Bay Oxygen Research Group (BORG) Meeting

July 28th, 2026
12:00 PM – 1:30 PM
Visit the meeting webpage for meeting materials and additional information.

Purpose: This was the July monthly meeting for the Bay Oxygen Research Group (BORG). In this meeting, the 4-D Interpolator Development Team began by answering questions relating to the current documentation. Then, Rebecca Murphy (UMCES) provided an overview of the workflow and Jon Harcum (TetraTech) presented on the interpolator's depth correlation.

Minutes

I. Welcome, Introductions & Announcements

Lead: ***Peter Tango*** *(U.S. Geological Survey, USGS)*

Upcoming Conferences, Meetings, Workshops and Webinars

- Restore America's Estuaries' 2026 Coastal & Estuarine Summit – September 22-25, 2026. San Francisco, California.
- Chesapeake Watershed Forum – November 13-15, 2026. Shepherdstown, West Virginia.
- National Water Quality Monitoring Council Virtual Gathering – March 9-11, 2027. Virtual.

Announcements

- With the updated structure and governance, the Bay Oxygen Research Group Action Team is moving into the Clean Water Goal Team. To stay up to date with the Clean Water Goal Team and their monthly meetings, please join the mailing list by emailing Allison Welch (awelch@chesapeakebay.net). You can also join the list for the Clean Water Goal Team Newsletter by following this link.

II. Documentation Questions and Review

Lead: ***Peter Tango*** *(USGS)*

Documentation has been provided to members. If you would like to access this, please reach out to Rebecca Murphy (rmurphy@chesapeakebay.net). More documentation will be shared at the end of the week which will review the four correlation components in the model.

Rebecca took a moment to thank members for leaving comments in the SharePoint documents. If you have any questions about this, you can reach out to Rebecca Murphy (rmurphy@chesapeakebay.net) or Allison Welch (awelch@chesapeakebay.net). There is a lot of documentation that will go with the code being written that will be pulled together in the coming months.

No questions were mentioned by members. If you have questions, feel free to mention them at the next BORG meeting or email them to Rebecca.

III. Overview of Workflow

Lead: ***Rebecca Murphy*** *(University of Maryland Center for Environmental Sciences, UMCES)*

In this presentation, Rebecca shared the workflow diagram that was shared at the July 1st BORG Meeting. She first gave a quick overview of this workflow diagram. Rebecca described how the data from all years in the tidal waters is organized and used in the mean mid-day interpolation, which is done one year at a time. The output from that goes directly into the simulation, but part of the output also goes into the parameterization step. This step describes the high-frequency variability, daily cycles and correlation using the data from the year being interpolated and all historical data. The parameterization and the mean mid-day interpolation goes into the simulation to get the hourly simulation by year.

Boxes on the slide with a dashed outline are still being worked on. In the previous meeting, there were several parts of the parameterization step that were dashed but have since been completed.

Next, Rebecca focused on the most recent work and next steps. Rebecca zoomed into the parameterization step to describe the recent work. This step involves using the residuals generated by the mean mid-day interpolation. A generalized additive model (GAM) is used to find patterns in the different exploratory variables in this data to estimate the correlation.

Some of the recent work has also been simulation testing. They are taking the outputs of the correlation parameters and the mid-day mean interpolation and running many simulations on that data. One reason they are doing this is to test the optimal number of simulations.

For next steps, the development team plans to test the interpolation results. The results of these tests and case studies will be brought to the group. The Criteria Assessment Protocol Action Team (CAP AT) has created decision rules for using the 4D interpolator. This group will send segments and years for initial evaluations, and the BORG team will provide that data. They are also working on documentation and have a November deadline.

Action Items:

- Leaders of the CAP AT will share segments and years of focus to the 4D Interpolator Development Team for initial evaluations. These will be segments that will inform the testing of the CAP AT decision rules.

