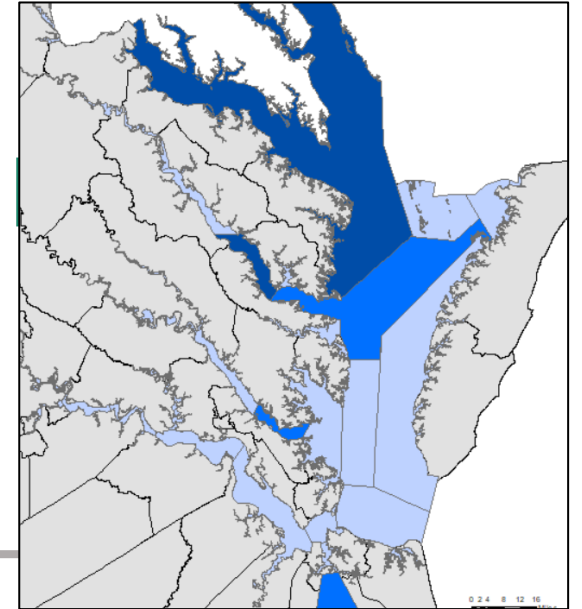


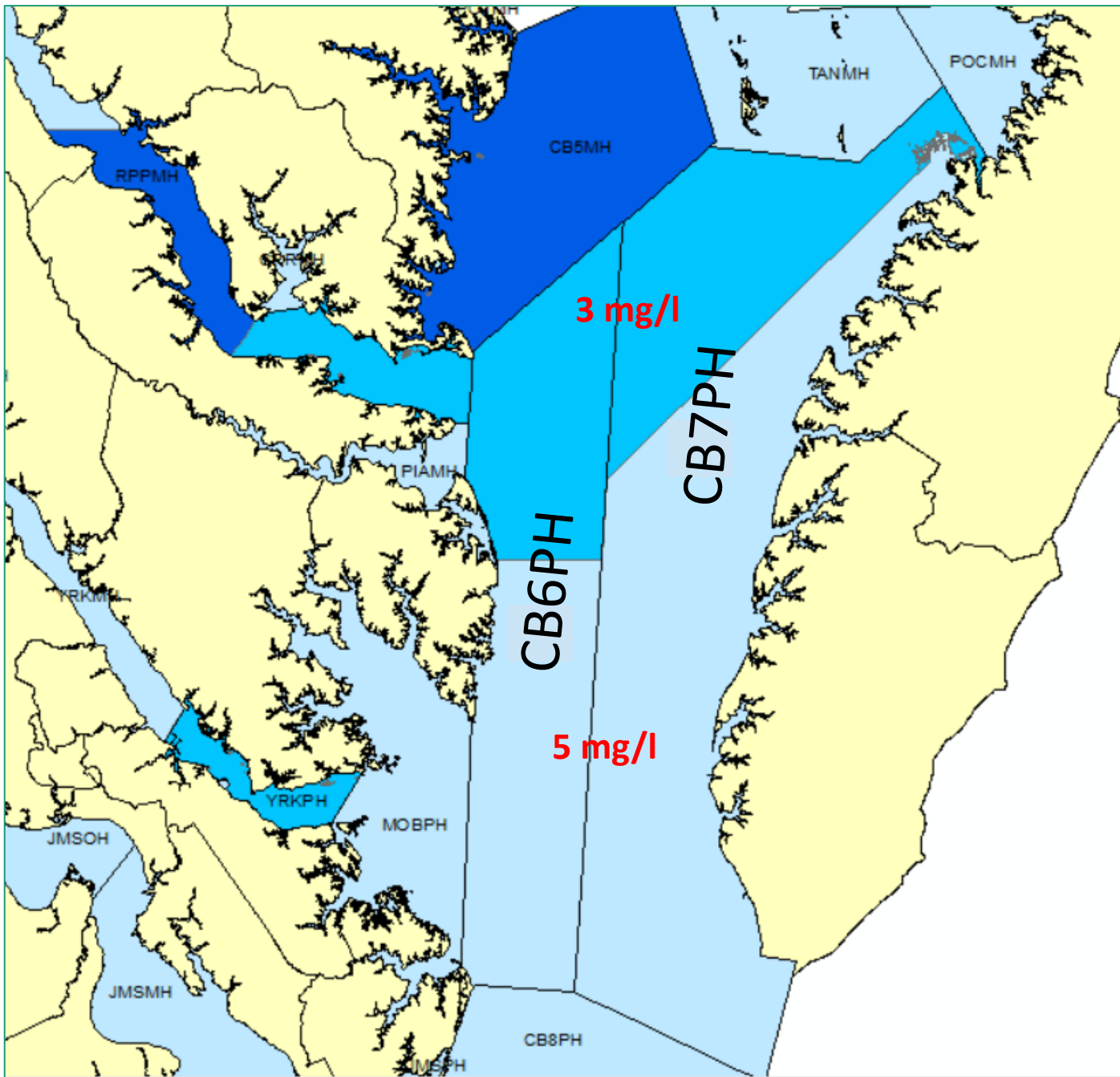
Update on Modeling Analysis for Proposed Boundary Extension of the Deep Water Sub-use in Virginia's Mainstem Chesapeake Bay



Tish Robertson and Richard Tian
Modeling Workgroup Quarterly Review
October 5, 2022

Recap

- CBPO climate change simulations indicate that CB6PH and CB7PH cannot attain Open Water DO criteria at WIP3 loadings.
- Attainment is predicted for all other mainstem Bay segments.
- CB6PH and CB7PH are special because only a portion of these segments is designated for the Deep Water use.
- Areas designed for the Deep Water use are assessed with less stringent DO criteria than areas without this designation.



Deep Channel

Deep Water

Open Water only

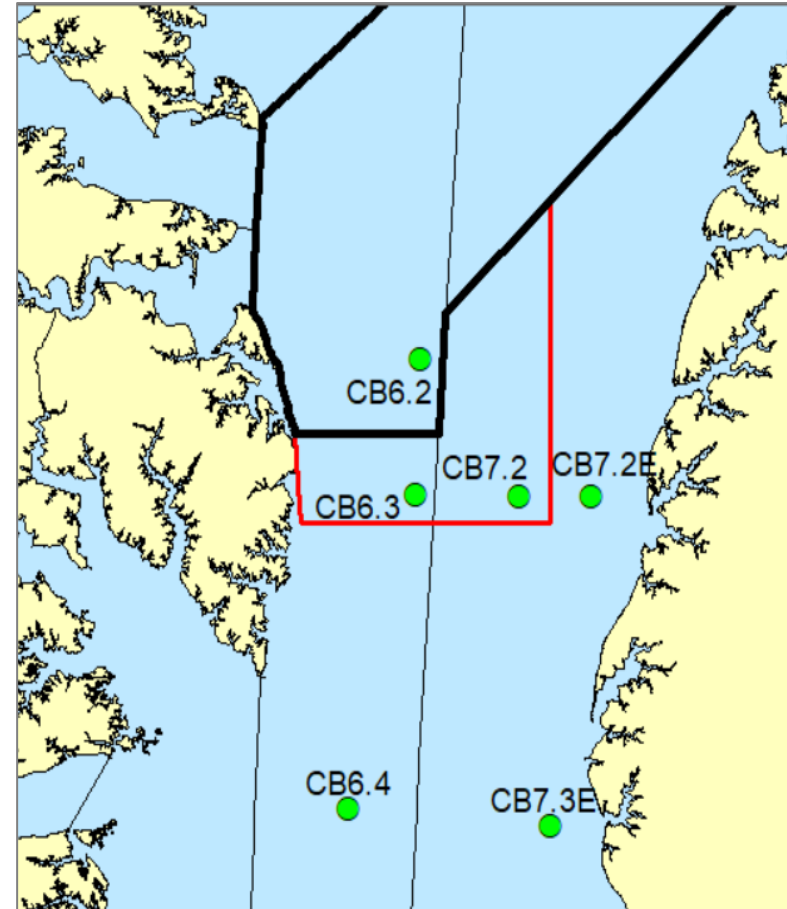
30-Day Mean Criteria

“Tidally influenced waters located...in areas where the measured pycnocline, in combination with bottom bathymetry and water circulation patterns, presents a barrier to oxygen replenishment of deeper waters. In some areas where a lower boundary of the pycnocline is not calculated, the **deep water designated use** extends from the measured depth of the upper boundary of the pycnocline down through the water column to the bottom sediment-water interface.” – *Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability (2003)*

