

Fishing Bay Case Study: *DO summary*

BORG meeting
Aug. 17, 2026

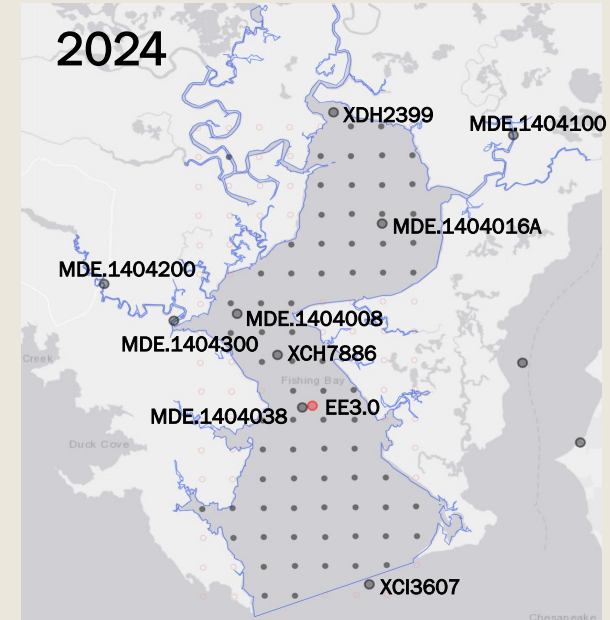
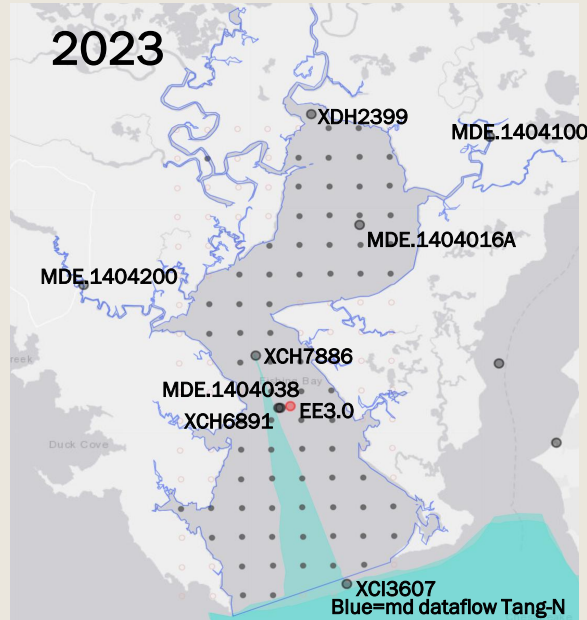
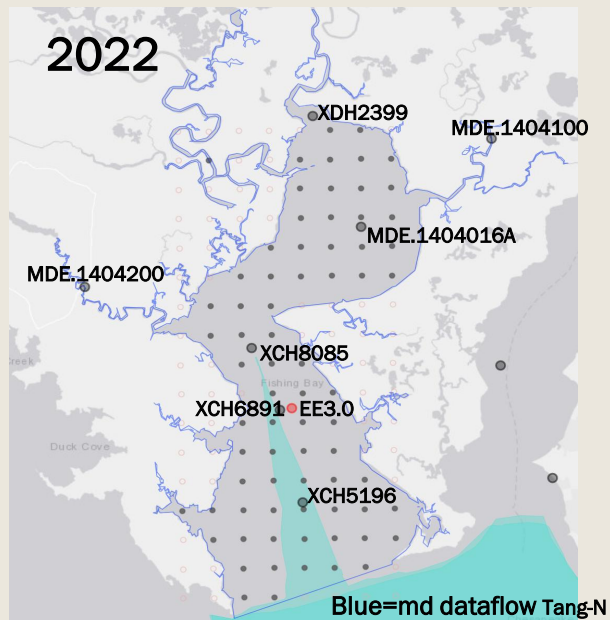
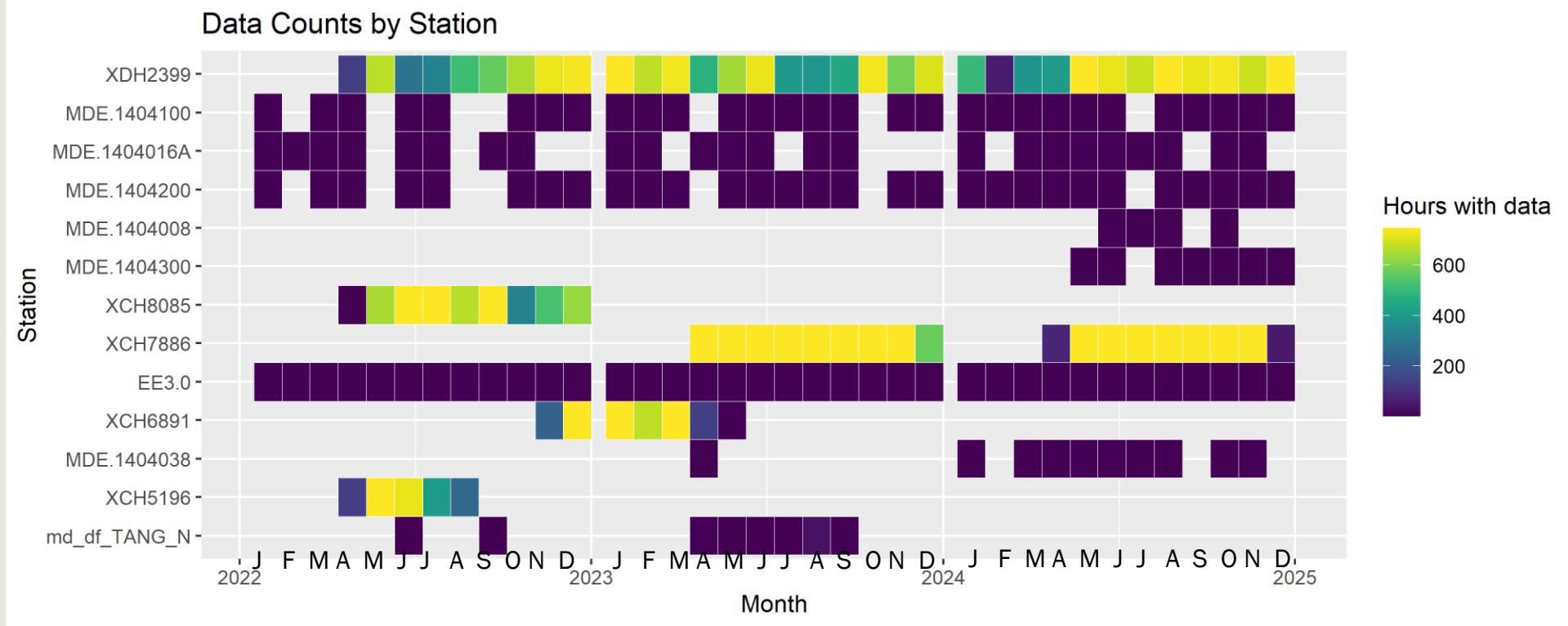
Rebecca Murphy (UMCES at CBP) for Development Team:
Elgin Perry (statistics consultant), Jon Harcum (Tetra Tech),
and Peter Tango (USGS)