IV. 4D Interpolator: Large-Scale Depth Correlation

Lead: ***Jon Harcum*** *(TetraTech)*

In this presentation, Jon explained how the large-scale depth correlation functions in the interpolator. There are four components in the tool. The large-scale correlation component is one of the four components and includes the depth component.

On slide 4, Jon showed a graph of dissolved oxygen (DO) across multiple depths. The team has observed that there is a relationship between patterns of dissolved oxygen at different depths. With this parameter, they are trying to estimate the relationship between DO at depths ±1 meter of each other. On slide 6, Jon shows how results vary between a model with no correlation versus with strong correlation. This shows how depth correlation impacts results even with the same mean mid-day result.

For this process, the data goes from the Data Lake into the daily interpolation and mid-day DO GAM by region, then into the DO GAM residuals. The mid-day GAMs are fit by segment

interpolation region. Jon focuses on one segment, CB4MH and zooms in on a particular station. Jon showed the average dissolved oxygen values by month and depth. These raw data are fit into a GAM. He compared the observed DO to the expected mid-day DO from the regional GAM. The residuals are the observed DO minus the GAM expected DO. This is performed for all of the stations over all of the years to get the repository of DO GAM residuals.

Next, Jon discusses how you get to the depth correlation from these results. He shows an example of one station on one day. The observed and expected DO results are compared and result in the residuals which are plotted. They want to compare the values that are one meter apart. In plot C, Jon plots the residual from 1-2m, 2-3m, 3-4m and so on. Then, plot D is a scatter plot of all residual pairs. This plot resulted in a strong correlation between depth. These results will usually vary within a station. The goal is to find a central tendency estimate for the correlation over a station and segment.

On slide 15, Jon shows some of the rules they've used for different situations they ran into with the full data set. On slide 16, Jon shows the coverage of depth correlation they have been able to achieve across each segment interpolation region since 1985.

When looking at the correlation results across the segment interpolator regions, there is a strong, positive depth correlation across regions, usually centering between 0.75 and 1. Most regions have similar central tendencies. Jon also created exploratory plots for one segment interpolation region that show how depth correlation shows seasonal patterns. In shallower waters, correlation decreases.

There was a concern that the bottom depth would impact the results. Deeper waters would have more observations. The concern was that the number of observations could skew this data. They picked 12 deeper water stations to test this concern. When the station has the fewest number of observations, correlation slightly decreases, but not enough to be causing the pattern of higher correlation at deeper stations. Based on this test, there wasn't enough evidence to change the approach.

They developed a model to estimate depth correlation in each segment interpolation region. They provided a balance for those with discrepancies in historical data and would be representative of that segment's seasonal variability and depth. This creates one depth correlation value for the segment which is used in the simulation process.

Action Items:

- The Development Team will edit 4D Interpolator Workflow figure based on member feedback.

Discussion Notes:

Comment from chat: *Peter Tango:* For those reading the documentation, you will see these graphics again.

Q: *Tish Robertson:* What is your operational definition of shallow? Is that a station that is less than 5 meters?

- ***A:*** *Jon Harcum:* We wouldn't have any stations in four meters of water that inform the depth correlation.
- ***Q:*** *Tish Robertson:* So, all of the stations are at least 5 meters deep. Would the shallow ones be 5-7m?
- ***A:*** *Jon Harcum:* Yes.

