Chesapeake Bay Program Hypoxia Collaborative Meeting

Wednesday, October 16th, 2024· 2:00 PM – 3:30 PM

Meeting Materials: Link

This meeting was recorded for internal use only to assure the accuracy of meeting notes.

Participants

August Goldfischer (CRC), Mark Trice (MD DNR), Breck Sullivan (USGS), Piero Mazzini (VIMS), Jay Lazar (NOAA), Kimberly Puglise (NOAA), Pierre St-Laurent (VIMS), Amanda Shaver (VA DEQ), Kevin Schabow (NOAA), Bruce Vogt (NOAA), Rebecca Murphy (UMCES), Max Ruehrmund (NOAA), Peter Tango (USGS), Christina Garvey (NOAA), Lew Linker (EPA), Brian Smith (MD DNR), Tom Parham (MD DNR), Cindy Johnson (VA DEQ), John B, Kaylyn Gootman (EPA), Jon Harcum (Tetra Tech), Dong Liang (UMCES), Tish Robertson (VA DEQ)

Minutes

2:00 PM – Updates

- Update on station locations, deployments, and build out - *Jay Lazar (NOAA)*

Presentation:

Jay shared an overview of the water column monitoring system, which has multiple sensors on an inductive wire held up on a buoy and moored to the sea floor. The system has 3m vertical resolution, and down to 2m wherever they get closer to the bottom.

Stations have been deployed since May. In 2024, there were three stations in the Choptank in three distinct segments. Those stations had between 3-6 sensors based on their depth. Deepest sensor observations were around 15m, which were those closest to the channel. This is the second year at the Lower Choptank. There were three stations in the Potomac, all in one segment, with 4-5 sensors per station. This is the second year at the Lower Potomac. Presently the station at Herring Creek is down.

Jay showed a map of the stations. The map also included the locations of Chesapeake Bay Interpretive Buoy Systems (CBIBS), the surface level meteorological and oceanographic data buoys. The proximity of the CBIBS provides an added level of validation for temperature and salinity at the surface.

Jay gave an overview of daily hypoxia data at Sharps Island. There was a two-week gap in data. There was a one-week gap in the system, and they're not sure yet if that data will be recoverable yet. They got out there, refreshed things, and had a sensor fail within hours after deployment (which is why the one-week gap became a two-week gap in data).

The fall and winter plan will be to remove the Potomac buoys in mid-November, as well as two of the Choptank buoys. They plan to keep one Choptank buoy in for sentinel observations, diagnostic conditions, and to continue to work through Quality Control (QC) routines. They'll evaluate the sensor requirements for the 6 station, 26 sensor system. This year they had the inventory to replace sensors when they went down. It's an opportunity to look at what the turnaround was on getting the sensors back, and what can be done next year with the sensors they have. They hope to have something out on this within the next month and a half. Then they'll create the 2024 end of year Quality Control report. Preparing for 2025, they hope to have buoys in the water before the Dissolved Oxygen (DO) drops and catch the front end of the season – putting buoys out around mid-March.

Jay gave an overview of the data quality control flow. They have daily inspections of the data. They do bi-weekly maintenance visits where they collect Conductivity, Temperature and Depth (CTDs) and characterize what the stations are putting out against the annually calibrated higher quality instruments. They compile a monthly overview of the visits and track daily reviews. This all gets rolled up in the seasonal measurement plots which have QC flags once QC work is completed. This goes into a seasonal performance review, and shared in an annual report. They hope to have the annual report out in mid-February.

Data can be accessed at this link. This site is still a work in progress.

There were no significant changes from 2023 QC routines. If you're getting the data right now, you don't have the final QC routines. That will be based on the CTD plots and will be available mid-February. The IOOS sites' final data availability will be in March. Once they have all the QC flags on their server, they have to go back to Axiom and ask them to re-pool the data from the year with all of the final data quality flags. That will then be available through the same site.

Discussion:

Tom Parham (MD DNR): it looks like you have good oxygen going deeper in the summer and shallower in the cooler months.

Jay: That's what we're seeing. The July and August timeline did get decent oxygen a little further down. That late August error, that 8m sensor was bad, and I don't think that data is recoverable. There's a bit of a 3-week gap in August.

Lew Linker (EPA): Looking at this plot, are we looking at the average of the day for each of the sensors with depth?

