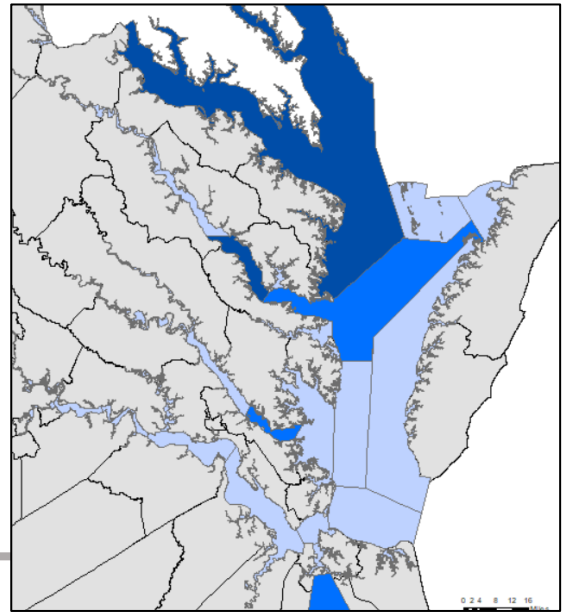
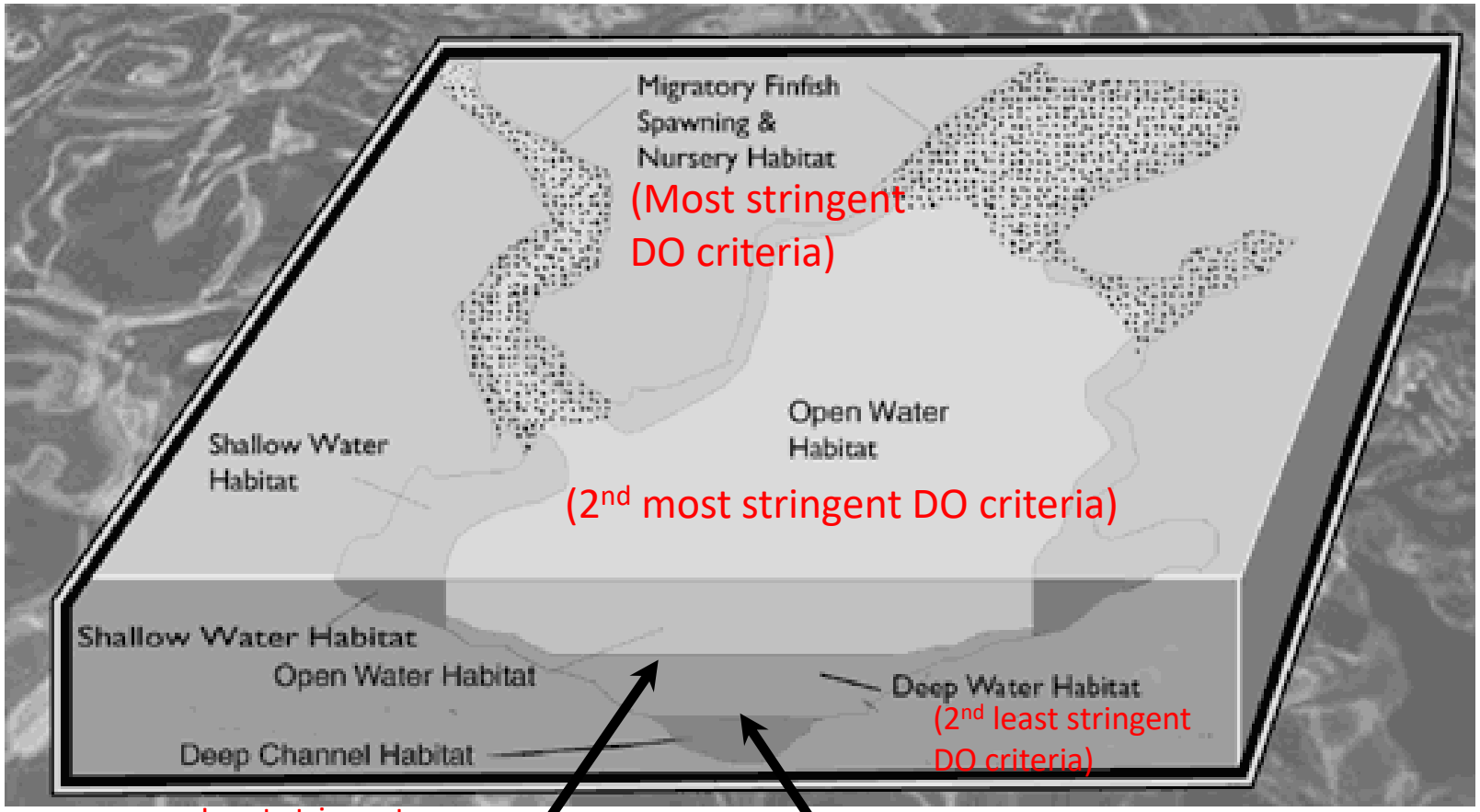
# Proposed Boundary Extension of the Deep Water Sub-use in Virginia's Mainstem Chesapeake Bay



Tish Robertson, Ph.D
Virginia Department of Environmental Quality-Office of Ecology

Criteria Assessment Protocols Workgroup

February 4, 2021


Migratory Finfish
Spawning &
Nursery Habitat
(Most stringent
DO criteria)
Shallow Water
Habitat
Open Water
Habitat
(2nd most stringent DO criteria)
Shallow Water Habitat
Open Water Habitat
Deep Water Habitat
(2nd least stringent
DO criteria)
Deep Channel Habitat
Least stringent
DO criteria)
Upper pycnocline
Lower pycnocline

The habitat features characterizing these subuses are described in EPA's *Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability (April 2003, Appendix A)*

| **Subuse** | **Spatial Occurrence** | **Temporal Occurrence** |
|---|---|---|
| Open Water | Exists shoreline-to-shoreline and throughout entire water column wherever oxygen replenishment is not impeded by a pycnocline; otherwise, exists from surface to uppermost pynocline boundary. | Year round |
| Deep Water | Exists below the upper pynocline wherever oxygen replenishment is impeded by this pycnocline. Extends to the lower pyncocline wherever the lower pycnocline impedes oxygen replenishment; otherwise, it extends to the bottom. | June 1 to Sept 30 |

DEQ

The horizontal extents of the Deep Water and Deep Channel sub-uses is provided in EPA's *Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability (*EPA 903-R-03-004*)*

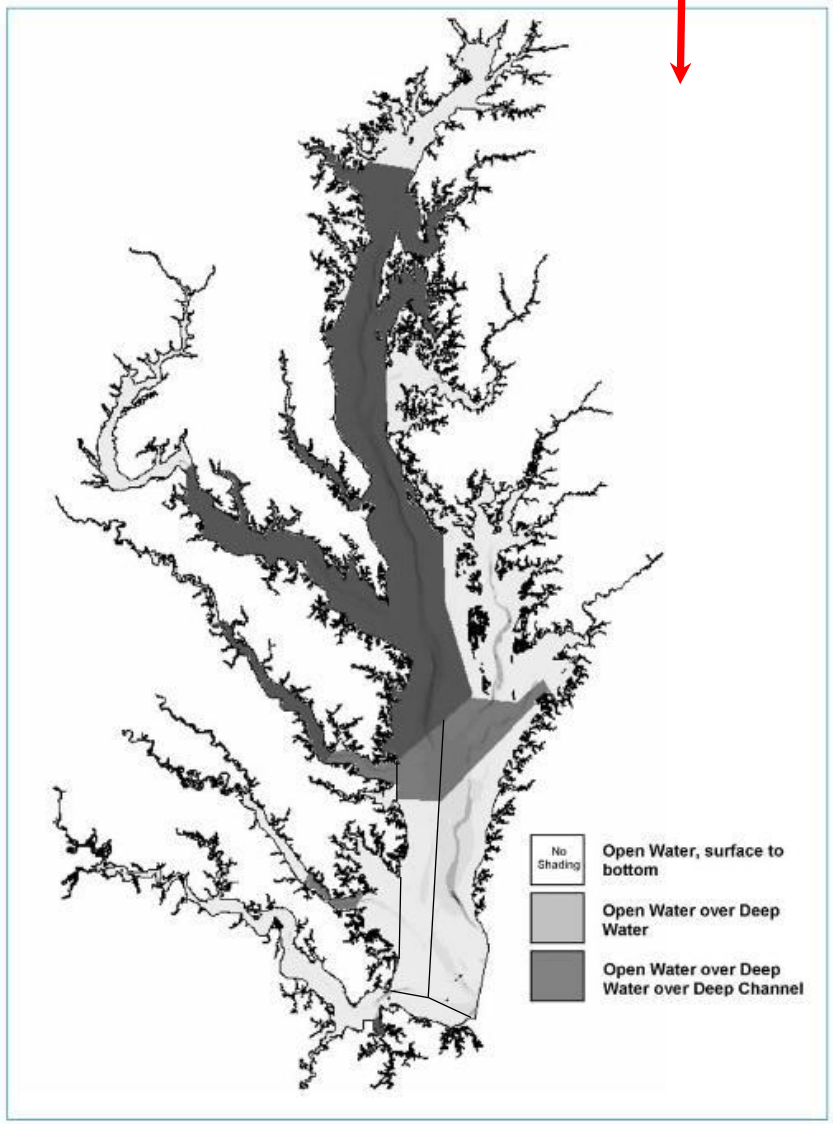



Figure IV-23. Map showing the dissolved oxygen designated uses of the Chesapeake Bay and its tidal tributaries.

The horizontal extents of the Deep Water and Deep Channel sub-uses is provided in EPA's *Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability (*EPA 903-R-03-004 *and its 2004* addendum*)*

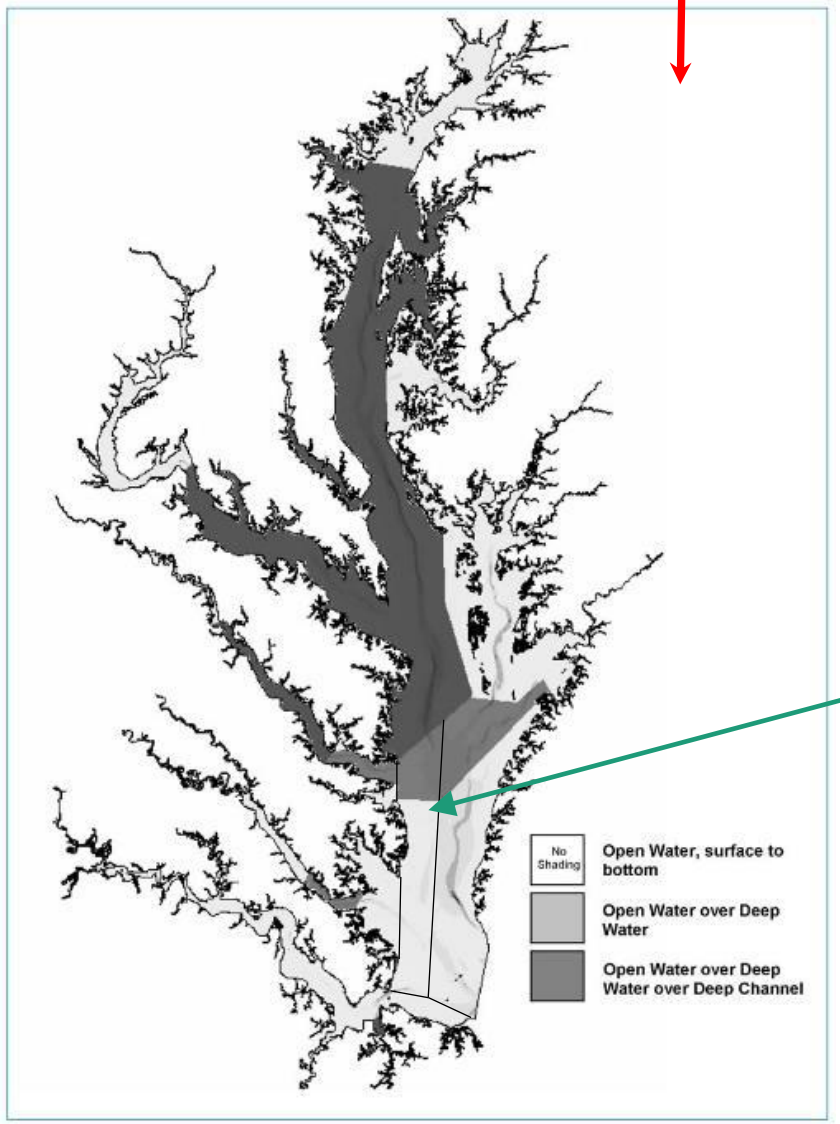
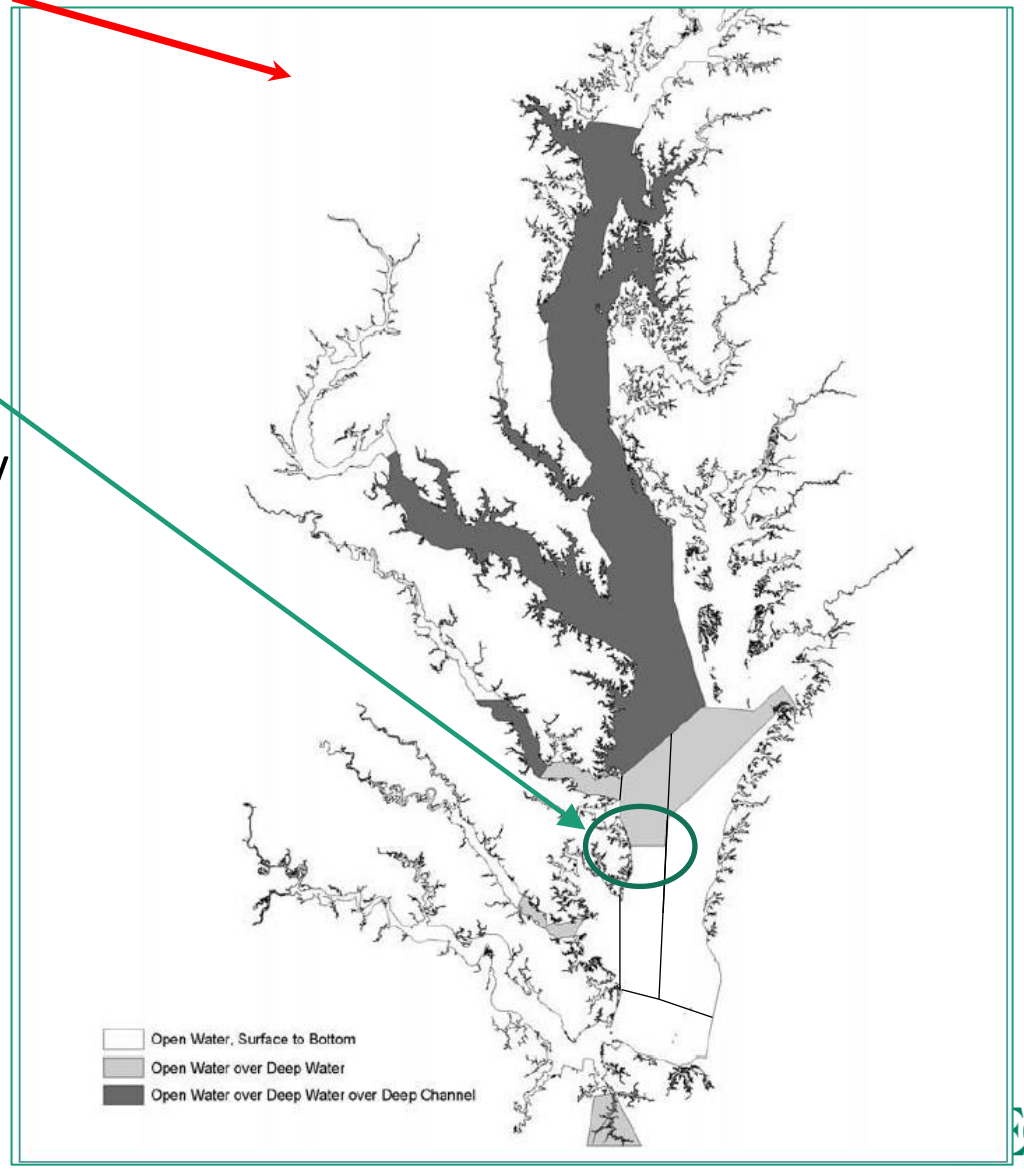
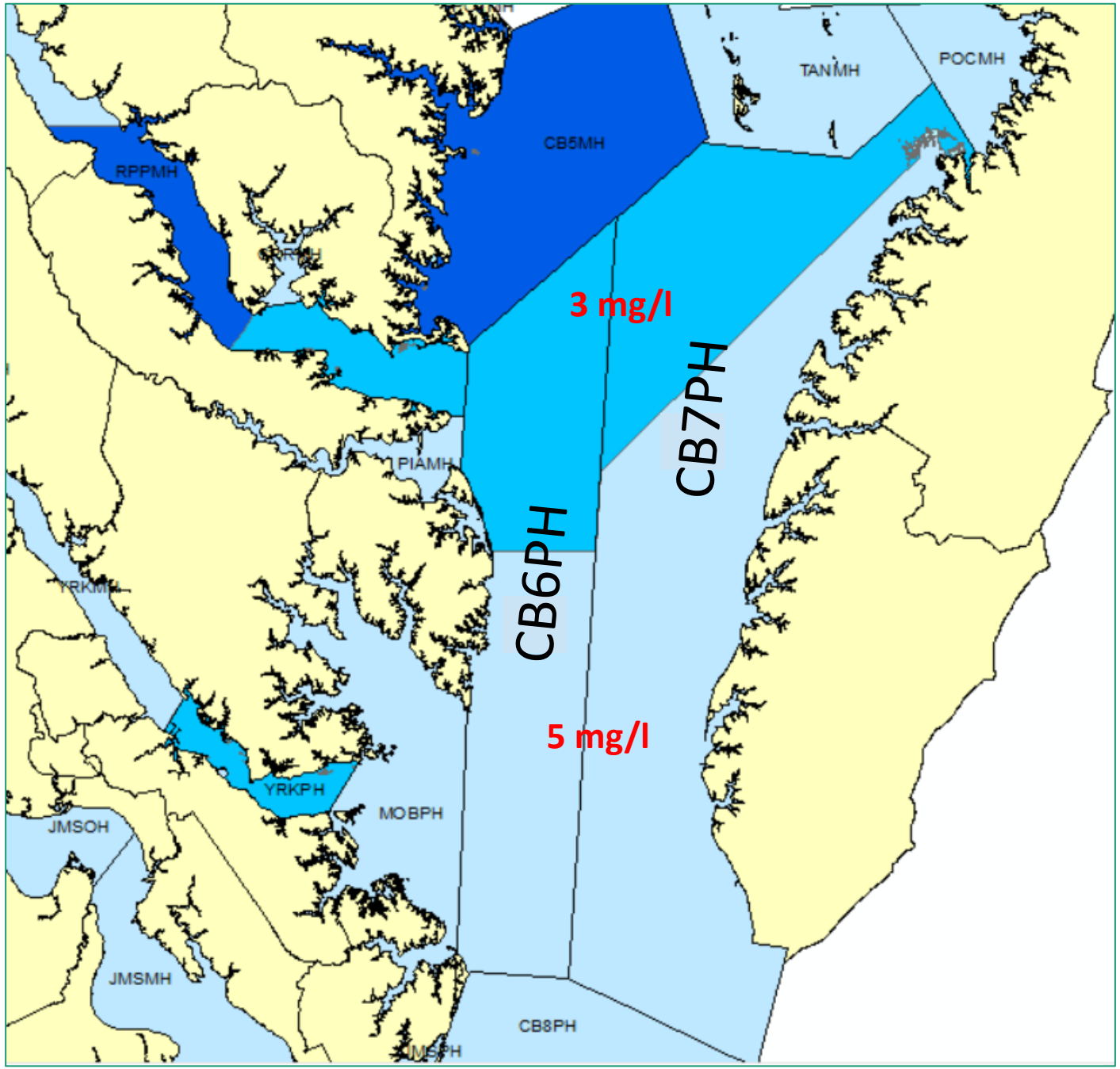



