Tidal waters interpolator grid:
Proposed resolution modifications to five segments
Version: 11/6/25

Background

To conduct a dissolved oxygen (DO) criteria assessment in the tidal waters of the Chesapeake Bay, DO data is interpolated to a grid that fills the volume of each segment. The gridded interpolation results are then summarized by segment and time as they are compared to the applicable water quality criteria. A spatial grid exists for the current 3-D interpolation approach. For the new space-time (4-D) interpolation, we want to use the same spatial grid as the 3-D tool (Figure 1). This decision was made for consistency, and due to the work already invested to build this interpolation grid.

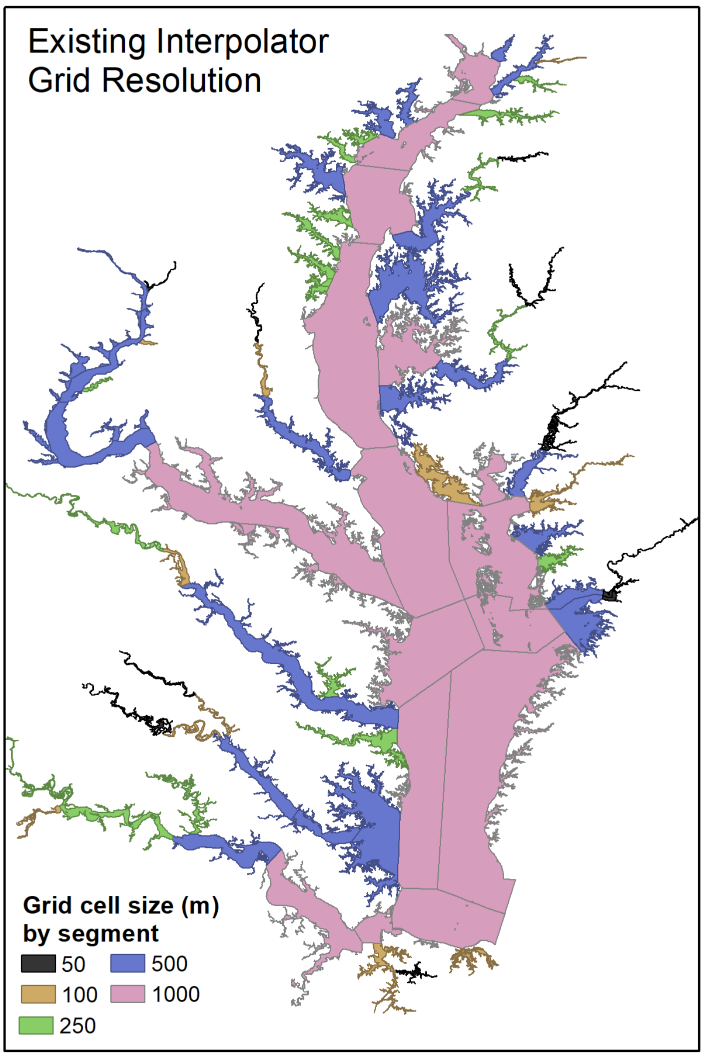


Figure 1. Current interpolator grid horizontal resolution by segment. Grid cell size indicates both length and width dimensions. All cells are 1m deep.

The current (3-D) interpolation grid consists of grid cells that are all 1m deep. The 1m grid cells are stacked in columns that extend to bottom of the water. The number of grid cells in the vertical varies throughout the Bay based on bathymetry. The grid resolution in the horizontal varies by segment and was designed to allow for finer resolution in segments with more constricted geography than in more open regions. All cells are square when viewed from the surface (e.g., dimensions of a 50m cell are 50m long x 50m wide x 1m deep). Figure 1 color-codes the segments by horizontal grid cells size.

The majority of area of the Bay is covered with 1km x 1km grid cells (pink segments in Figure 1). Additional grid cell horizontal resolutions in the tidal tributaries are 500m, 250m, 100m, and 50m. Table 1 presents the count of segments and total surface area covered by each of these grid cell size resolutions.

Table 1. Segment count by grid size

Cell size	Number of segments	Area (km^2)
50 m	15	91
100 m	15	265
250 m	19	497
500 m	26	2,467
1 km	17	8,341

Testing with 4-D interpolation

The draft version of the 4-D interpolator was fit to data in every segment of the Chesapeake Bay for one year. Our goal is to implement the tool so that it could be run on a standard 32-GB laptop for ease of transfer to analysts at partner organizations and states, even if run times are longer than they would be on a workstation.