Jay: Yes.

Lew: What is the time step of the sensors? What is their finest resolution?

Jay: 10 minutes.

Lew: That's great. So you could have a 10-minute time series of all of the sensors.

Jay: Yes. The display wouldn't let me go any finer, but it's embedded in there. If you were to look at a smaller section, you'd see the 10-minute data.

Lew: Do the oceanographers among us think with the data available we can look at seiches and internal waves? I think we'll be able to catch seiches very well. Maybe not internal waves (which aid in mixing right at the pycnocline). To people using the data, is it simply a matter of downloading it at that very fine scale?

Jay: Correct. It's publicly available through that URL. There will be more complete quality control flags associated with each data of record a little later on. This is more or less as it's coming off the buoy raw.

Lew: When is the earliest date in the record? Two years in Potomac, two years in Choptank?

Jay: I believe the end of April and early May 2023.

Lew: And there were earlier prototype efforts out in the mainstem that's not a part of this record?

Jay: It's not on this slide but those deployments are available with the rest of the data at the URL. 2022 we had East and West Gooses locations.

Lew: Did early prototypes go back to 2020?

Jay: Yes. Caribbean Wind did their pilot work in 2020, which was on the East Gooses location.

- Update on the Choptank con-mons – *Brian Smith (MD DNR)*

Brian: I manage the continuous monitoring program with MD DNR. We currently have 4 con-mons deployed in the Choptank. On August 21st, these 4 stations were deployed in conjunction with 4 existing markers. There is one at the mouth of the Tred Avon, one at the Choptank River Light station, one a station off of Castle Haven Point, and one at Sandy Hill sanctuary. Jamie Strong, who is managing the field portion of the project, deployed these four. He had some concerns about the one at the Choptank River Light, it's a very rocky substrate and he was concerned about it damaging equipment and vessels servicing that station. When he went back on September 11th this equipment was moved up to the mouth of Broad Creek. These four stations currently have data online for about 3 weeks deployment.

Jay: Is that surface level or bottom DO? What were depths?

Brian: Bottom DO. Tred Avon marker is 2.8, Castle Point is 2.5 – they're all about 2.5-3m below the surface, except Sandy Hill Sanctuary is at 5m. They are all anchored .3 off the bottom.

2:15 PM – Discussion Part 1: How are you currently using or plan to use the data from the hypoxia stations to support projects?

- *Pierre St. Laurent (VIMS) - slides*

Pierre shared an overview of how the data is used in the Chesapeake Bay Environmental Forecasting System (CBEFS).

Pierre: In general, we use the data for model development, evaluation and model improvement. Whenever possible we like to have the data and the model results side by side to increase the confidence of end users in the product. CBEFS is evaluated with monitoring data, con-mon data, and the 6 vertical profilers described earlier.

A comparison between CBEFS and data from 6 profilers:

For the Choptank from upstream moving downstream, the mean values are similar in the model and the data. There are some issues in the data for example a huge drop down to zero which is probably an instrument issue. The main thing I notice comparing the time series is there is a lot more high frequency variability in the observed bottom oxygen than in the modeled bottom oxygen. The model captures the daily solar cycle which contributes to a 24-hour frequency in the model results and it has a good reproduction of the barotropic tides. What the model doesn't have is a resolution fine enough to capture internal tides or internal waves. My working assumption for the lack of high frequency variability in bottom oxygen is the model doesn't have the mesh size sufficient to resolve the kind of processes that Lew brought up earlier. This could be verified with a spectral analysis of the data.

For the second station in the Choptank, initially the model overestimates the weekly variability, and for the later portion of the time series it is in much better agreement with the surface measurements. At the bottom, the model is missing a lot of high frequency variability we see in the data. The periods of relatively lower and higher oxygen seem to be correctly captured by the model in general.

For Sharps Island, the last station on the Choptank transect, the model has the weekly variability that is exaggerated at the early portion of the time series but gets better later on in the time series. At the bottom, the data shows very large pulses of high oxygen. In my experience this is internal waves passing by. The data thinks the water is hypoxic consistently throughout the time series at the bottom. The model is a little more optimistic, typically oscillating between 0-4mg/l at that station. These mismatches could be due to the topography. A 600 m mesh captures some of the variability, but not all of the complexity of real-life topography.