Figure IV-23. Map showing the dissolved oxygen designated uses of the Chesapeake Bay and its tidal tributaries.

Boundary was extended because Bay Model predicted nonattainability of Open Water use in CB6PH with previous boundary






Deep Channel

Deep Water

Open Water only

30-Day Mean Criterion

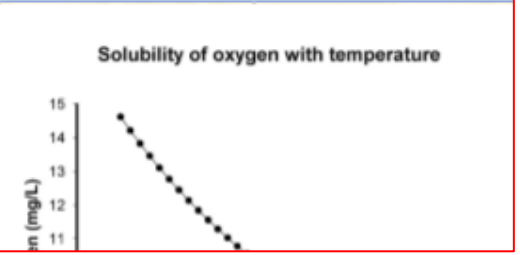


DEQ

# Achievement of Open Water DO Water Quality Standard

Chesapeake Bay Program
*Science, Restoration, Partnership*

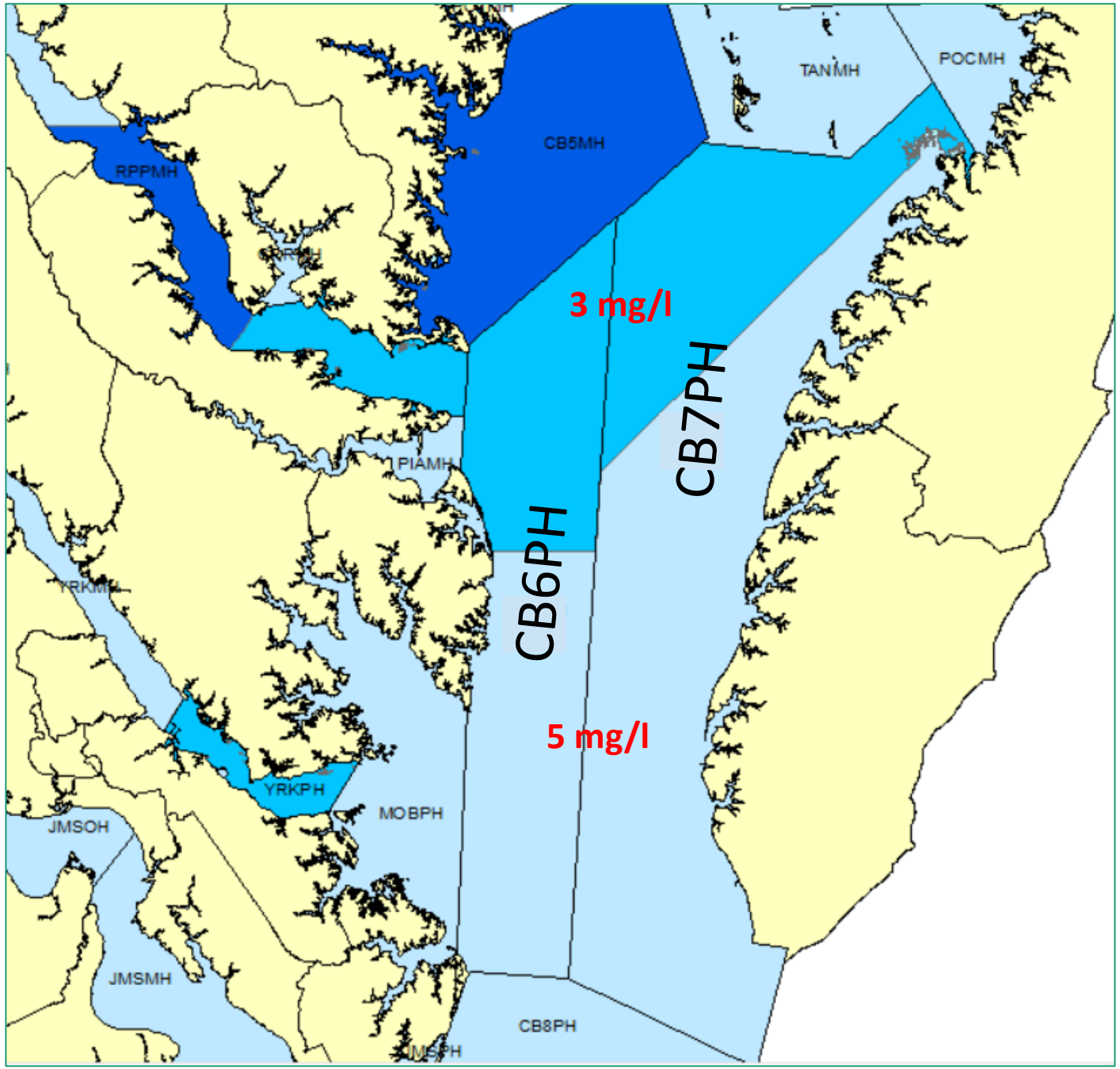
| CB Segment | State | 2025 Climate 2025 Land Use 204TN 14.0TP 1993-1995 DO Open Water | 2035 Climate 2025 Land Use 208TN 14.6TP 1993-1995 DO Open Water | 2035 Climate 2035 Land Use 209TN 14.7TP 1993-1995 DO Open Water | 2045 Climate 2025 Land Use 212TN 15.4TP 1993-1995 DO Open Water | 2045 Climate 2045 Land Use 213TN 15.7TP 1993-1995 DO Open Water | 2055 Climate 2025 Land Use 220TN 16.7TP 1993-1995 DO Open Water | 2055 Climate 2055 Land Use 222TN 17.1TP 1993-1995 DO Open Water |
|---|---|---|---|---|---|---|---|---|
| CB1TF | MD | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| CB2OH | MD | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| CB3MH | MD | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| CB4MH | MD | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| CB5MH_MD | MD | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| CB5MH_VA | VA | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| CB6PH | VA | 0.4% | **0.7%** | **0.8%** | **1.0%** | **1.1%** | **1.3%** | **1.4%** |
| CB7PH | VA | **1.1%** | **1.8%** | **1.9%** | **2.8%** | **2.9%** | **4.0%** | **4.1%** |
| CB8PH | VA | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| BSHOH | MD | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | | |
| GUNOH | MD | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | | |
| MIDOH | MD | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | | |
| BACOH | MD | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | | |
| PATMH | MD | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | | |
| MAGMH | MD | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | | |
| SEVMH | MD | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | | |
| SOUMH | MD | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | | |
| RHDMH | MD | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | | |




(From Linker, 2020)

Bay Model indicates that TMDL nutrient reductions will bring most of the mainstem Bay into compliance with water quality standards. The exceptions are CB6PH and CB7PH Open Water.

DEQ




Deep Channel

Deep Water

Open Water only

30-Day Mean Criterion

Is the attainability problem in CB6PH and CB7PH the result of an overly restrictive delineation of the Deep Water sub-use?

Is it possible there are portions of CB6PH and CB7PH being assessed as Open Water when they really should be assessed as Deep Water?

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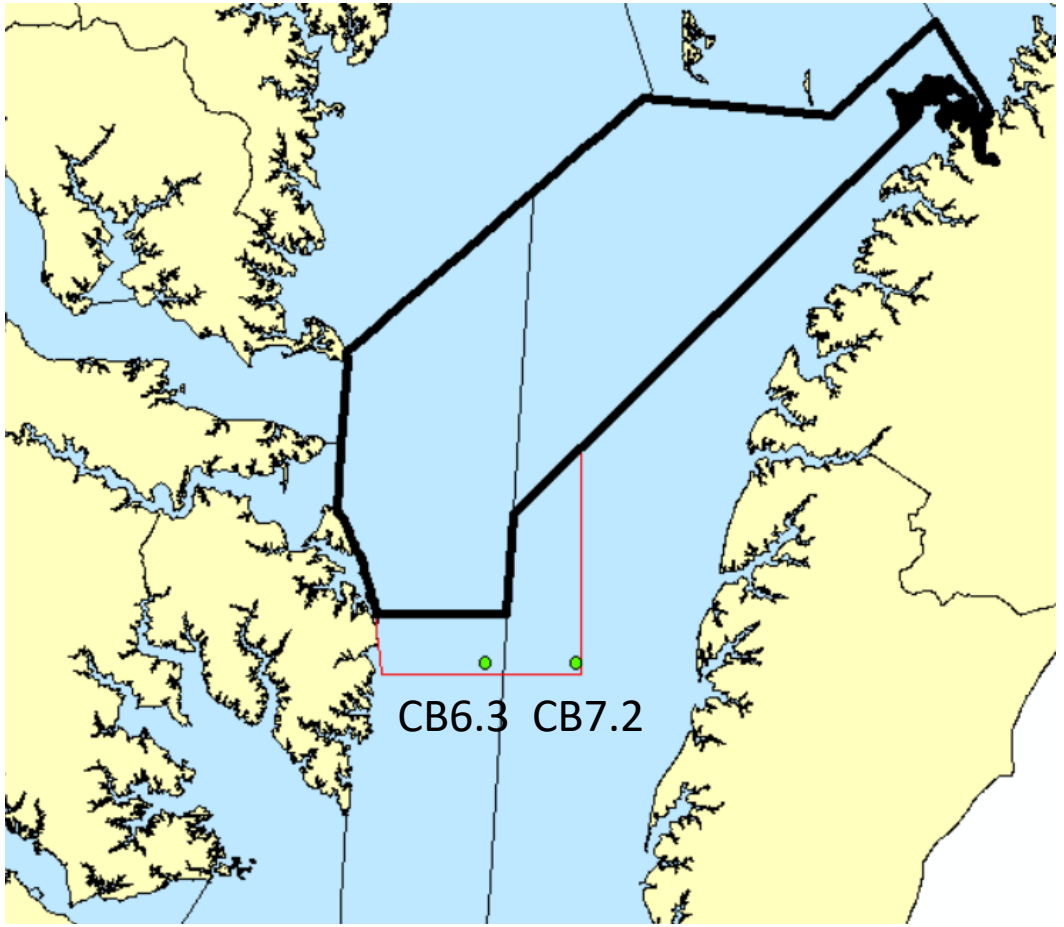
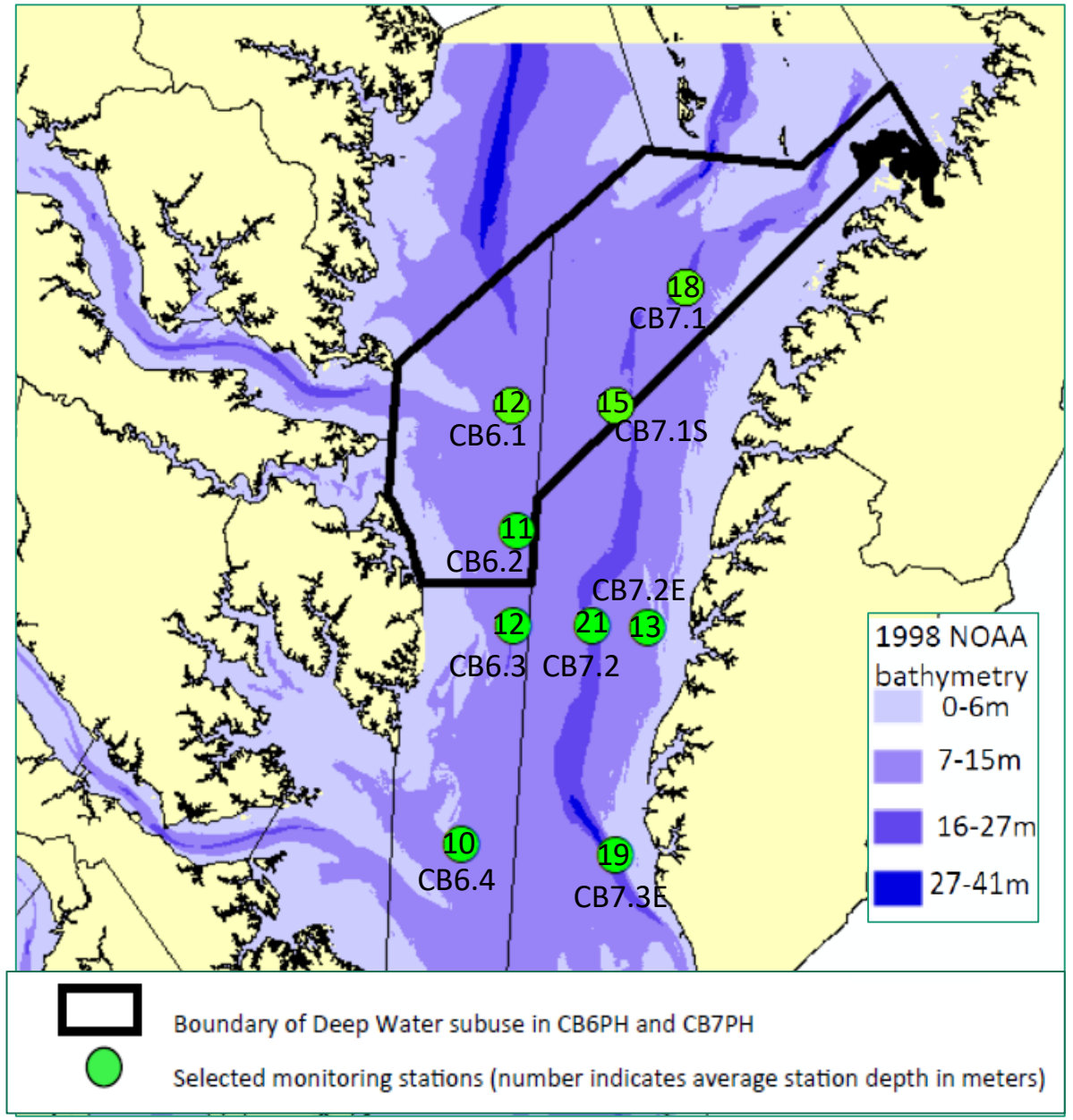
Deep Water Habitat appears to be present at CB6.3 and CB7.2 based on the following:

- Bathymetry
- Intensity/persistence of stratification
- Persistence and thickness of below pycnocline hypoxic layer



# Bathymetry

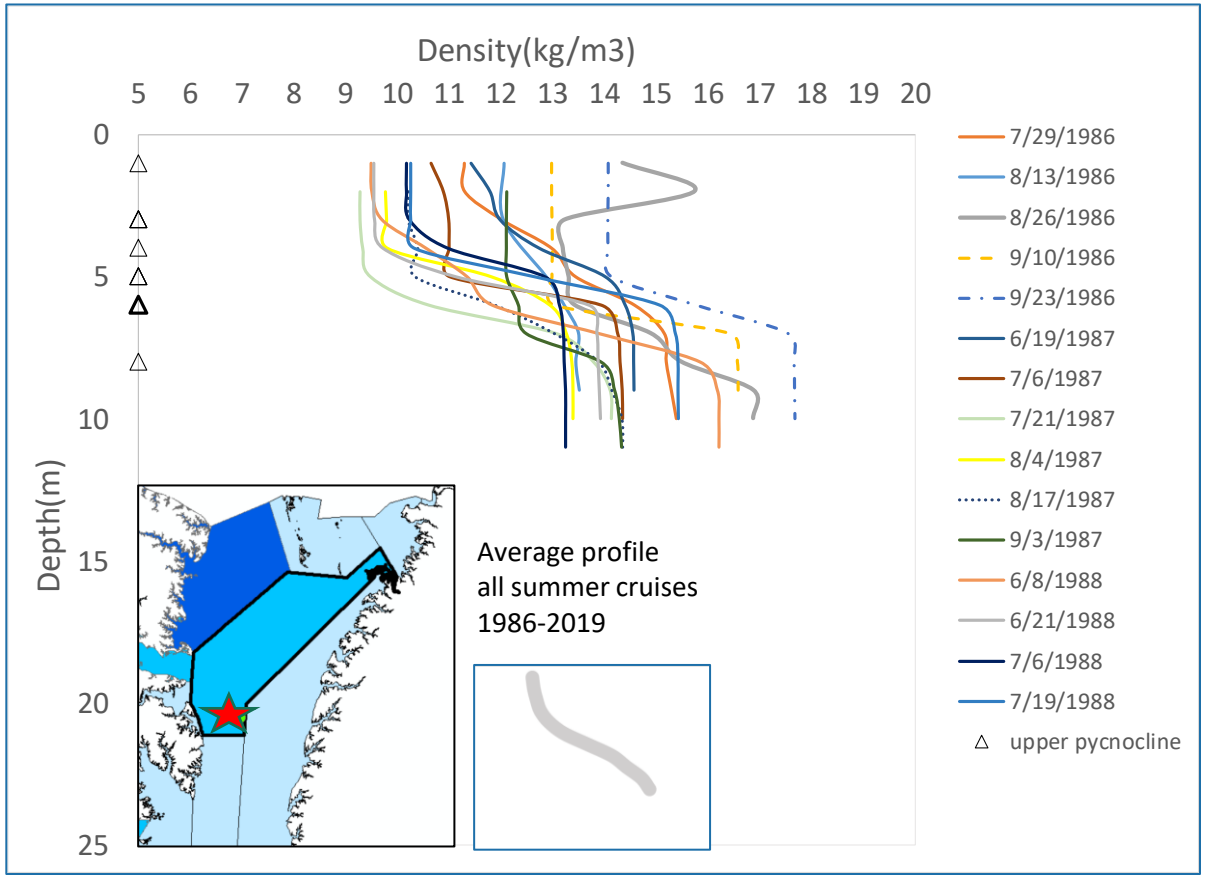
Open Water stations in CB6PH and CB7PH are just as deep as the Deep Water stations.



