refinement and reconciliation. Temporal changes in sediment loading from shore erosion are accounted for in the model based on wave and inundation predictions.

Larry Sanford then presented data on processes affecting nearshore suspended sediments and turbidity, focusing on two studies in the Choptank and Little Choptank Rivers on Maryland's Eastern Shore. He concluded that when hardened shorelines are directly adjacent to unprotected shorelines, alongshore tidal currents carry suspended solids from the eroding shorelines to the protected shorelines, resulting in little difference in average suspended sediment levels. Uniformly hardened shorelines did have lower suspended solids/turbidity during events than did unprotected shorelines. Most erosion happened during big wave events with surface elevations near mid-bank apparently producing the largest response. Introduced sediments either transported offshore (fines) or settled quickly (sands). Settling of eroded fines was complex, and very likely involved time dependent flocculation. However, a constant settling rate of 0.05-0.2 mm s^{-1} seemed to describe the overall settling process reasonably well. Higher settling speeds were empirically associated with higher concentrations. Nearshore bottoms adjacent to a hardened shoreline continued to deepen at approximately the same rate as if the shoreline were still eroding. Intriguingly, background

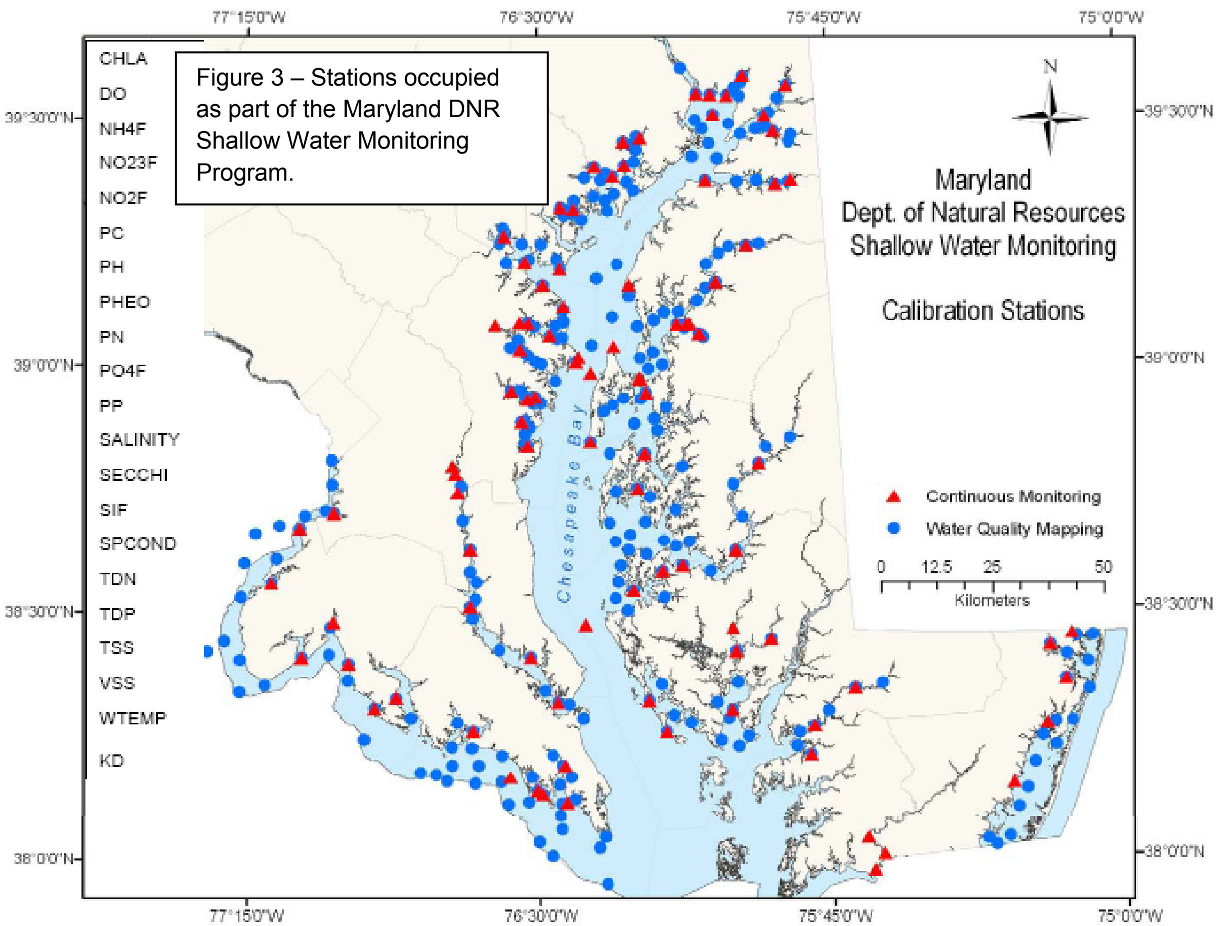


Figure 3 – Stations occupied as part of the Maryland DNR Shallow Water Monitoring Program.

suspended sediment concentrations that most affect day-to-day turbidity levels were higher during summer than during winter, suggesting an important role for biological processes. In general, however, these suspended sediments are primarily inorganic solids rather than phytoplankton.