For the Potomac stations, the most upstream is St. Clements. The mean surface and bottom values are reasonably captured by the model. There are some incidents of very low surface oxygen which I assume are artifacts; the model doesn't have that. At the bottom, very high amplitude, high frequency variability that the model doesn't have. There might be an increasing trend in both the model and data during this period of record.

The central Potomac station is close to the very deep trench of the Potomac. According to the model the depth is 16 m. Looking at the surface oxygen there was some incident in the surface record, but otherwise there's a reasonable match between the model and the data. Near the bottom, the data suggest it's consistently hypoxic. The model is a little more optimistic, it believes there is an improvement in early August not supported by the data.

The last station in the Potomac has a good match in the surface, but at the bottom missing the high frequency, high amplitude variations. There is a good match in the low frequency in the bottom oxygen.

For mid-water column variability and vertical structure:

In the first Choptank station, mid-water column low oxygen values might be artifacts, as well as some very low oxygen near the surface. In the second Choptank station, there was some quality control here. The oxycline, which is the depth at which oxygen changes concentrations abruptly, is a little more shallow in the model than in the observations. We are hoping to use information about the vertical structure of the oxygen to guide the model in tuning of the vertical mixing. In the Sharps Island station, in the model results the model believes there is an improvement in oxygen concentration in the beginning of August. I mentioned this to Aaron Bever and he pointed out there was a storm at that moment and according to the model it did improve oxygen concentrations passed that day. According to the data you don't see much of an improvement after that date. However there are stations you do see that signature, such as in Herring Creek, the central Potomac station. This is good information for us because it tells us there is some observational support for this improvement but the model seems to exaggerate the benefits of that storm in terms of reoxygenating the water column. That tells us there is some work to be done on fine tuning the vertical mixing of the model.

If it hasn't been done yet one could conduct a spectral analysis on the data. It could confirm that the missing variability at the bottom is due to the limited resolution of the model and its inability to capture internal waves. Scully 2016 (JGR-O) highlights events of wind driven lateral tilting of the oxycline in the Bay's main stem. This is an entirely different mechanism that can drive similar oscillations in bottom oxygen.

Discussion:

Tom Parham: For the DO array it's on a 10-minute time stamp averaged to a daily average, and for the CBEFS model what's the smallest time stamp you're averaging to the daily value?

Pierre: Aaron Bever is the right person to answer these questions. My best guess is he is saving hourly snapshots.

Lew: I have a feeling many of our models will be humbled by some of the things you're seeing. That variation close to the bottom, where does that arise? Is there some additional turbulence causing that? At this point I know we're speculating. I appreciate your points as we get into finer resolution at least we can hope that we can better capture some of the things we're seeing. That DO it looks like on a day-by-day basis episodically going up to 8 mg/l and you could see a little bit of surface bottom interplay but where does that come from? It has to be some kind of top-down phenomenon. It's also fascinating to see the spring fresh high nutrients, phytoplankton and sediment fluxes was the classic set-up in the estuary but by July things settled down with hypoxia. I think probably it was a storm event that initiated things settling down, but re-aeration from a storm event is relatively short lived. Then a long period of relatively less hypoxia. It's showing we'll be learning a lot about the structure and hypotheses of hypoxia in the Bay. When we apply our models to this fine scale data we'll probably all be humbled together as well.

Peter: Mark Trice might've seen something in the data towards the end of September and October that was a little rebound.

- *Rebecca Murphy (UMCES) - slides*

Rebecca shared an overview of how the data from the hypoxia stations is and will be used in the 4-Dimensional (4-D) interpolator for development and when the interpolator is in operation.

Rebecca: The goal of the Bay Oxygen Research Group (BORG) is to develop a spatial-and-temporal interpolation tool for water quality monitoring data collected in the tidal waters of the Chesapeake Bay, thus enabling the evaluation of both long- and short-duration water quality criteria. Specifically, the tool should be able to: Interpolate observed dissolved oxygen in space and time (“4D”), provide statistical estimates of uncertainty, reproduce daily and hourly variability of the data, and allow for post-processing of the interpolation output into designated uses (DU). The focus on development so far has been on dissolved oxygen, but ultimately chlorophyll a and clarity may be evaluated as well.

Although this tool will interpolate the data and not necessarily build in the processes of hydrodynamics like the dynamic model Pierre discussed, it would still be useful for the BORG team to have some conversations with Pierre about some of the things he’s seeing in the data.