# Stratification

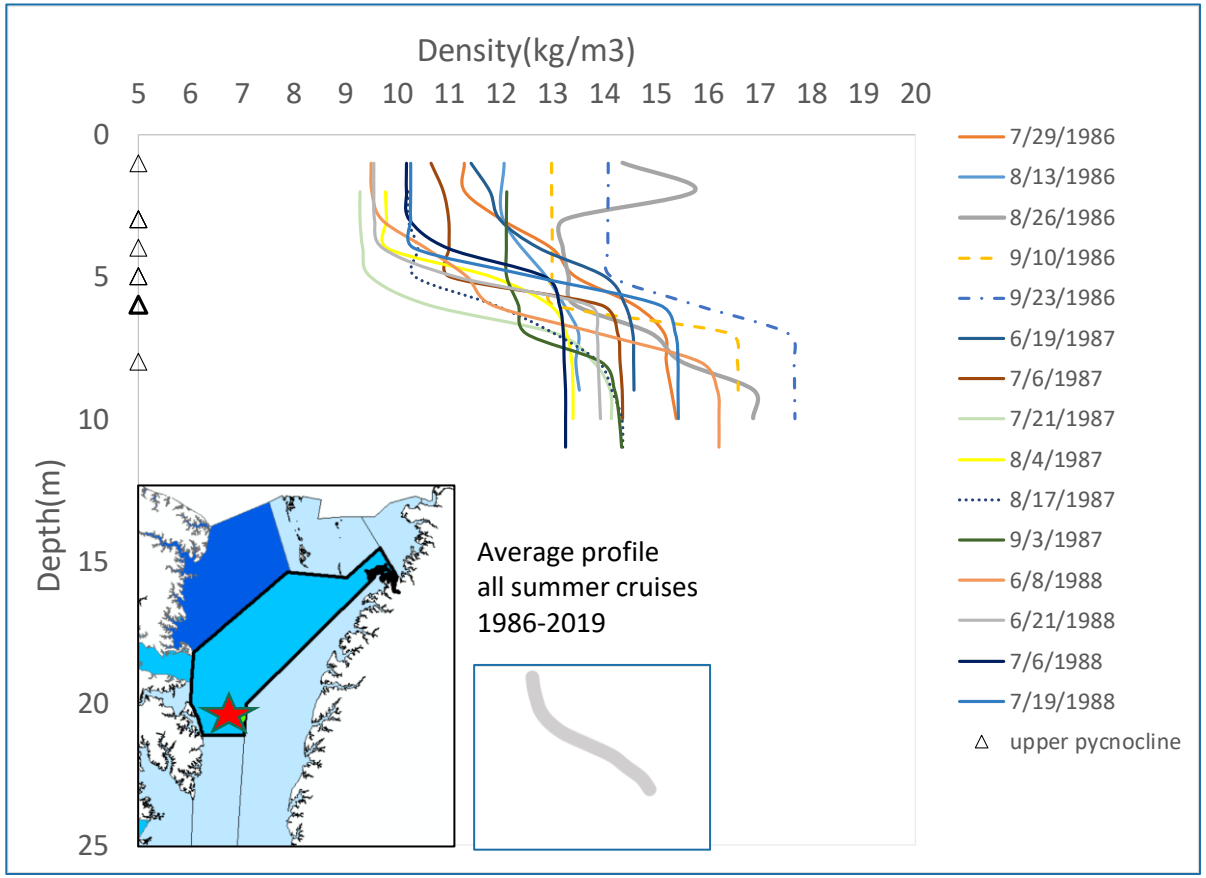
# Stratification

## CB6.2 (Deep Water)

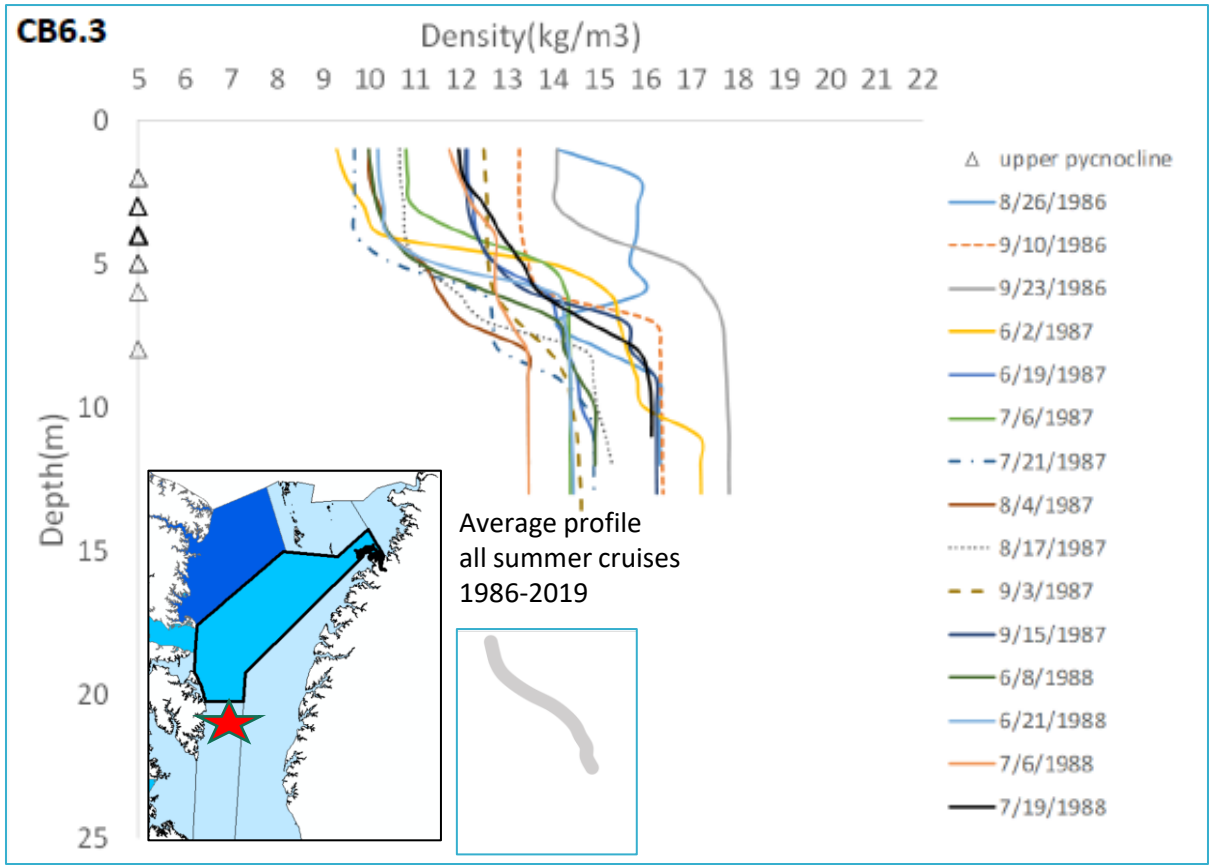


# Stratification

## CB6.2 (Deep Water)



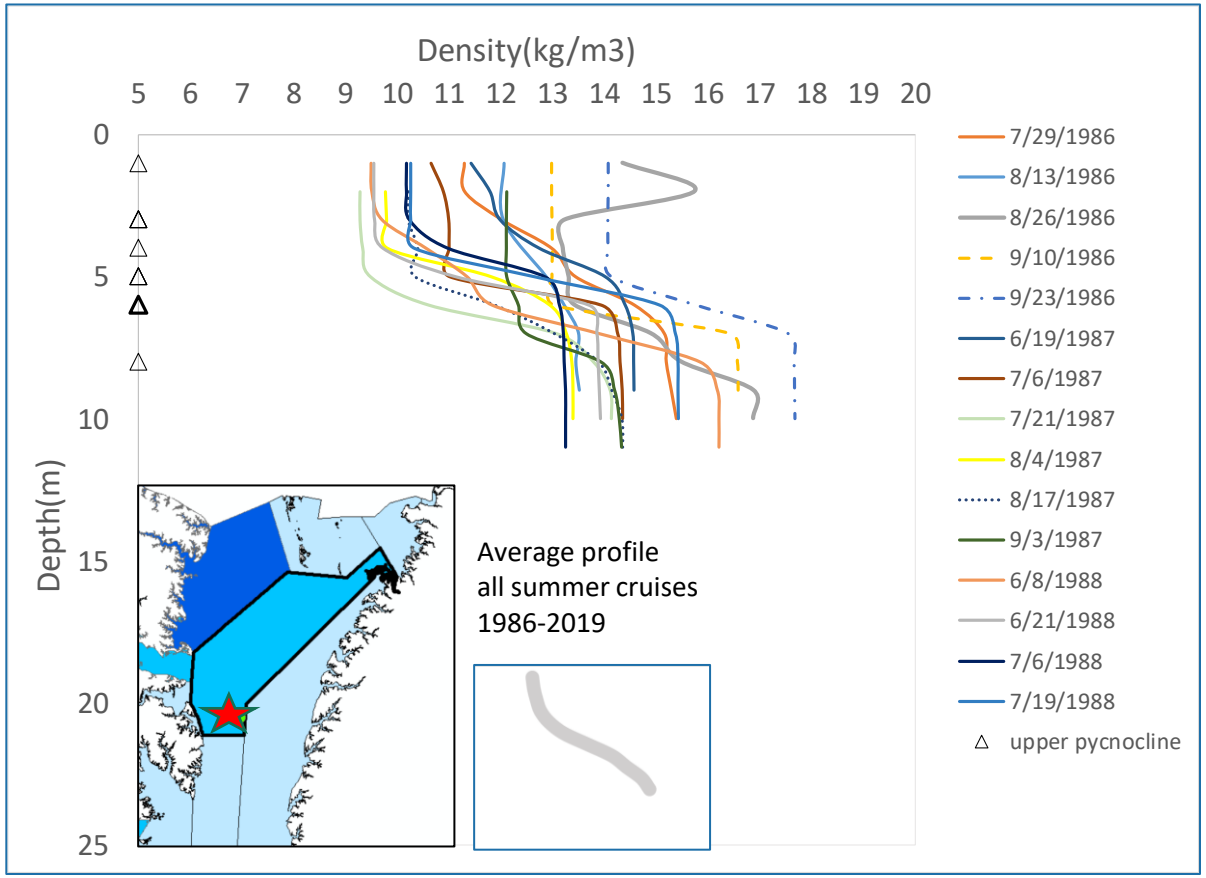

## CB6.3 (Open Water)



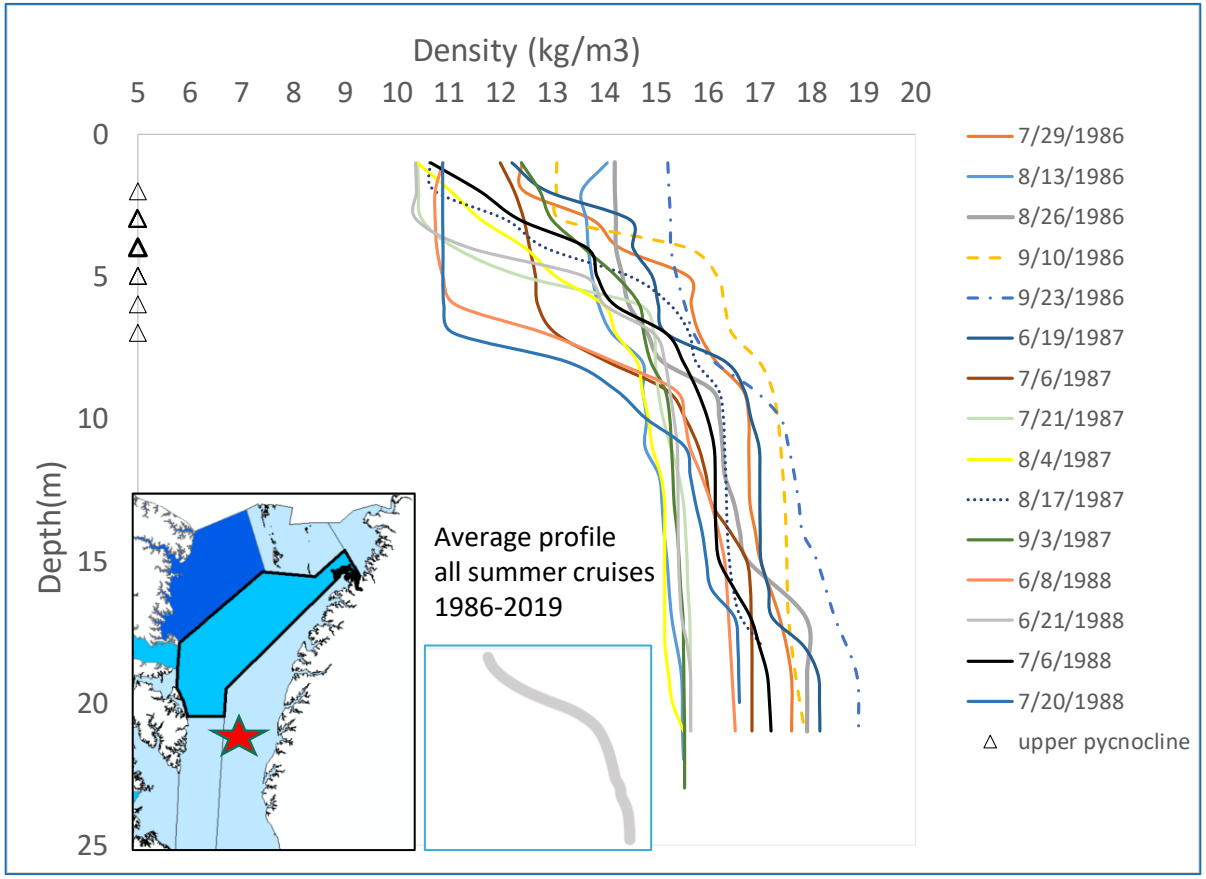

DEQ

# Stratification

## CB6.2 (Deep Water)



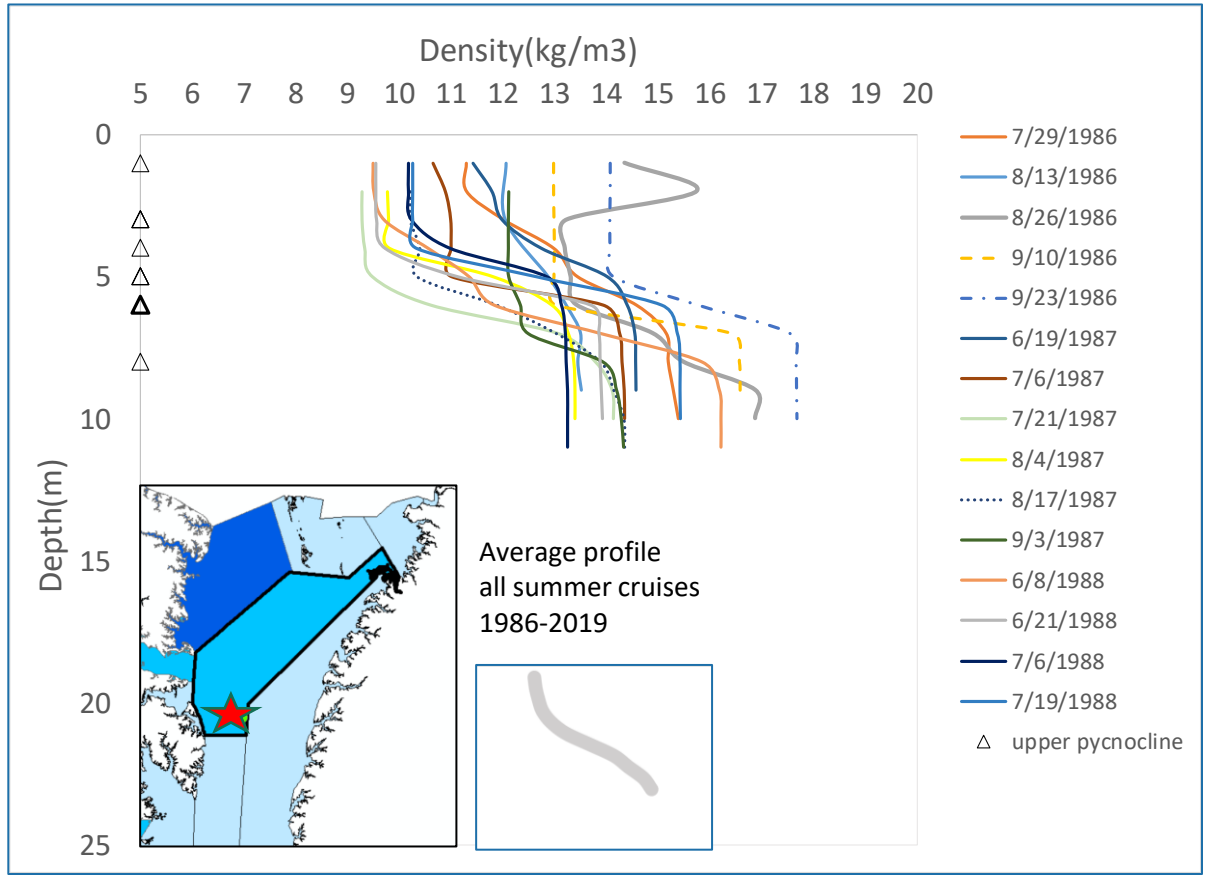

## CB7.2 (Open Water)



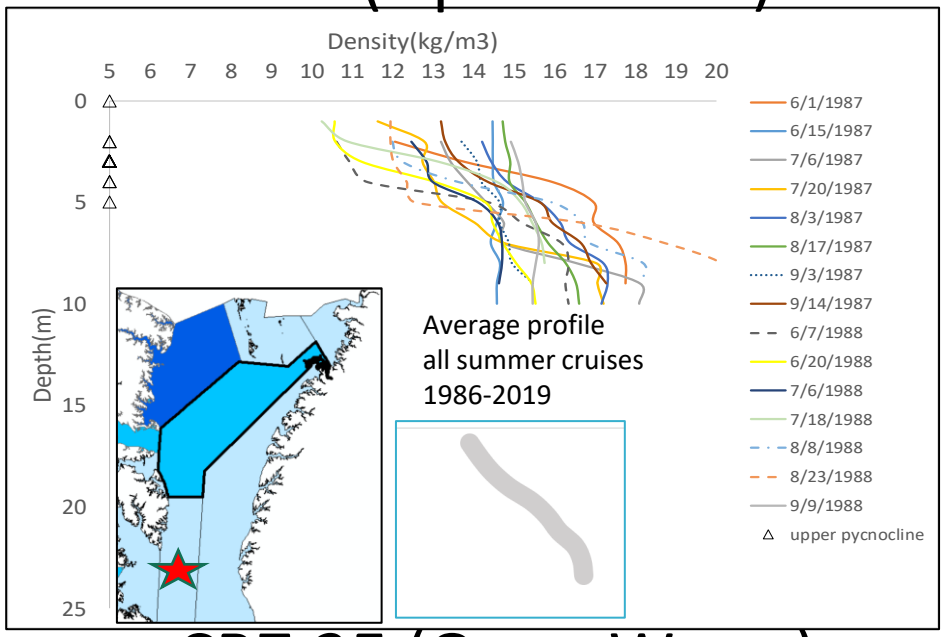

DEQ

# Stratification

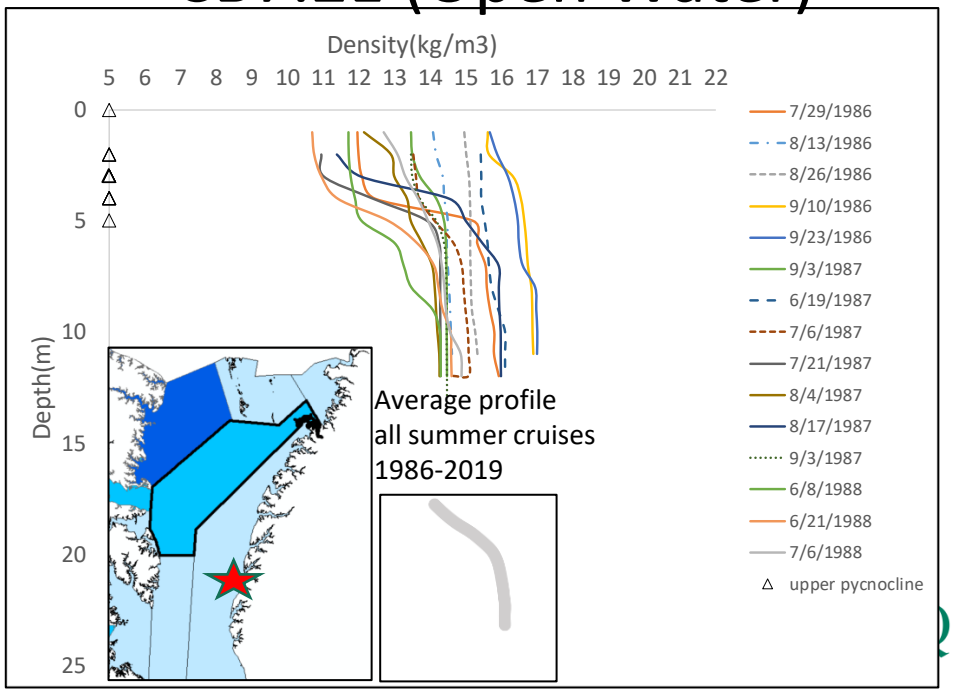
## CB6.2 (Deep Water)