However, testing demonstrated that it was not possible to perform simulations with a standard 32-GB laptop for four segments: CHOTF, PMKTF, MPNTF, NANOH. This is due to both a combination of the high resolution of these segments and the orientation of them that requires the creation an even larger matrix for some of the 4-D computations. All four segments can be run with an older workstation with more RAM. The grid density for these four segments in the water quality interpolator grid is 50 m. One additional segment with a 100 m density (HNGMN) also took a large amount of laptop computer resources in comparison to other segments.

A limited test (focused on NANOH) was performed to evaluate whether “thinning the grid” will reduce memory requirements such that the simulations could be performed on a 32-GB laptop. The test ran 2 simulations for each condition (Table 2). Results showed that thinning the grid to 100m allowed for the segment to be analyzed on a 32-GB laptop, and thinning the grid reduced run time as well.

Table 2. Test using NANOH segment with existing grid (50m) and thinned grid to 100m and 200m.

Segment	Grid Size [m]	Run time [min]
NANOH	50	28.32*
NANOH	100	6.44
NANOH	200	1.56

A complete test was then performed on all five of these segments, thinning them each by half (50m to 100m, and 100m to 200m). Results in Table 3 show that each segment's interpolation was feasible at the thinned resolution on the less powerful laptop with a shorter runtime than on the workstation.

Table 3. Results thinning each of the 5 segments and run times on separate computers.

	Run time [min]	
Segment	**Current Grid (128 GB workstation)**	**½ Thinning (32 GB laptop)**
CHOTF	6.85	2.41
MPNTF	12.81	5.59
NANOH	28.32	3.21
PMKTF	19.61	6.67
HNGMN	24.98	8.70

Impact of grid thinning: visual analysis

A map of the entire tidal waters is shown again in Figure 2, with the five segments circled. These five segments are the only segments with proposed changes. Changes to the counts and overall area in each coverage are shown in Table 4. For each of these five, we made maps of what the current resolution looks like, as well as the thinned resolution (Figures 3-7). The final grid coverage may vary slightly from these maps since we will likely reduce the existing grid rather than creating a new grid to fill in the segment as was done for demonstration with these maps.

Figures 3-7 are promising in that it appears the coverage of the segment area is still good with the thinned grids. An additional important test is to be sure the results of a DO interpolation do not lead to significantly different conclusions with a modified grid resolution. A summary of those tests is below, starting on page 10.