All the DO data collected in the Bay will be used including fixed station data, Tier 3 citizen science data, high frequency con-mon data at high frequency, high frequency vertical array data. We’ll make full use of DataFlow data in the future, and any emerging data sets. All that data is used in different parts of interpolation. We have split it up into 4 pieces. Mid-day space and time interpolation will give an overall picture of oxygen every day throughout space in the Bay. Large-scale correlation component will capture variability spatially and temporally. Within-day cyclic interpolation will use the high frequency data to see the daily and tidal cycles of oxygen in places where we have that data and interpolate it where we don’t have that data to provide an hourly picture of oxygen in the Chesapeake Bay. That comes with a small-scale correlation component to capture uncertainty bounds and variability.

These pieces were designed to represent different spatial and temporal features of the DO data; ultimately, it will be the sum of these 4 components that will be used as our interpolation results, not any incremental results. Putting all the pieces together, our goal is to get hourly interpolation everywhere with a lot of simulation results, so with a range of uncertainty.

Where is the vertical array data used in this tool? In every one of the 4 components. There’s a little piece that won’t be used in the spatial autocorrelation part but otherwise it will be used in every piece of the statistical model. That can be split up into development and testing, parameterization and implementation.

For development and testing, we’ve been using a dataset that Jon Harcum pulled together that mostly ended in 2022 and then we extended the NOAA vertical array data in it to 2023. We’re not using this year’s data yet but in winter we’ll add it to an updated testing set and start using it. It’s key for all the pieces of the model. For the daily estimate of oxygen everywhere, for example, we’re using that data along with all the other data as we build the tool. For the hourly part, we find cyclic parameters for hourly variability, figuring out how to represent them with depth, season, and space. Jon crunched through 2 years of vertical array data and con-mon data with wavelet analysis, identifying which subdaily we should model. We need a daily cycle that shows biological activity with clear tidal signal. The vertical array data with depth helps us identify which cycles we should model deeper in the water column. We could probably pull out some of those vertical array wavelet results and look at what Pierre was talking about.

Within the last couple months, Elgin did a test case using 2022 data to see how we're going to put all 4 pieces of the interpolation tool together. Elgin presented the result of this test case at the Bay Oxygen Research Group meeting in September 2024 (see page 6 of the minutes for a detailed description). We will be doing more of these test cases in the future.

The profiler data will also be useful in identifying the pycnocline at high frequency in order to split up the designated uses. We'll be using the salinity and temperature data.

We'll use the data for parameterization as well. Correlation components of the model are being parameterized with available data. We'll identify what the correlation hour to hour is in our results after applying our cyclic model. The data will be used for day-to-day autocorrelation as well. Jon has been creating a database of what the correlation information is at these daily and hourly frequencies are and we'll use that in our simulations for the 4-D interpolator. We can also get depth to depth residual correlation with the vertical arrays.

When the 4-D interpolator is fully built, when the states are using it for interpolation before doing criteria assessment, any vertical array data being collected in that year being assessed (assuming the data meets the quality requirements) will be used in the interpolation.

Discussion:

Lew: In one day, all those expressions of the pycnocline, the average of them all seemed to be a more convincing/classic pycnocline than the standard direct observation. The black line fixed station is the overall representation, but the overall cloud looked more classically like a pycnocline. Looking at this information, do you expect we could improve error bars on our DO measurements for the fixed monitoring stations we have? If we were to look at that figure at a particular depth, we'd have an array of DO measurements over a single day. And we'd have one fixed station snapshot. Would the record of that DO over that day compared to the snapshot give us a better sense of the uncertainty at particular stations?

Peter commented in the chat: Not surprising and very amazing to see the daily variability in habitats as a function of the new data.

Rebecca: We also did an analysis of what time the fixed station data were collected. It's almost always the middle of the day so we're missing information of what happens in the night and most of the day. Just with the interpolator we get the range of what oxygen likely was in that day.

Lew: It sounds like we'll take these fine scale vertical profilers of oxygen and include them right in the database with everything else. Do you get a sense that anything may change with our assessment of criteria? Some of these DO events seem more episodic compared to our more historically static understanding of DO. Do you think this new data may influence the way we see our assessment of the criteria?

Rebecca: Yes. That's something the Criteria Assessment Protocol Workgroup is working on.