- ***Response:*** *Tish Robertson:* I am trying to figure out why the correlations wouldn't be as tight in the shallower waters. I am wondering if it has to do with the fact that you are more likely to encounter the pycnocline with your observations. If you are at deeper stations, most of your results would be within the pycnocline. Maybe that is why the correlation would be better in the deeper waters.
- ***Response:*** *Jon Harcum:* The fixed station network is out there sampling year-round. Our pycnocline is more well defined during our summer months.
- ***Response:*** *Tish Robertson:* We see it outside of the summer too.
- ***Response:*** *Jon Harcum:* If we look at the graph on slide 18, when we look at the correlation, we see a slightly lower correlation in the summer months than the winter months. There could be some value in that. You'll get some pycnocline in mid-depth waters. I was thinking the amount of turbulence from freshwater flow was causing more mixing and we weren't seeing as strong of a pattern. As we get into the more open waters, maybe more structure is coming in. We are getting some stations that are relatively shallow. There are many segments that are shallower than 5m. The tidal fresh for certain. When we're looking at that correlation, it is taking the values we are seeing at about 5m and extending those results in shallower areas.
- ***Response:*** *Tish Robertson:* I think your hypothesis makes sense. I was trying to figure out what could be causing it.

Q: *Tish Robertson:* I'm interested in longitudinal circulation patterns in the mainstem. Virginia's mainstem has a lot of oceanic inflow. That makes for some interesting profiles. You get switchbacks in the profile because of the oceanic water intrusion. Do you find the correlations are better as you moved north?

- ***A:*** *Jon Harcum:* I didn't compare a segment interpolation region in CB7/8 to CB2, for example. When we develop a parameter model, it's done on a segment interpolation region. I'd only look at location within the segment interpolation region. I didn't try to look across the segment interpolation regions because I wasn't trying to make a parameter that fit the whole Bay. I wanted to break it up by portion in any case. We did preliminary work that showed it was problematic to do the whole Bay at once. These calculations were some of the last to get online.
- ***Response:*** *Tish Robertson:* I was curious if the correlation in CB2 is significantly different than those in CB7/8.
- ***Response:*** *Jon Harcum:* When looking at the figures on slide 17, it didn't perk my interest. It didn't seem like anything was happening there that I need to be mindful of. I have individual scatter plots for each segment interpolation region. We could go back and look at it, but I didn't try to do anything across segment interpolation regions.
- ***Response:*** *Rebecca Murphy:* These are the correlations between the residuals from the daily GAM fit. Our daily GAM is trying to fit what we can explain. If the oxygen in the vertical profile is well explained by the GAM in a certain region, then there probably would not be very much residual correlation in the depth direction. There are a few things that could cause regions to differ.
- ***Response:*** *Elgin Perry:* Jon is doing depth correlation estimates by interpolation regions. If there are gross spatial patterns, the methodology will pick that up. We settled on bottom depth and season as the two important terms in the GAM you fit to the depth correlations. Jon looked at water body latitude and longitude as well. We didn't find evidence that they were important predictors within a segment. They didn't add much to it. Because this is done by segment, we didn't look for a gross spatial pattern across the Bay. If that exists, the process will pick that up since it's on a segment basis.

- ***Response:*** *Tish Robertson:* That makes sense. I am glad you are doing it region by region. I know we like to talk about circulation patterns when understanding Bay DO impairment. If we can glean something like that from the existing analysis, I think that would be informative. It wouldn't help with any practical decision making, but it'd be a cool thing to learn.

Q: *Leah Ettema:* I want to go back to the interpolator workflow figure. I got a little confused with the data lake in the mean mid-day interpolation step. For the mean mid-day interpolator, does one year of data go into both the daily pycnocline interpolation and the daily DO interpolation?

