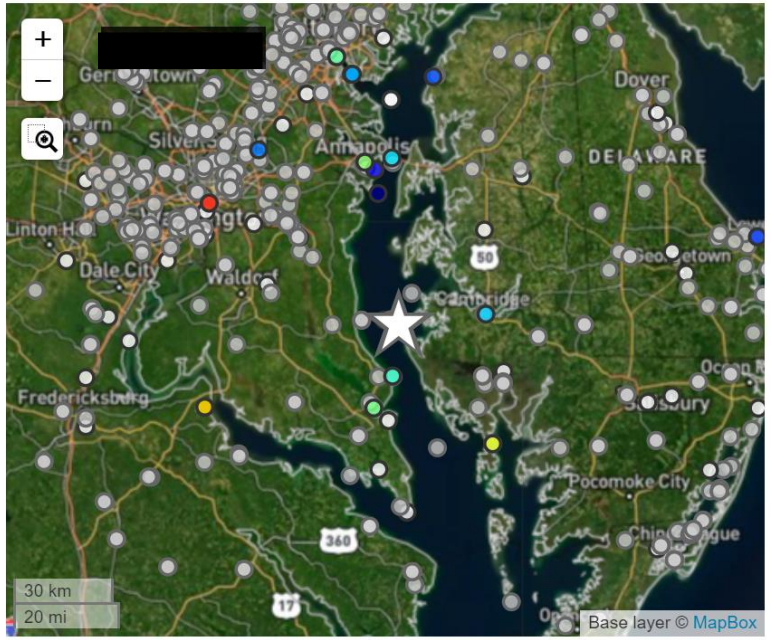
NOAA Chesapeake Bay Interpretive Buoy System

East Gooses (2022)



Location	38.5570,-76.3920
Temporal Coverage	May 16, 2022 12:00 (EDT) - Aug 31, 2022 22:50 (EDT)
Platform	Profiling Buoy
Web site	https://buoybay.noaa.gov
Metadata	ERDDAP station page
URN	east-gooses

Data collected by NOAA, stored at:
https://sensors.ioos.us/#metadata/114122/station/data

Some preliminary profiler data analysis: East Gooses 2022

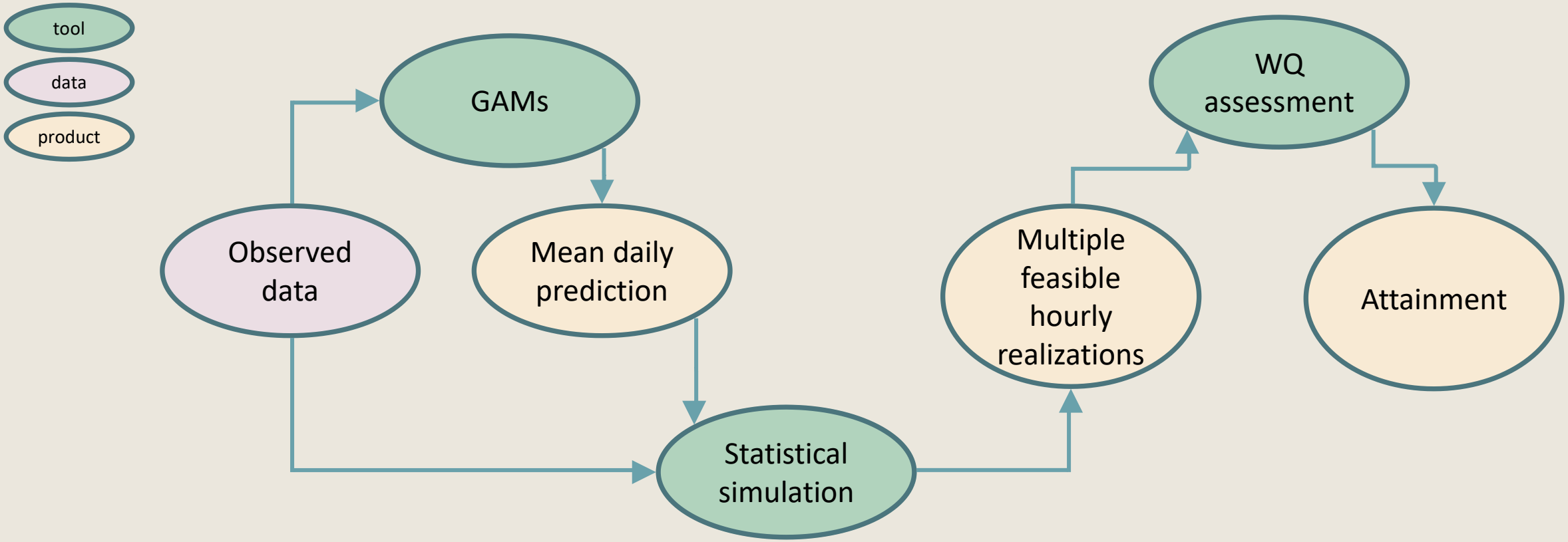
Rebecca Murphy, UMCES at CBP

Hypoxia Collaborative
June 15, 2023

Some immediate uses of the profiler data

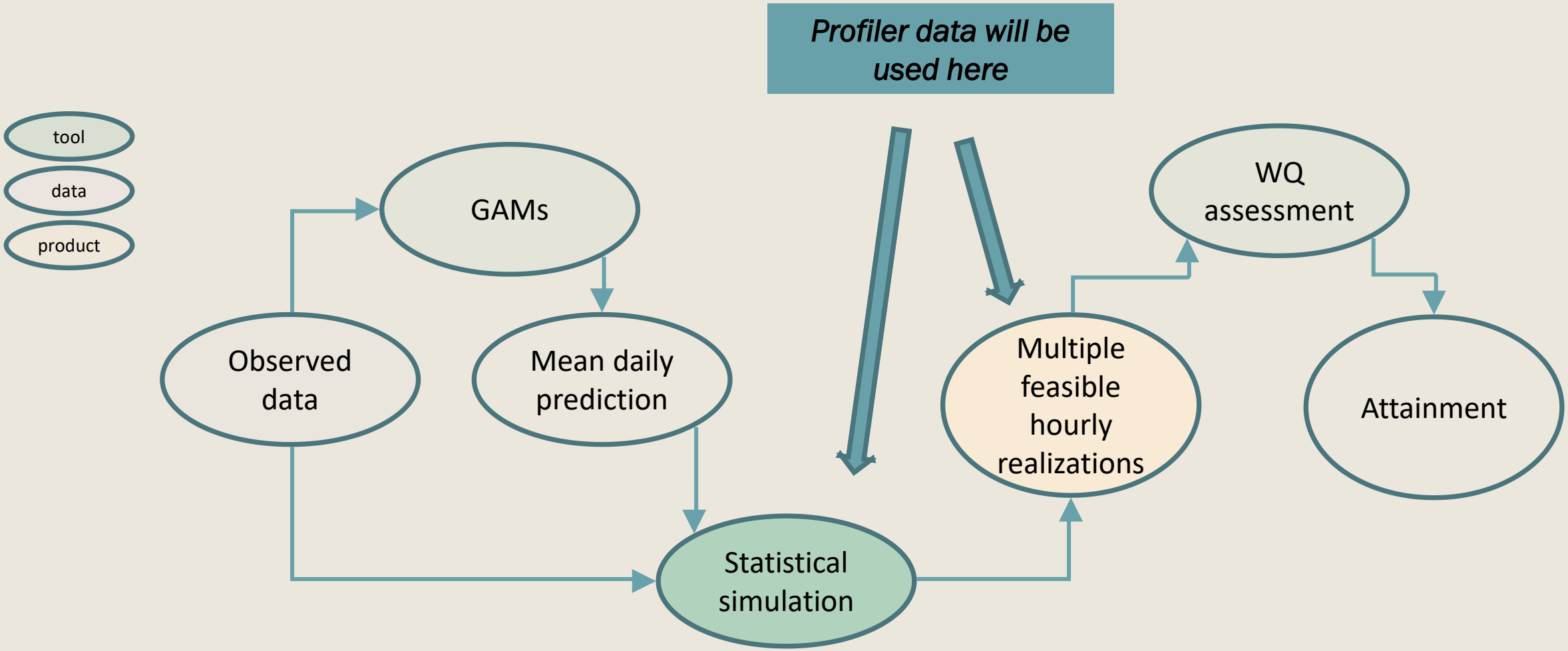
- **4D-interpolator** development and implementation
  - *The goal of the 4d tool is to get a full tidal spatial-and-temporal interpolation of observed DO in the tidal waters for use in criteria assessment.*
  - *Right now, the profiler data will be useful to help us learn about patterns and relationships in short-term DO variability in deeper waters that we will use to build the tool.*
- **Criteria assessment**
  - *The data can be used to help us learn about short-term variability and inform the decision process for how to assess the instantaneous, 1-day, and 7-day mean criteria.*