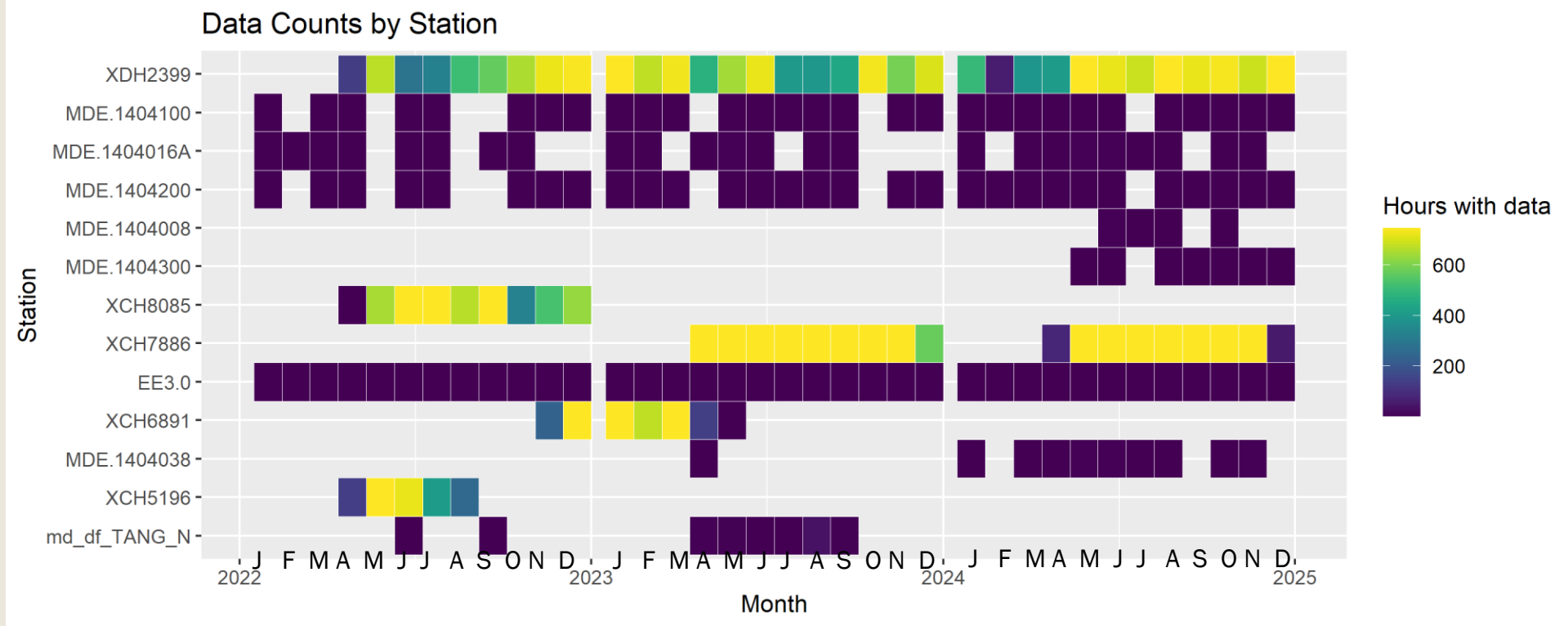
Station locations and interpolator grid*



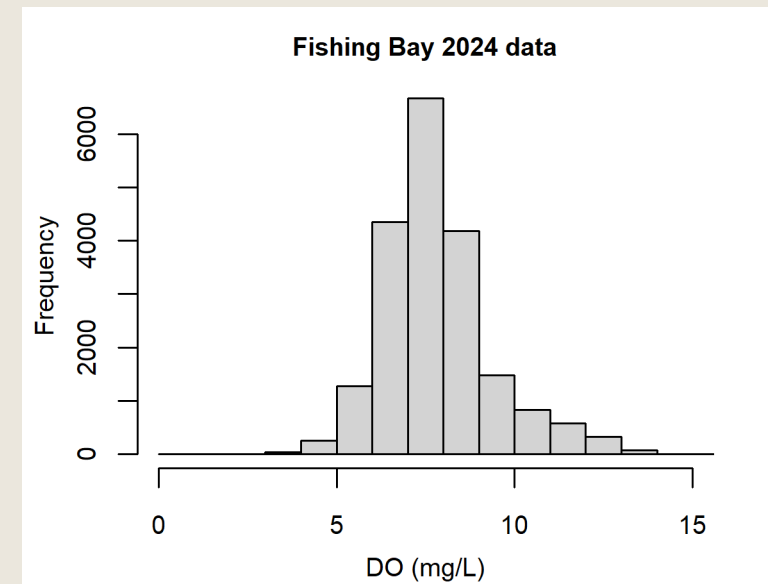
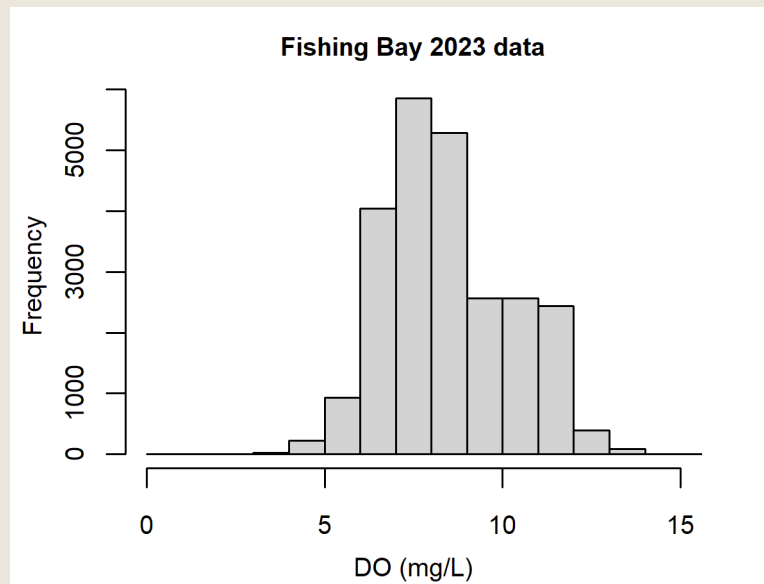
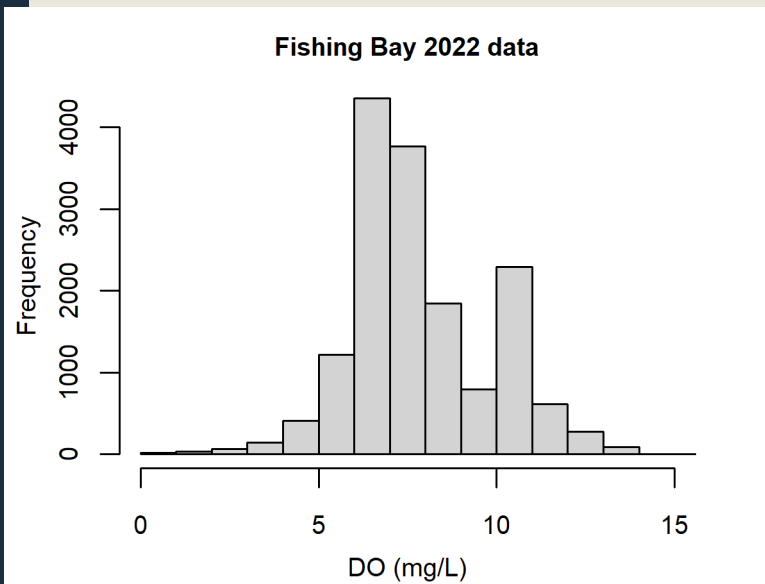
Interpolator grid cell
(could have multiple
depths)

*note: grid is the same between the 4D and 3D interpolators





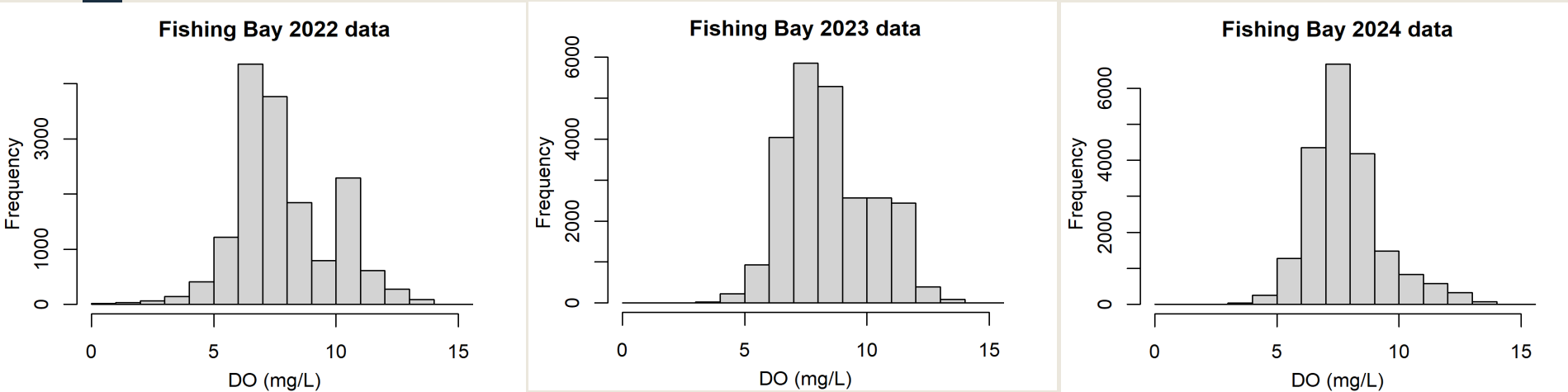
Observed data histograms (from monitoring stations: all year, high frequency subset to hourly)