## CB6.4 (Open Water)

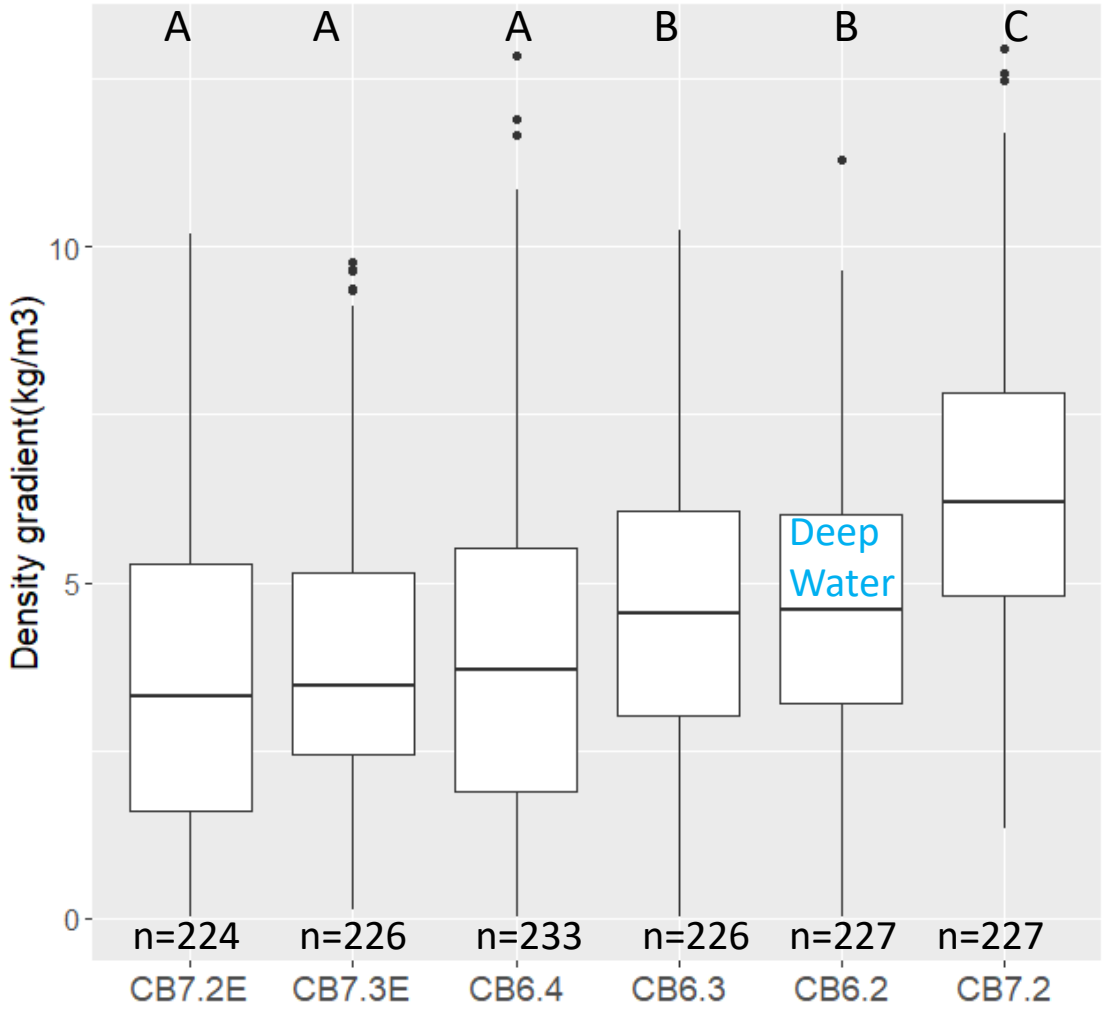


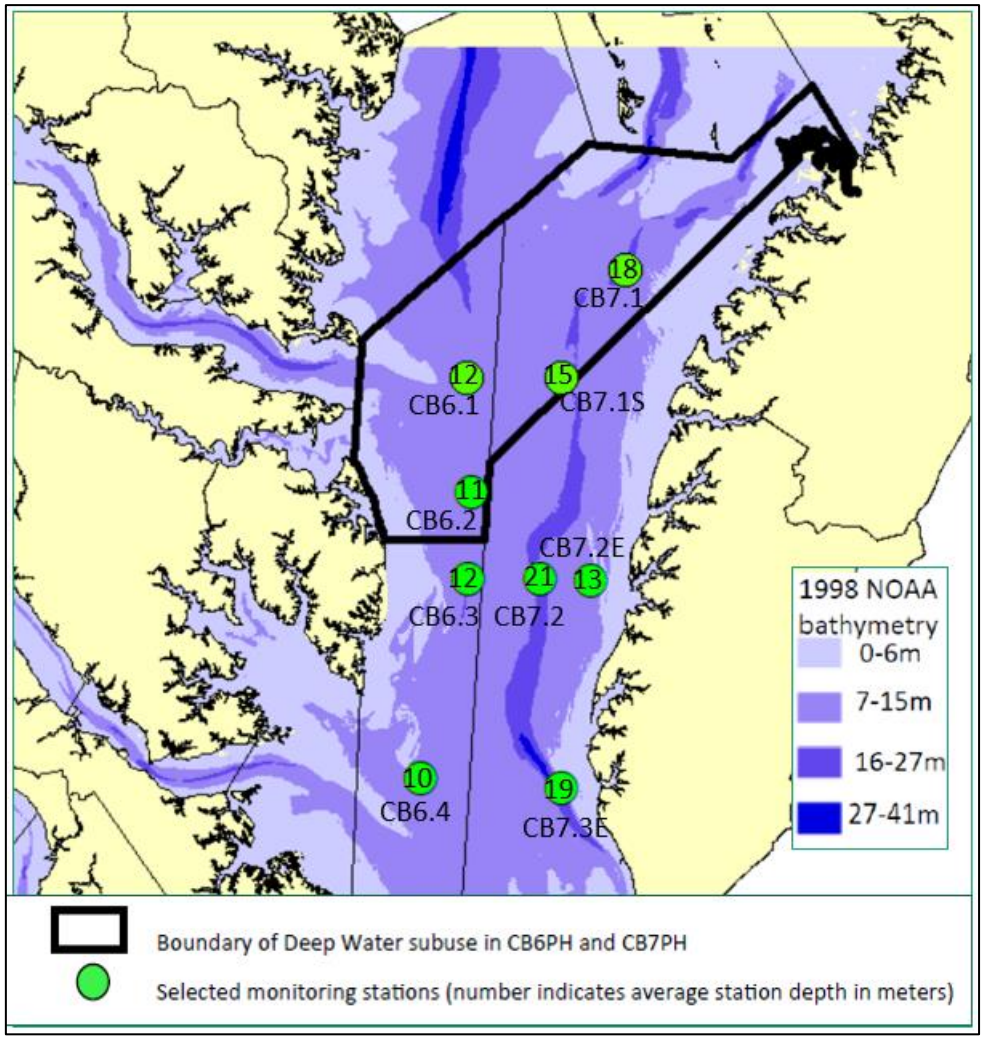

## CB7.2E (Open Water)



# Stratification

Boxplots of density gradients observed at selected mainstem stations from 1986 to 2019. Letters represent statistically similar groups (Conover's post-hoc test with Hochberg adjustment). n = no. of vertical profiles analyzed.

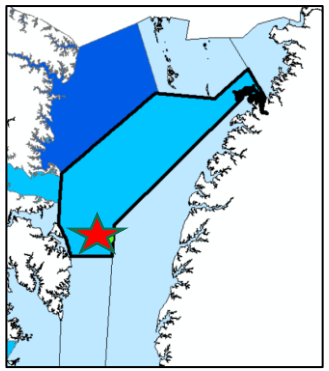


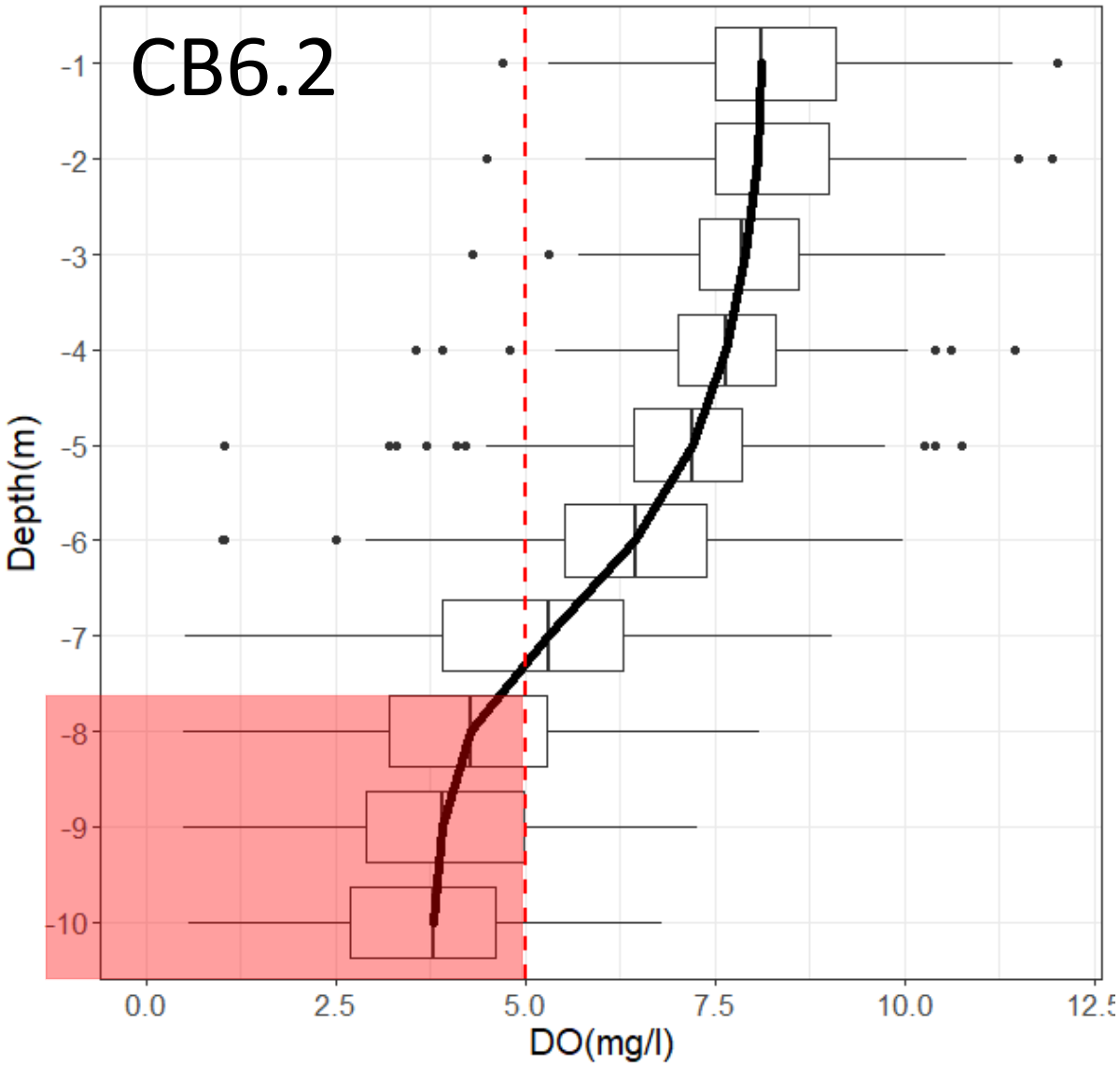




DEQ

# Hypoxia

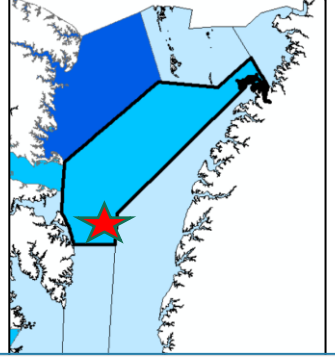
# Composite DO vertical profile based on summer monitoring events 1986-2019 (n=227)





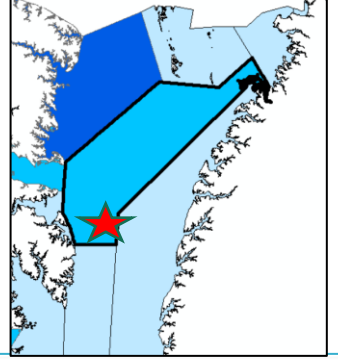

= Open Water 30-Day Mean Criterion

# CB6.2



Stratified water column almost all the time in the summer.

CB6.2



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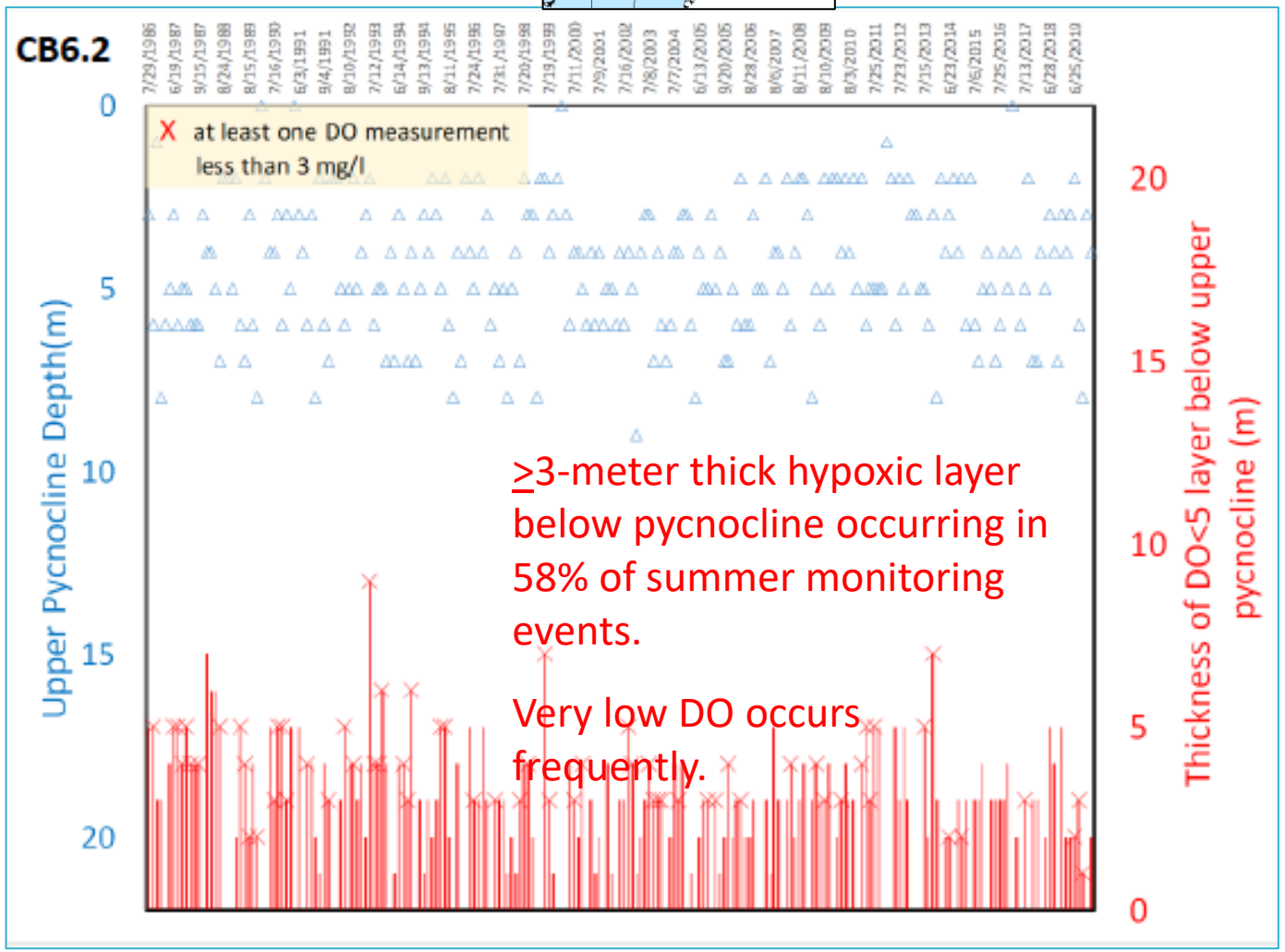
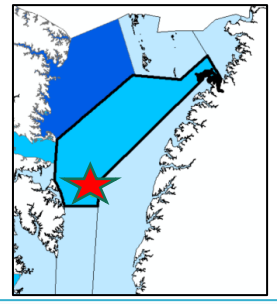
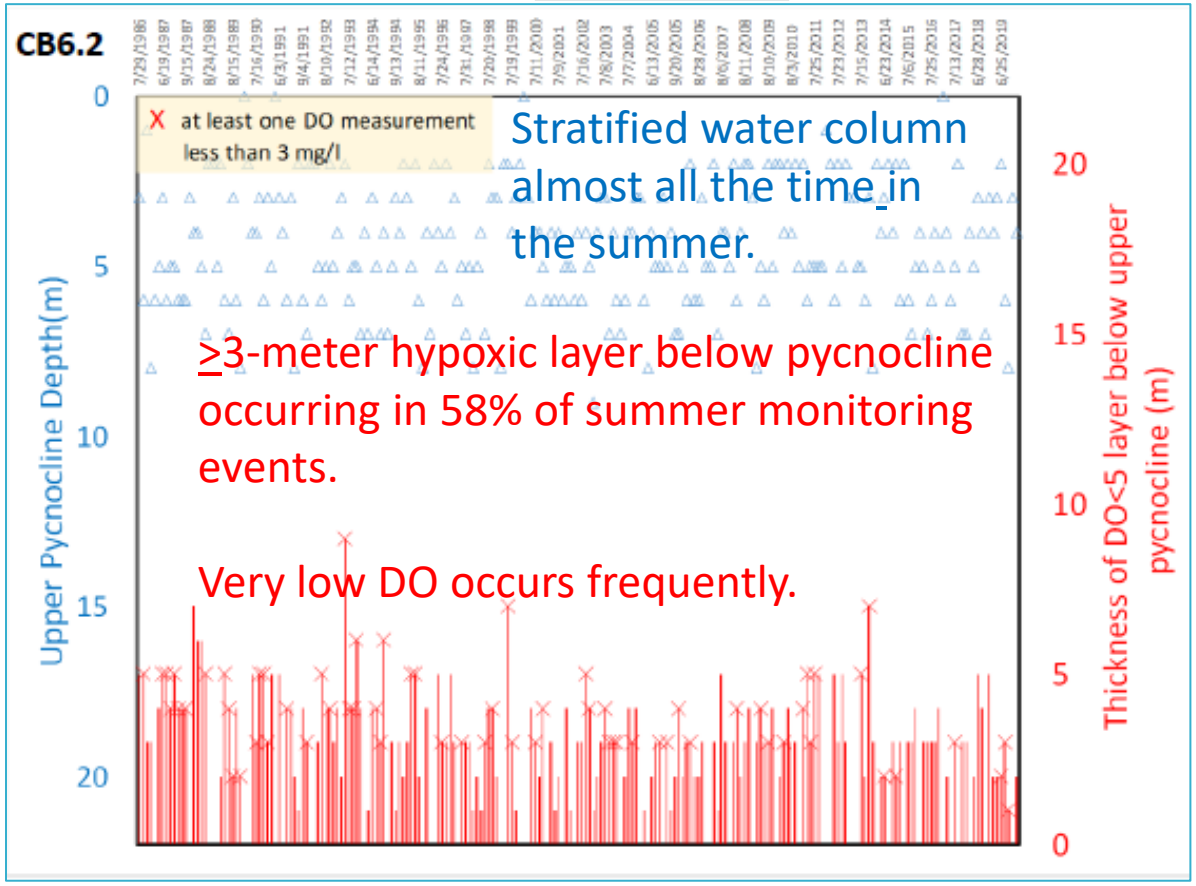