4D interpolator: plan



From Gary Shenk

4D interpolator: plan

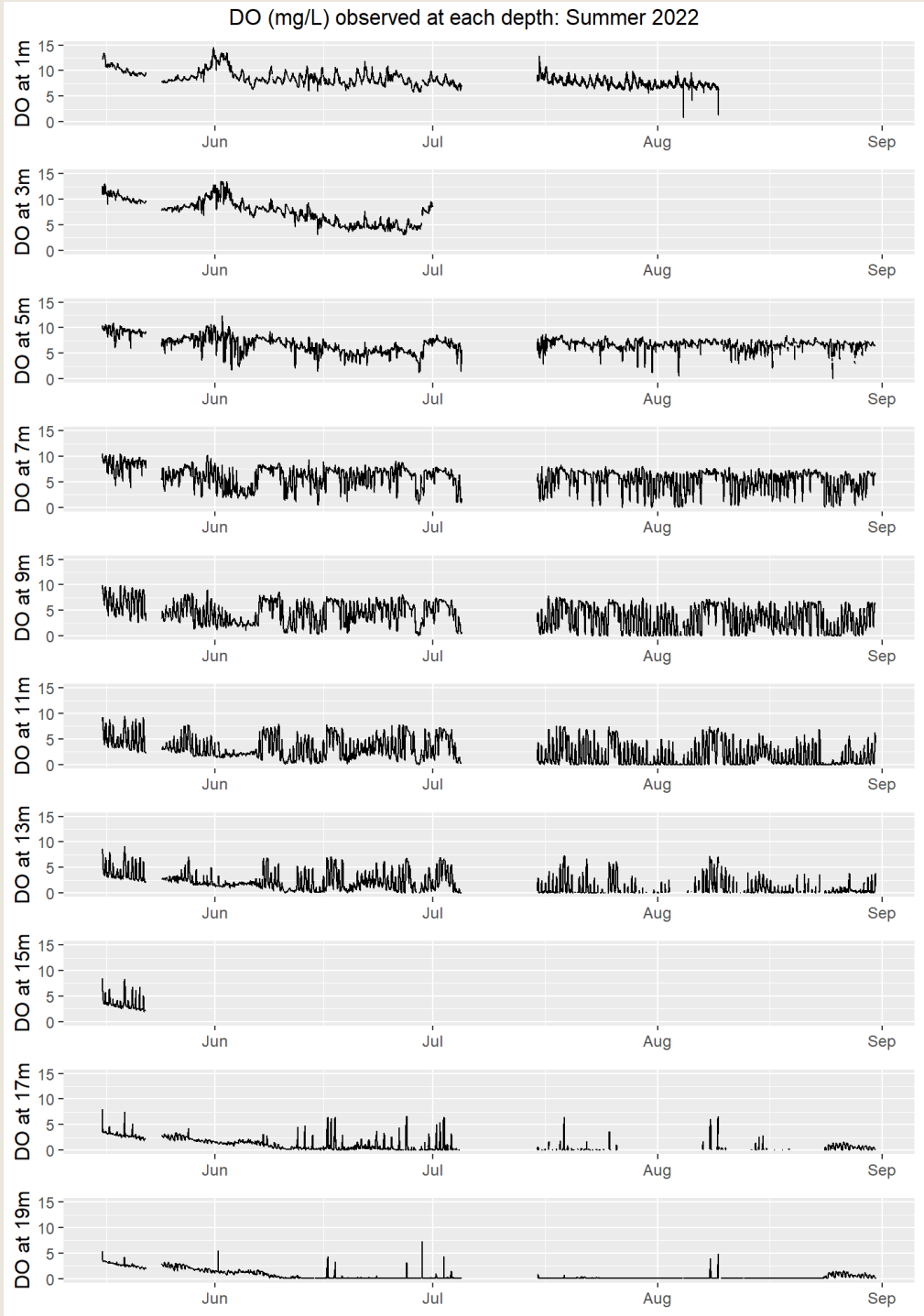


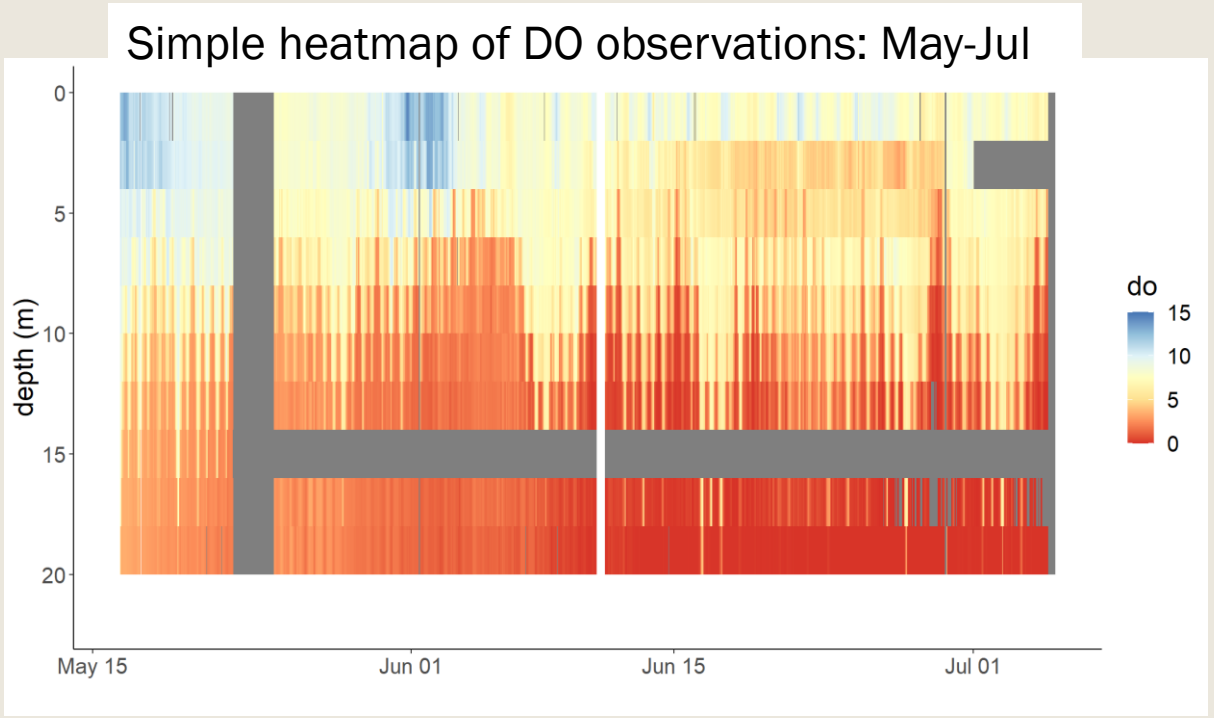
East Gooses 2022 data

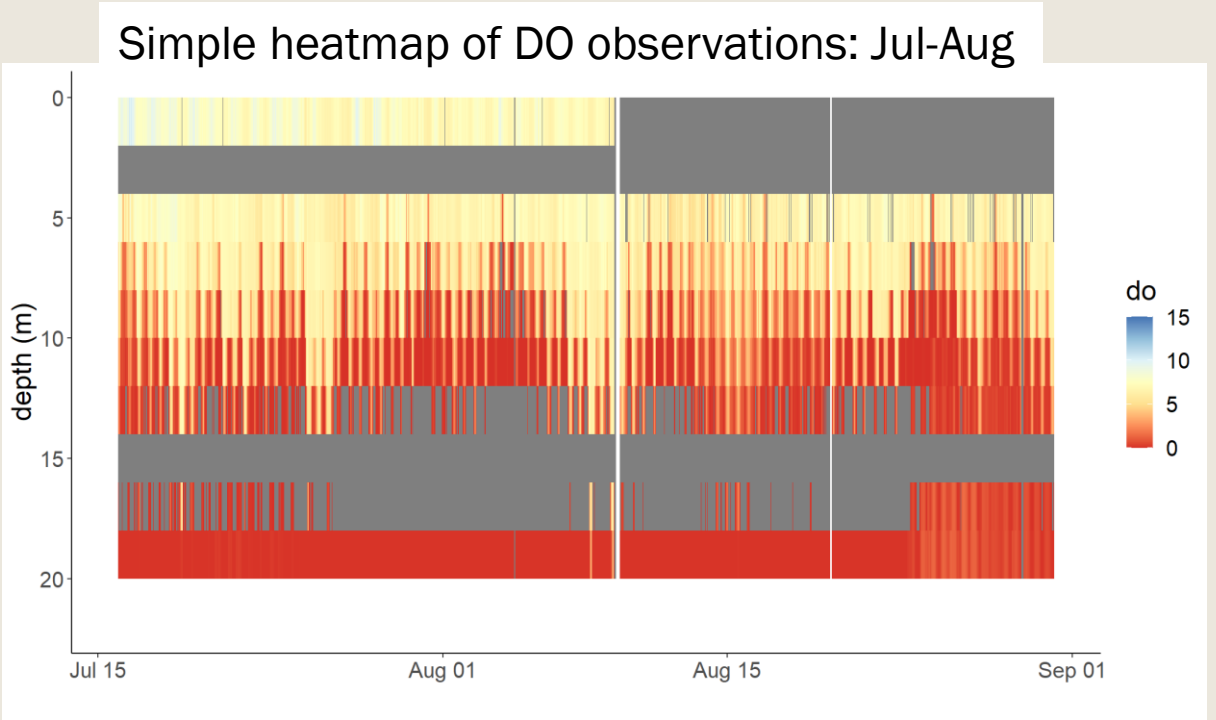
- Took a look at the data, mostly with criteria assessment questions in mind
- Still would like to do this same analysis and some combined examination of the West Gooses 2022 as well
- 10 minute samples, 10 depths
- Using the preliminary data received from Jay Lazar