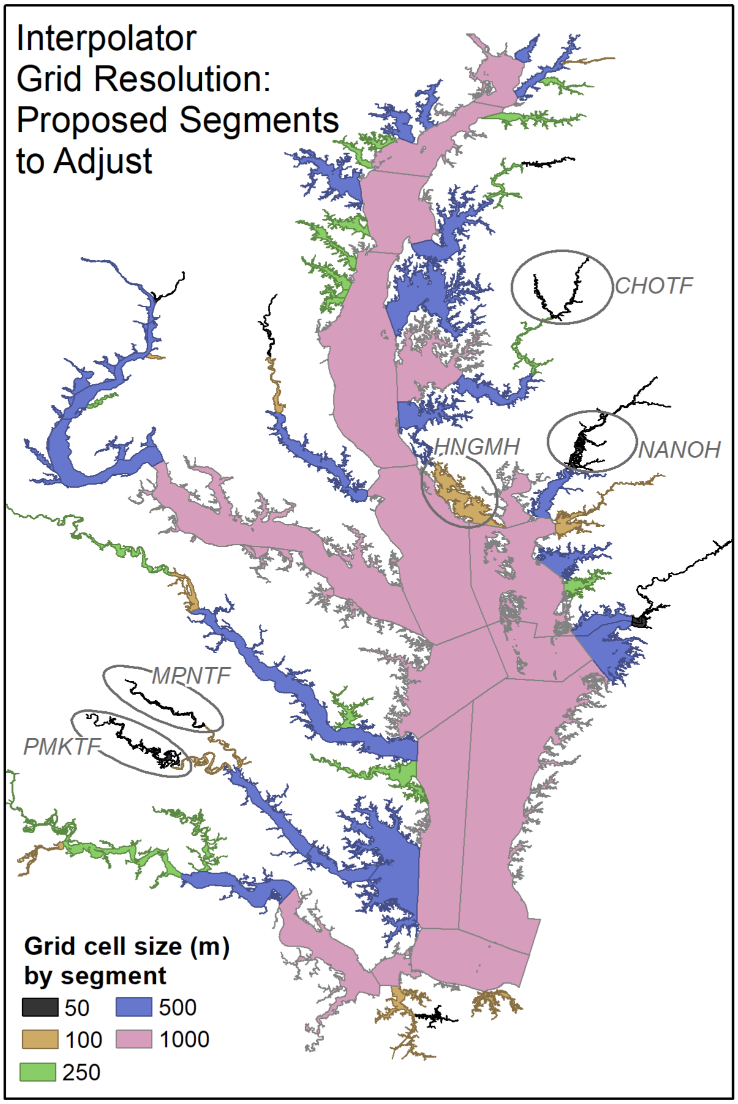


Figure 2. Repeat of Figure 1 showing existing interpolator grid resolution by segment. Five circled segments show the location of the proposed changes.

Table 4. Interpolator grid cell information, current and with thinning. Changes with thinning are shaded.

Cell size	Number of segments		Surface area (km^2)	
	Current	With thinning	Current	With thinning
50 m	15	11	91	40
100 m	15	18	265	218
250 m	19	20	497	595
500 m	26	26	2,467	2,467
1 km	17	17	8,341	8,341

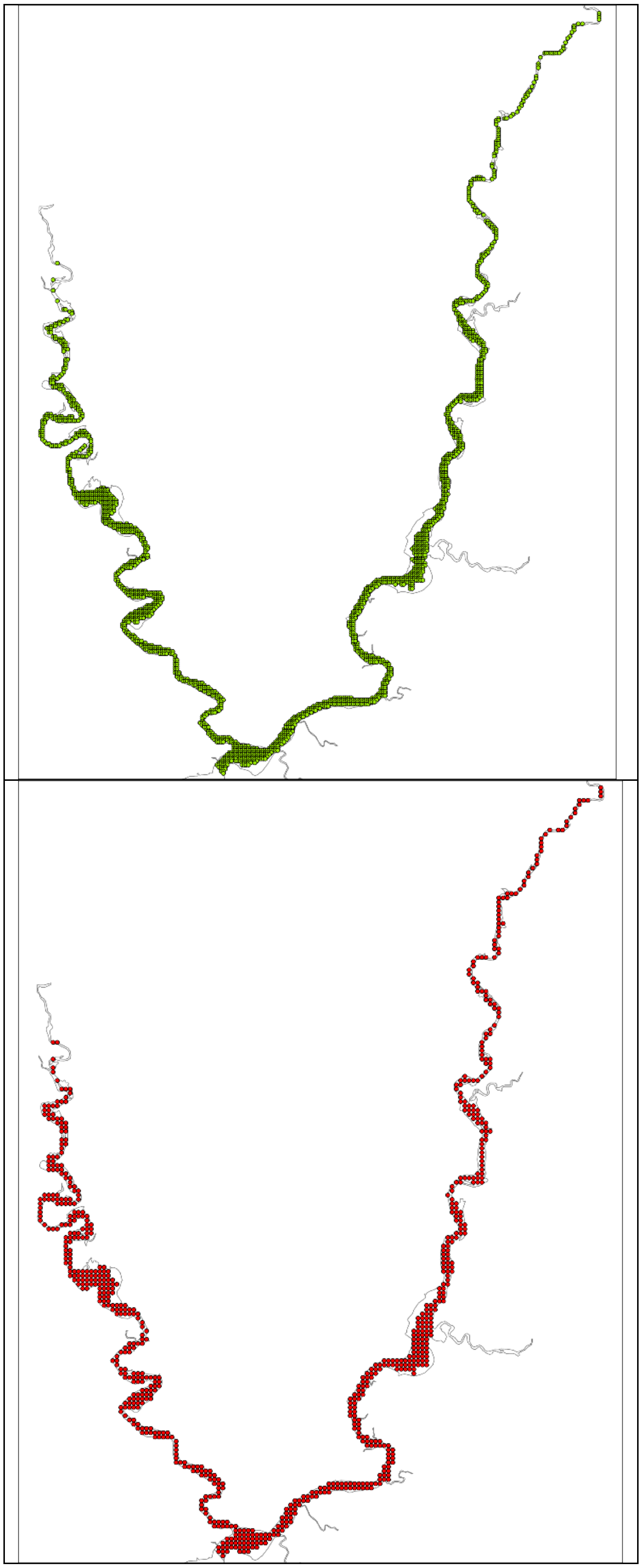


Figure 3a-b: MD Choptank tidal fresh segment (CHOTF) with 50m resolution (top) and 100m resolution (bottom).