“If a pycnocline is present but other physical circulation patterns (such as influx of oxygen rich oceanic bottom waters) provide for oxygen replenishment of deeper waters, the **open-water fish and shellfish designated use** extends down into the water column to the bottom water sediment interface.” - *Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability (2003)*

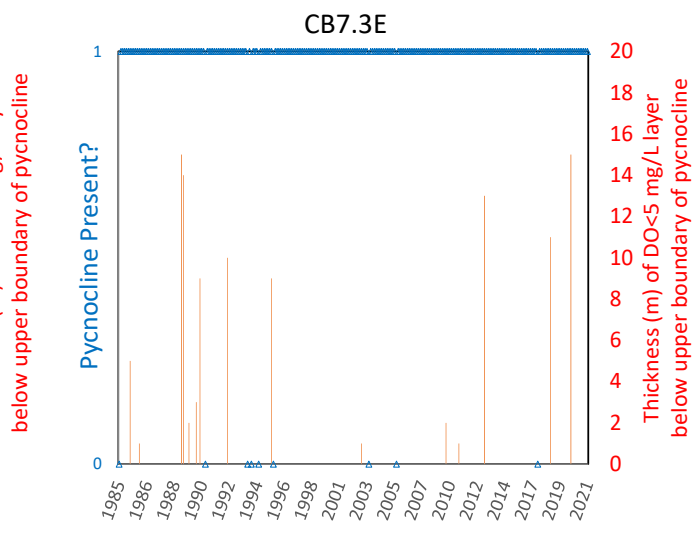
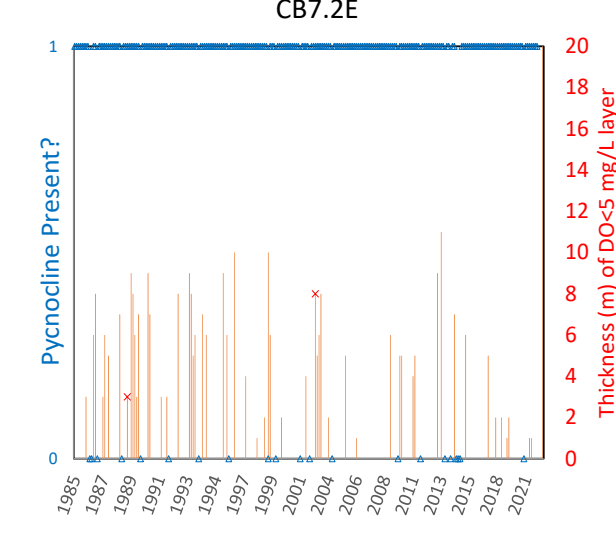
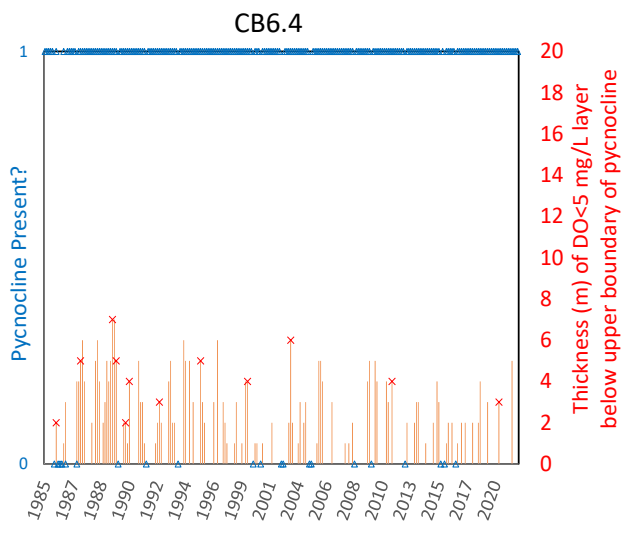
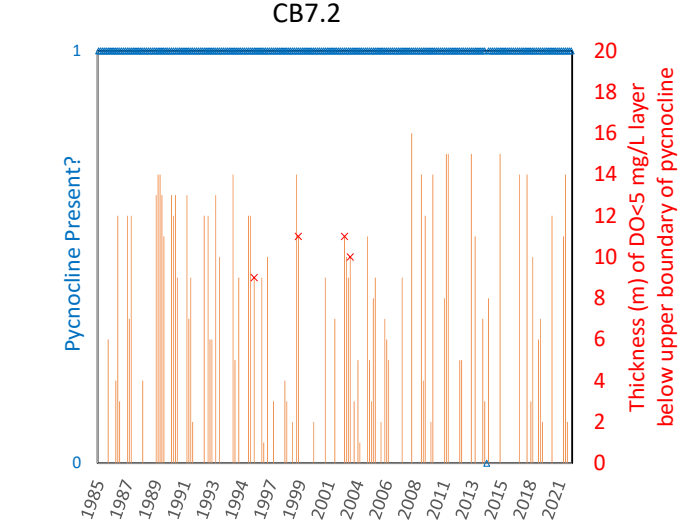
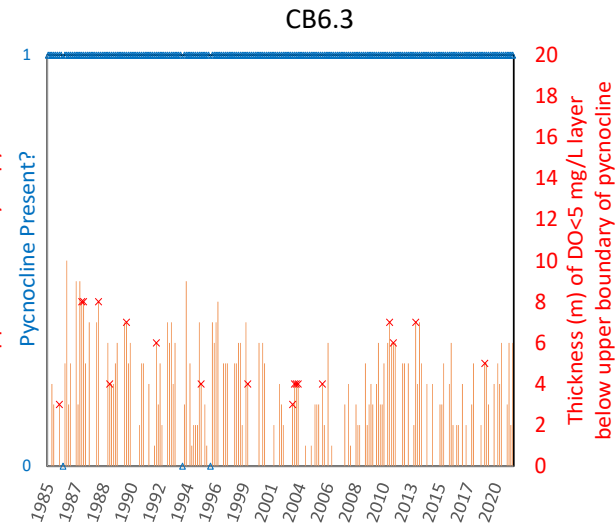
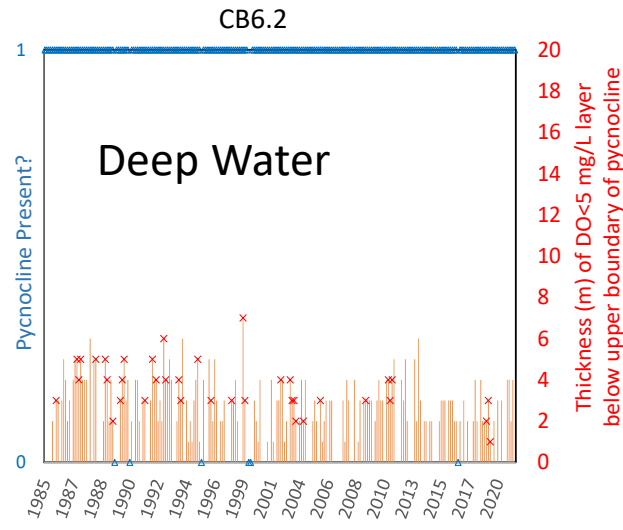
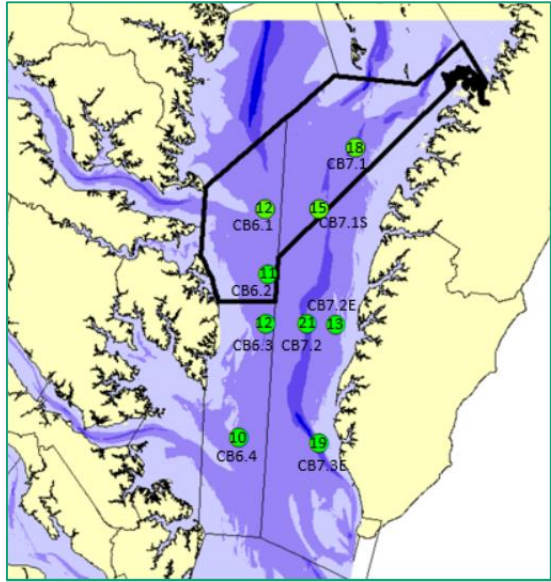
Historical and contemporary monitoring datasets indicate that the Deep Water Habitat is definitely present at CB6.3 and CB7.2 based on the following criteria:

- Bathymetry
- Intensity/persistence of stratification
- **Persistence and thickness of bottom hypoxic layer**



□ Current DW boundary □ An alternative DW boundary

Hypoxia Below Upper Boundary of Pycnocline

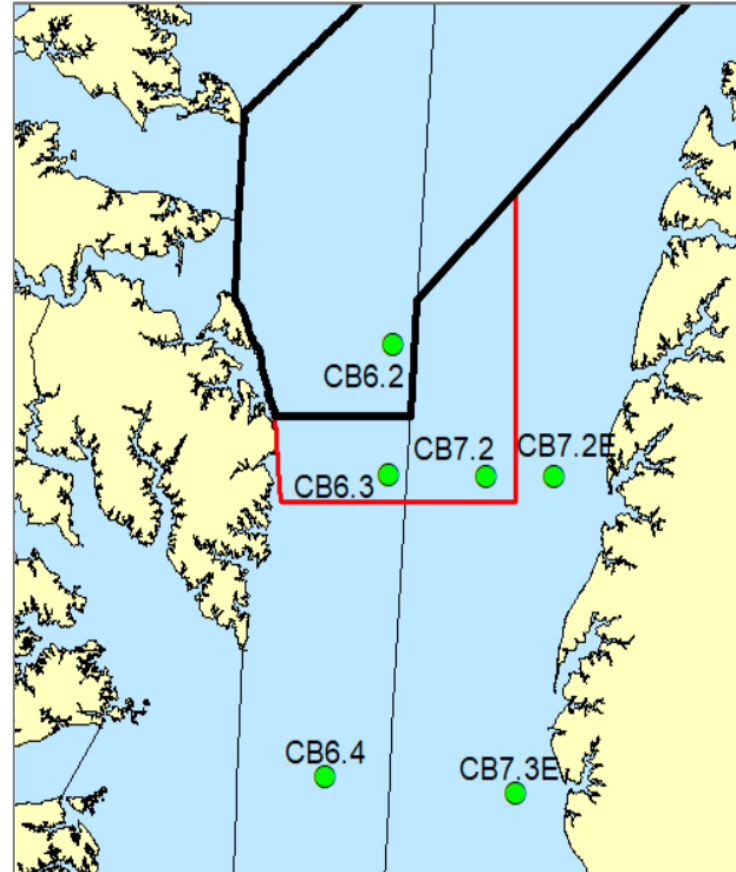




Pycnocline occurrence and thickness of the hypoxic layer below the upper boundary of the pycnocline computed from vertical profile data collected June-September 1985-2021. A pycnocline value of 0 signifies that no pycnocline was present at a particular monitoring event. "X" indicates those hypoxic events for which a DO concentration less than 3 mg/L was recorded at one or more depths.

Takeaways from Monitoring Datasets

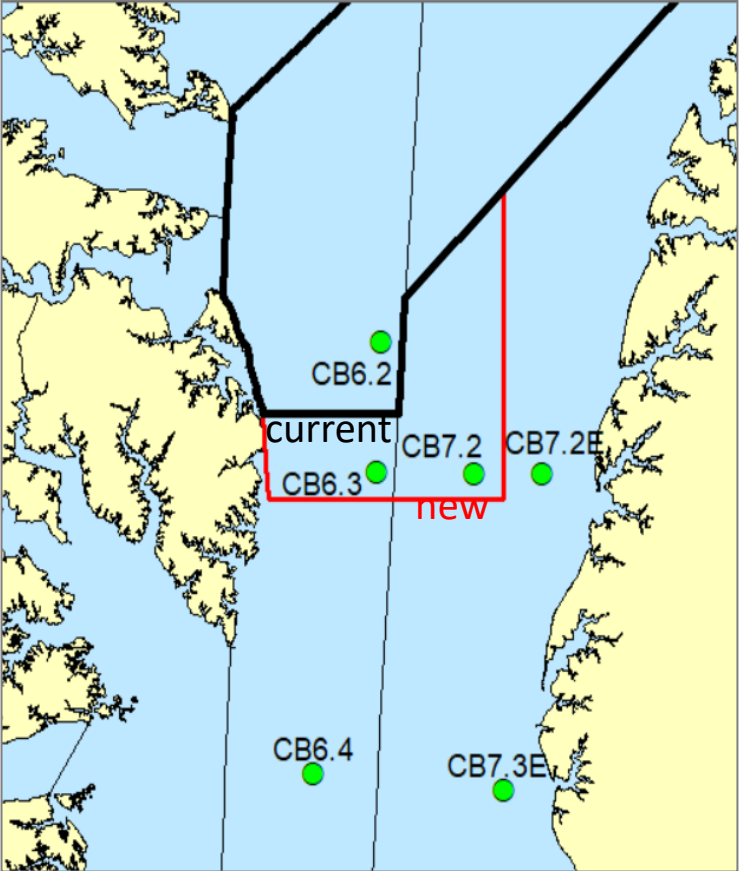
- Deep Water habitat definitely exists at stations CB6.3 and CB7.2.
- CB6.4 and CB7.2E show features of Deep Water habitat, but not as prominently as the upstream stations.

So how far does the Deep Water habitat extend into CB6PH and CB7PH ?



-  Current Deep Water boundary
-  A very conservatively drawn alternative Deep Water boundary

Modeling Team Analysis 1#: How much does the conservatively drawn boundary affect criteria attainment?



DO Criteria Nonattainment Rates for Three Scenarios and Three Boundaries

		Historical			Historical		WIP3 2055 Climate Change		
		1993_1995			2018_2000		1993_1995		
		Current Boundary	New Boundary	No Boundary	Current Boundary	New Boundary	Current Boundary	New Boundary	No Boundary
Cbseg	State								
CB6PH	VA	2.40%	1.95%	0.00%	0.02%	0.00%	1.46%	1.20%	0.00%
CB7PH	VA	5.46%	2.93%	0.00%	2.40%	0.43%	4.72%	2.21%	0.00%
Cbseg	State	Deep Water	Deep Water	Deep Water	Deep Water	Deep Water	Deep Water	Deep Water	Deep Water
CB6PH	VA	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CB7PH	VA	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Nonattainment is still predicted. New boundary needs to be encompass more area.