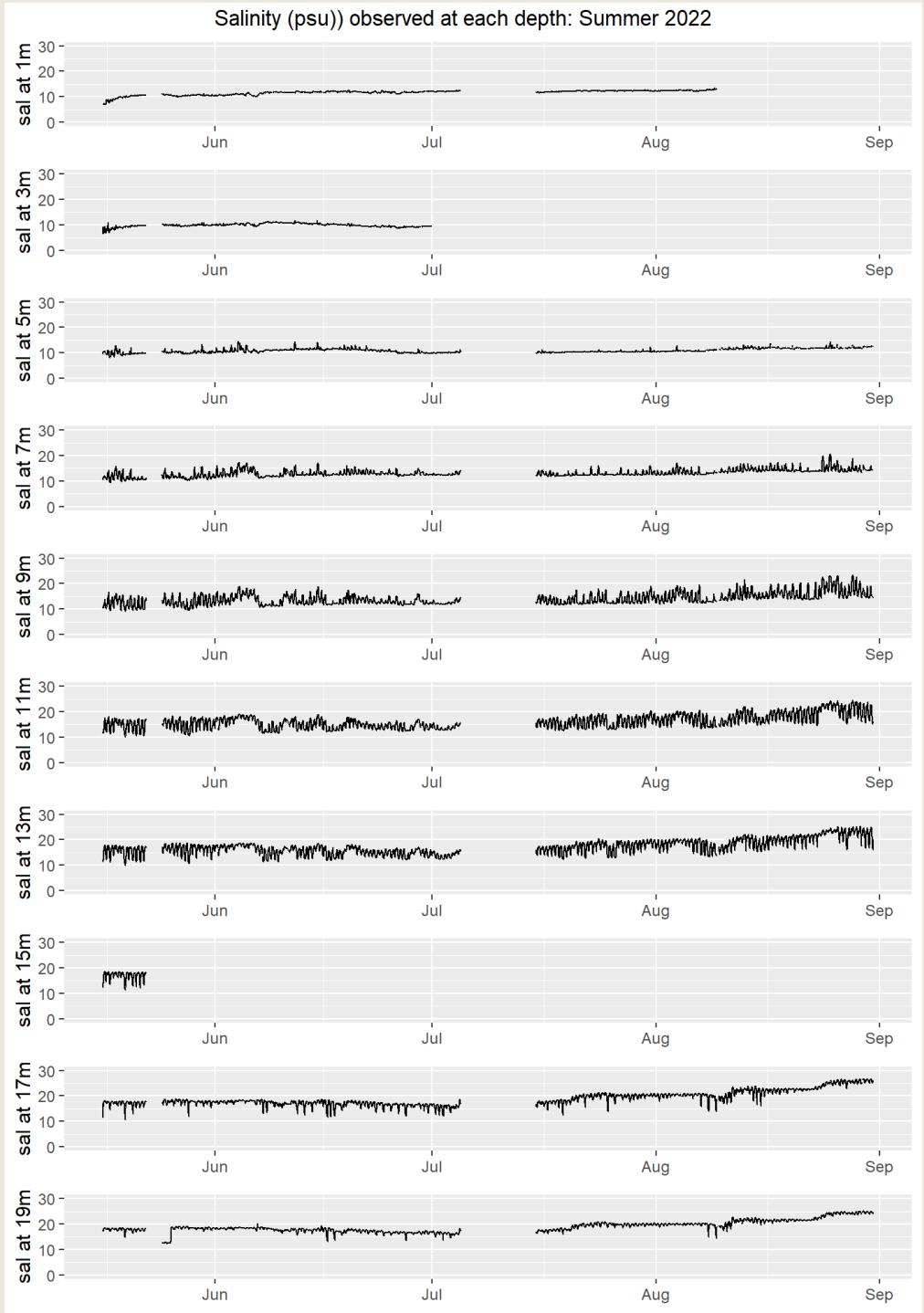
DO counts by depth, East Gooses profiler May 16-Aug 31, 2022

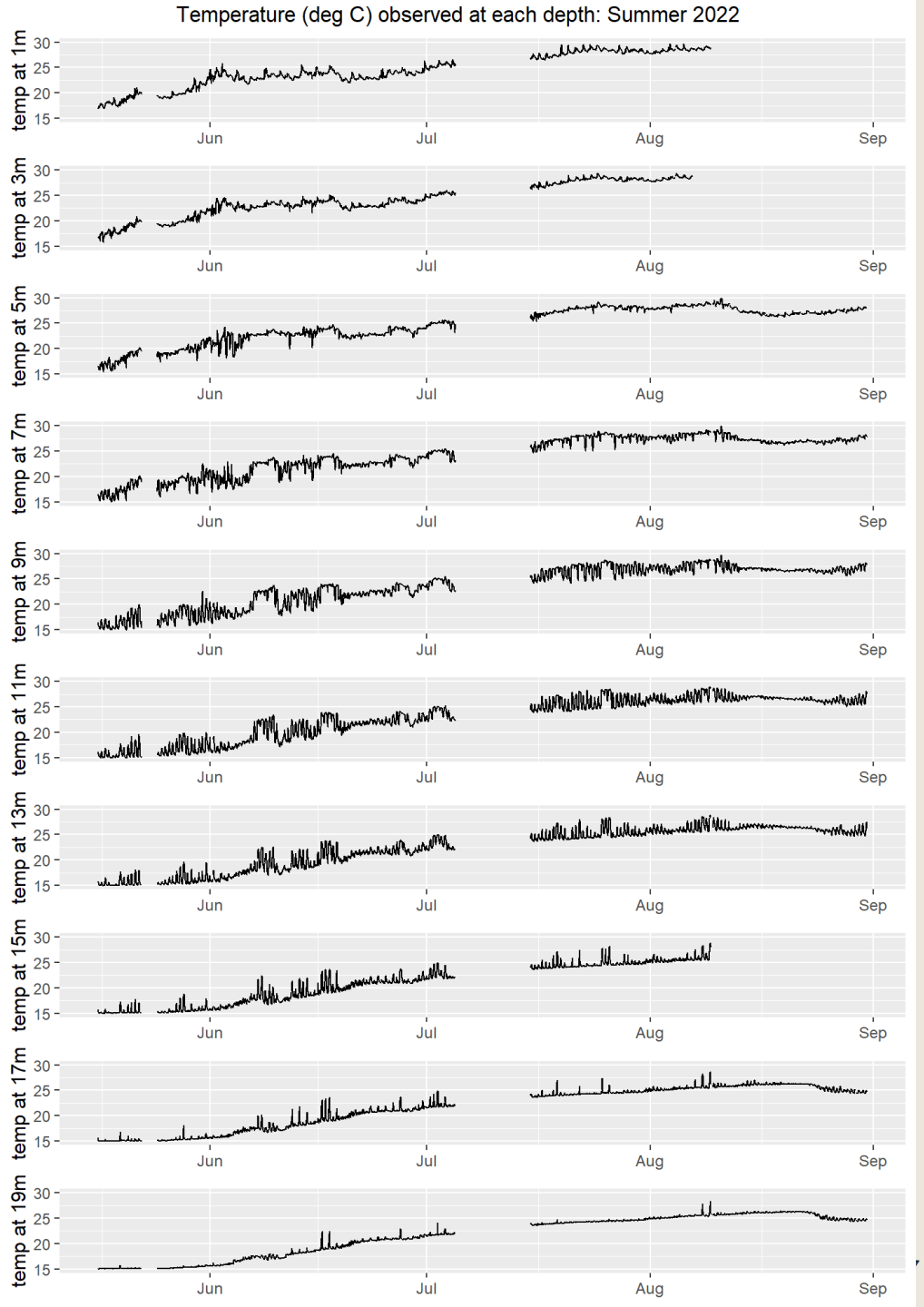
depth (m)	count
1	10,271
3	6,161
5	13,176
7	13,315
9	13,260
11	13,384
13	10,794
15	863
17	8,298
19	13,355