- ***A:*** *Jon Harcum:* Yes. The data lake has all data in it. When we run a mean mid-day DO interpolation or the pycnocline interpolation, it uses one year of data at a time. If you wanted to do a three-year assessment, we'd run it three times.
- ***Response:*** *Leah Ettema:* I wonder if it would be clearer to move the data lake box out and below the combined data and have an arrow that says, "one year of assessment period." There is a filtering step between the data lake and the daily pycnocline that is missing. It's explained at the top, but it isn't clear when that happens. Also, in the parameterization, it says "using all the historical data" but it looks like the only input is the DO GAM residuals. Is that one year of residuals? Maybe if the data lake is outside, you could point to it in the parameterization box.
- ***Response:*** *Jon Harcum:* The DO GAM residuals box is cumulative of 40 years. Today we did a parameterization where I pulled out six years of data. In reality, I ran the mean mid-day interpolation for all 40 years of data for all 27 segment interpolation regions, so I performed the mean mid-day interpolation about 1,000 times. That gives me 1,000 GAM residuals which is compiled into the repository of residuals. Today we looked at the depth correlation over six years. As you go from one profile to the next, there is strong correlation overall, but it jumps around a lot. We're using all of the GAM residuals to inform correlation.
- ***Response:*** *Leah Ettema:* So, when you do the three-year assessment period, you need all of the DO GAM residual data. My issue is with the flow chart depiction. I was assuming the data lake was filtered for the three-year assessment period and when you follow the arrows, it looks like the DO GAM residuals are just in the three-year assessment period. It might be good to distinguish what cumulative means.
- ***Response:*** *Jon Harcum:* That's a good comment. We can try to do that.
- ***Response:*** *Leah Ettema:* I can't look at this right now and determine what changes with a new assessment year. Are the daily pycnocline, daily DO, and mid-day DO the only places where you are looking at one year of data based on the assessment period?
- ***Response:*** *Jon Harcum:* The pink daily DO interpolation box is one assessment year and the pycnocline would be the corresponding year of data.
- ***Q:*** *Peter Tango:* Is it confusing because we say three-year assessment while knowing the interpolation is designed to be run on a one-year basis?
- ***A:*** *Leah Ettema:* I don't think the three-year is confusing, but I wasn't clear if it was just the daily DO or if GAM residuals were also one year at a time.
- ***Response:*** *Rebecca Murphy:* I think your suggestion to move the data lake is a great idea. We can do that and maybe it will be clearer that we are querying one year at a time. There could be a box that says "one year of data" where the data lake is now. We'll have to think about how to clarify that the parameterization is 40 years of data. The mean mid-day interpolation and the simulation is one year at a time. We could add that label if it helps. When you run the simulation part of the tool, it's one year, which is the same year as the mean mid-day DO.
- ***Response:*** *Jon Harcum:* Then you would aggregate those simulations for the assessment period you are interested in.

- ***Response:*** *Elgin Perry:* The three-year assessment period is included in the last step where the criteria assessment output is computed. I agree with Leah that it's not easy to see what is going on right now. We need to say something in the mean mid-day interpolation box about it cycling through every year of available data. You could represent that it feeds residual results back to the data lake. That feeds into the parameterization of the cyclical parameters. If you sketched it out that way, it would be clearer that when you get to the correlation step that it is looking at all 40 years of data. The three-year assessment period comes after the simulation. I think we need to talk about it and come up with a different visualization. This visualization is a huge step forward from where we were before.
- ***Action Item:*** The Development Team will edit 4D Interpolator Workflow figure based on member feedback.

Q from chat: *Melinda Cutler:* When do the 3-year runs get aggregated together?

- ***A from chat:*** *Peter Tango:* Good question Melinda - on the chart, the lower right pink box shows the delivery of information into an output to create a 3-year period of information for assessment (or some other years).
- ***Response from chat:*** *Melinda Cutler:* Maybe making that an action box, "3 years aggregated together" heading into that portion would be helpful to clarify when this step occurs.

V. Adjourn

Next Meeting: ***August 17, 2026***

Attendees:

- Allison Welch, CRC
- Andrew Keppel, MD DNR
- Cindy Johnson, VA DEQ
- Efeturi Oghenekaro, DOEE
- Elgin Perry
- Joe Morina, VA DEQ
- Jon Harcum, TetraTech
- Leah Ettema, EPA
- Mark Trice, MD DNR
- Matt Stover, MDE
- Melinda Cutler, MDE
- Peter Tango, USGS
- Rebecca Murphy, UMCES
- Richard Tian, UMCES
- Tish Robertson, VA DEQ