Modeling Team Analysis #2: Deep Water mapping under simulated climate change conditions



Where in CB6PH and CB7PH do we find...

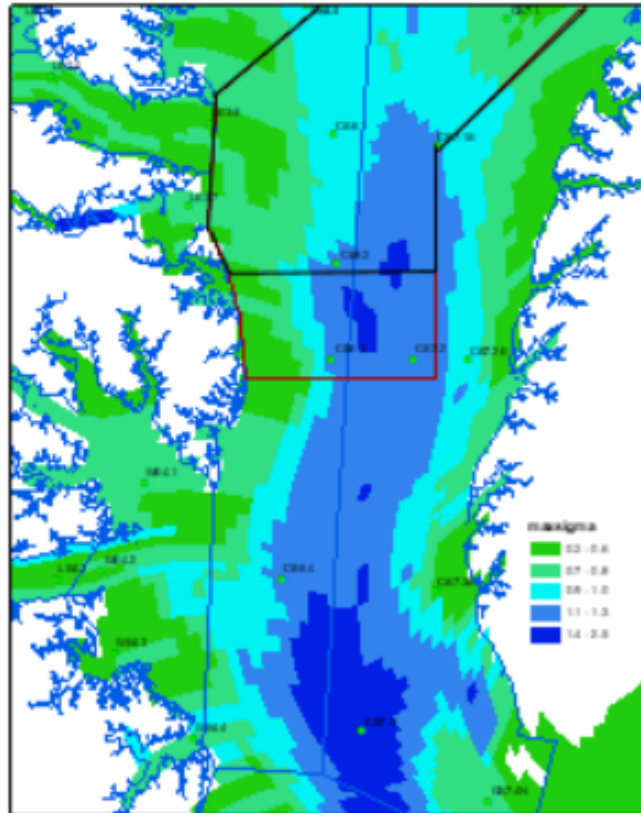
- Strong stratification?
- A large surface-bottom DO gradient?



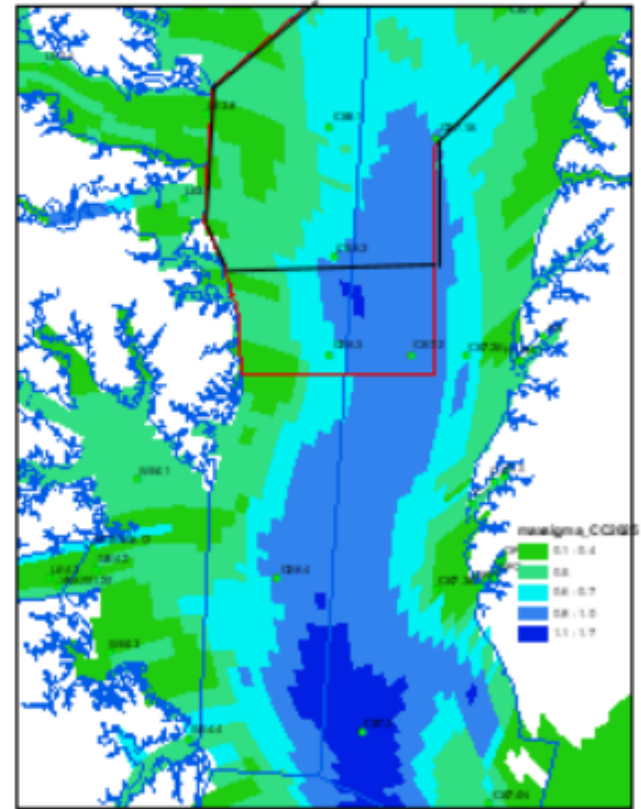
Deep Water Habitat

Maximum sigma-t slope—largest sigma-t delta within the water column

Calibration (1993-1995)