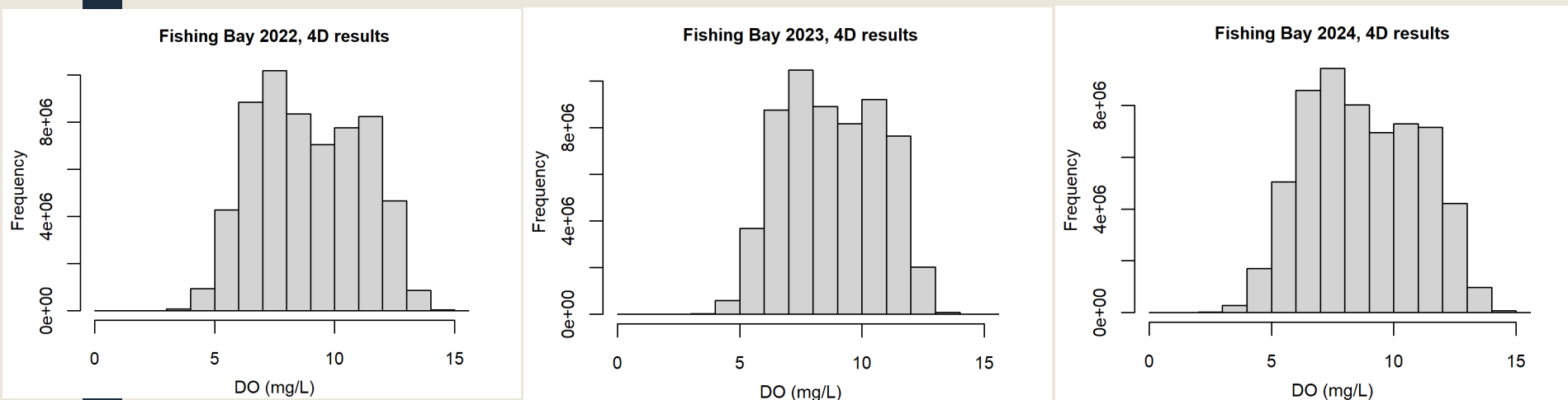
Observed-to-4D output histograms

Observed data histograms

(from monitoring stations: all year, high frequency subset to hourly)



4D interpolation results – annual, every cell, every hour, 50 realizations



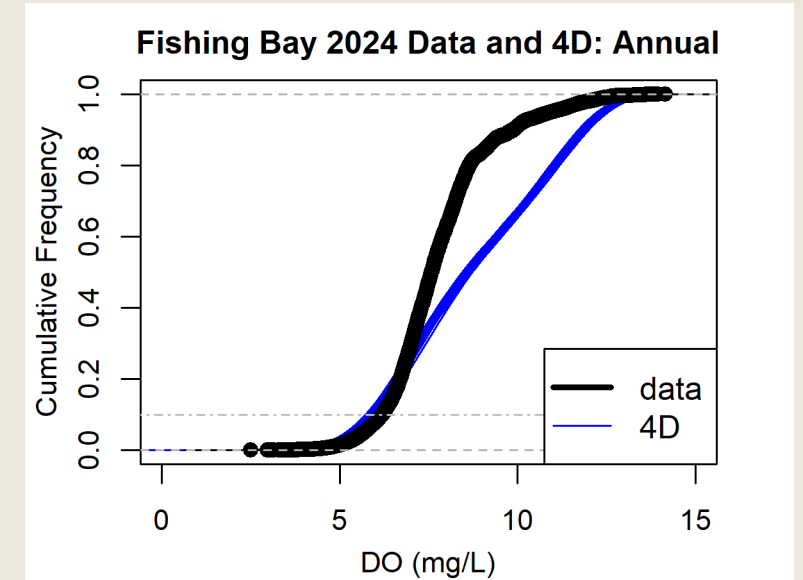
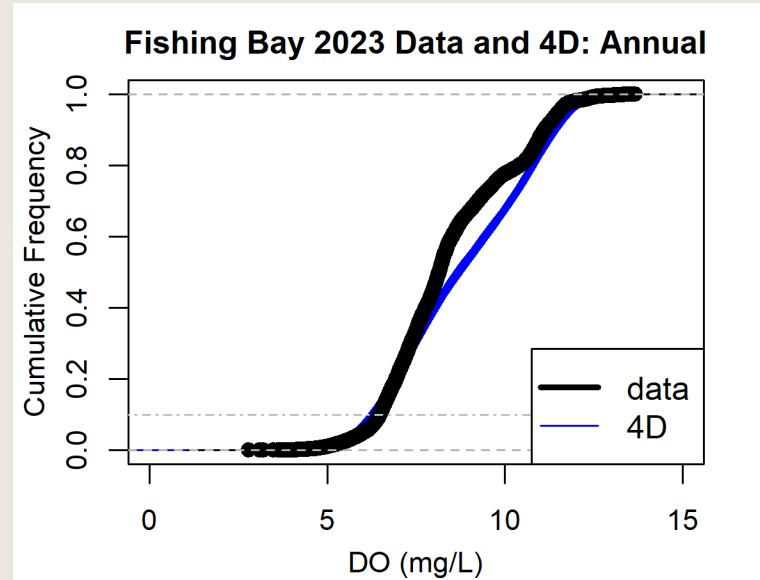
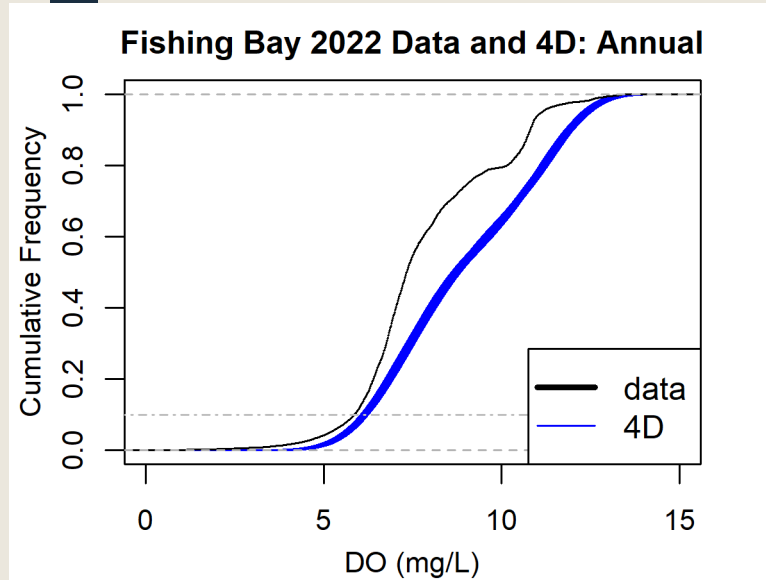
Observed

- The shapes of the data histograms are driven in part by distribution of sampling over the year.
- Most noticeable is the shape in the 10-12 mg/L range – perhaps due to the amount of non-summer high frequency sampling.

4D

- 4D histograms represent even spatial and temporal coverage, hence are differently shaped from the data (but have similar range).
- For 4D: year-to-year, there is little difference in the 4D result distributions in FSBMH – only slight differences in the spread.

