Progress updates: 4-dimensional (4-D) interpolator

Bay Oxygen Research Large Group
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Summary of recent work

1. Dataset structure and compilation (Jon Harcum, Tetra Tech, lead)
2. Segment Interpolation Regions (Rebecca Murphy, UMCES/CBP, lead)
3. Pycnocline interpolation (Rebecca Murphy, UMCES/CBP, lead)
4. 4-D complete interpolation structure (Jon Harcum, Tetra Tech, lead)
5. Exploring use of output in criteria assessment (Elgin Perry lead)

We have summarized on each slide what this work means for future users of the 4-D interpolator. Most of the work to-date is one-time development work. Using the 4-D interpolator in the future should not require updating these methods regularly.

Dataset structure and compilation

Database structure is complete and an initial dataset of all high frequency data, fixed station data, and CMC Tier 3 data through 2023 is being used for testing.

- **Purpose:** This step enabled us to use ALL high frequency data in EVERY part of the interpolation.
- Overcame data management hurdles by adopting 'Apache Parquet', an open-source file format.
- Thank you for the individual conversations with data teams (Mark Trice, Dave Parrish, Mike Mallone) and GIS support (Angie Wei).

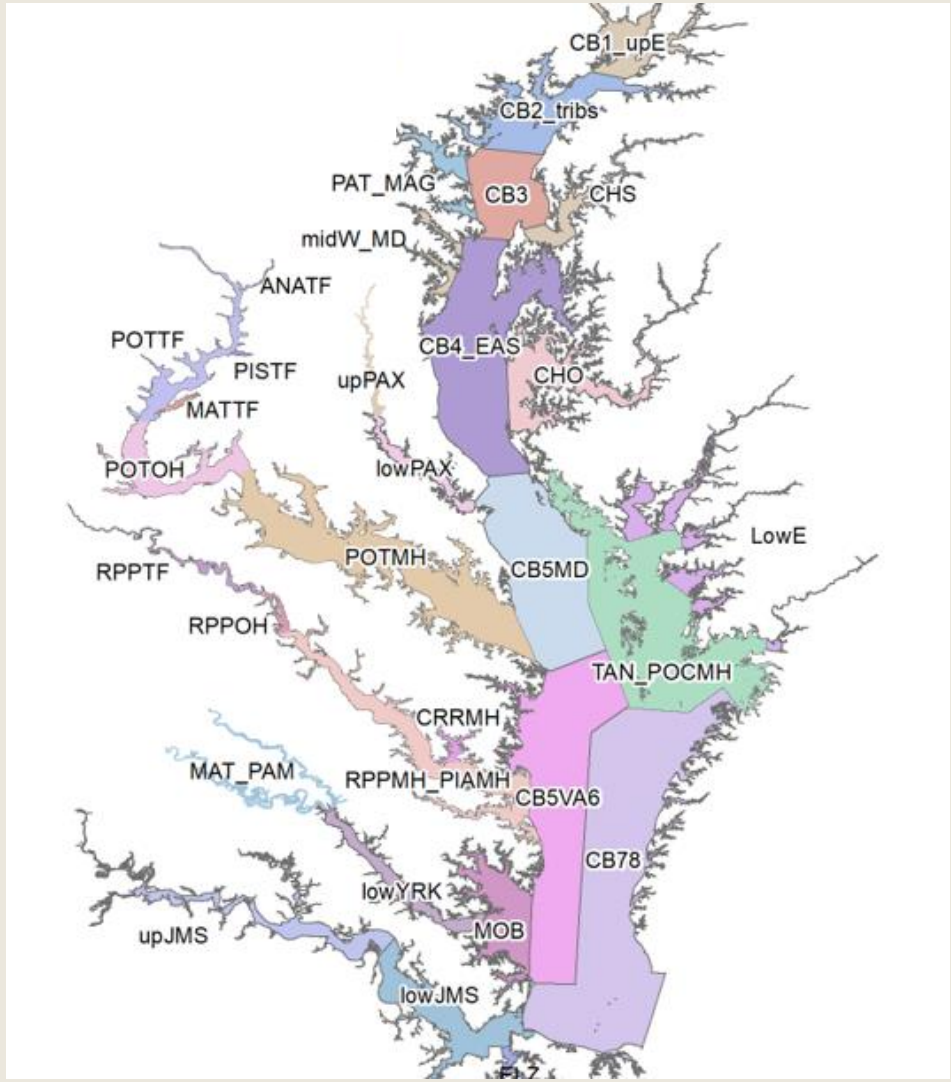
What will future users need to do?