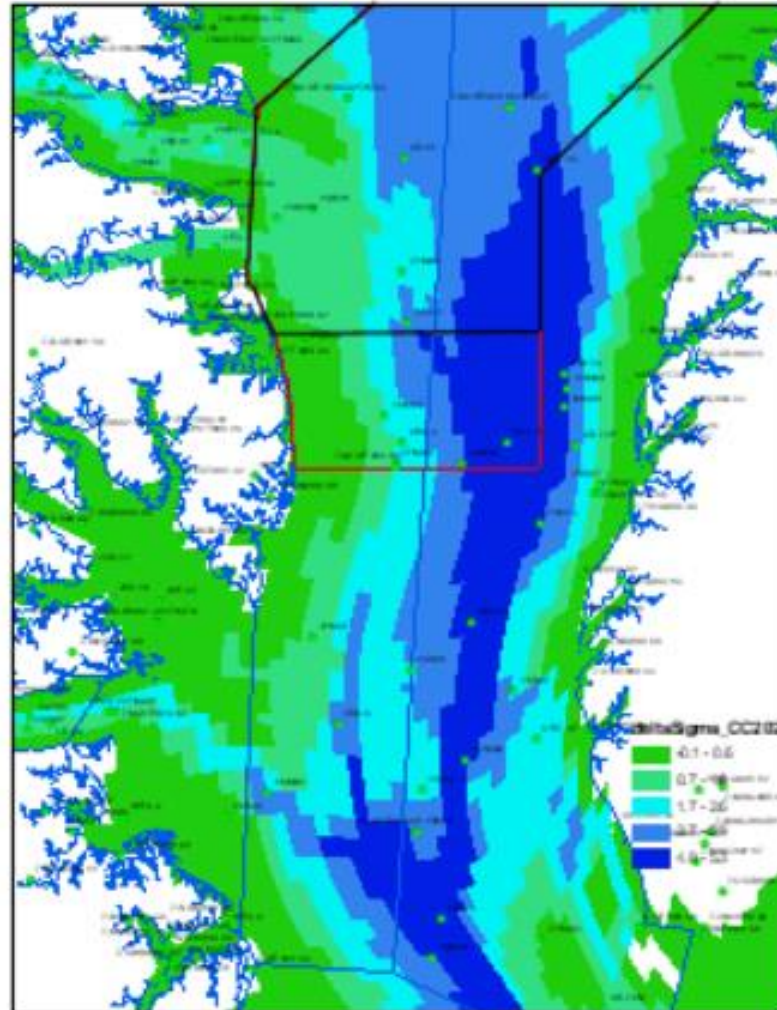


Climate Change 2025



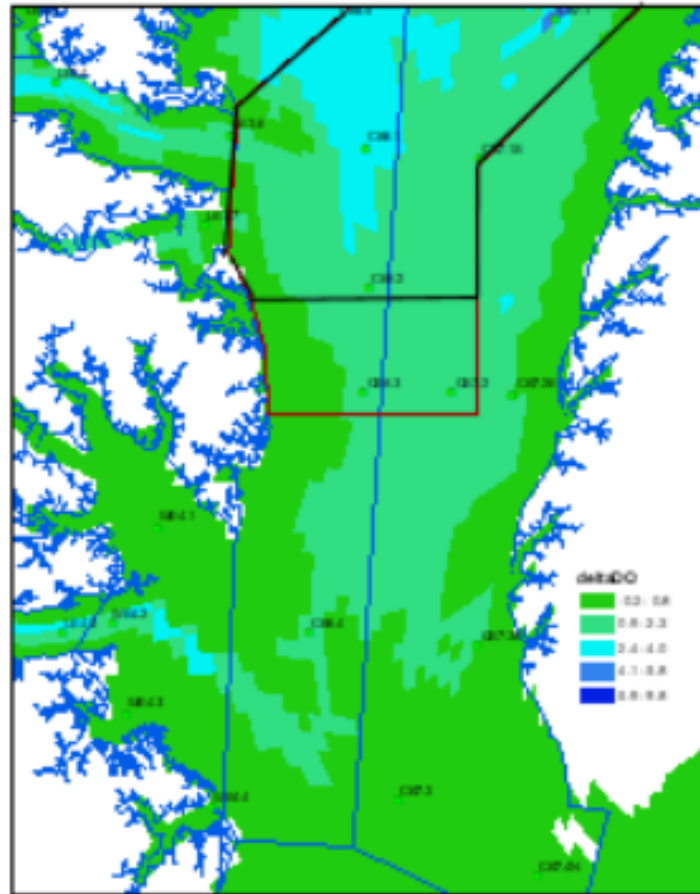
Average sigma-t gradient (bottom sigma-t – surface sigma-t)

Climate Change 2025

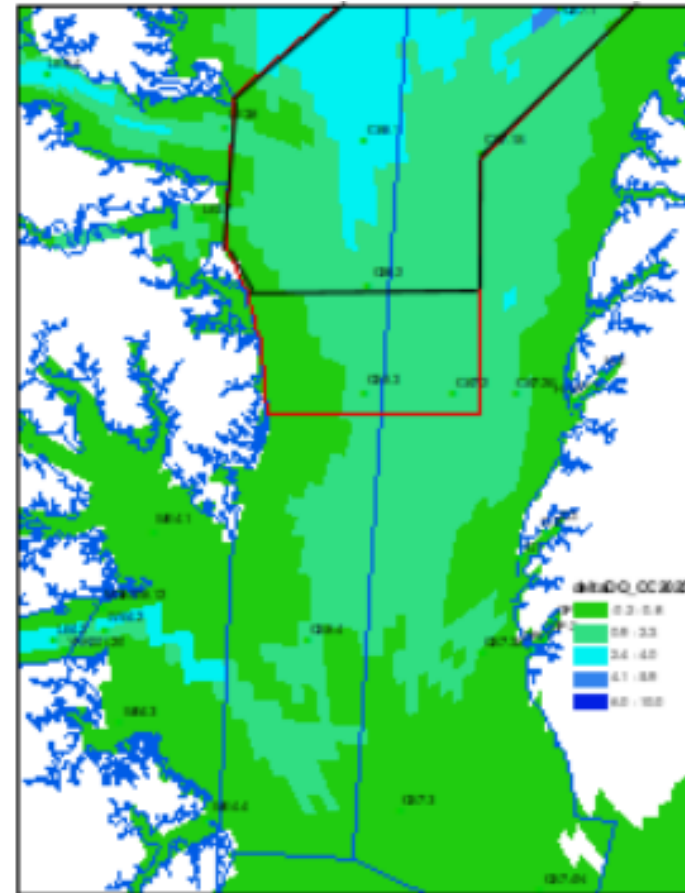


Average DO gradient (surface DO – bottom DO)

Calibration (1993-1995)

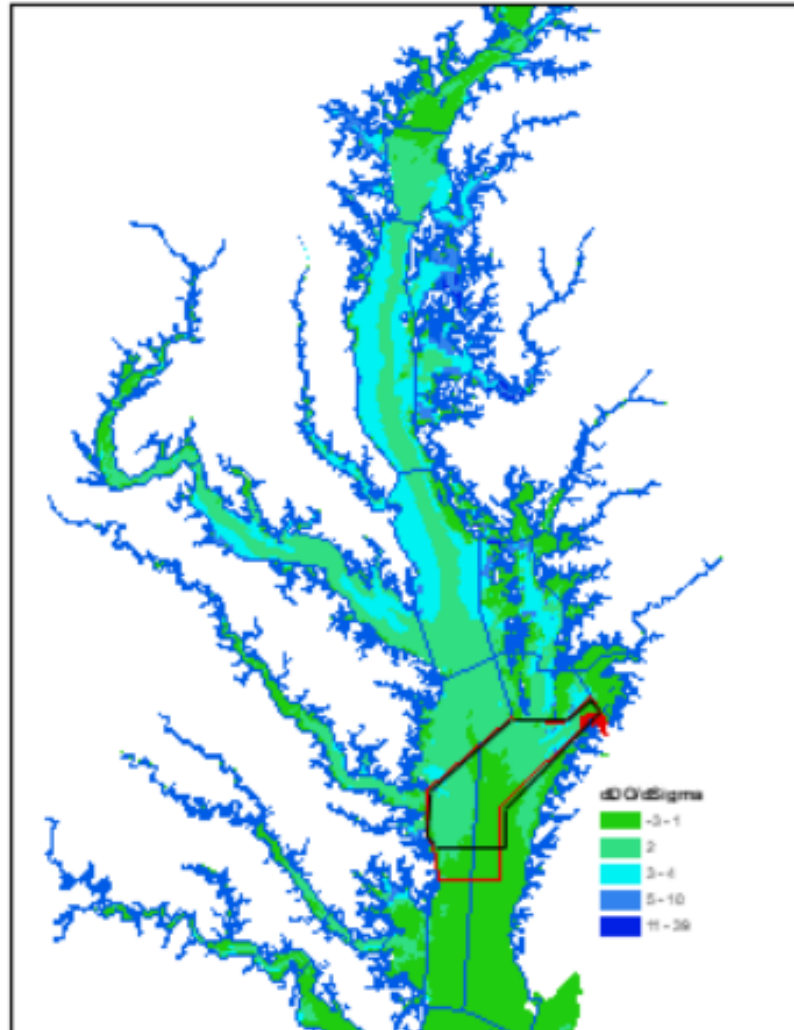


Climate Change 2025



Average DO gradient/Average sigma-t gradient

Climate Change 2025



Takeaway from mapping

- Deep Water conditions exists beyond the conservatively drawn alternative boundary.
- But the mapping does not point to a clear-cut boundary for the Deep Water use.