Figure 4a-b: MD Middle Nanticoke River (NANOH) with 50m resolution (left) and 100m resolution (right).

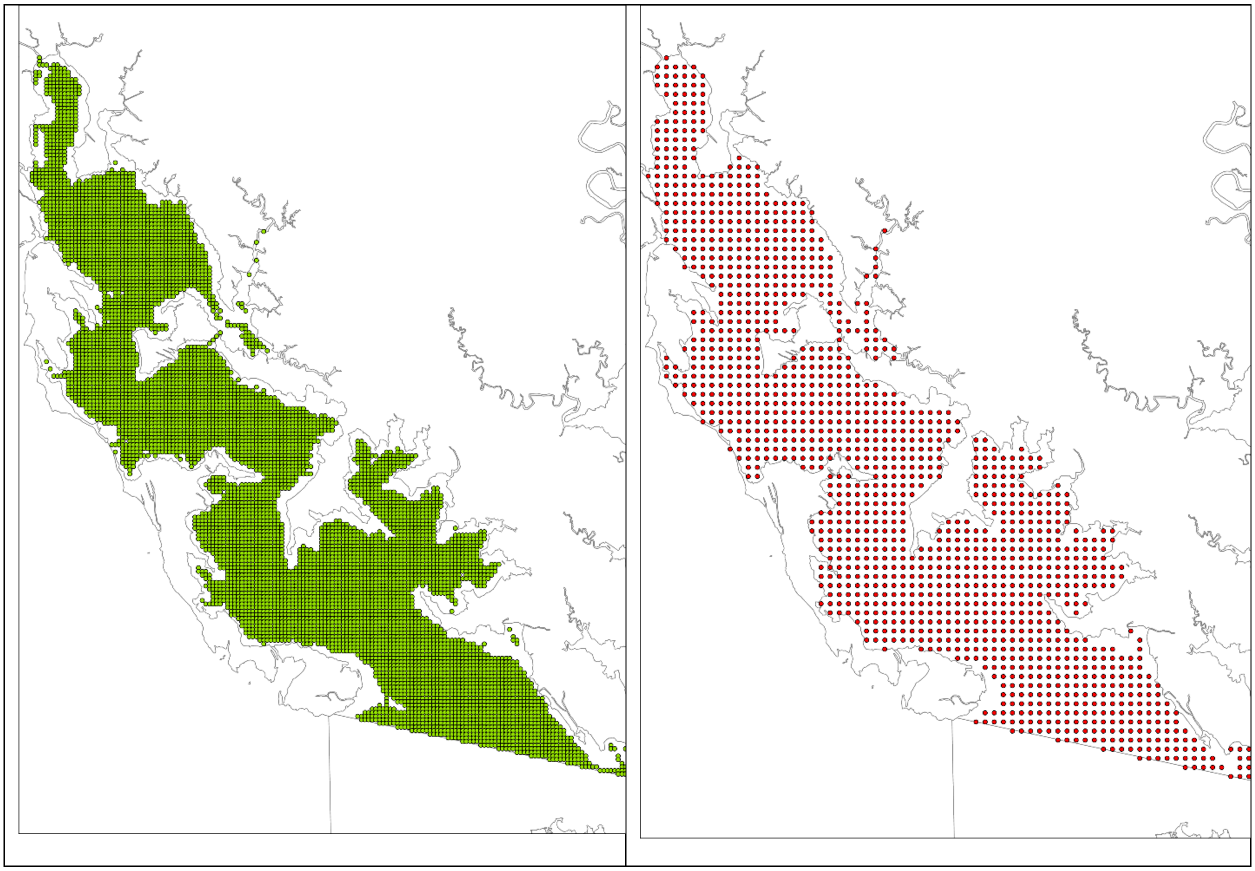


Figure 5a-b: MD Honga River (HNGMH) with 100m resolution (left) and 250m resolution (right).