## CB6.2



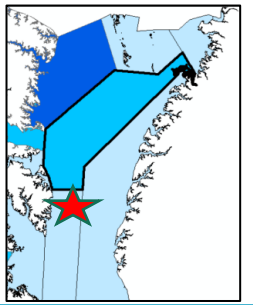


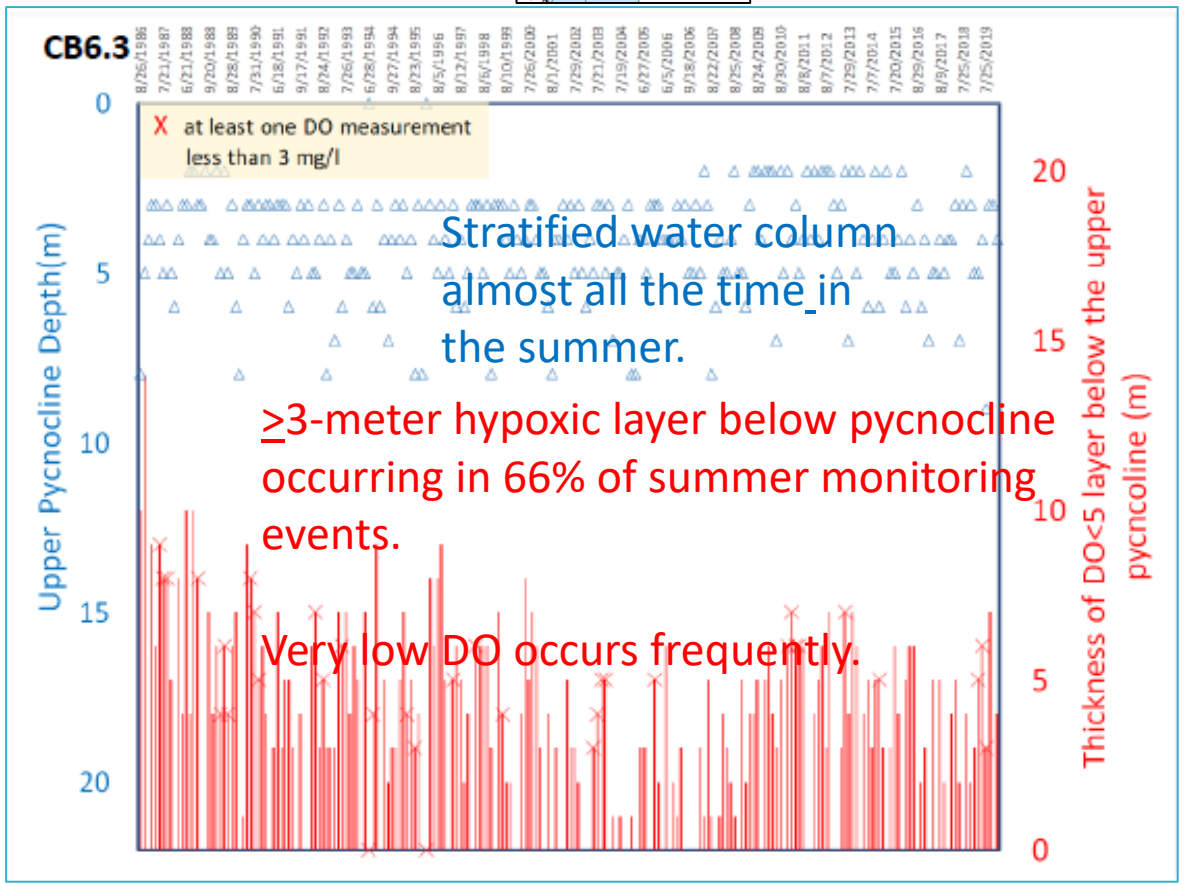

Stratified water column almost all the time in the summer.

≥3-meter hypoxic layer below pycnocline occurring in 58% of summer monitoring events.

Very low DO occurs frequently.

## CB6.3






Stratified water column almost all the time in the summer.

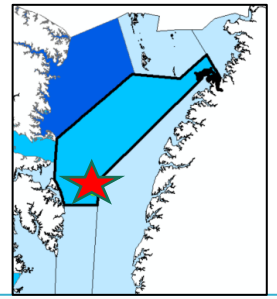
≥3-meter hypoxic layer below pycnocline occurring in 66% of summer monitoring events.

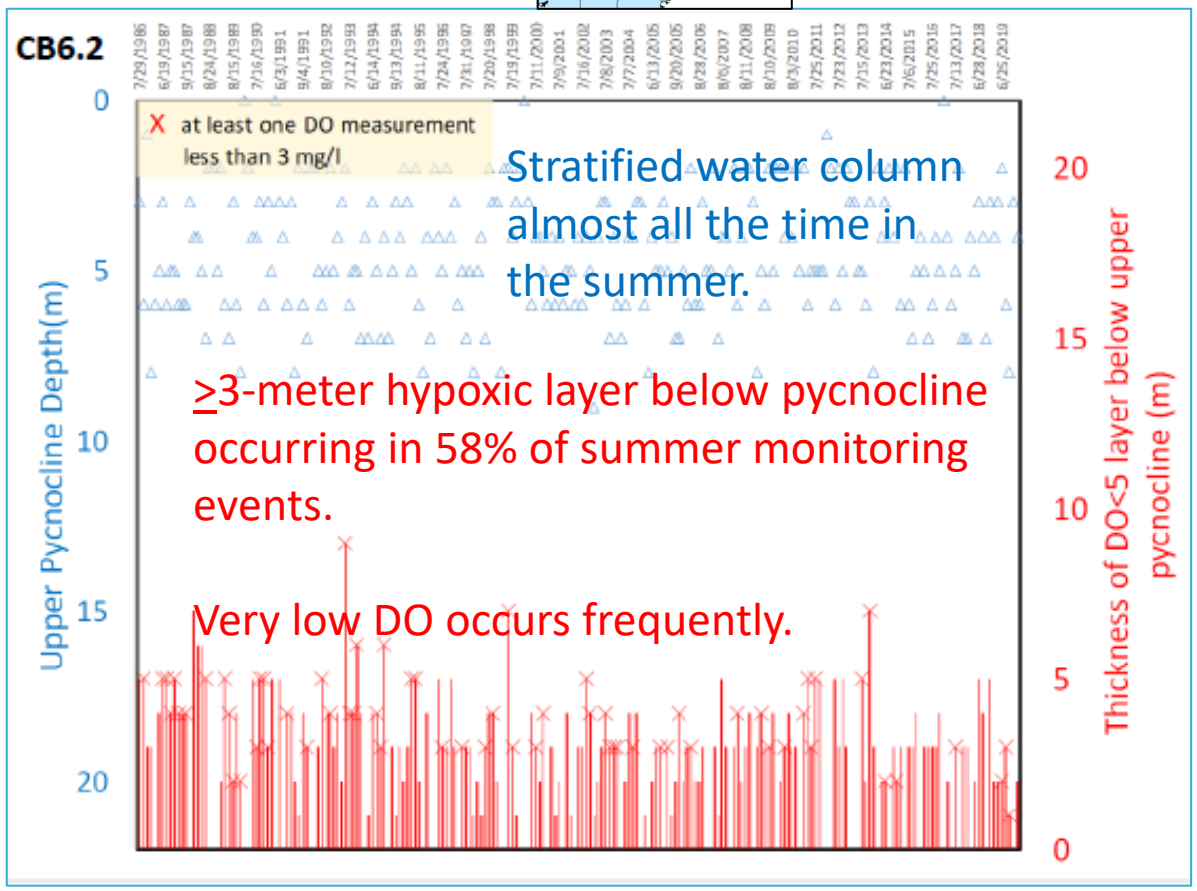
Very low DO occurs frequently.



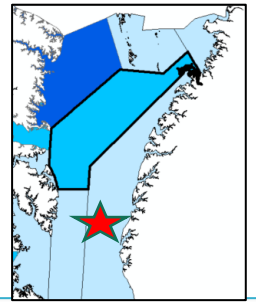
DEQ

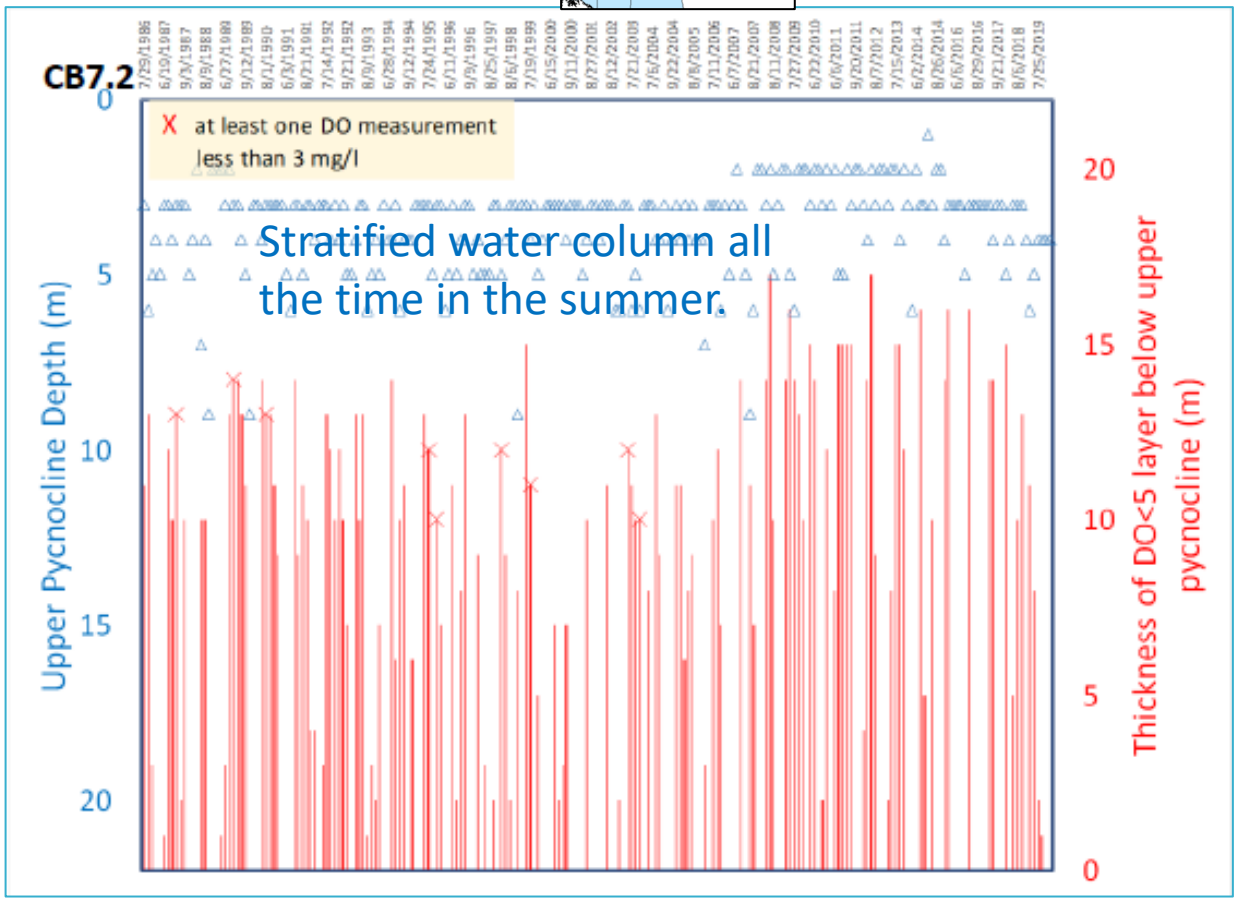
## CB6.2






## CB7.2



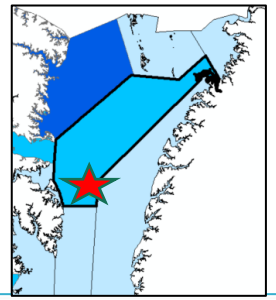


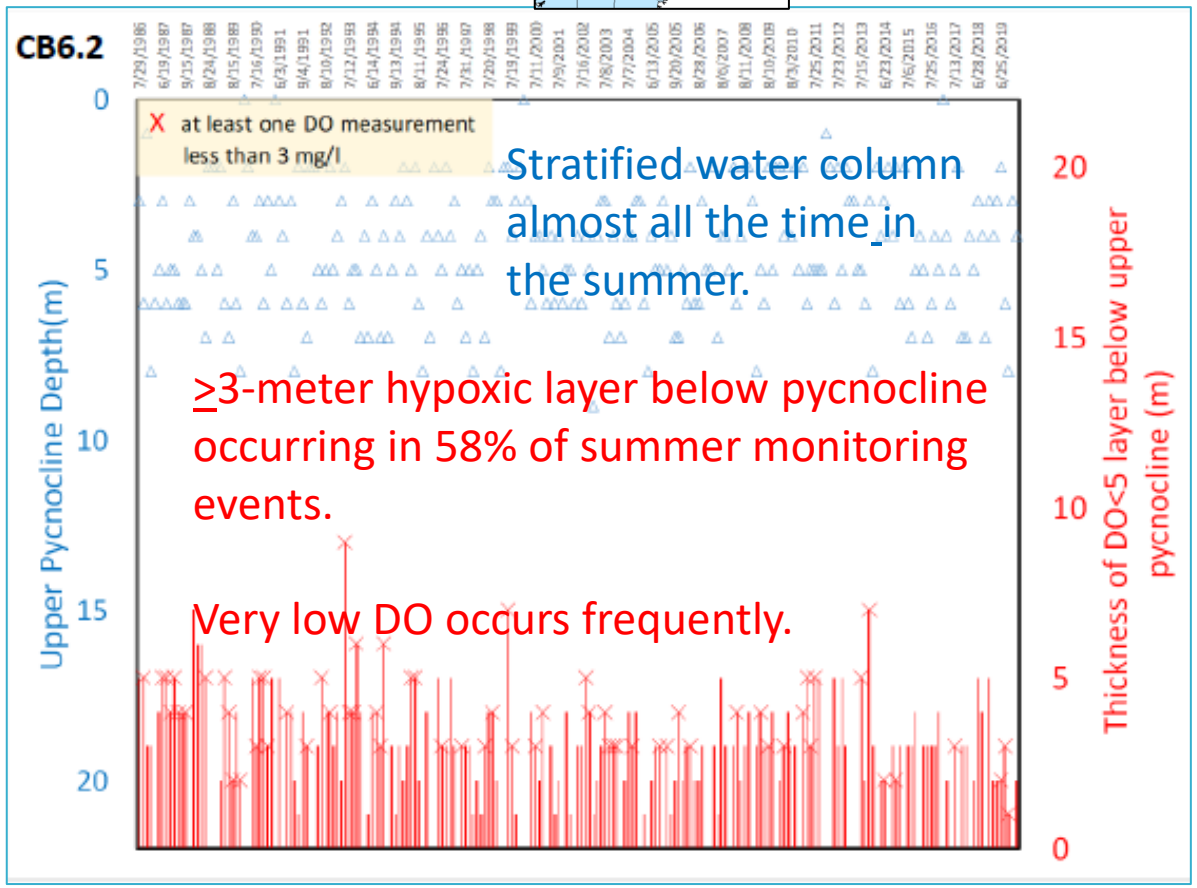

≥3-meter hypoxic layer below pycnocline occurring in 53% of summer monitoring events.

Very low DO occurs sometimes (but not recently!)