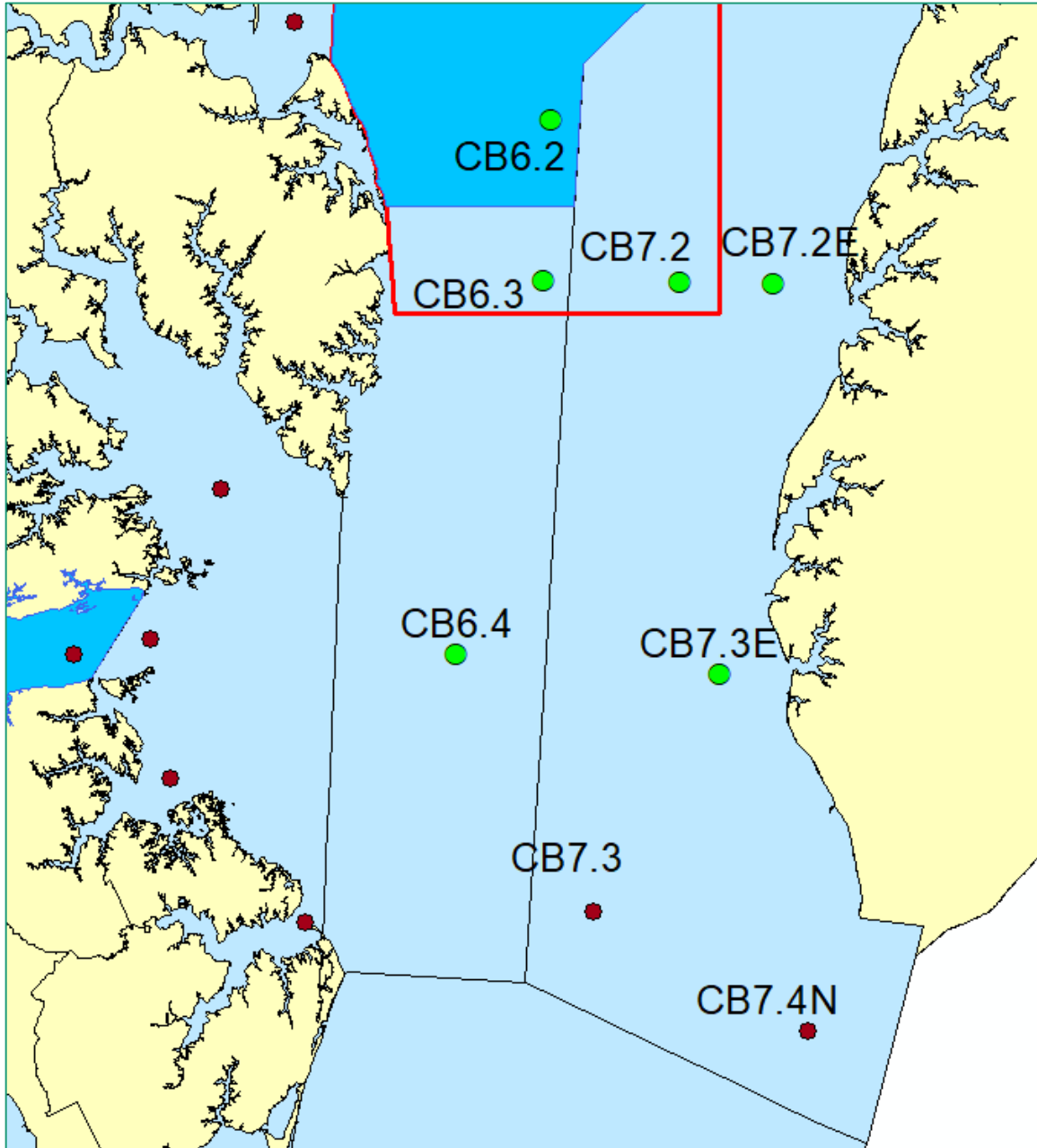
What features separate Deep Water from Open Water?

- It isn't just a recurring pycnocline.

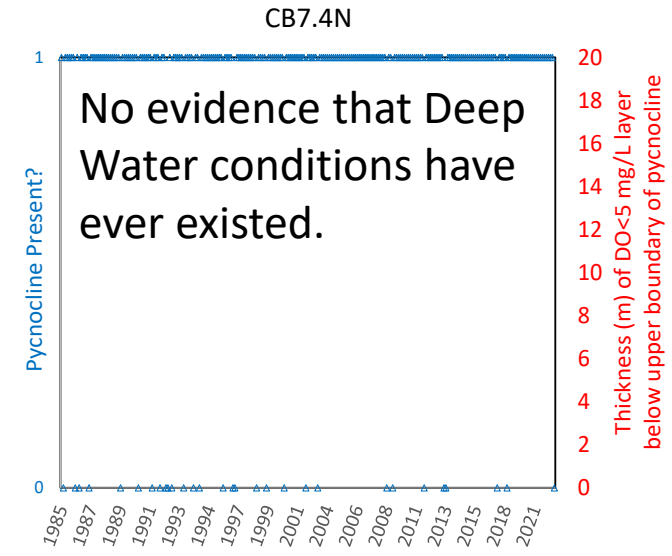
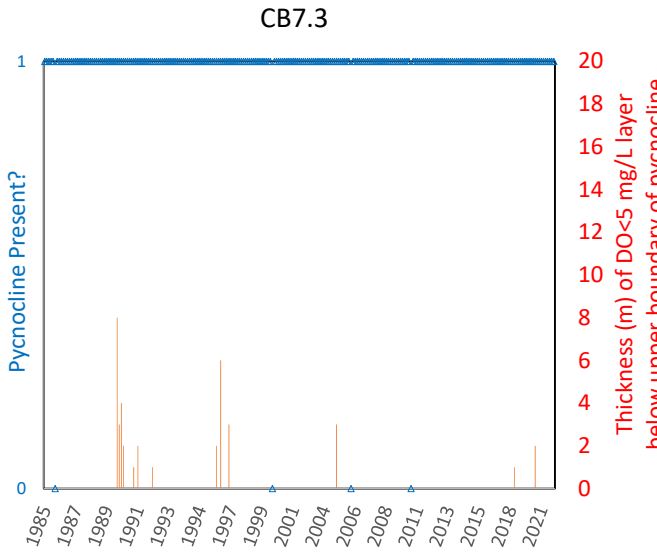
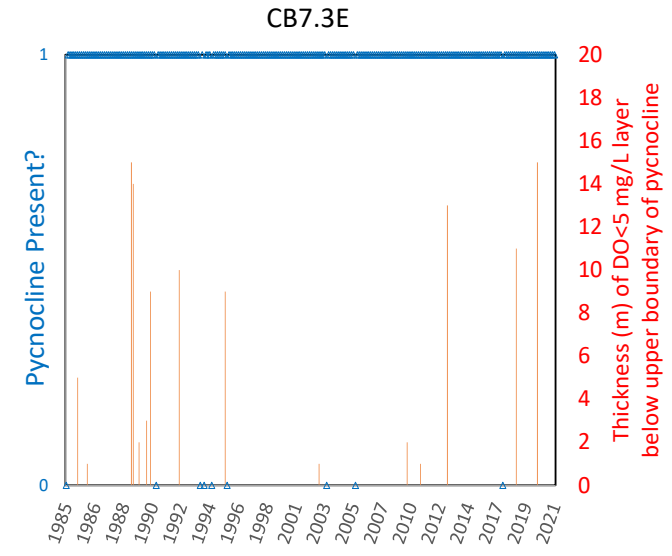
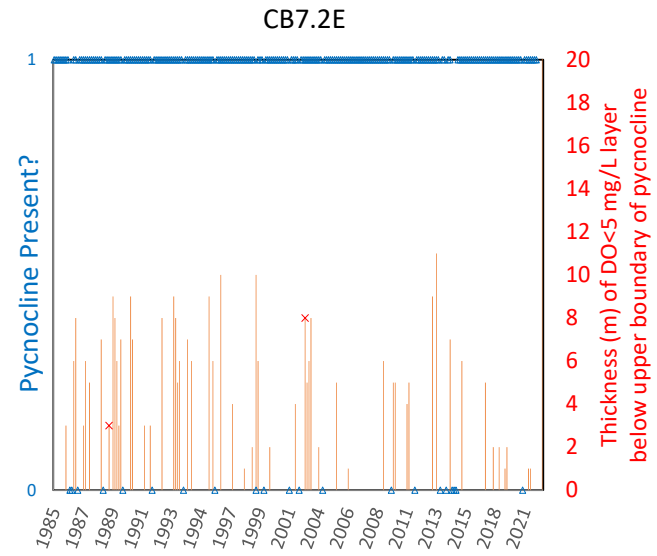
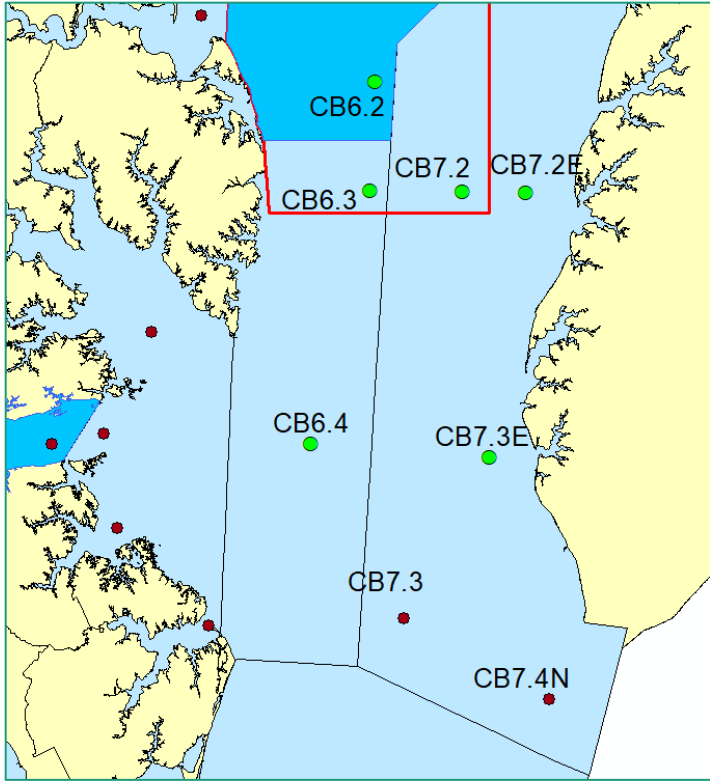
"If a pycnocline is present but other physical circulation patterns (such as influx of oxygen rich oceanic bottom waters) provide for oxygen replenishment of deeper waters, the **open-water fish and shellfish designated use** extends down into the water column to the bottom water sediment interface." - *Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability (2003)*