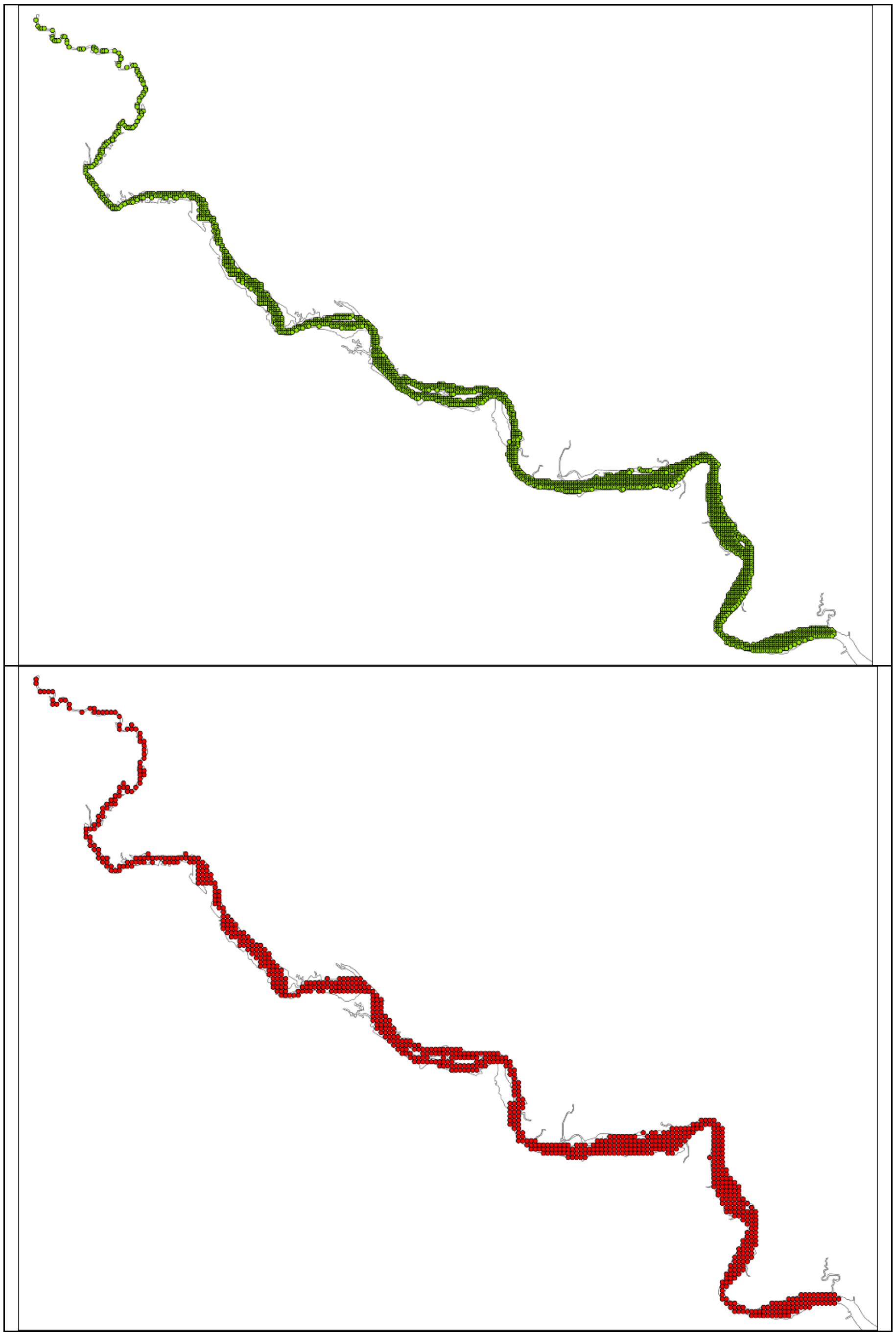


Figure 6a-b: VA Upper Mattaponi River segment (MPNTF) with 50m resolution (top) and 100m resolution (bottom).