Each year data inputs should be a routine process once we have built the structure. Occasionally updates to the input processing will be made as new types of data become available.

Segment Interpolation Regions

Will be presented next in this meeting.

- **Purpose:** This work identified reasonable spatial extents to the mid-day and spatial interpolation (i.e., GAM) part of the 4D interpolator.
- Memo dated 7-8-25 emailed on 7-9-25.



What will future users need to do?

No action is required for individual interpolations. However, future updates may be necessary if there are significant changes, such as major station reductions or additions. These updates can be made with spreadsheet edits.

Pycnocline

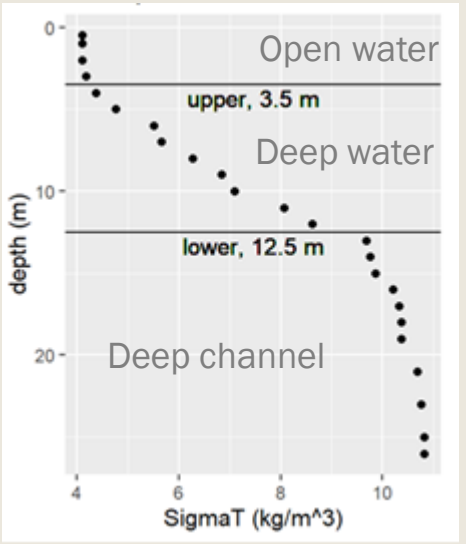
- First part of code is the same as what is currently done for the 3D interpolator!
- Second part parallels what is currently done!

Pycnocline code has been incorporated into draft software.

Purpose: The upper and lower depths of the pycnocline are needed to delineate the boundaries of the designated uses in the 4-D oxygen interpolation output.

- We conducted preliminary tests, and Tish presented aspects of averaging with CAP.
- Currently we are still finalizing the exact interpolation equations to use. Also, decisions will be needed with CAP on dealing with pycnocline movement for time averaged criteria.

Density and Pycnocline: CB4.3C 7-11-2017

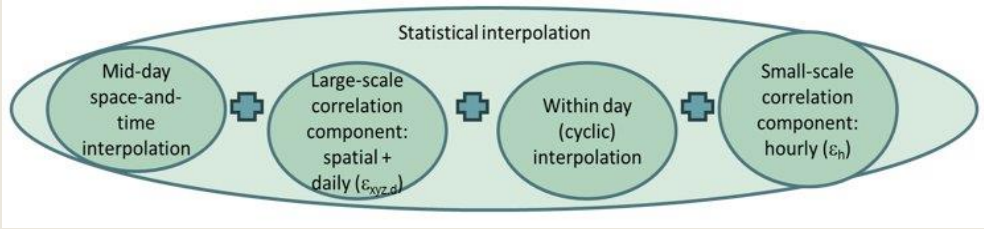


What will future users need to do?

This is one-time method development. New data each year will feed into the pycnocline interpolation. Ideally, users would examine pycnocline results used in an assessment, which would improve transparency over the current approach.

4-D complete interpolation structure

Built R package that links all 4 parts of 4D interpolation.



- **Purpose:** Seamlessly run mid-day + daily cycles + correlation components to generate interpolation output as simulations for a year on interpolator grid.
- Integrates: 1) newly compiled data set, 2) segment interpolation regions, 3) parameterization for correlation and daily cycles, 4) pycnocline ID and interpolation, and 5) bathymetry and designated use ID on interpolator grid.
- Work over the next few months:
  - Continue to streamline data and analysis workflows
  - Continue refining parameters with existing data to improve interpolations.
  - Case studies.

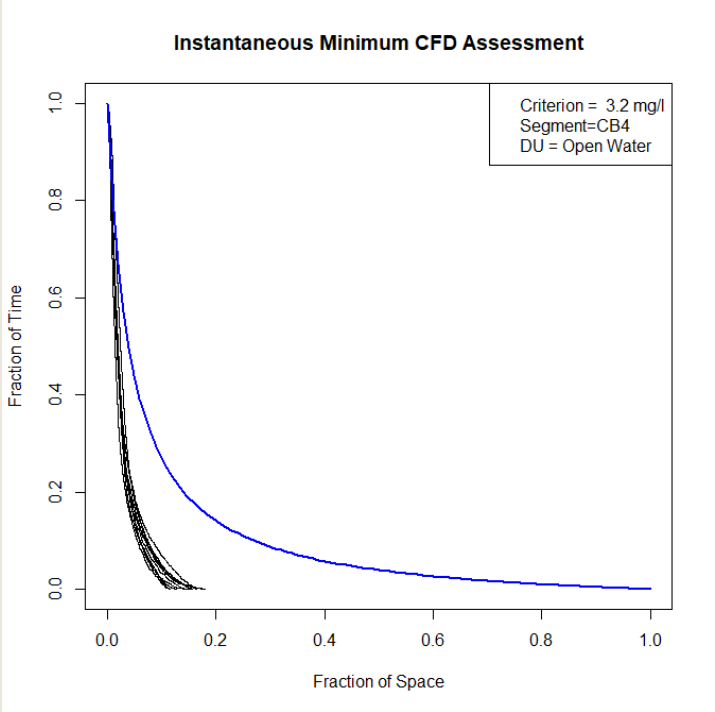
What will future users need to do?