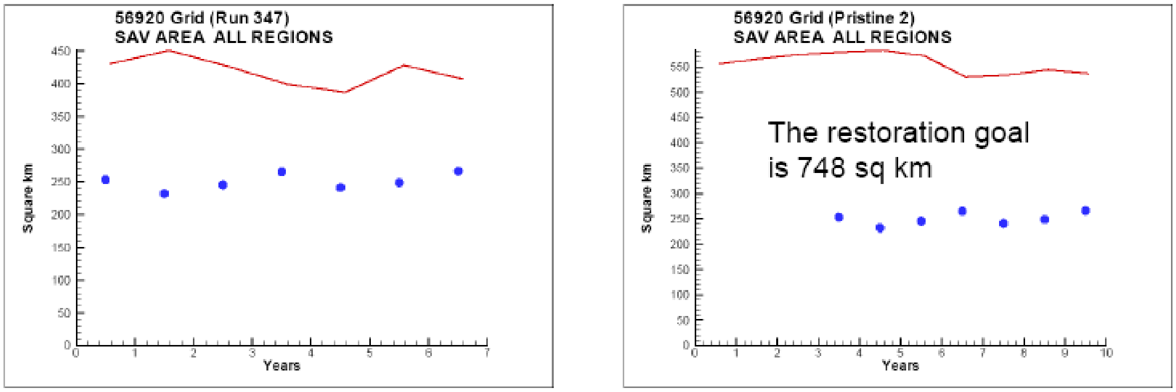
Mark Trice presented an overview of Maryland DNR's water quality monitoring programs, focusing on data availability from the shallow water monitoring program. He first outlined the three basic forms of monitoring activities. Long-Term Fixed Station Monitoring for the CBPO has been carried out with monthly/twice monthly cruises year round since 1985, mostly in deeper water. There are more than 80 stations in Maryland waters, with a full suite of parameters and depth profiles collected. The shallow water monitoring program (SWMP) has been carried out since 2003, with two complementary aspects. Figure 3 shows locations in the Maryland Bay that have been occupied in the SWMP. The continuous in situ monitoring program deploys internally recording monitoring instruments that collect data every 15 minutes. Parameters measured include dissolved oxygen (DO), turbidity, chlorophyll, temperature, salinity, pH, and surface elevation. Sensors are calibrated and serviced every two weeks. The water quality mapping program is carried out in conjunction with the continuous monitoring program. It incorporates monthly cruises April through October in 10+ Chesapeake Bay segments, using dataflow systems onboard small survey boats. Data collected every four seconds in transit include DO, turbidity, chlorophyll, temperature, salinity, and pH, with calibration data collected at 5-7 sites each cruise. To increase spatial coverage, most segments are occupied for three year periods before moving to a new location. Virginia has a similar program in selected locations. Between them, these shallow water monitoring programs are a valuable resource for comparison to WQSTM predictions in shallow water, and for independently evaluating the effects of management actions.