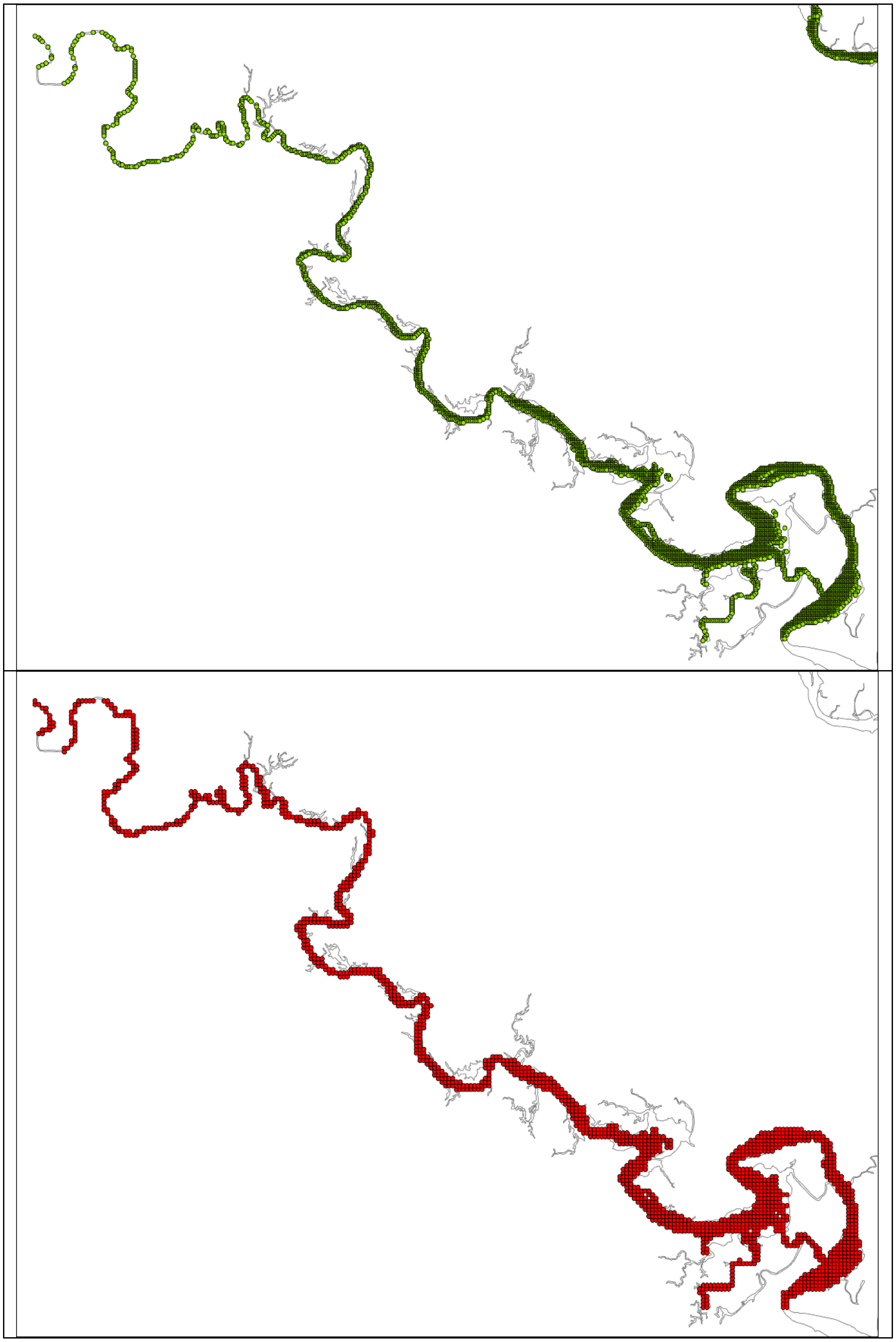


Figure 7a-b: VA Upper Pamunkey River segment (PMKTF) with 50m resolution (top) and 100m resolution (bottom).