Training will start in 2026, and documentation will begin to be available for review. Future analysts will be able to run an interpolation in R on a PC after uploading the newest data.

Link to criteria assessment

Working with draft 4-D DO results to explore how the interpolation output could be used in criteria assessment.

- **Purpose:** Generate examples for the CAP workgroup to discuss short-term criteria methods and using the 4-D output.
- Used multiple draft 4-D interpolator simulation sets for CB4MH in 2022 and the top 1-5m of results as an example of Open Water to compare with the 10% CFD curve.
- Working with, in coordination with CAP, vertical array high frequency DO and pycnocline to address questions on high frequency designated use movement.



Example: CFD assessment curves for the instantaneous minimum criterion in segment CB4 for the period 6/1/2022-8/31/2022 (From Elgin Perry)

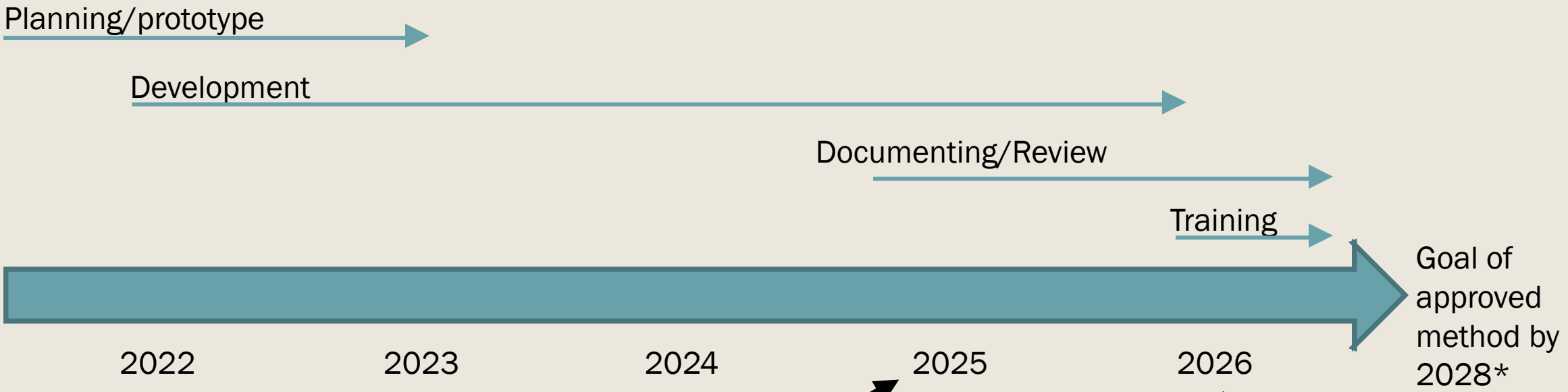
What will future users need to do?

This is one-time method development. Ideas can be discussed at CAP. Ultimately users will need to summarize the results, which will include an evaluation of more criteria than currently evaluated.

Summary of next steps

- **Pycnocline:** Finish testing, and address criteria-related summary questions.
- **Case study:** 4-D interpolation compared to current and other approaches (e.g., Fishing Bay).
- **Parameter refinements:**
  - *Depth correlation parameters,*
  - *Temporal correlation parameters,*
  - *Daily and tidal cycles,*
  - *Modifications as results are examined throughout all segments.*
- Work with **CAP workgroup** on using 4-D output for criteria assessment and on new questions that arise from methods to evaluate the short-term criteria.
- Documentation and users' guidance.

4-D interpolator development timeline



By the end of 2025:

- Working 4-D tool,
- Examples applied to several segments,
- Collaboration ongoing with CAP on criteria assessment methods.

In 2026-2027:

- Documenting,
- Additional functionality as needed for linking to criteria assessment,
- Preparing for review & review.

*with 2030 goal of reporting on all criteria