DO (mg/L) observed at each depth: Summer 2022
DO at 1m
DO at 3m
DO at 5m
DO at 7m
DO at 9m
DO at 11m
DO at 13m
DO at 15m
DO at 17m
DO at 19m
0
5
10
15
Jun
Jul
Aug
Sep


Simple heatmap of DO observations: May-Jul
depth (m)
0
5
10
15
20
May 15
Jun 01
Jun 15
Jul 01
do
15
10
5
0

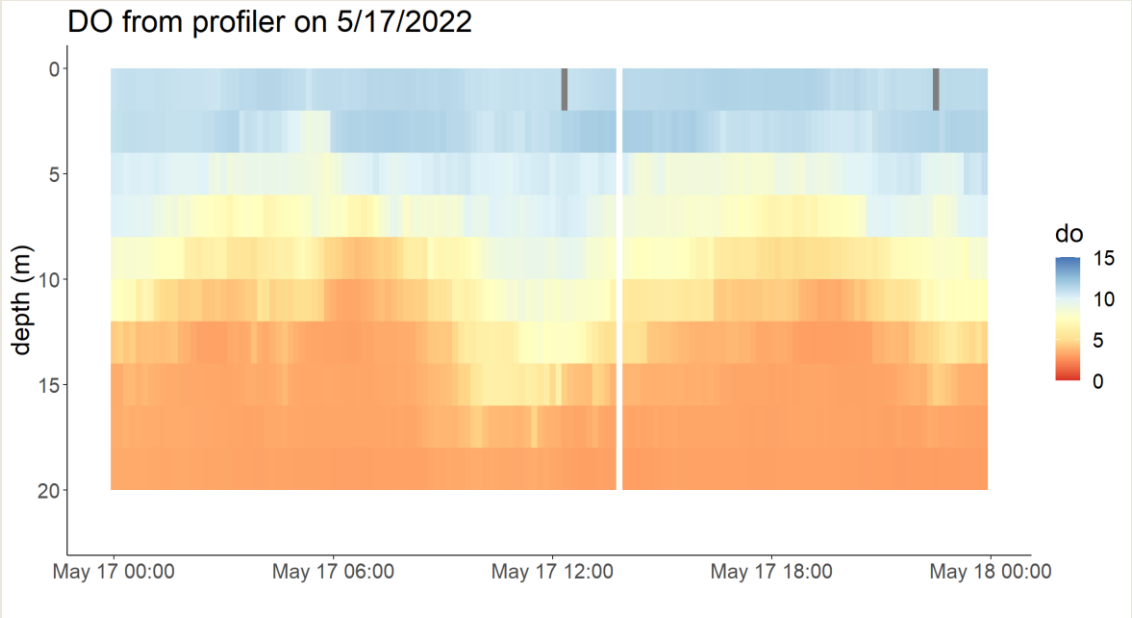

Simple heatmap of DO observations: Jul-Aug
depth (m)
0
5
10
15
20
Jul 15
Aug 01
Aug 15
Sep 01
do
15
10
5
0

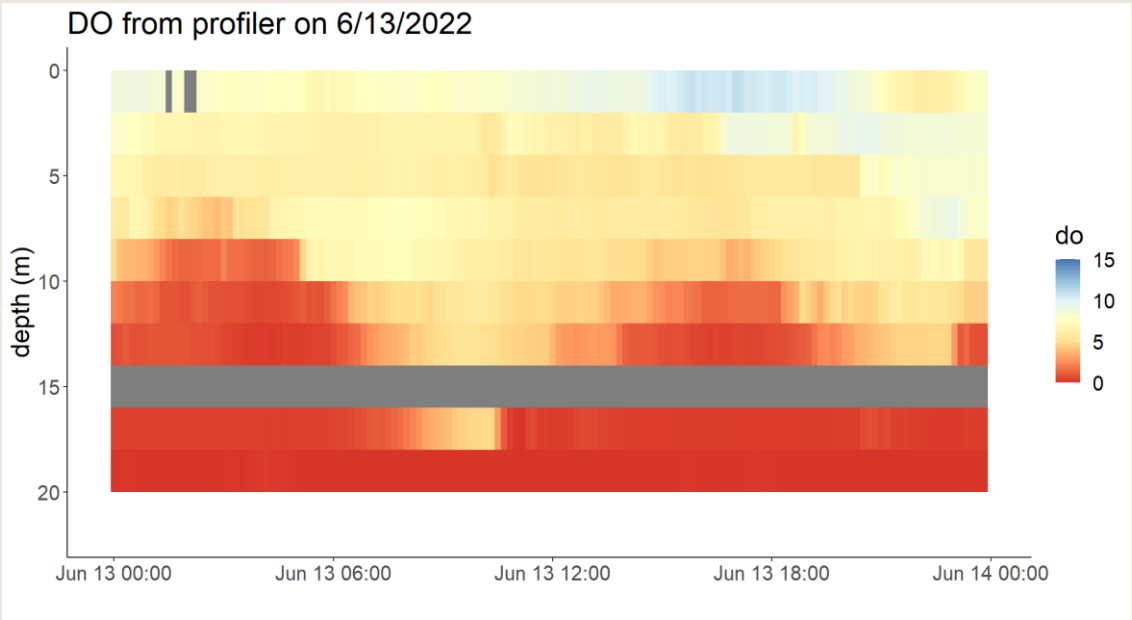

Salinity (psu)) observed at each depth: Summer 2022
sal at 1m
sal at 3m
sal at 5m
sal at 7m
sal at 9m
sal at 11m
sal at 13m
sal at 15m
sal at 17m
sal at 19m
0
10
20
30
Jun
Jul
Aug
Sep


Temperature (deg C) observed at each depth: Summer 2022
temp at 1m
temp at 3m
temp at 5m
temp at 7m
temp at 9m
temp at 11m
temp at 13m
temp at 15m
temp at 17m
temp at 19m
15
20
25
30
Jun
Jul
Aug
Sep

Single-day views

- Tidal influence of mid-depth cycling is clear from this data.
- For 4D tool, we'll be trying to correlate these dynamics with other observed to get reasonable mid- and deep-depth hourly predictions in places and times without data.
- Having this data from multiple profilers will help us identify how these patterns and relationships change in space.





Criteria assessment ideas:
Considering instantaneous criteria

- Instantaneous criteria exist for Open Water, Deep Water, and Deep Channel in this station's segment.
- Explored this data with those criteria in mind:
  - *Identified the pycnocline from the 10-minute profiler data*
  - *Split the DO into designated uses (DUs) from those pycnocline computations*
  - *Compared the observed DO to the instantaneous criteria*
  - *Compared the profiler results to doing this with the full record of CB4.3E data*

Criteria assessment ideas:
Considering the instantaneous criteria

Designated Use	Criteria Concentration/Duration	Protection Provided	Temporal Application
Migratory fish spawning and nursery use	7-day mean ≥ 6 mg liter^{-1} (tidal habitats with 0-0.5 ppt salinity)	Survival/growth of larval/juvenile tidal-fresh resident fish; protective of threatened/endangered species.	February 1 - May 31
	Instantaneous minimum ≥ 5 mg liter^{-1}	Survival and growth of larval/juvenile migratory fish; protective of threatened/endangered species.	
	Open-water fish and shellfish designated use criteria apply		June 1 - January 31
Shallow-water bay grass use	Open-water fish and shellfish designated use criteria apply		Year-round
Open-water fish and shellfish use	30-day mean ≥ 5.5 mg liter^{-1} (tidal habitats with 0-0.5 ppt salinity)	Growth of tidal-fresh juvenile and adult fish; protective of threatened/endangered species.	Year-round
	30-day mean ≥ 5 mg liter^{-1} (tidal habitats with >0.5 ppt salinity)	Growth of larval, juvenile and adult fish and shellfish; protective of threatened/endangered species.	
	7-day mean ≥ 4 mg liter^{-1}	Survival of open-water fish larvae.	
	Instantaneous minimum ≥ 3.2 mg liter^{-1}	Survival of threatened/endangered sturgeon species.[1]	
Deep-water seasonal fish and shellfish use	30-day mean ≥ 3 mg liter^{-1}	Survival and recruitment of bay anchovy eggs and larvae.	June 1 - September 30
	1-day mean ≥ 2.3 mg liter^{-1}	Survival of open-water juvenile and adult fish.	
	Instantaneous minimum ≥ 1.7 mg liter^{-1}	Survival of bay anchovy eggs and larvae.	
	Open-water fish and shellfish designated-use criteria apply		October 1 - May 31
Deep-channel seasonal refuge use	Instantaneous minimum ≥ 1 mg liter^{-1}	Survival of bottom-dwelling worms and clams.	June 1 - September 30
	Open-water fish and shellfish designated use criteria apply		October 1 - May 31

[1] At temperatures considered stressful to shortnose sturgeon (>29°C), dissolved oxygen concentrations above an instantaneous minimum of 4.3 mg liter^{-1} will protect survival of this listed sturgeon species.