Impact of grid thinning: DO analysis

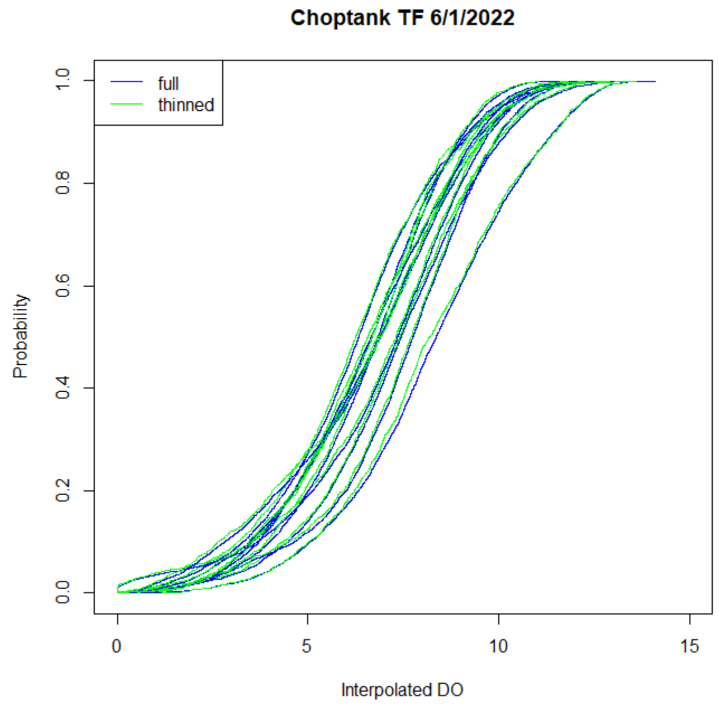
An analysis was done to compare interpolation results computed for several of the segments both with and without grid thinning. The simplest way to obtain a coarser grid is to simply thin the current grid by selecting every other line of latitude and longitude. This method of thinning is assessed by comparing interpolation simulation results from the current grid with results from a thinned grid subsampled from the current grid. Comparisons are made by superimposing empirical distribution functions (EDFs) of simulated DO from the current grid and the thinned grid. Comparing the EDFs allows one to readily assess differences in the proportion of observations in violation of any DO criterion.

In order to evaluate seasonal effects on the thinning comparison, a once a month snap-shot in time was compared for 10 simulations in each of two example segments (CHOTF and PMKTF). The evaluation was implemented for first day of each month at the 11:00 am hour. This resulted in 12 comparison figures for each segment where each figure shows 10 comparisons for a total of 240 comparisons. Below, two sets of results are shown for each example segment, for June 1 and Sept 1, 2022 (Figures 8 and 9).

The EDFs shown in Figures 8 and 9 for current and thinned data (blue and green) appear as closely matched pairs for all simulations. This result shows that the effect of thinning on summary statistics such as the mean DO or the proportion of interpolated DO values below a criterion threshold is minimal. The separation between the pairs of curves illustrates the effect of random factors in the simulation procedure. It is clear that the effect of thinning is much smaller than the effect of these random factors. Results were similar for the other 10 months evaluated for each segment (results not shown here).

It is interesting to note that the effect of random factors in the Choptank tidal fresh (Figure 8) appears to be larger than for the Pamunkey (Figure 9). But be sure to note that these are draft interpolation simulation results and several updates to the interpolation method and parameters were made after these results were generated. It is expected that the exact shape of the EDFs will be different with the final results, however, there is no reason to think the conclusion about thinning the grids will change with the final adjustments to the interpolation method.

8a.



8b.

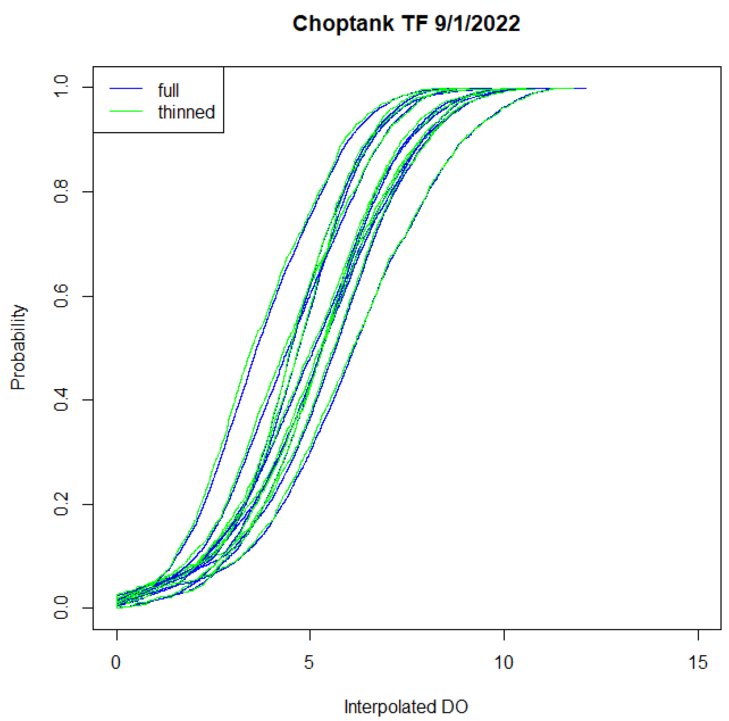
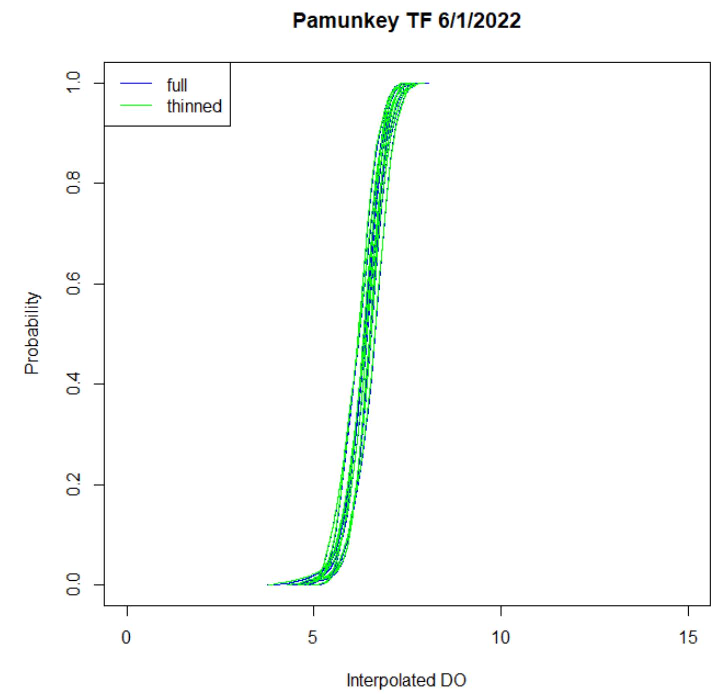