- It is low DO below the upper boundary of a recurring pycnocline.

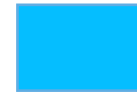
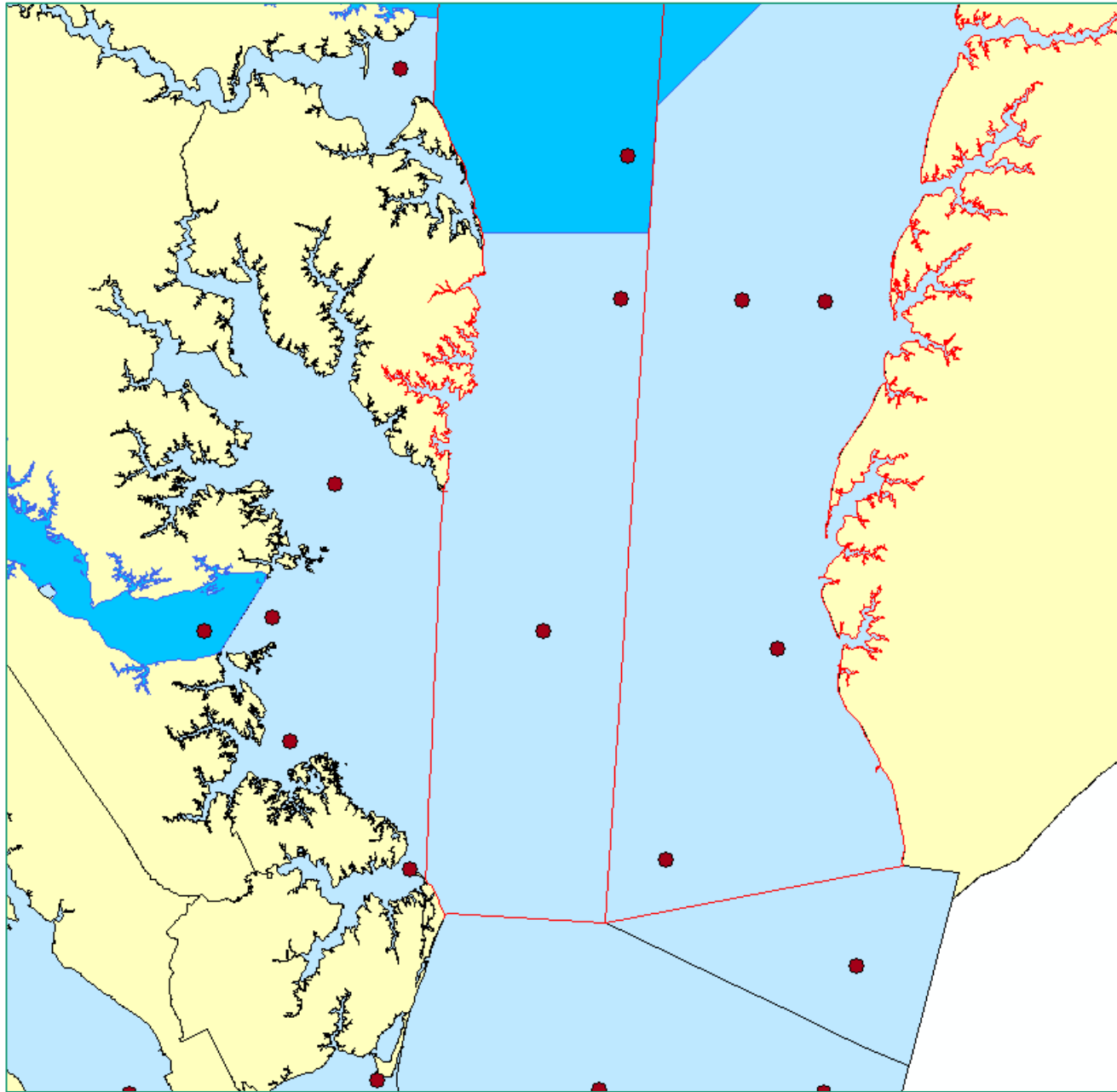
"Tidally influenced waters located...in areas where the measured pycnocline, in combination with bottom bathymetry and water circulation patterns, presents a barrier to oxygen replenishment of deeper waters. In some areas where a lower boundary of the pycnocline is not calculated, the **deep water designated use** extends from the measured depth of the upper boundary of the pycnocline down through the water column to the bottom sediment-water interface." – *Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability (2003)*



Where in CB6PH and CB7PH
have we never seen low DO
in the bottom waters?



Pycnocline occurrence and thickness of the hypoxic layer below the upper boundary of the pycnocline computed from vertical profile data collected June-September 1985-2021. A pycnocline value of 0 signifies that no pycnocline was present at a particular monitoring event. "X" indicates those hypoxic events for which a DO concentration less than 3 mg/L was recorded at one or more depths.