From EPA 2003 Ambient Water Quality Criteria

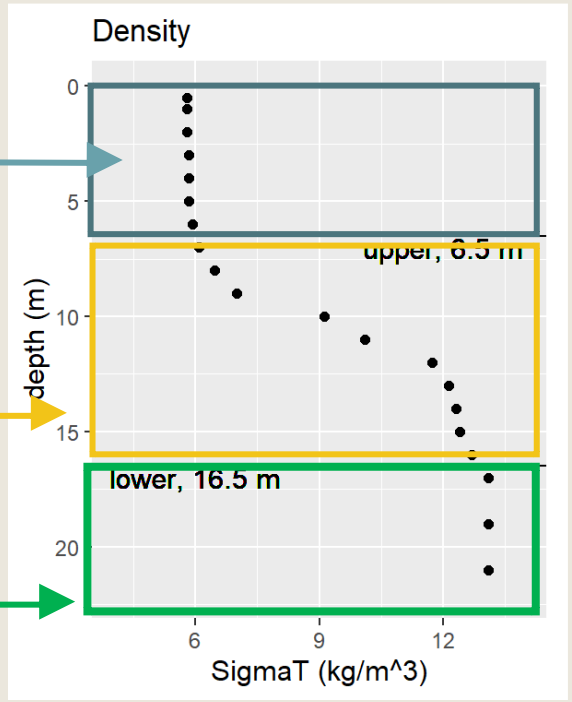
Criteria assessment ideas:
1) Identify Designated Uses (DU)

- Identify an upper and lower limit to the pycnocline.
- This uses the vertical gradients of density and salinity.
- Split water by the pycnocline
  - *Open Water (OW): above the "upper pycnocline"*
  - *Deep Water (DW): between upper and lower, or just below OW if there is no DC*
  - *Deep Channel (DC): below "lower pycnocline" (if it exists)*

Open Water (OW)

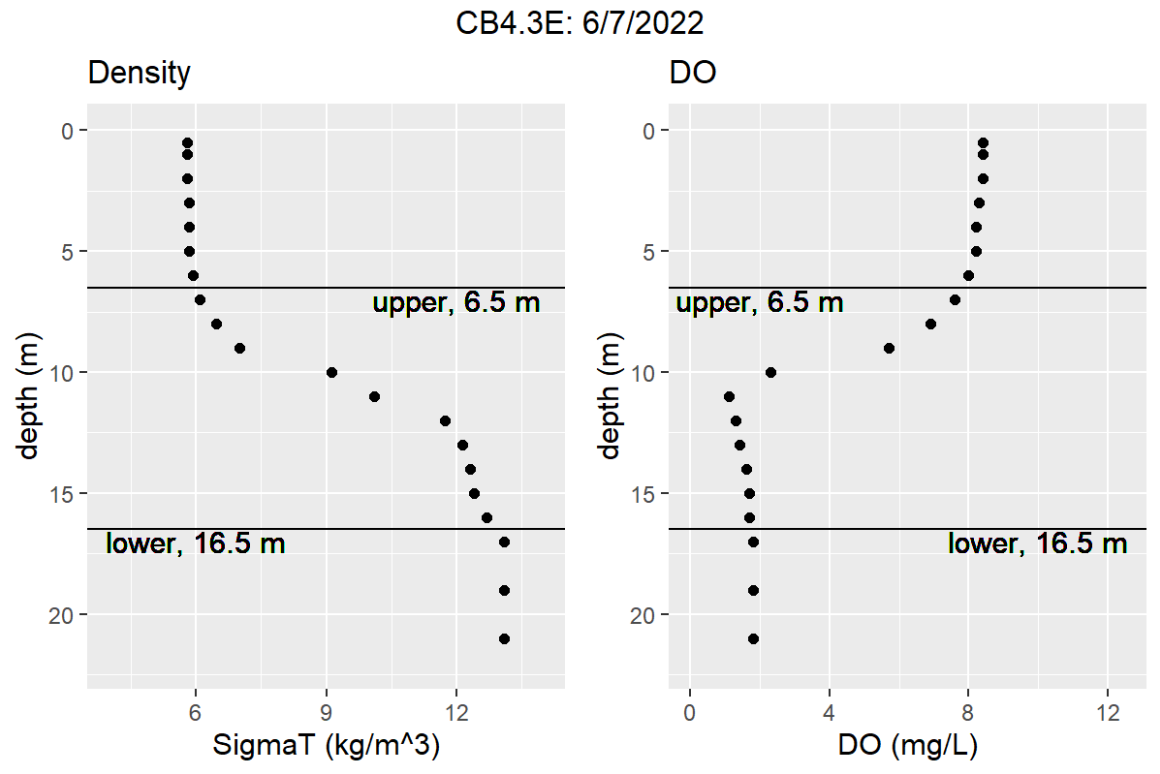
Deep Water (DW)

Deep Channel (DC)

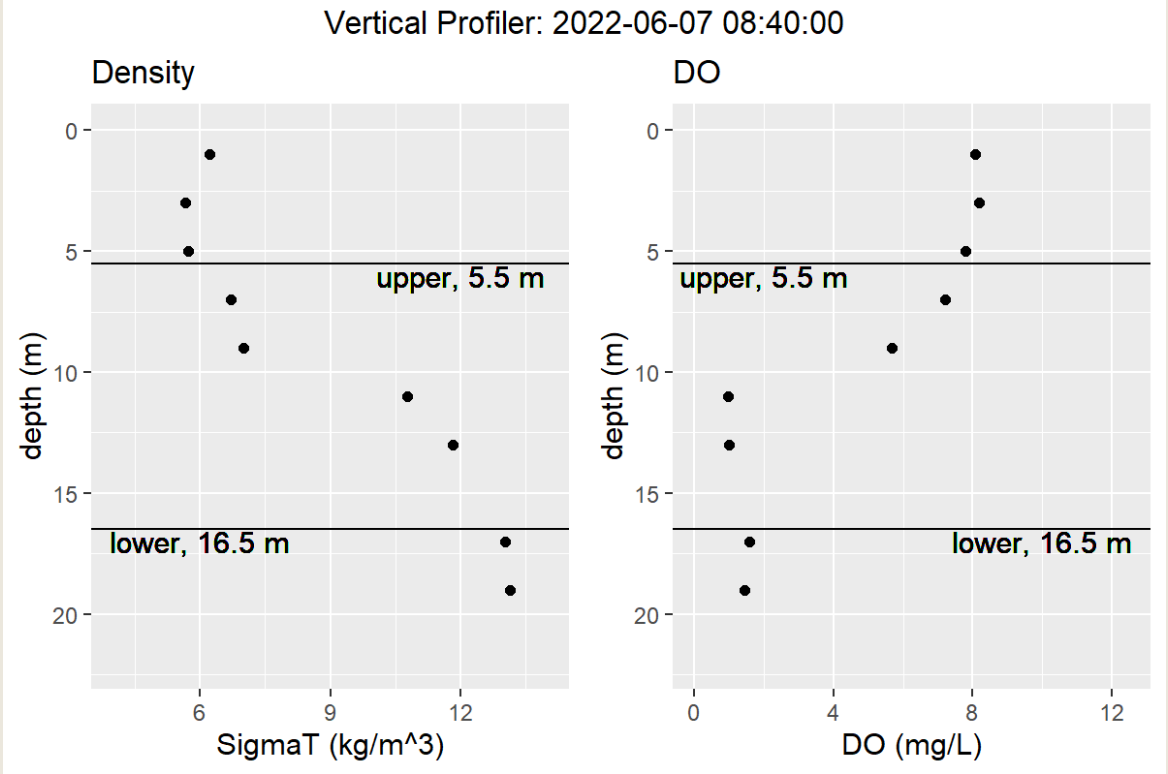


Criteria assessment ideas:
1) Identify Designated Uses (DU)