DEQ

## CB6.2



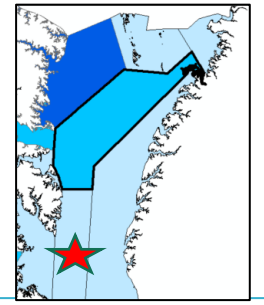


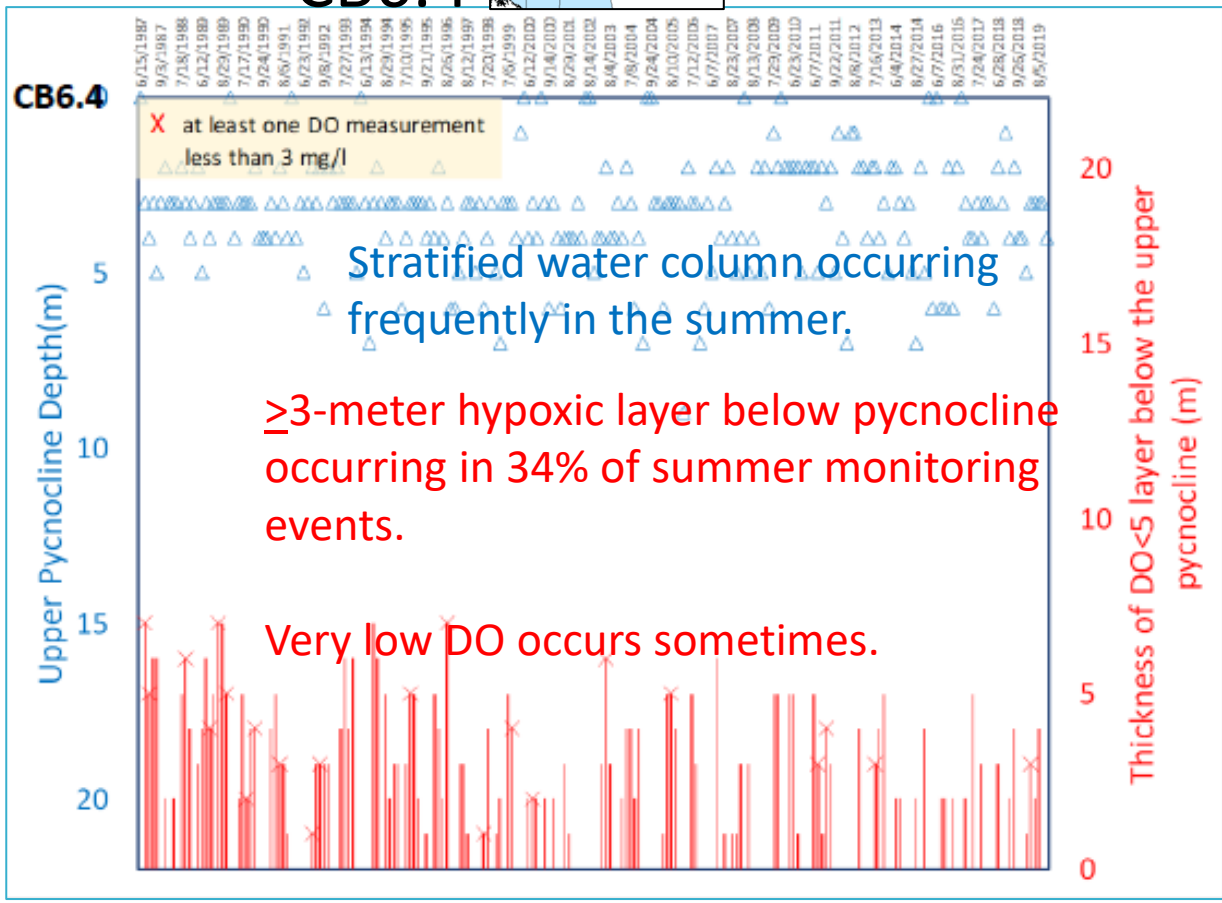

Stratified water column almost all the time in the summer.

≥3-meter hypoxic layer below pycnocline occurring in 58% of summer monitoring events.

Very low DO occurs frequently.

## CB6.4






Stratified water column occurring frequently in the summer.

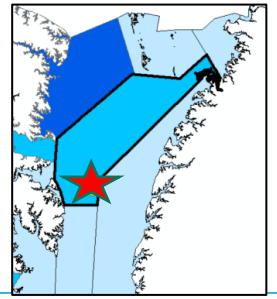
≥3-meter hypoxic layer below pycnocline occurring in 34% of summer monitoring events.

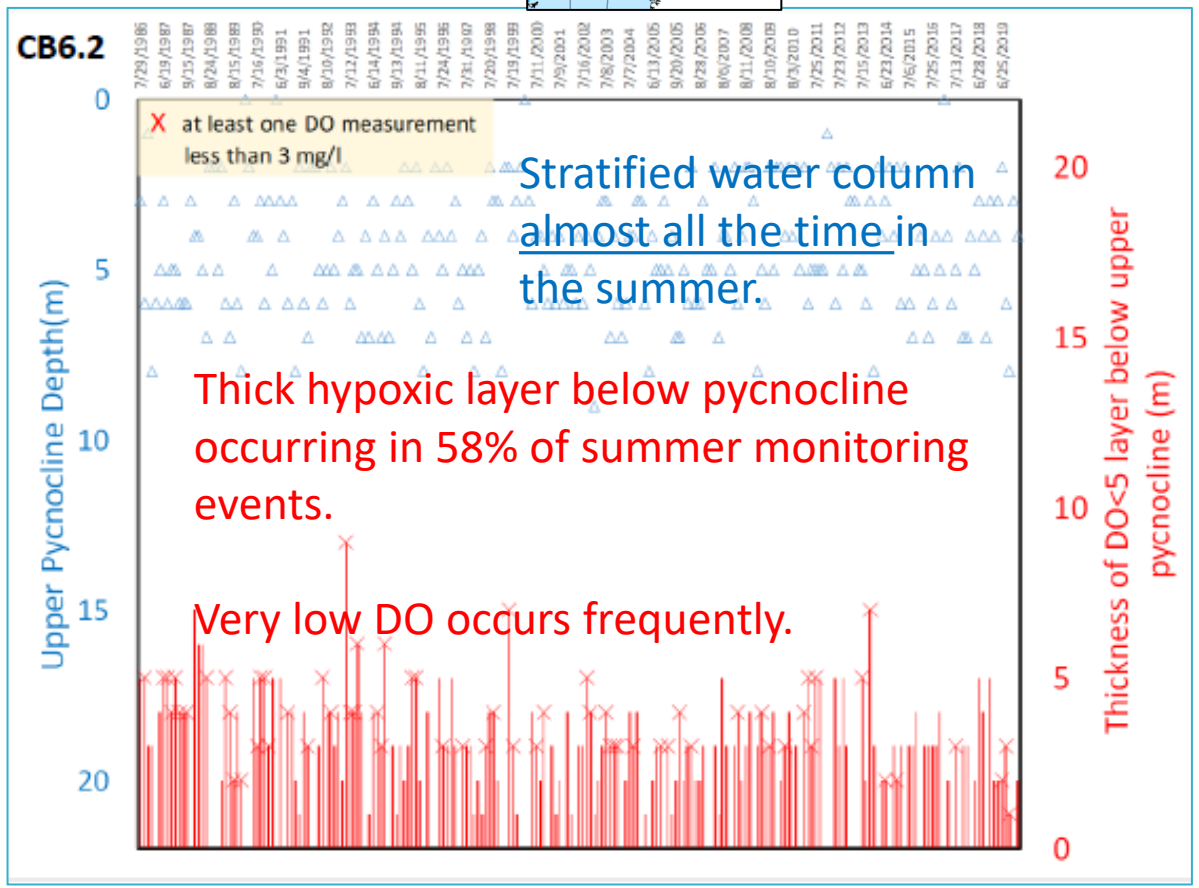
Very low DO occurs sometimes.



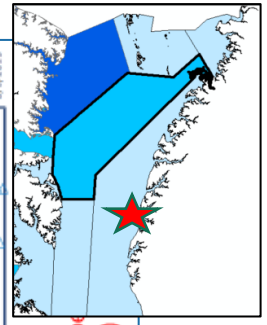
DEQ

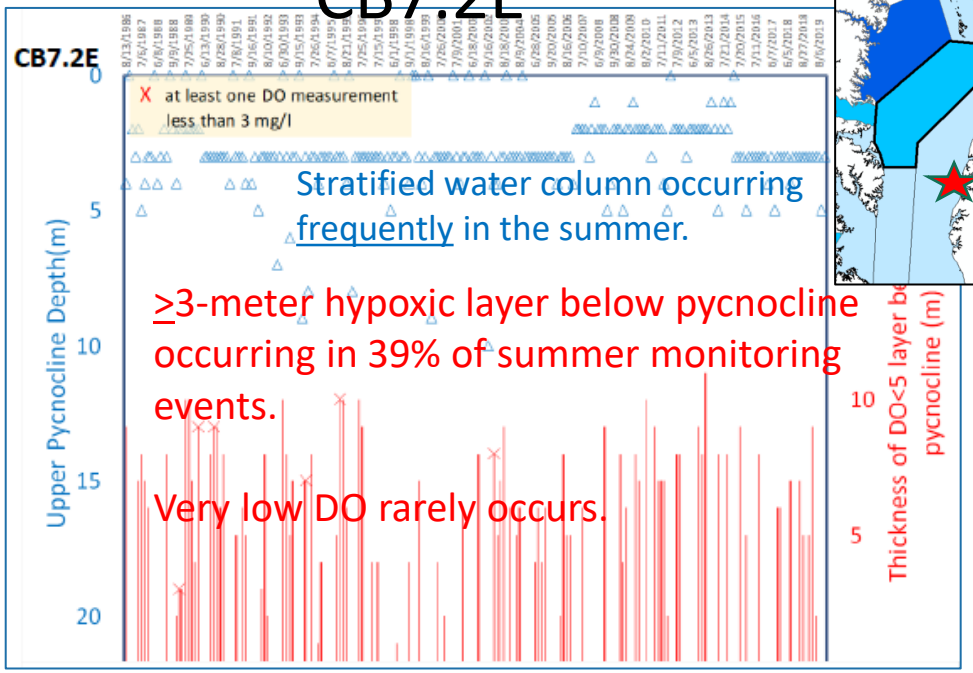
## CB6.2



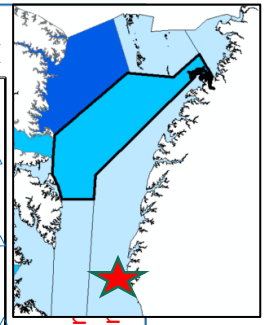



## CB7.2E






## CB7.3E



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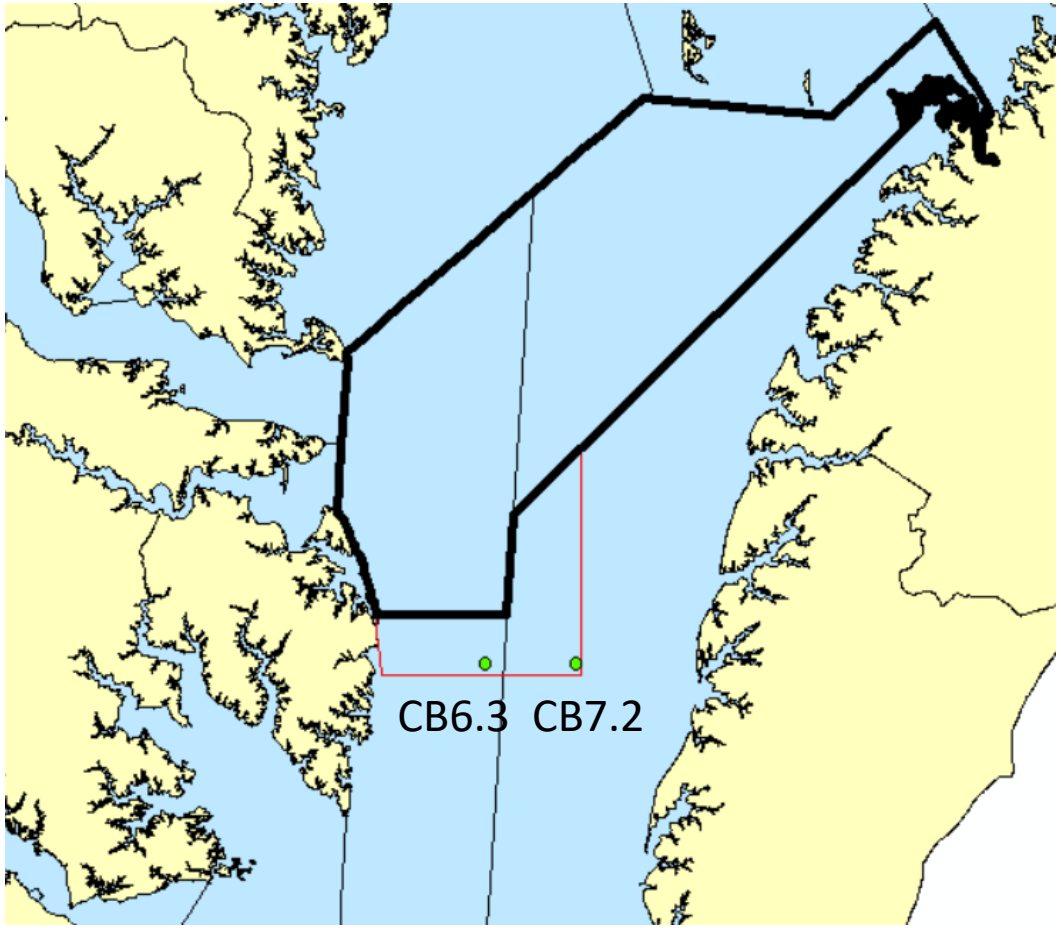
# Conclusion



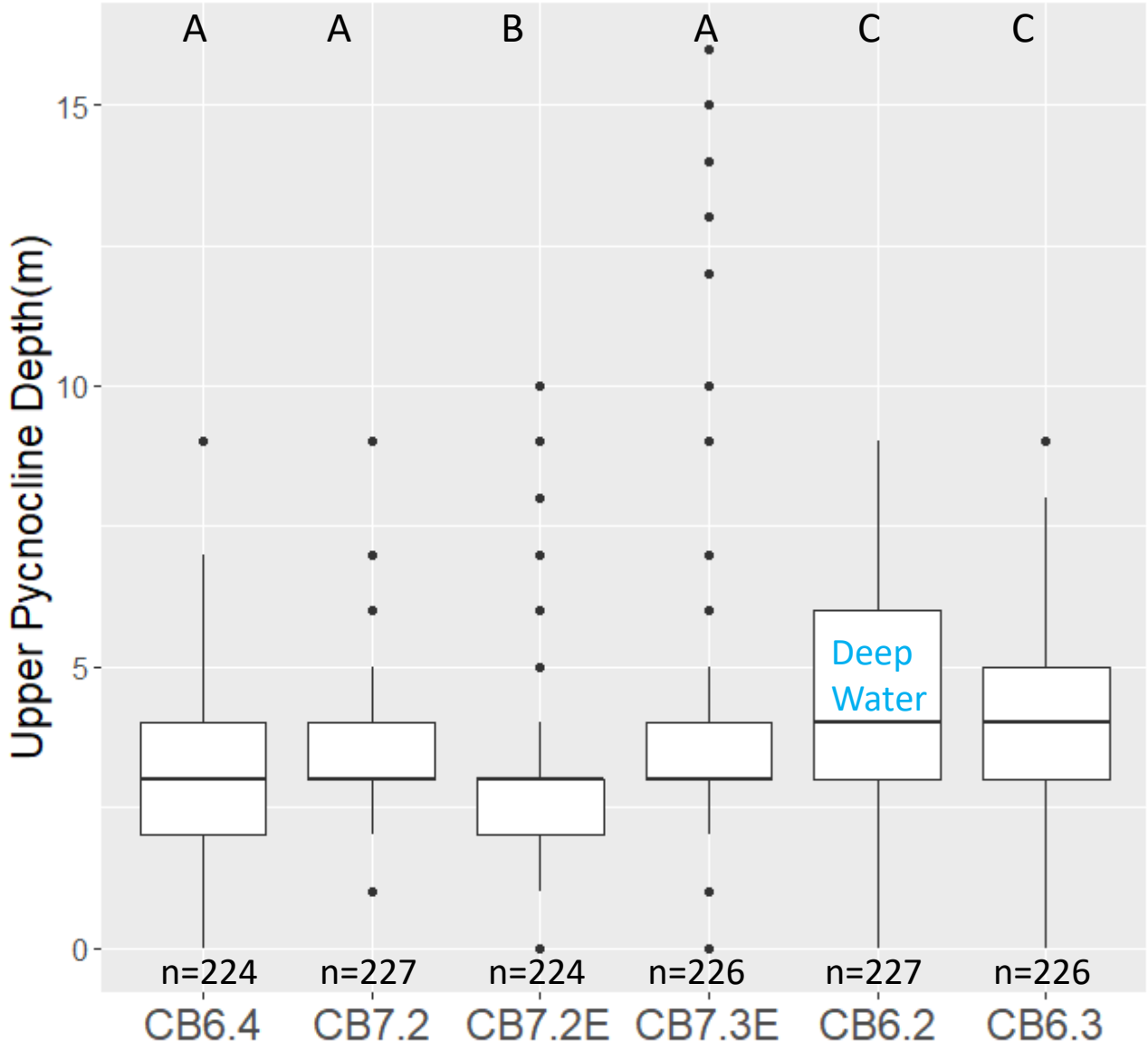

- There is empirical evidence supporting the extension of the Deep Water boundary to include stations CB6.3 and CB7.2. These locations are similar to Deep Water station CB6.2 in terms of bathymetry, stratification, and hypoxia.
- The evidence for Deep Water habitat at CB6.4 and CB7.2E is not as strong.
- Modeling is needed to test the attainability of the Open Water use given the proposed Deep Water boundary.