Carl Cerco rounded out the first day with an extended presentation on suspended sediment, water clarity and SAV in the WQSTM. He began with a description of changes in the new WQSTM that directly affect calculations of suspended sediment, water clarity, and SAV abundance. There are still limitations of the sediment transport calculations, but this model now contains a sophisticated modern sediment transport component. The new version of the model has dynamic sediment resuspension and deposition based on bed shear stresses from wind-driven waves and prevailing currents. Its sediment bed model is based on the non-cohesive version of the ROMS community sediment transport model, and it incorporates four solids classes including two clays, silt, and sand. Sediment loads from above the fall line are taken from the Watershed model. Sediment loadings from shore erosion are from estimates by Halka, Hardaway, and Hopkins as described above. Spatial variation is based on observations, temporal variation is computed from wave energy and inundation calculations, and marsh erosion is explicitly included. The present model also employs a rigorous optical model, which explicitly accounts for color, absorption, and scattering. It is parameterized with observed optical properties, when available, and otherwise with interpolated parameterizations based on best professional judgment and/or tuning. In the latest version of the model, SAV cell areas are independent of hydrodynamic cell dimensions. SAV cells are divided into four depth increments: <0.5 m, 0.5 to 1 m, 1 to 1.5m, and 1.5 to 2 m. SAV area is the primary validation parameter for comparison to aerial overflight estimates. There are explicit submodels for different SAV species in different salinity zones of the Chesapeake system that account for different light and nutrient sensitivities and seasonality.

In spite of all of the model changes, the SAV predictions in particular are still not behaving as desired (Figure 4). In the runs presented, existing SAV area is over-estimated. Under extreme load reductions, on the other hand, computed SAV area shows limited response, restoration goals are not met, and SAV does not recover out to two meter depth system-wide. There is some indication of nutrient limitation under extreme nutrient load reductions but this is not a major factor.

Cerco spent the second half of his talk discussing possible solutions to these problems. The over-prediction of existing SAV area can be largely resolved by limiting the potential growth area to approximate wave limitation. A set of limitations that worked reasonably well were to specify no SAV growth area inside the 0.5 meter depth contour in less energetic segments, inside the one meter contour in more wave exposed segments, and with no depth limitation in tidal fresh segments (Figure 5). This still does not correct the lack of response to extreme load reductions, however. It is possible that better accounting for expected positive feedbacks between SAV growth and bottom stress reduction, suspended solids reduction, and proximity to existing SAV beds may overcome some of these problems, but these possibilities are still under investigation.

Carl Friedrichs began the second day of the workshop with an excellent summary of the main points of the first day's presentations, much of which is incorporated here. He finished with strawman recommendations to prime discussion, and a lively general discussion ensued.