Figure 8a-b. Draft simulation results for Choptank tidal fresh segment on June 1, 2022 (a) and Sept 1, 2022 (b), with both the 50m grid (blue lines) and thinned 100m grid (green lines). Note this is a draft version of the interpolation simulation.

9a.



9b.

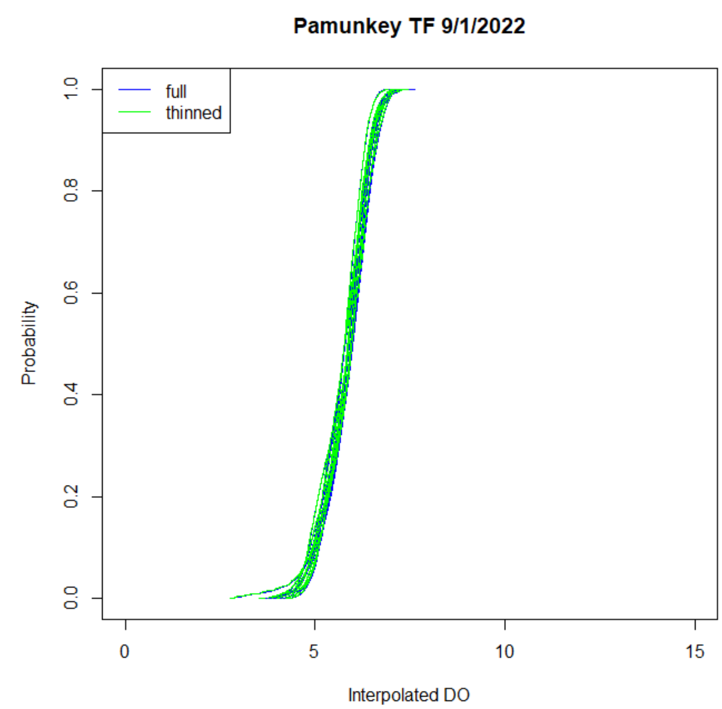


Figure 9a-b. Draft simulation results for Pamunkey tidal fresh segment on June 1, 2022 (a) and Sept 1, 2022 (b), with both the 50m grid (blue lines) and thinned 100m grid (green lines). Note this is a draft version of the interpolation simulation.

Summary

An adjustment to the current interpolator grid in five segments is being proposed. Note this is not an adjustment to the boundaries of the segments, but just the interpolation grid resolution that has currently been used. We saw no impact of these grid changes on the shape of the EDF distributions for the DO interpolation results in two of the segments tested. Thus, it is not expected that this grid thinning will results in any different conclusions regarding criteria assessment. These grid resolution edits would, however, have a large impact on a user's feasibility of running the 4-D tool in terms of computing power needed and run time.