Fixed-station CB4.3E sample on 6/7/22



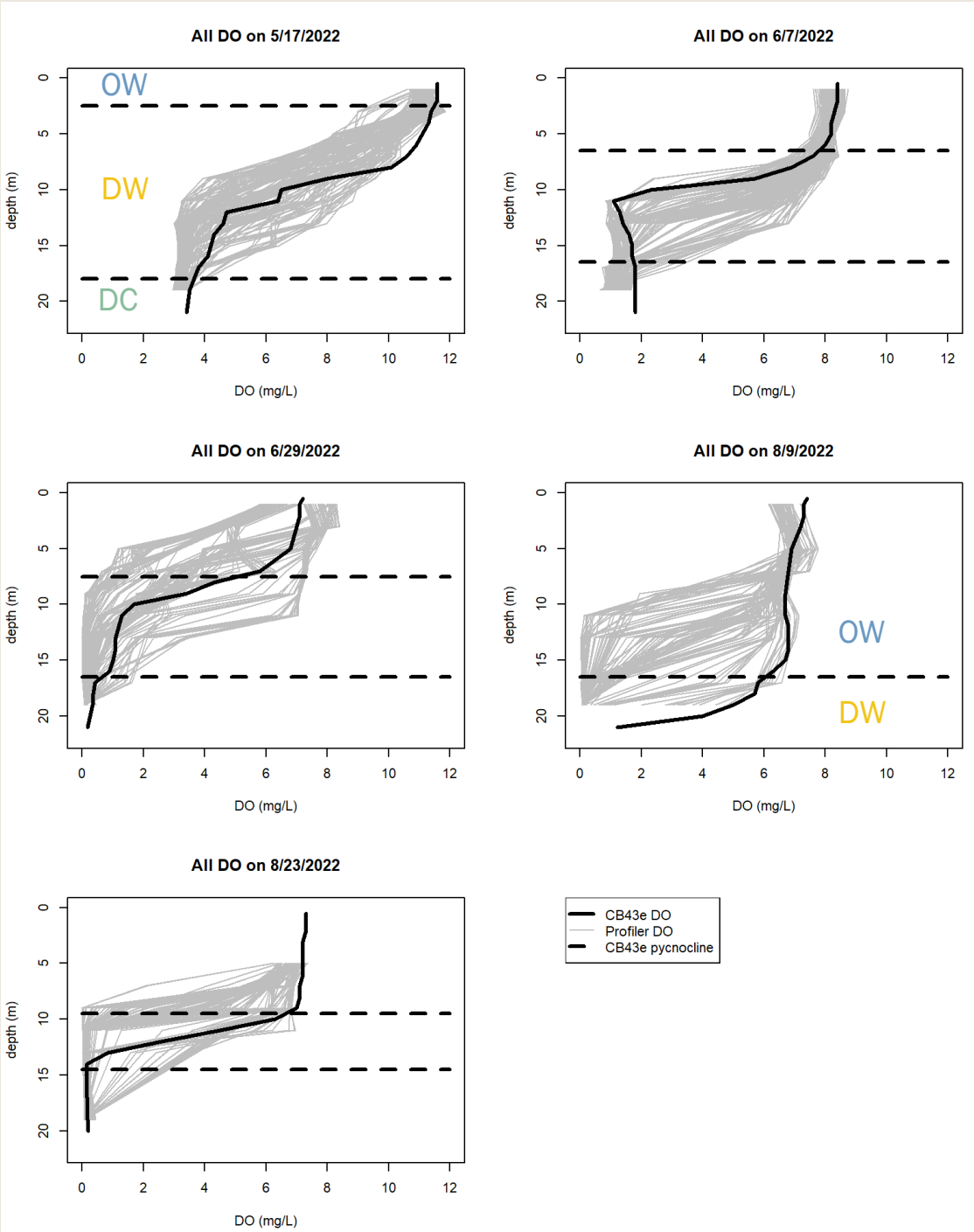
Compare to profiles and computed pycnoclines for same time from profiler



Criteria assessment ideas:
2) Distribution of pycnocline

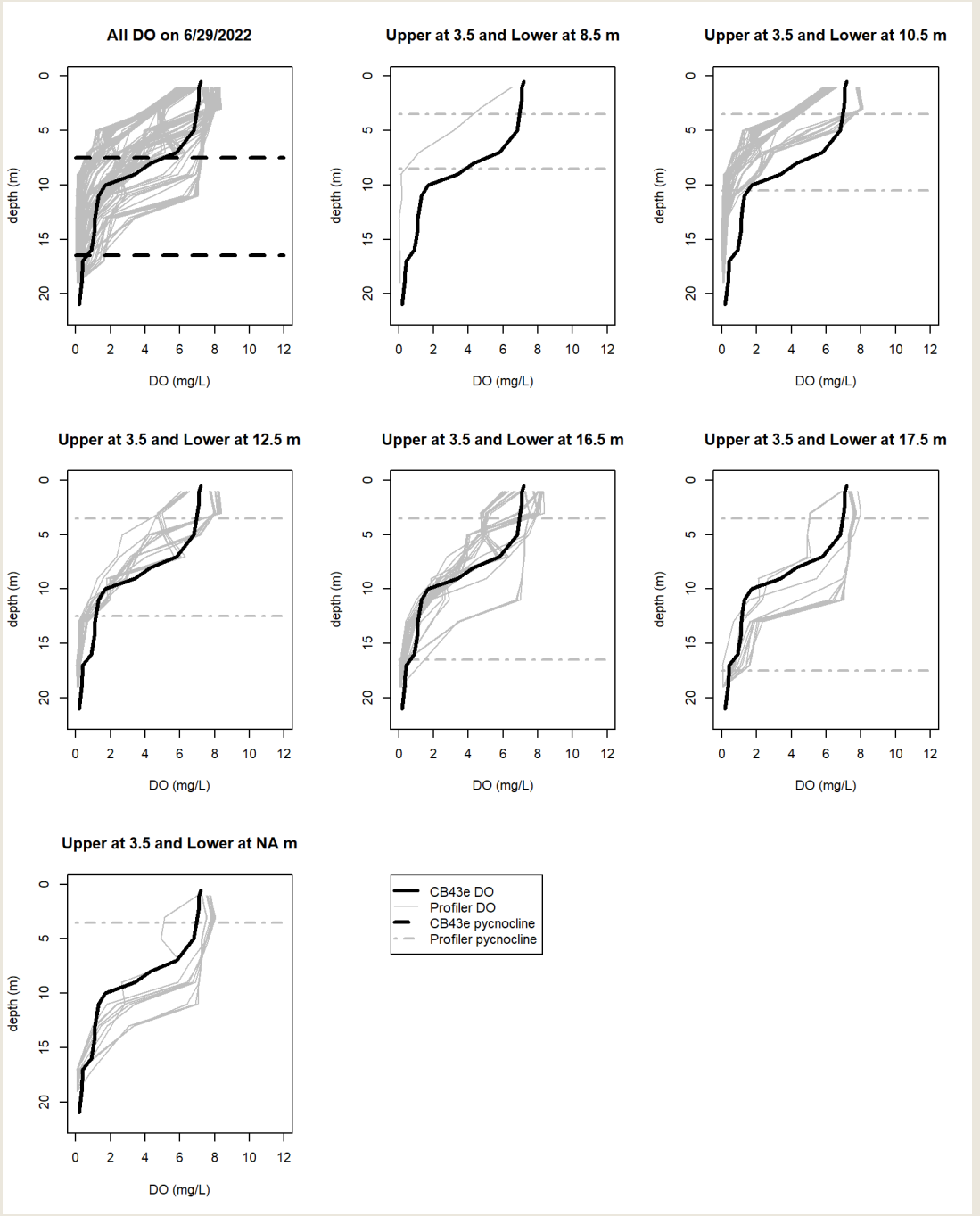
- These show all within-day profiler DO profiles on each day that CB4.3E was sampled for the fixed-station network.
- Black dotted lines are the pycnocline identified from just the CB4.3E samples
- Daily variation is large at the mid-depths, up to 6 mg/L

(Note: 8/9 when the CB4.3E sample doesn't fall in the middle is a day when the profiler had an 8 hour gap)



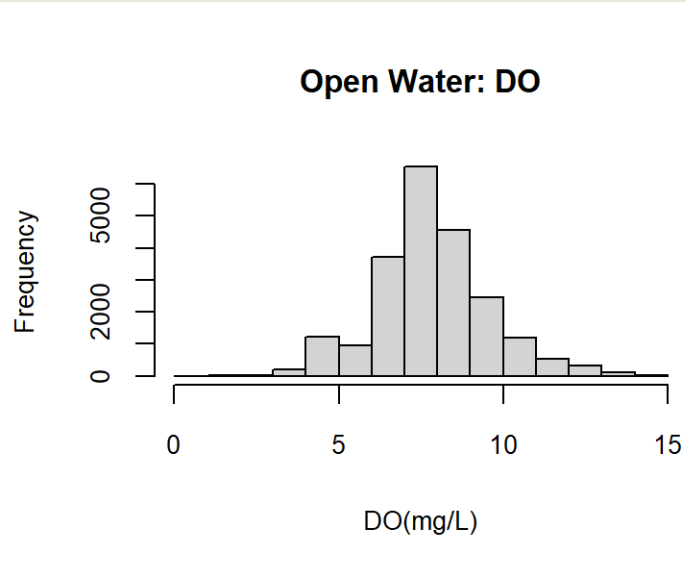
Criteria assessment ideas:
2) Distribution of pycnocline