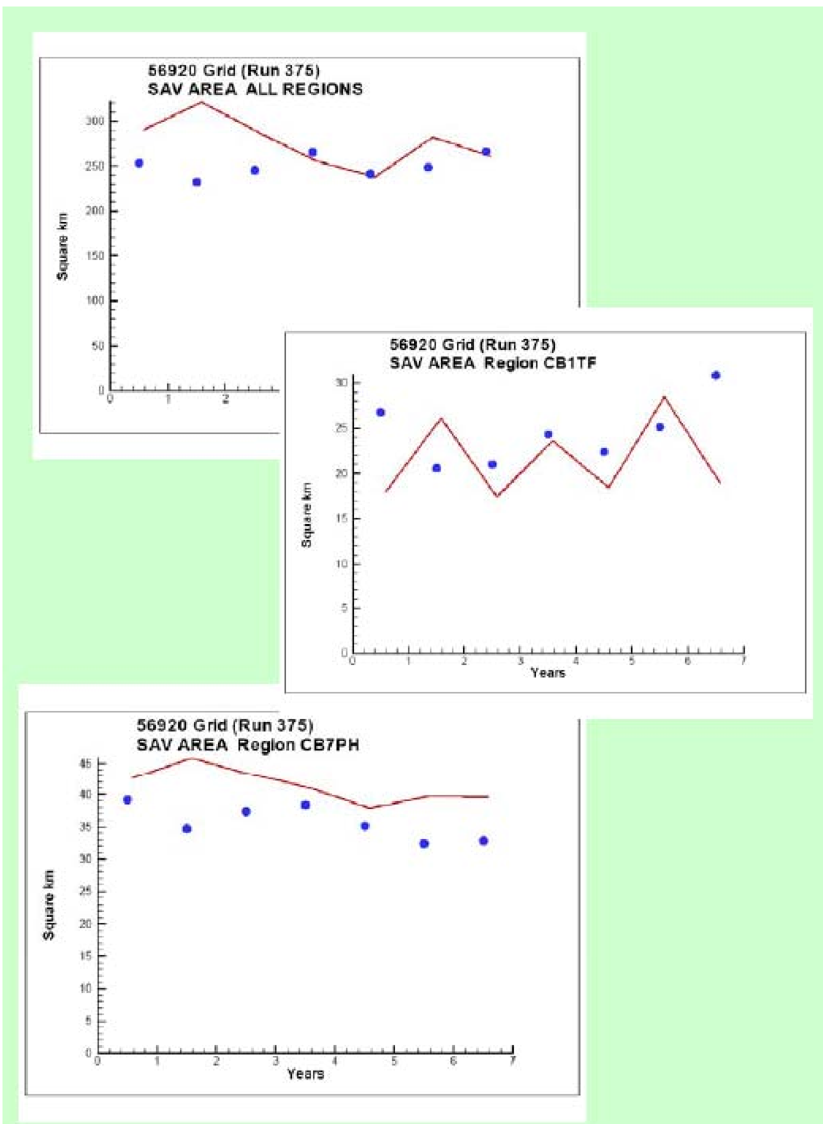


Figure 4 (above) – summary plot of predicted SAV area (red line) in all regions under present conditions, compared to observations (left), and predicted SAV area under severely reduced loading (right).

Figure 5 (left) – Predicted SAV area under present conditions after spatially variable restrictions on potential growth area.

Conclusions and Recommendations

After extended discussion, both during the presentations of the first day and following Carl Friedrichs' summary the morning of the second day, the workshop participants agreed on the following conclusions and recommendations:

1. The SAV model has been significantly improved and is continuing to show promise. For example, it predicts the mean extent and spatial distribution of SAV in the Chesapeake Bay well, after reasonable limitation of potential growth areas. However the unrealistic predicted changes in SAV over decadal time scales and under extremely low ("pristine") loading conditions suggest that the SAV model is not yet ready to be used for regulatory purposes.

2. Both the existing SAV model and present scientific understanding suggest that nutrient reductions will help improve SAV abundance more than sediment load. Nutrient reductions are beneficial to SAV both through reductions in epiphytes and improvements in overall water clarity, the latter through mechanisms that are not yet completely understood.

3. Attempting to reduce nearshore turbidity through blanket application of shore protection measures would be a mistake. Reducing shore erosion inputs makes the most sense in cases where fastland and nearshore sediments are dominantly clays and silts. However, where shore erosion contributes much-needed sand to the nearshore zone, habitat benefits of that sand supply for both SAV and beach ecosystems may be more beneficial than any potential reductions in turbidity from shore protection. Even shore erosion that contributes fines to the system may be beneficial, if those fines are a source of sediment for nearby deteriorating marshes.

4. Given the still tentative nature of the SAV model, the short time frame available for finalizing modeling tools, and the dual nature of goal attainment requirements (SAV acreage OR water clarity acreage), it is recommended that short-term CBP modeling efforts concentrate on improving and verifying water clarity predictions. There are several scenarios that should be investigated more completely: (i) decadal time-scales where data is available, (ii) seasonal and spatial variability in shallow water using the shallow water monitoring data, and (iii) changes in clarity for pristine/best-case conditions versus present-day simulations.

Suggestions for improving water clarity predictions include: (i) linking the settling rate of very fine sediment in an inverse fashion to DOC and/or other biologically influenced parameters, such as phytoplankton production or Chl-a and (ii) more realistically linking light attenuation to the suspended sediment particle size distribution.

5. The relatively recent shallow water monitoring data are a valuable resource both for model calibration/verification and for independent assessment of the effectiveness of management actions.

6. There were many suggestions for improving the SAV model as well, but these should be considered after the clarity predictions are thoroughly vetted.