- *Lew Linker (EPA)*

Lew: The modeling perspective is long term. 95% of our efforts are focused on the 1991-2000 standard bay hydrology calibration. Yet we know good stuff is way out in the recent years like starting in 2022 to the present for the stations we're talking about. There will be 4 areas of influence with Bay Program modeling. One is as we're looking at the time series of DO, I think we'll learn about processes and structure in DO. That will have influence in the modeling. The other is direct application. We're in Phase 7. We'll have a Phase 8 that will look beyond 2035 assessment of water quality. The direct observation of this data set will be front and center and widely used. I think this will be used in Phase 8 and at the tail end of Phase 7. And the third and fourth: things like seiches and internal waves. The tilting of the pycnocline and resulting movement of hypoxia on the shores as well as the mixing within the water column. This will provide information in terms of how we evaluate mixing in the water column. We can now capture seiches pretty effectively in Phase 6. I'm fairly confident schism will do the same but we'll have better tools for assessment with these new data. In summary, we'll use the data in processes, direct applications, and looking at specific processes such gravity waves and seiches.

3:00 PM – Discussion

Jay: One of the things we want to understand more is how resilient the sensors are. We had DO sensors fail. Our temperature sensors were solid throughout. Conductivity sensors did a good job as long as we kept them clean. We want to evaluate cleaning methods for the sensors and whether they contributed to sensor performance issues. We're trying to balance efficiency on the water with getting the maintenance that we need done. The sensors could be a little more reliable. We could look at replacing them with better sensors. Initially to get the system where we envisioned we needed a lot of sensors; we found a cost effective way to do that. Now we can look at if there was a trade-off in sensor durability and whether it's more cost-effective to get better but more expensive sensors up front. We are also trying to figure out how many sensors it takes in reserve to adequately do this, which is also related to the reliability of the sensors. We didn't have the vertical resolution that Pierre suggested would be ideal. In an ideal world we'd have much greater vertical resolution. There would also be benefits to this for having a level of redundancy for when a sensor goes out. Ultimately we have to strike a balance between the cost of maintenance, equipment and durability.

Jay: In thinking about the utility of this information – there's a limit to the depth in which we're going right now. But as long as we're characterizing that low DO border or area effectively maybe there's not as much value in going deeper. From a living resources perspective, maybe having a 5-meter sentinel would be useful – it's below the surface but also meaningful to a majority of the Bay's living resources. We thought about this with this year's deployments. Would we consider there being any value in placing all of them at a 5-m depth vs a shallower depth? I'm thinking about using what Pierre presented on to identify an optimal depth for the con-mons that gets at the quality of water column for living resources.

Brian: Are you asking if all the stations can be deployed at 5 meters?

Jay: Yes.

Brian: Where they are now they are all .3 m off the bottom. Are you suggesting to find areas that are at 5 m and trying to deploy in those areas?

Jay: Yes. We would identify the 5.3 m contour and use that to identify locations, maybe in a similar configuration but slightly deeper waters that allow us to monitor what's happening with better spatial resolution.

Brian: We chose these sites in conjunction with existing markers so the stations would be more secure. I would have to talk to the field office to find out whether there are other markers out there and what the depth is for those. We also in selecting these sites took into account meetings we had with Peter and the CBP trying to deploy these in conjunction with the arrays. We'd have to have a discussion about that. I know there are concerns about the equipment with putting a buoy in the more open waters which is why the decision was made to deploy them in conjunction with existing markers.

Peter: Thinking about one depth or multiple depth, being able to look at multiple depths over a transect would allow us to look where the fluctuations of the hypoxic zone is. We need that resolution across multiple depths in order to see that change happening. A single depth gives us the sense of where something is happening once, but multiple depths allow us to see expansion and contraction of hypoxia in time. The axis of the Bay allows us to see changes through time in the way you think a transect could give you a resolution that's not visible if we kept everything at the same depth.

3:20 PM – GIT funding proposal update – *Peter Tango (USGS)*

Peter: The GIT funding proposal was supported by EPA to go forward through Chesapeake Bay Trust and will be funded. The proposal was developed in collaboration with colleagues including state and federal partners from MD DNR, VA DEQ, NOAA. This proposal will assist us with our network developments looking at where to deploy monitoring segment by segment. We will keep you posted on the next steps.

3:30 PM – Adjourn