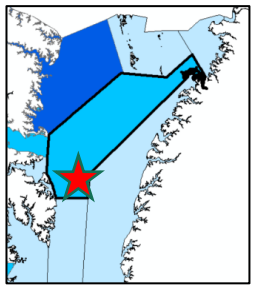
DEQ

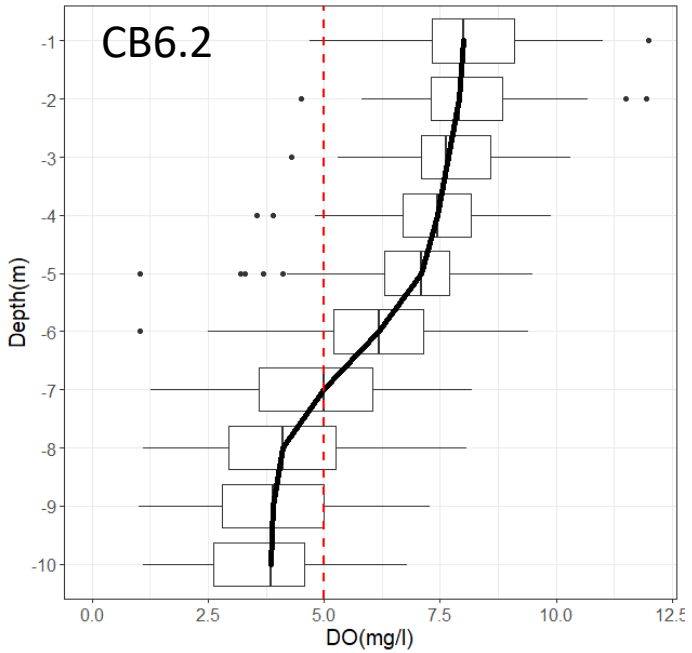
# Questions?

Boxplots of summer density gradients observed at selected mainstem stations from 1986 to 2019. Letters represent statistically similar groups (Conover's post-hoc test with Hochberg adjustment). n = no. of vertical profiles analyzed.



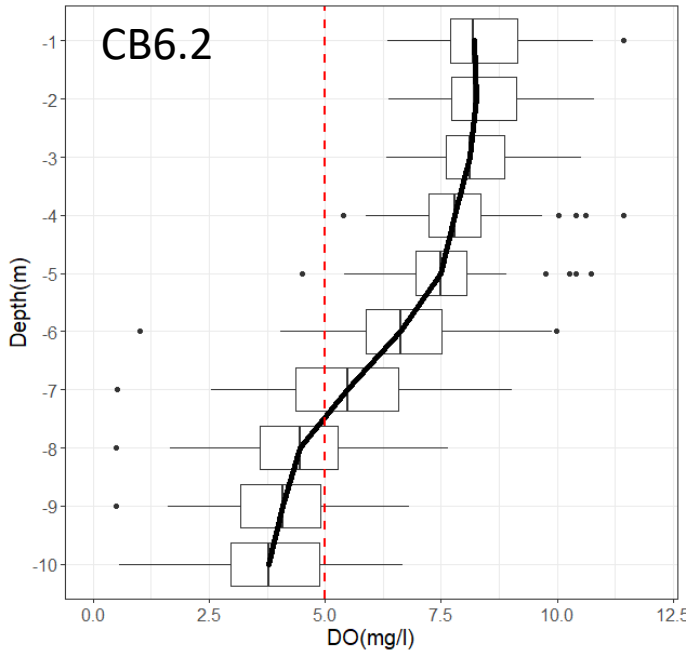

DEQ

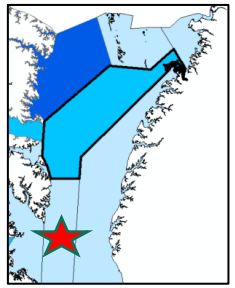


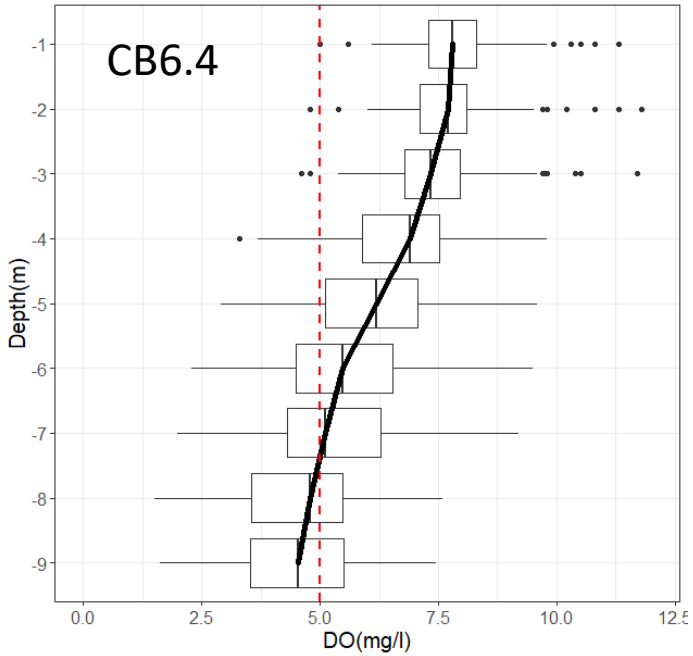



Δ

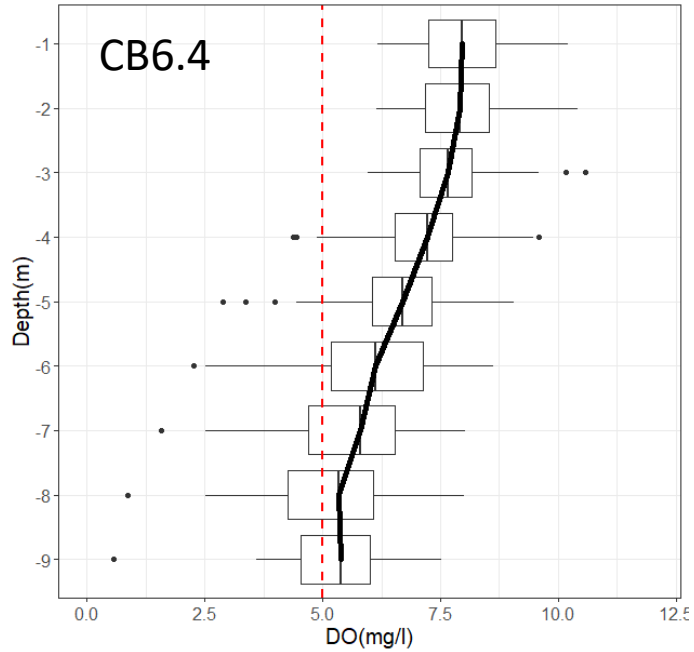
0.2
0.4
0.5
0.3
0.4
0.4
0.5
0.4
0.2
-0.1



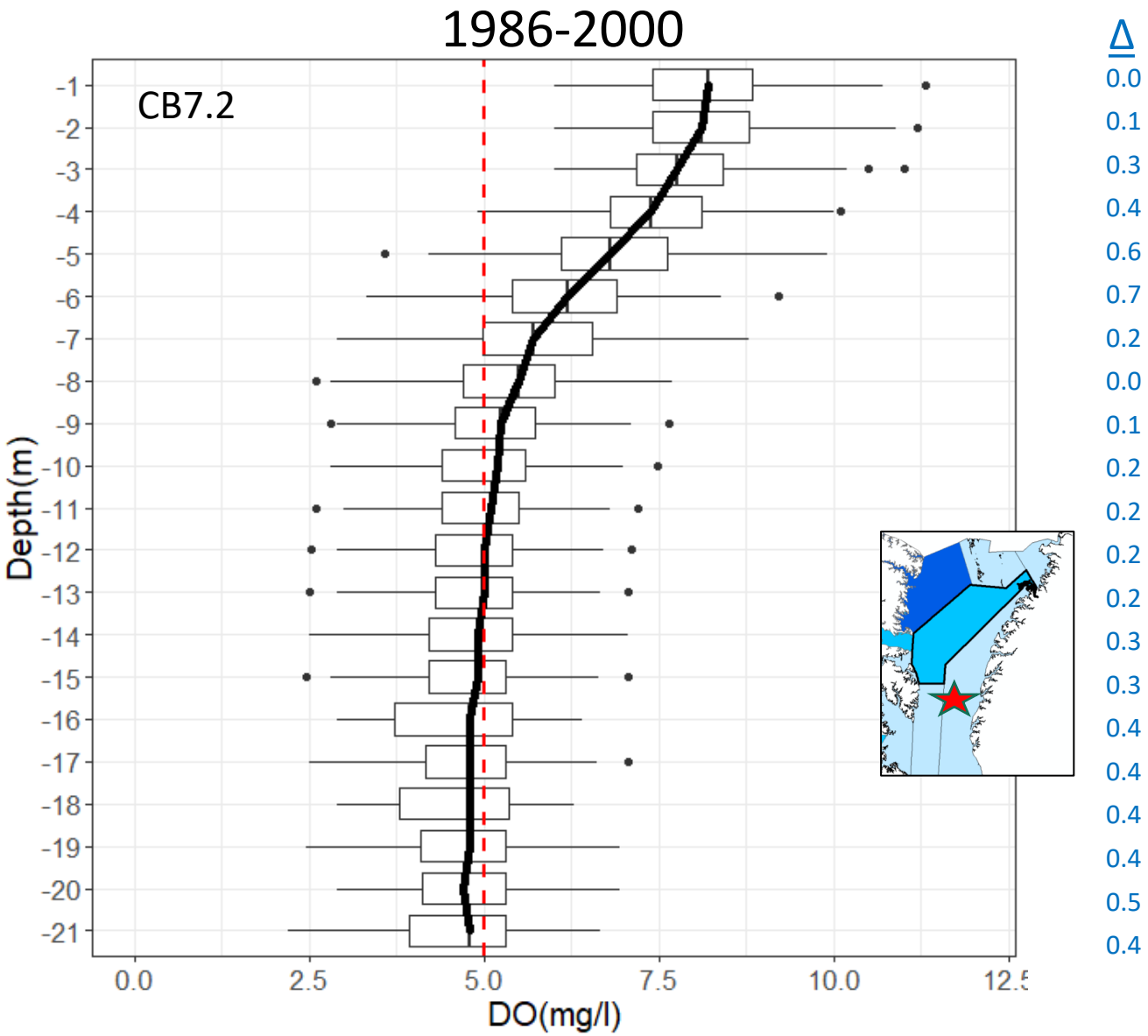



0.2
0.2
0.3
0.3
0.5
0.6
0.7
0.6
0.8



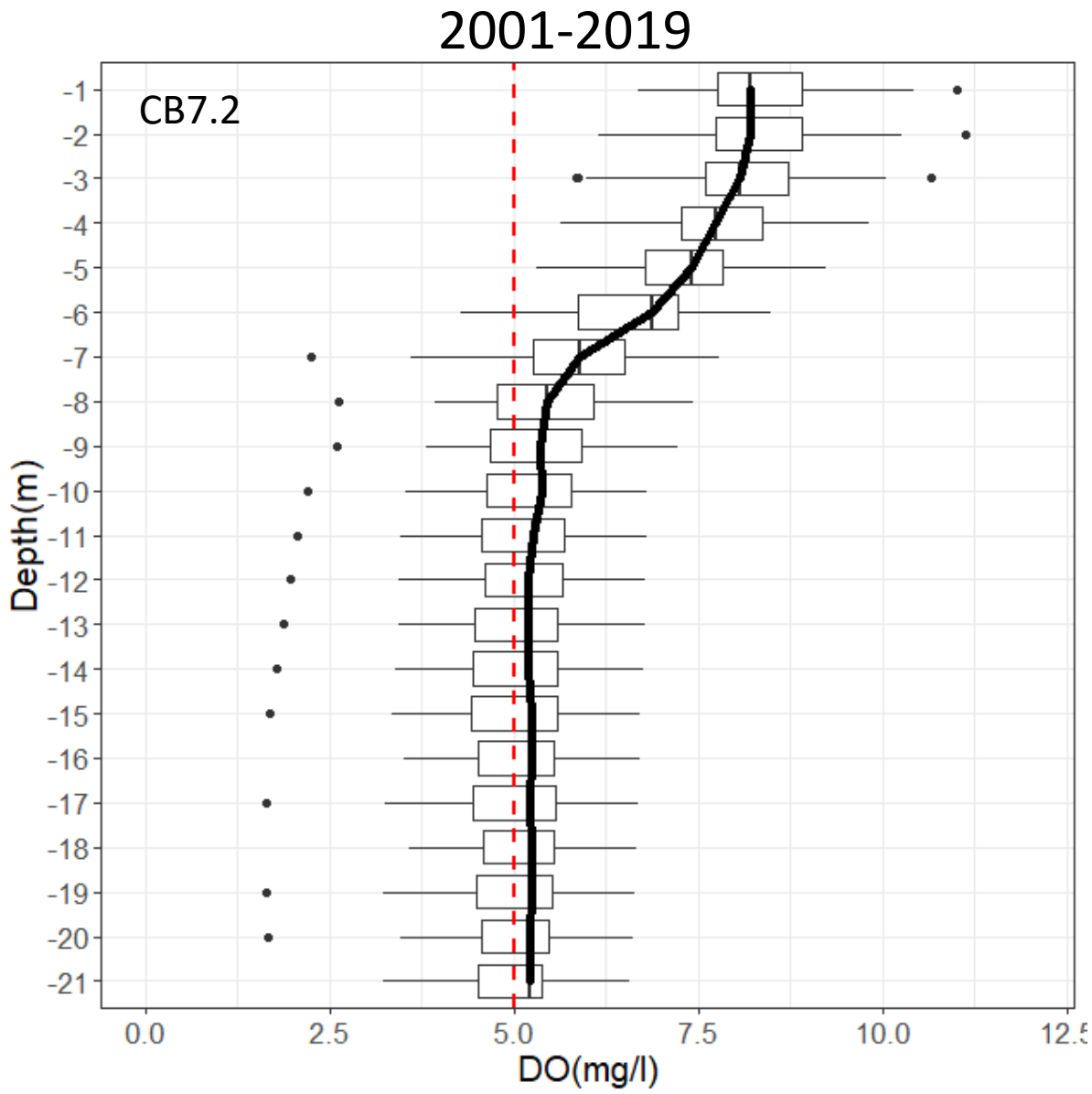



DEQ


1986-2000
CB7.2
Depth(m)
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
-18
-19
-20
-21
0.0
2.5
5.0
7.5
10.0
12.5
DO(mg/l)




Δ
0.0
0.1
0.3
0.4
0.6
0.7
0.2
0.0
0.1
0.2
0.2
0.2
0.2
0.3
0.3
0.4
0.4
0.4
0.4
0.4
0.5
0.4


2001-2019
CB7.2
Depth(m)
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
-18
-19
-20
-21
0.0
2.5
5.0
7.5
10.0
12.5
DO(mg/l)



DEQ