Compare observed-to-4D with EDFs

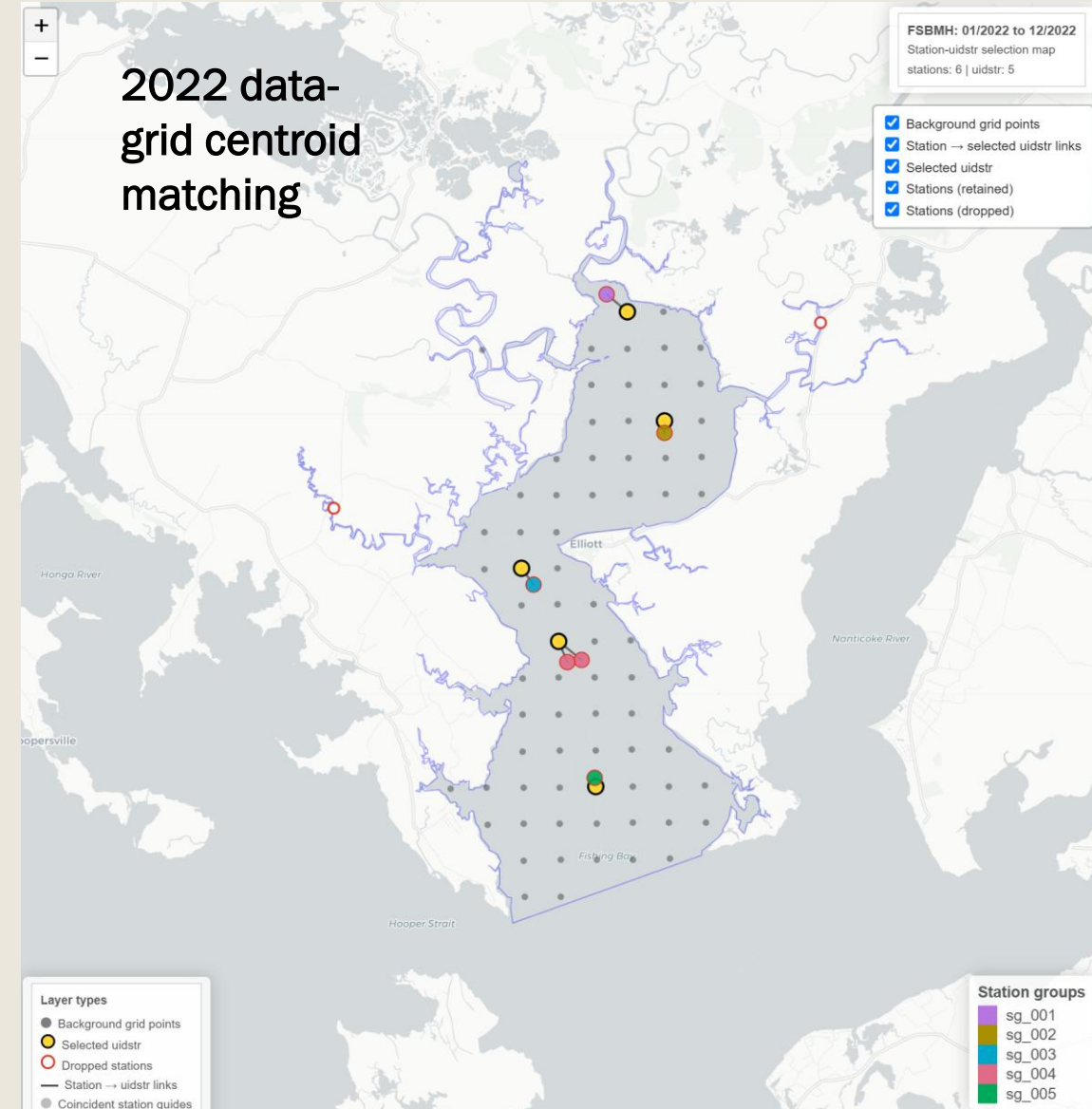


Data = all hourly observations at stations used in the interpolation; 4D = all hourly interpolation results in all grid cells for 50 simulations

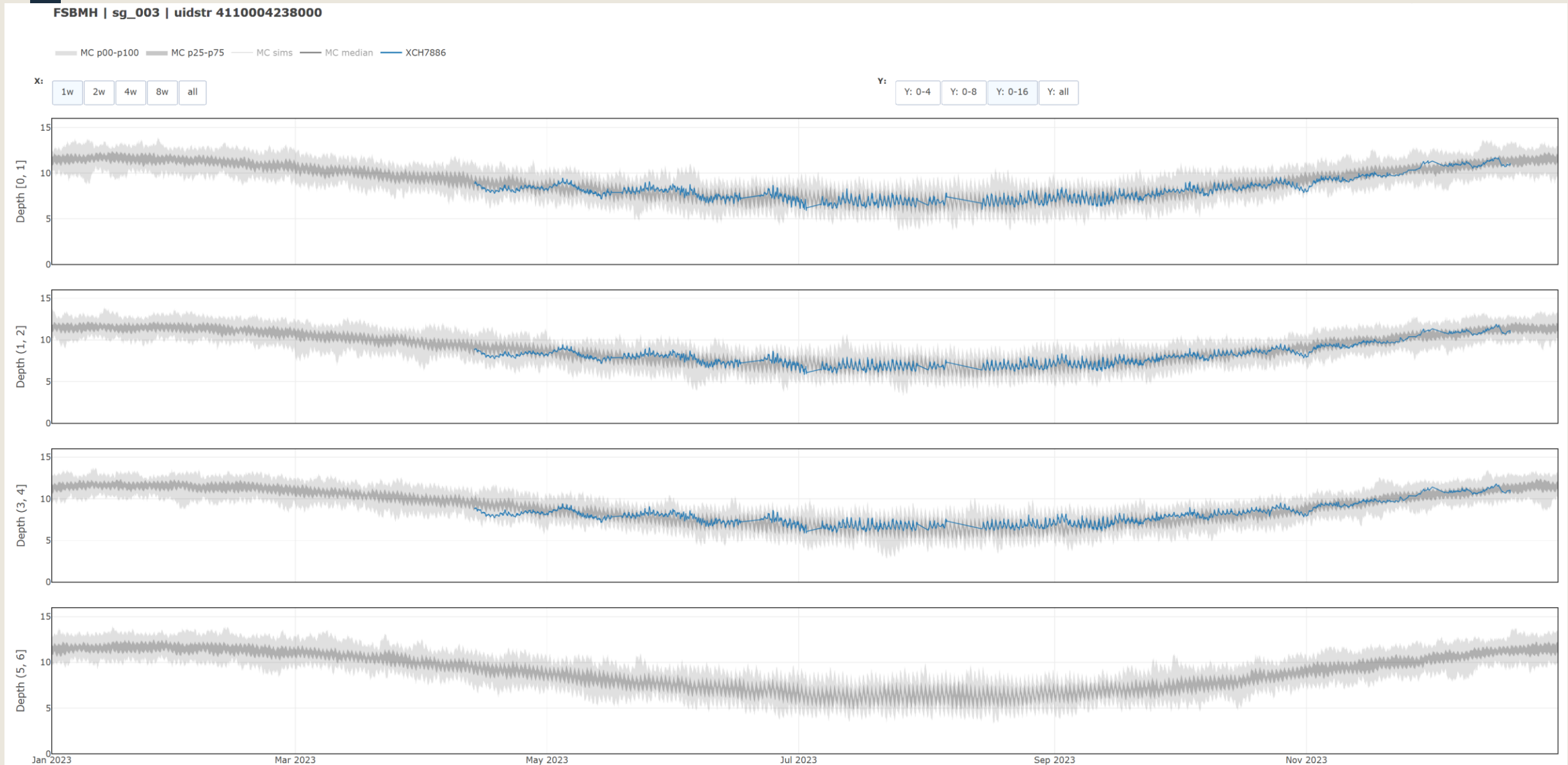
- Like the histograms, the shape of the data EDFs are highly influenced by temporal coverage of the high frequency data.
- However, it is promising that the 4D EDFs are similar to the data in the lower DO region.

Time series comparisons

- Comparisons to data were done at every station.
- The 4D interpolation DO is very similar to the data.
 - *At monthly sample stations, the data is within the simulation range.*
 - *At high frequency stations, the data falls within the simulation range, with few exceptions.*
- Mid-Bay high frequency stations on next slide. EE3.0 in extra slides.