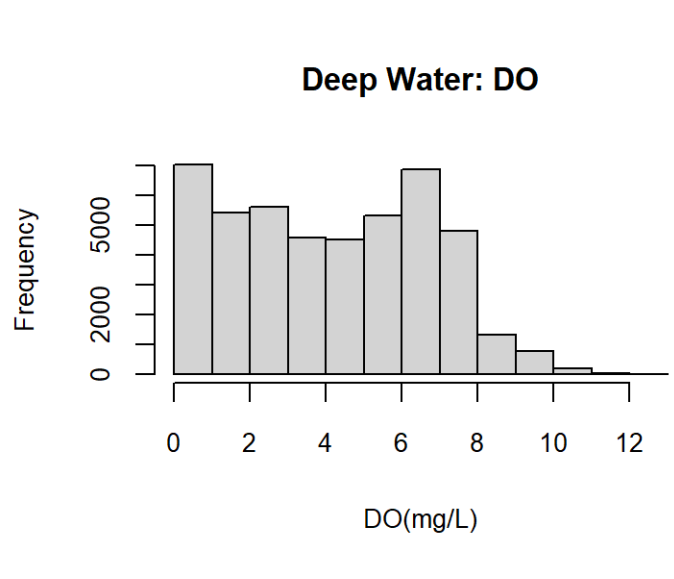
- Just one day, 6/29
- Light gray pycnocline lines are identified throughout this day from the profiler. DO profiles are shown for the periods on a panel for the periods with that pycnocline set.
- Take-away:
  - *The pycnocline computation from the profiler data seems to be working well, and*
  - *is fine enough resolution to capture these within-day changes.*

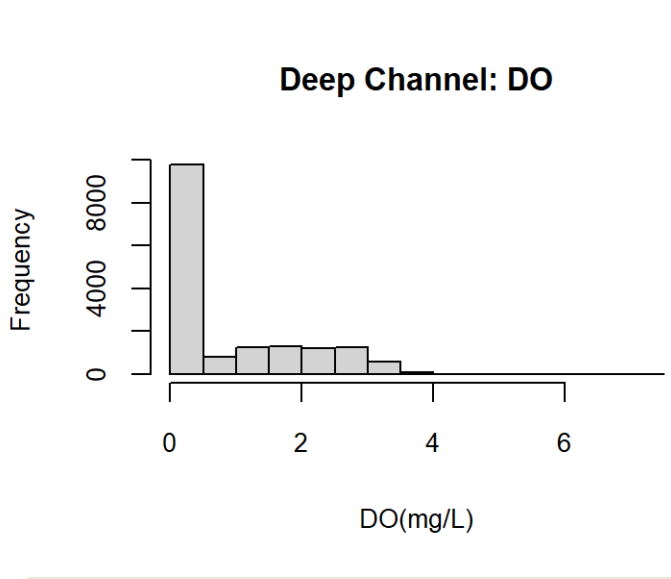


Criteria assessment ideas:
3) Compare DO to criteria

- DO from the profiler was split by DU for every 10 minute period.

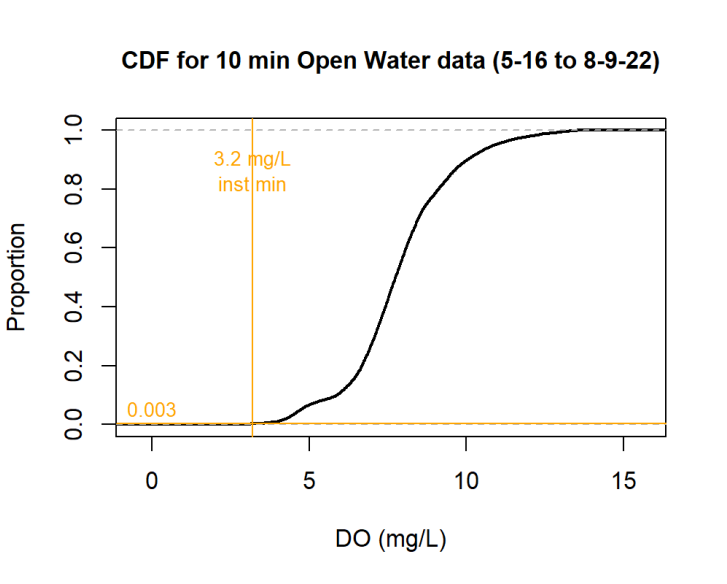


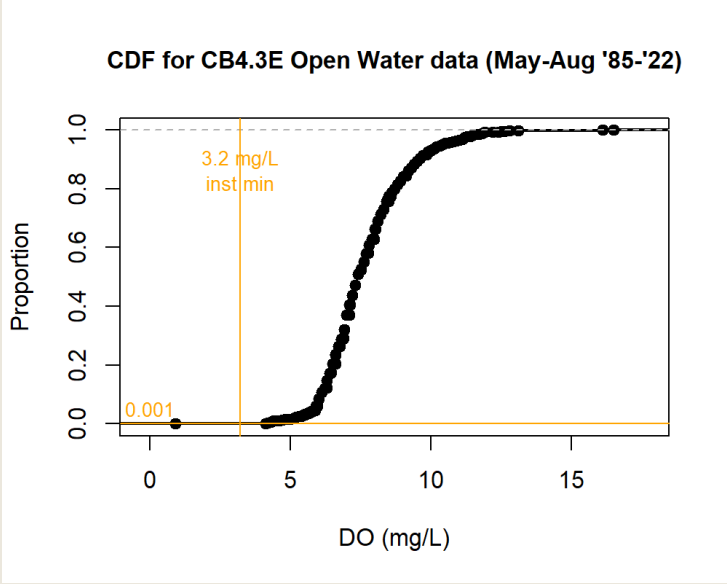




Criteria assessment ideas:
3) Compare DO to criteria

- Empirical cumulative density functions (CDFs) were created for all DO observations in the DU, and compared to the instantaneous criteria
- Data from Aug 9 onward was excluded because upper pycnocline would not have been detected accurately with missing depths
- OW for example:

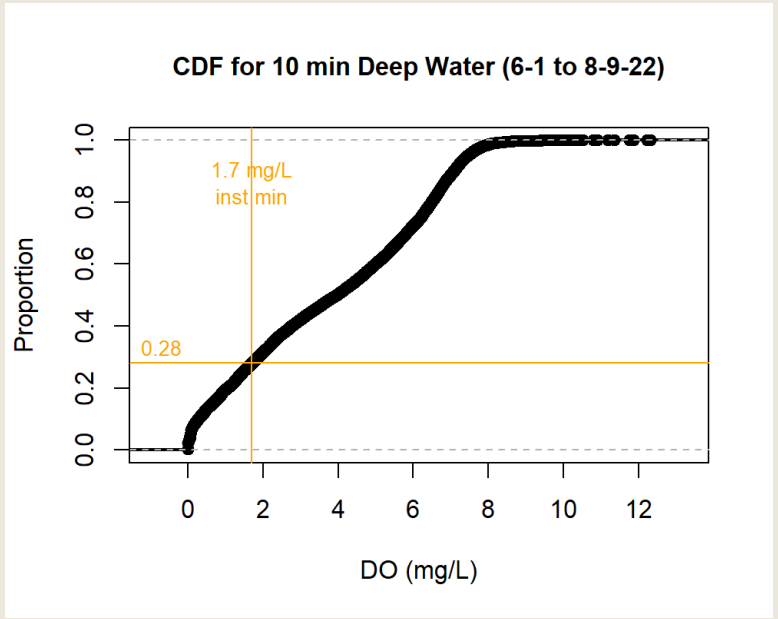


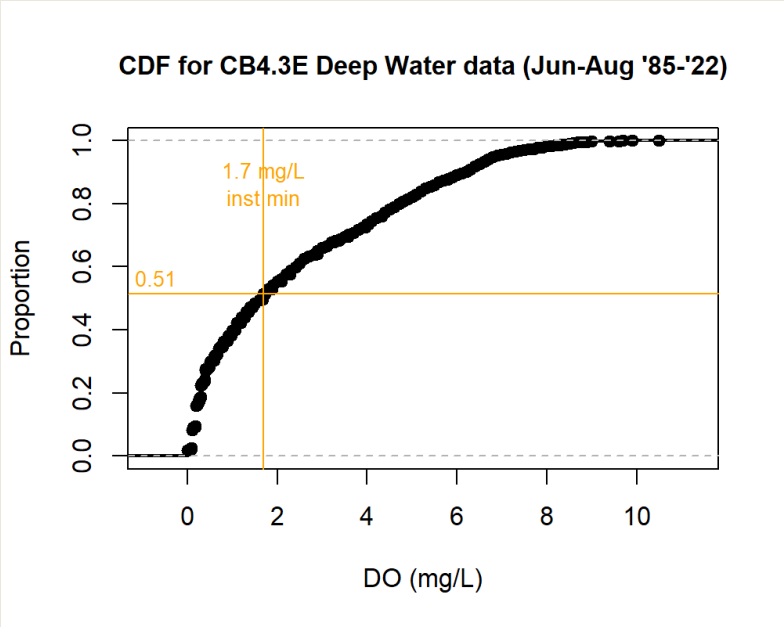


East Goose Profiler DO: 2022

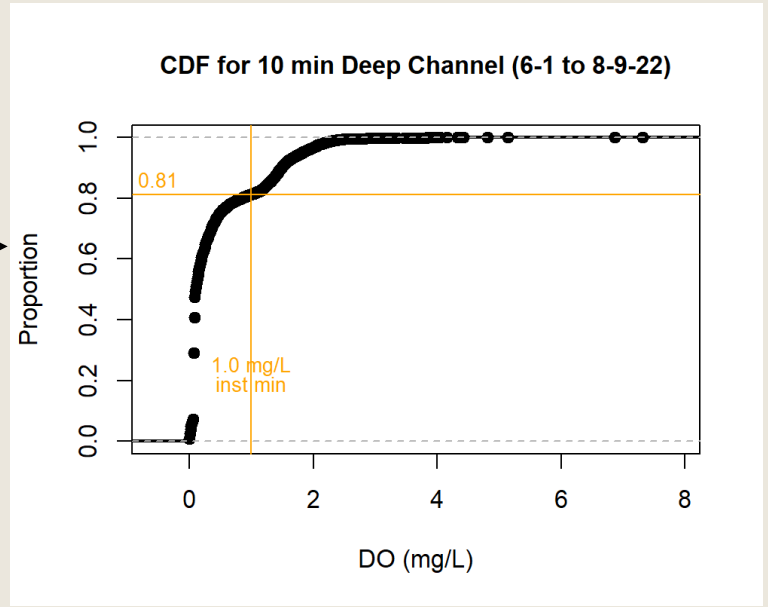
Fixed Station CB4.3E over time: 1985-2022

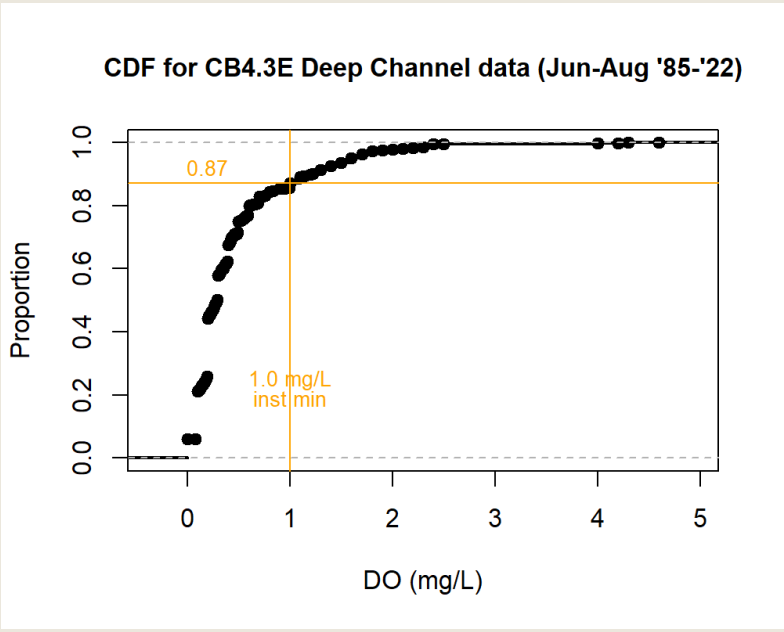
Deep Water →





Deep Channel →





Criteria assessment ideas:
4) Take-away thoughts

- This is not a full criteria assessment
- However, this shows us already:
  - *The profiler data can be used successfully to compute the DUs split by pycnocline*
  - *The DUs at mid-depths are going to vary even within a day*
  - *The oxygen at mid- and deep-depth at this station in summer of 2022 went below the instantaneous criteria frequently*

Profiler data analysis: Next steps

- Soon:
  - *Will also examine the West Gooses data from 2022 and the East 2020 summer data*
  - *Aggregate the data to 1-day and 7-day means to think about comparison to those criteria*
  - *Interpolator development: Examine variation with depth, correlation with other parameters, ideas for simulation tool*
- With additional data this year and next:
  - *Examine idea of empirical assessment compared to interpolated-based assessment*
  - *Build spatial patterns from all profilers together into interpolator*

Thank you to the Hypoxia Collaborative
and the NOAA field crew for all the work to get this great data!

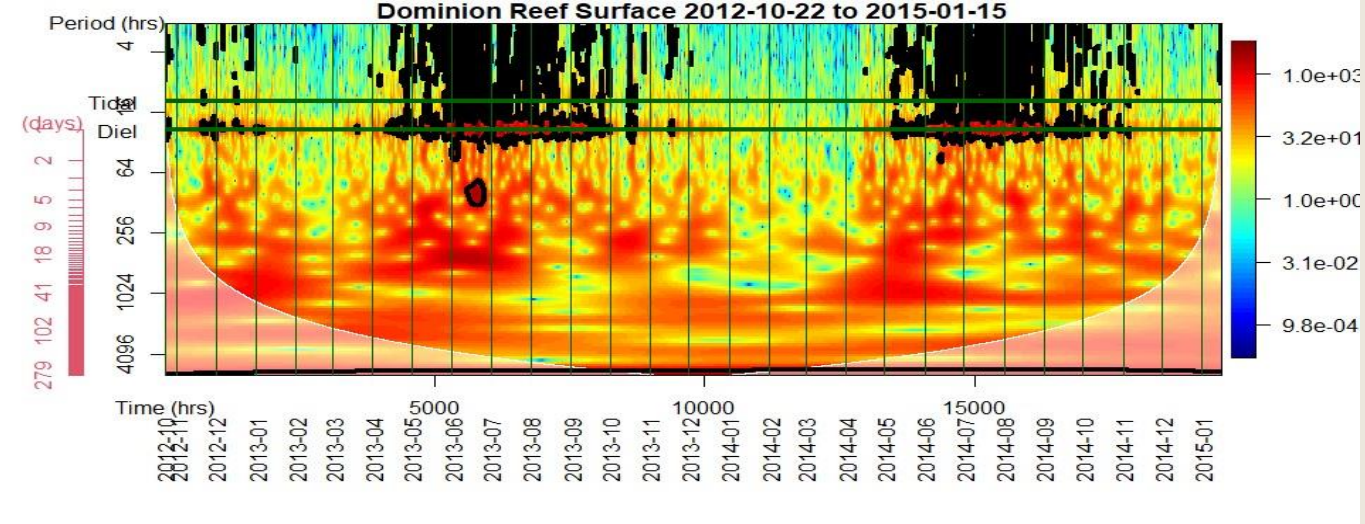
extras

4d Development timeline

Calendar Year	2022				2023				2024				2025				2026				2027			
Calendar Quarter	Q1 Jan-Mar	Q2 Apr-Jun	Q3 Jul-Sep	Q4 Oct-Dec	Q1 Jan-Mar	Q2 Apr-Jun	Q3 Jul-Sep	Q4 Oct-Dec	Q1 Jan-Mar	Q2 Apr-Jun	Q3 Jul-Sep	Q4 Oct-Dec	Q1 Jan-Mar	Q2 Apr-Jun	Q3 Jul-Sep	Q4 Oct-Dec	Q1 Jan-Mar	Q2 Apr-Jun	Q3 Jul-Sep	Q4 Oct-Dec	Q1 Jan-Mar	Q2 Apr-Jun	Q3 Jul-Sep	Q4 Oct-Dec
Project Year	Year 1				Year 2				Year 3				Year 4				Year 5				Year 6			
1. Development-daily estimates (Phase 1)																								
2. Develoment-hourly estimates (Phase 2)																								
3. Development - shallow water																								
4. Development - GIS tasks																								
5. Development -combined daily & hourly (Phase 3)																								
6. Development-criteria evaluation																								
7. Software																								
8. Documenting																								
9. Training																								
10. Year of Review																								
11. Operational																								

4D interpolator hourly mean preliminary testing

Identifying patterns with wavelet tool:



Ongoing: Examining patterns in the hourly data & testing approaches for simulation…

Use high frequency observations to fit a daily cycle sin-cos model, then predict:

$$DO_h = lc * h + sc * sin\left(\frac{2\pi * h}{24}\right) + cc * cos\left(\frac{2\pi * h}{24}\right) + \tau_h \quad h = 1{:}24$$