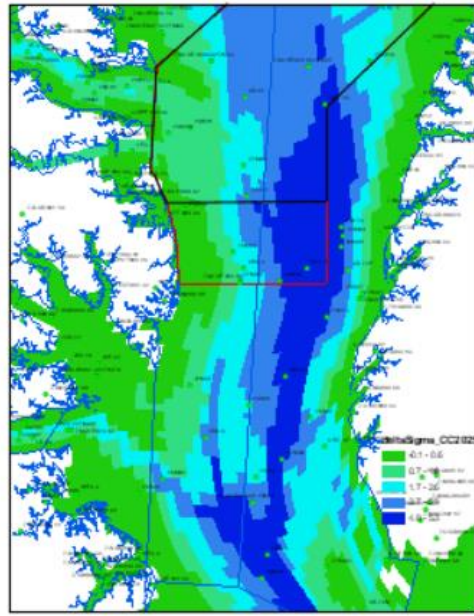
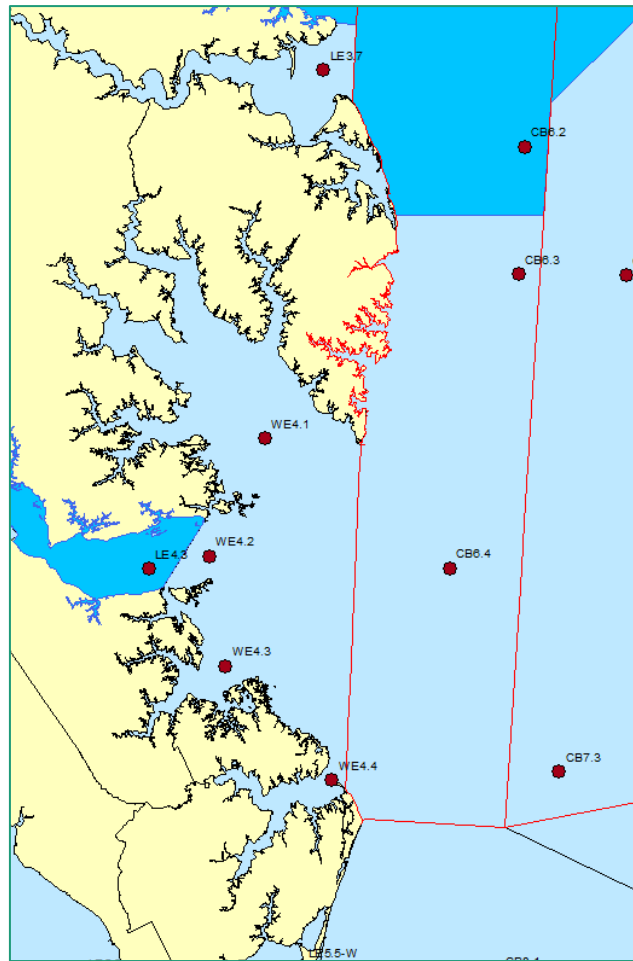
Currently designated for Deep Water



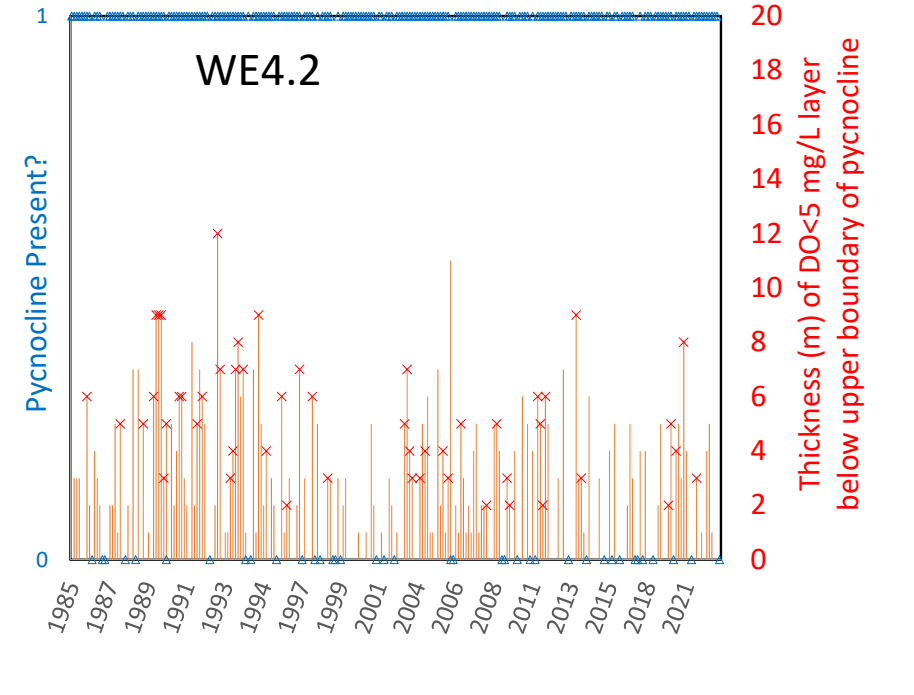
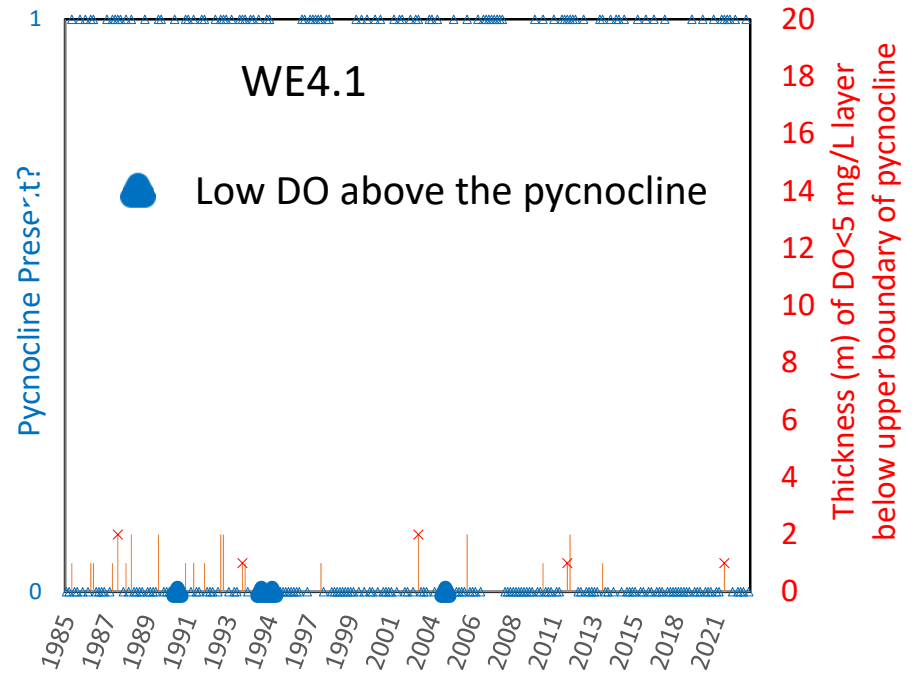
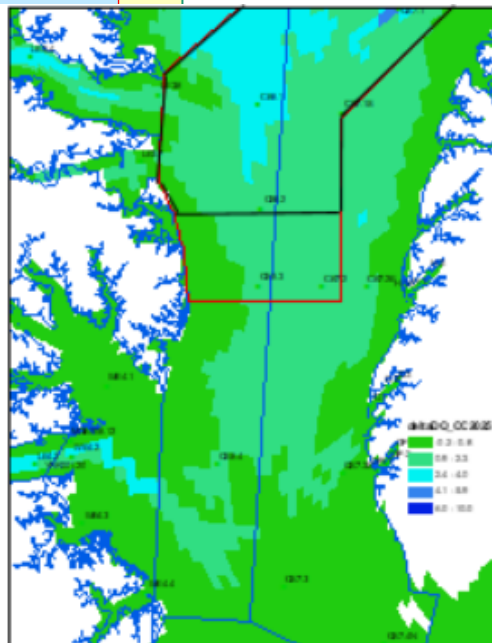
Tentatively proposed Deep Water boundary for CB6PH and CB7PH

With this new alternative boundary, attainment is predicted for CB6PH and CB7PH under climate change with WIP3 loadings.

Average Sigma-t gradient



Average DO gradient



Questions?