XCH7886 in 2023 with 50 simulations at location



XCH7886 in 2023: showing just one simulation

FSBMH | sg_003 | uidstr 4110004238000

MC p00-p100 MC p25-p75 MC sims MC median XCH7886

X:

1w

2w

4w

8w

all

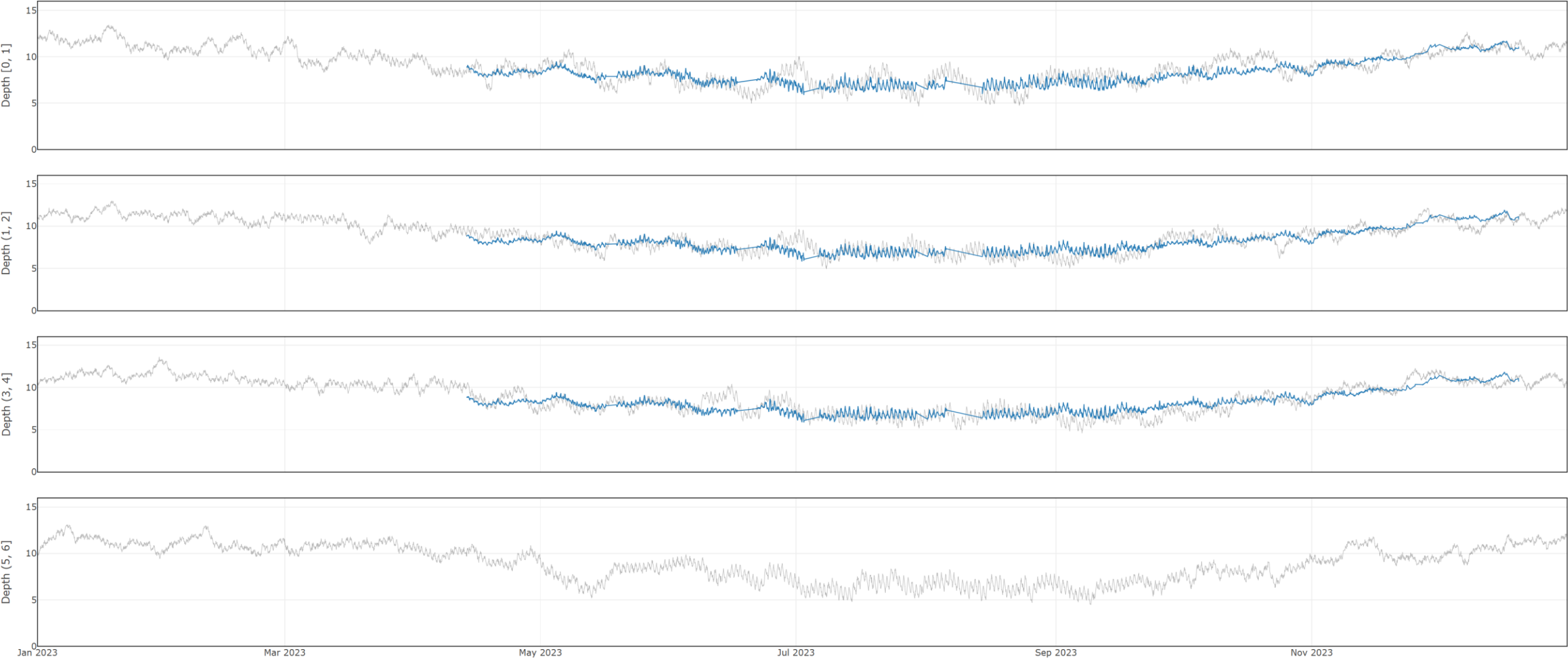
Y:

Y: 0-4

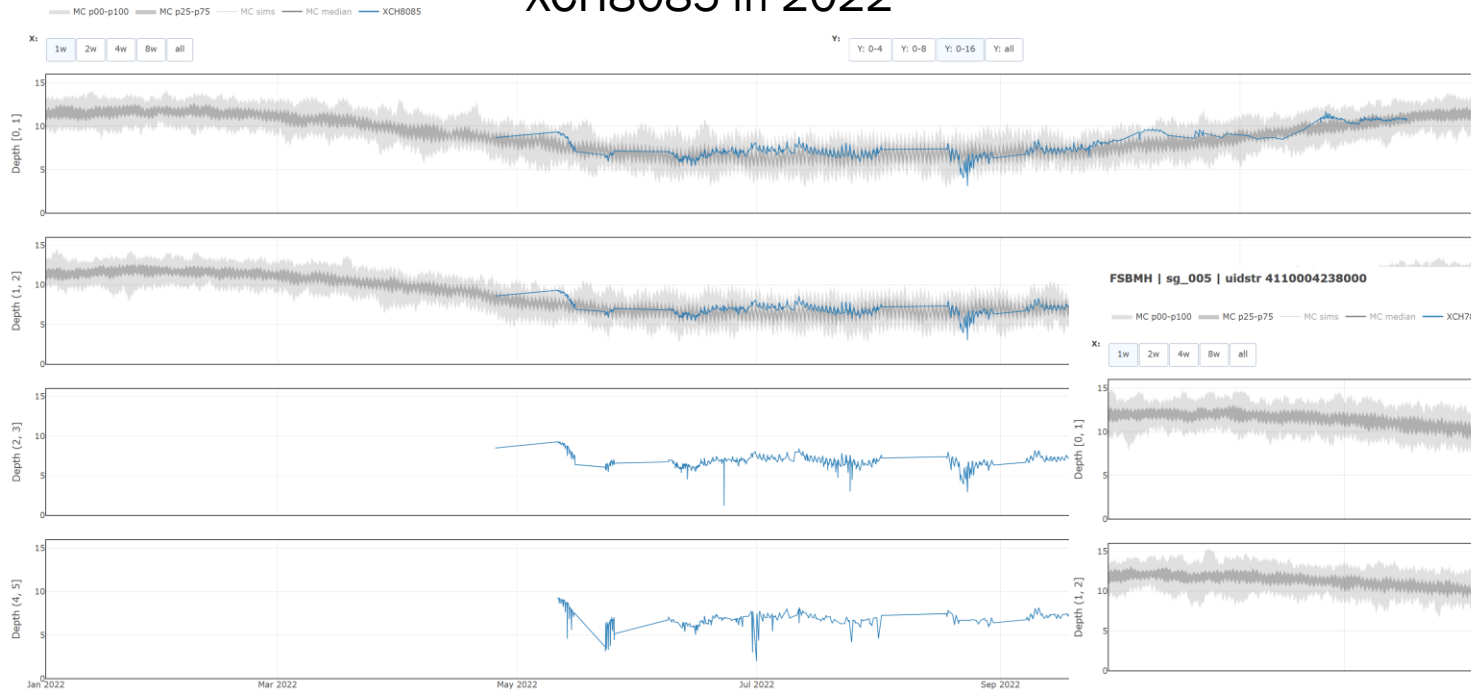
Y: 0-8

Y: 0-16

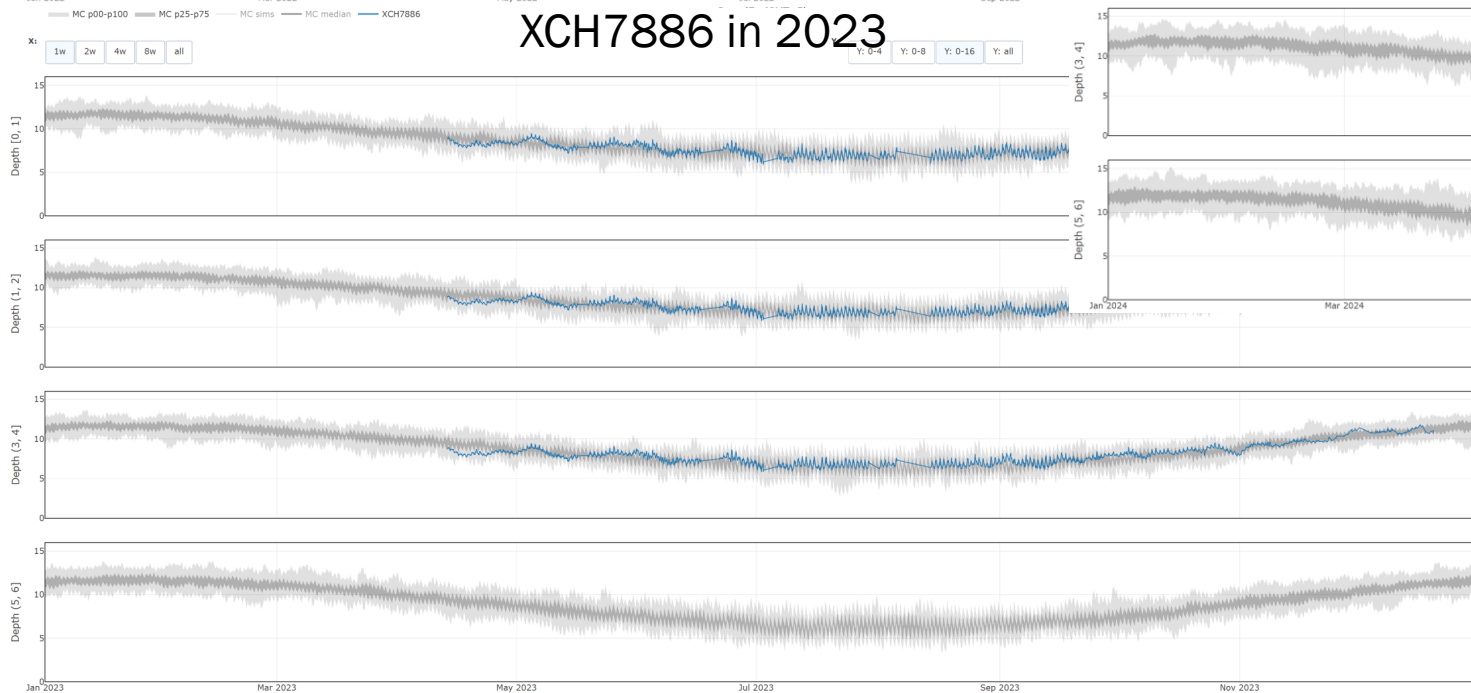
Y: all



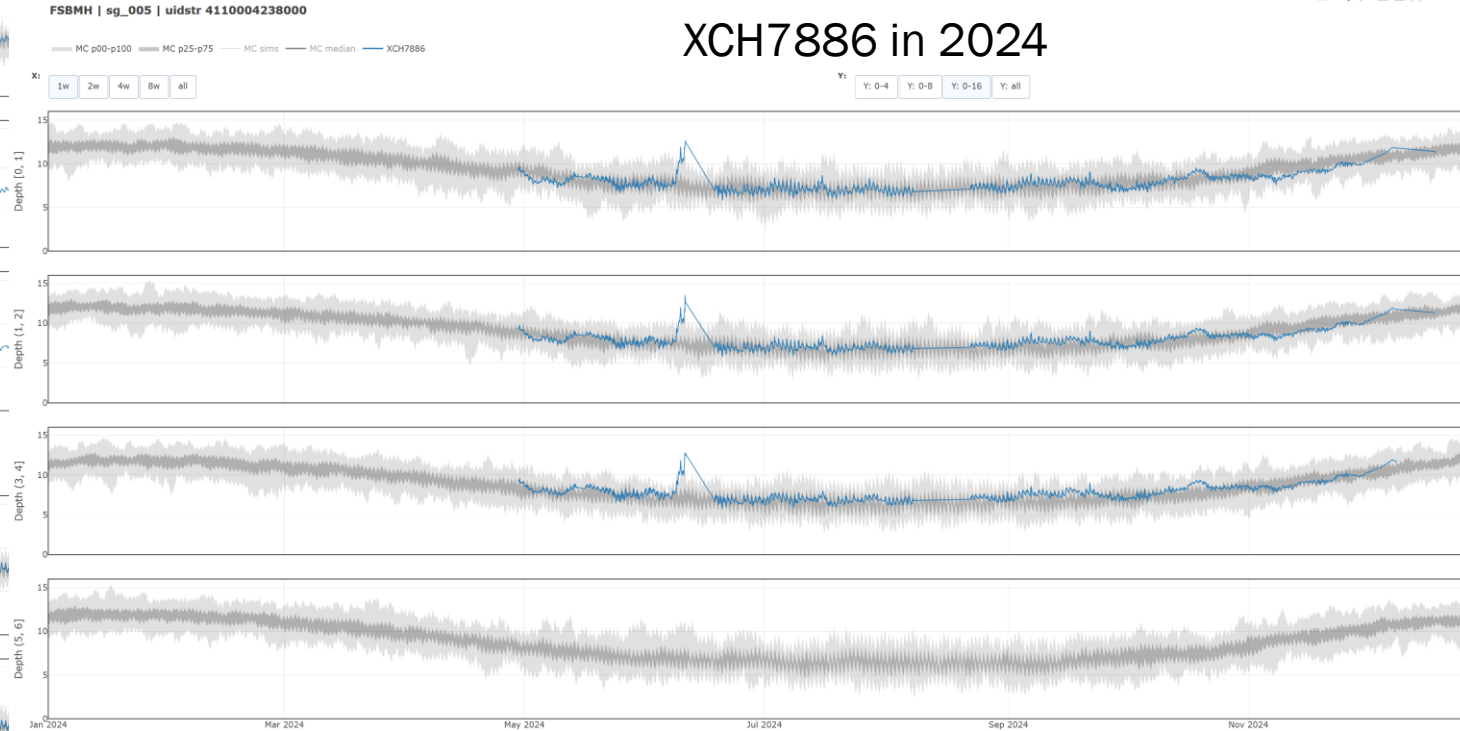
XCH8085 in 2022



XCH7886 in 2023



XCH7886 in 2024



- These two stations are at similar locations.
- Not much difference year-to-year in the observed DO.
- 4D simulations match the magnitude of the data values well.

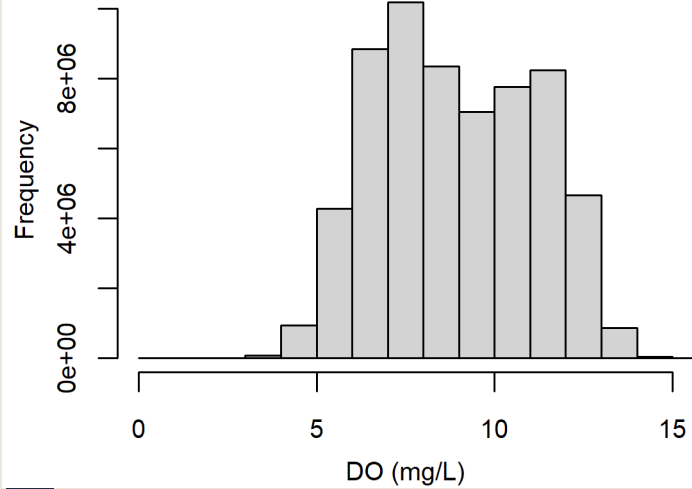
Notes on the 3D (current) interpolator

- Uses Inverse Distance Weighting (IDW) interpolation.
- Process involves grouping all data in a segment (and nearby stations) collected in a 2-week period that is submitted to the CBP data hub.*
- Data over the two week period is aggregated to one data set and interpolated as a fixed point in time (e.g., 1_June_2024 and 2_June_2024 would be the first and second half of June).

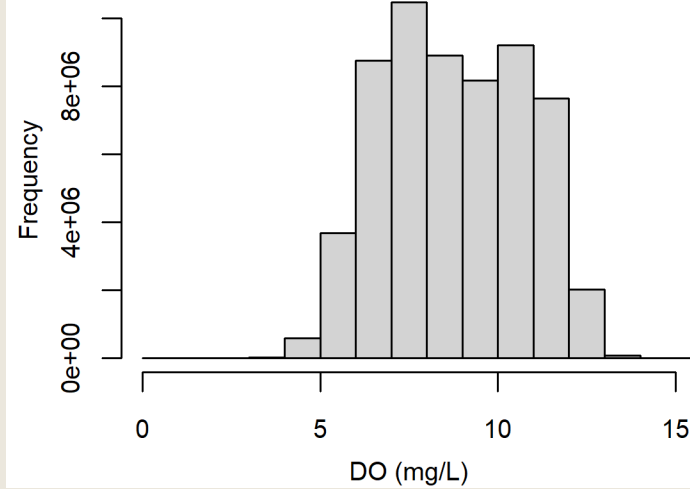
*This includes long-term fixed monitoring from the states, grab-sample calibration data at ConMon and Dataflow sites, and Tier 3 CMC-submitted data (e.g., MDE and citizen groups). No data at high frequency (e.g., 15 min or dataflow along the track) is used.

4D interpolation results – annual, every cell, every hour, 50 realizations

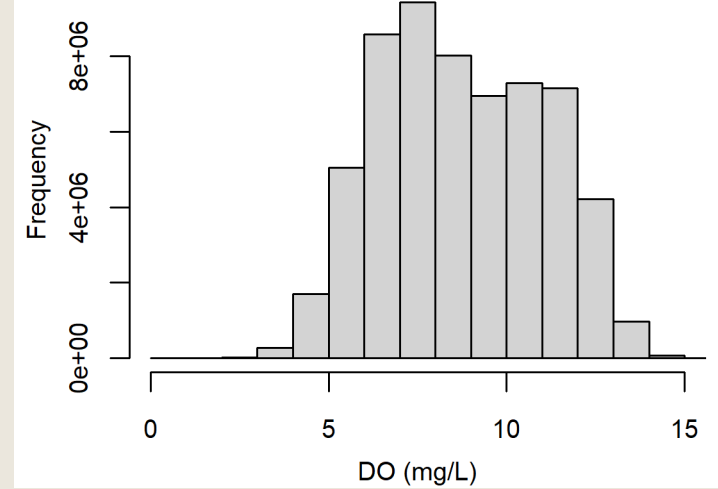
Fishing Bay 2022, 4D results



Fishing Bay 2023, 4D results

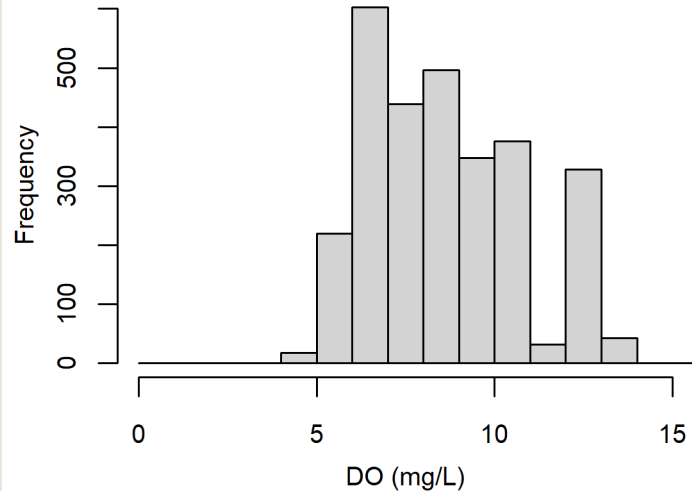


Fishing Bay 2024, 4D results

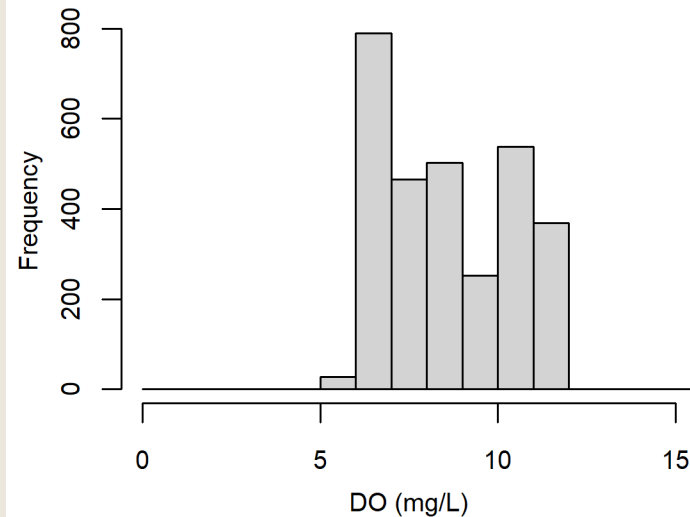


3D interpolation results – annual, every cell, 2 values per month

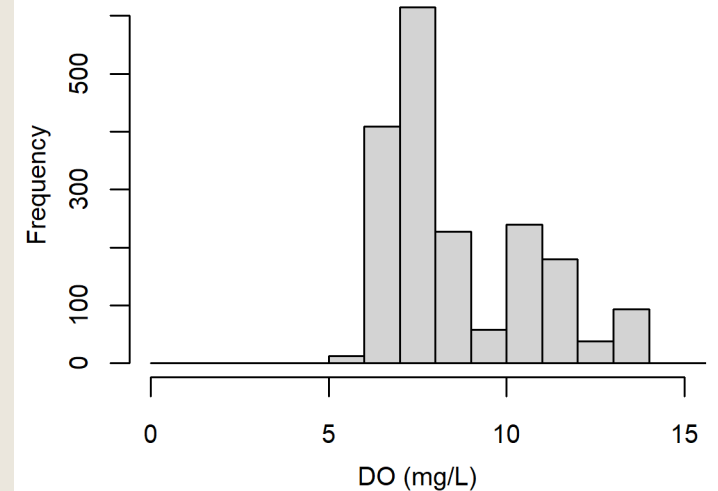
Fishing Bay 2022, 3D (current method)



Fishing Bay 2023, 3D (current method)

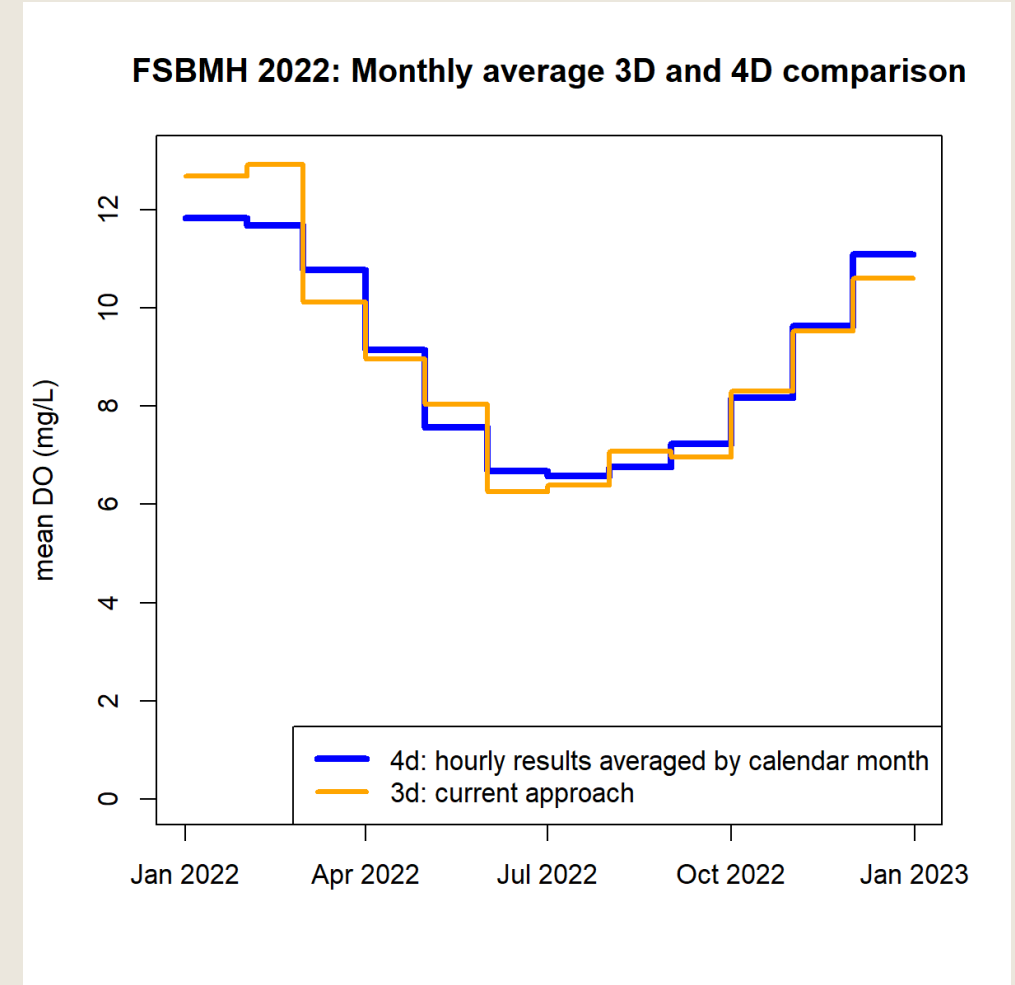


Fishing Bay 2024, 3D (current method)



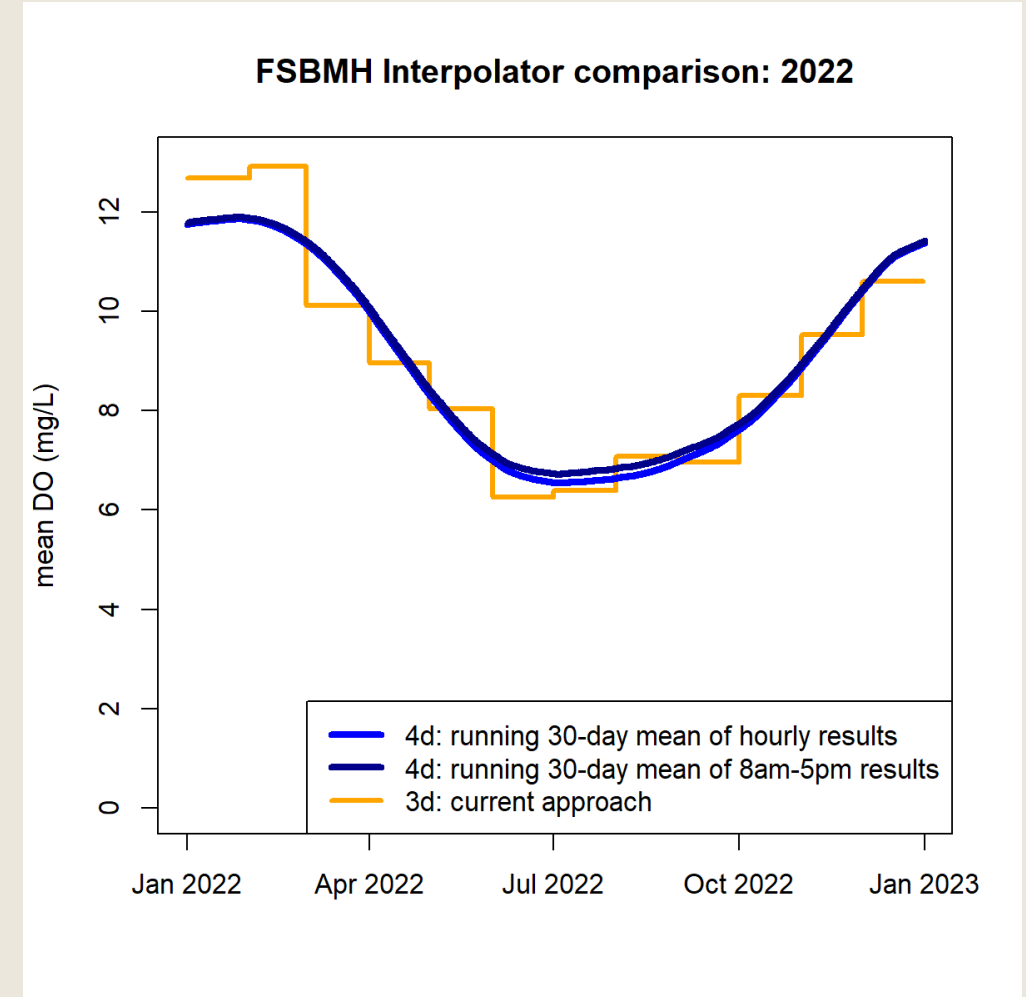
Compare 3D to similarly-aggregated 4D DO results

- 3D is predominantly used to generate monthly average results by cell. This graphic is designed to compare a similar 4D output aggregation. ➡
- Differences in input data:
 - 4D is interpolating all the high frequency data across hours,
 - 3D interpolates grab samples manually split into bi-weekly periods.
- Difference in results:
 - 4D: Hourly interpolation results are averaged to the month.
 - 3D: Two bi-weekly estimates are averaged to the month.



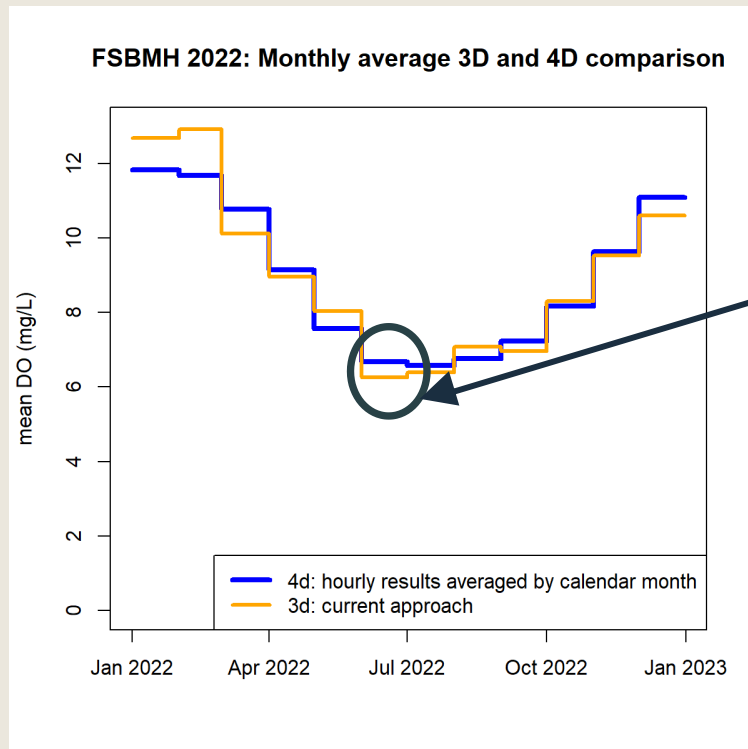
Compare 3D to rolling average 4D DO results

- With the hourly 4D results, it is easy to do a rolling 30-day average instead of only calendar month.
- Since grab samples are typically in the day-time, we also computed average 4D results that only include 8am – 5pm (darker line).
 - Daytime summer DO is very slightly higher than 24-hour.



Dig into 3D-to-4D discrepancies

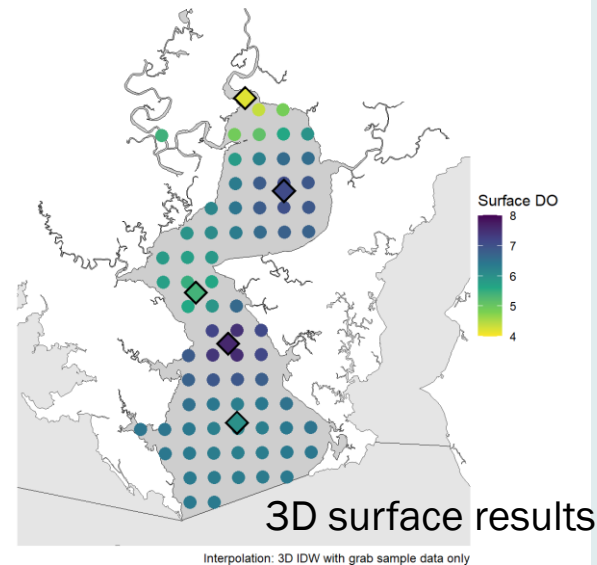
The 3D process of splitting the data into “cruises” and averaging the subsequent bi-weekly results seem to be the reason for all the discrepancies we checked (e.g., Jan, Feb, June). When equal coverage of data is not available in both the first and second half of the months, artifacts can appear in the 3D monthly averages.



Example 3D process and results for June 2022

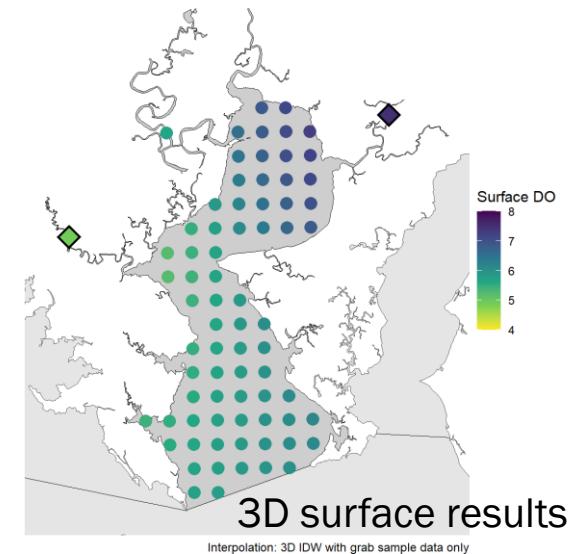
Early June: Sampling at most stations = expected DO interpolation results

Early June 2022: current approach



Late June: Only the two MDE tributary stations are in this period, so the interpolation is just a gradual change between them.

Late June 2022: current approach

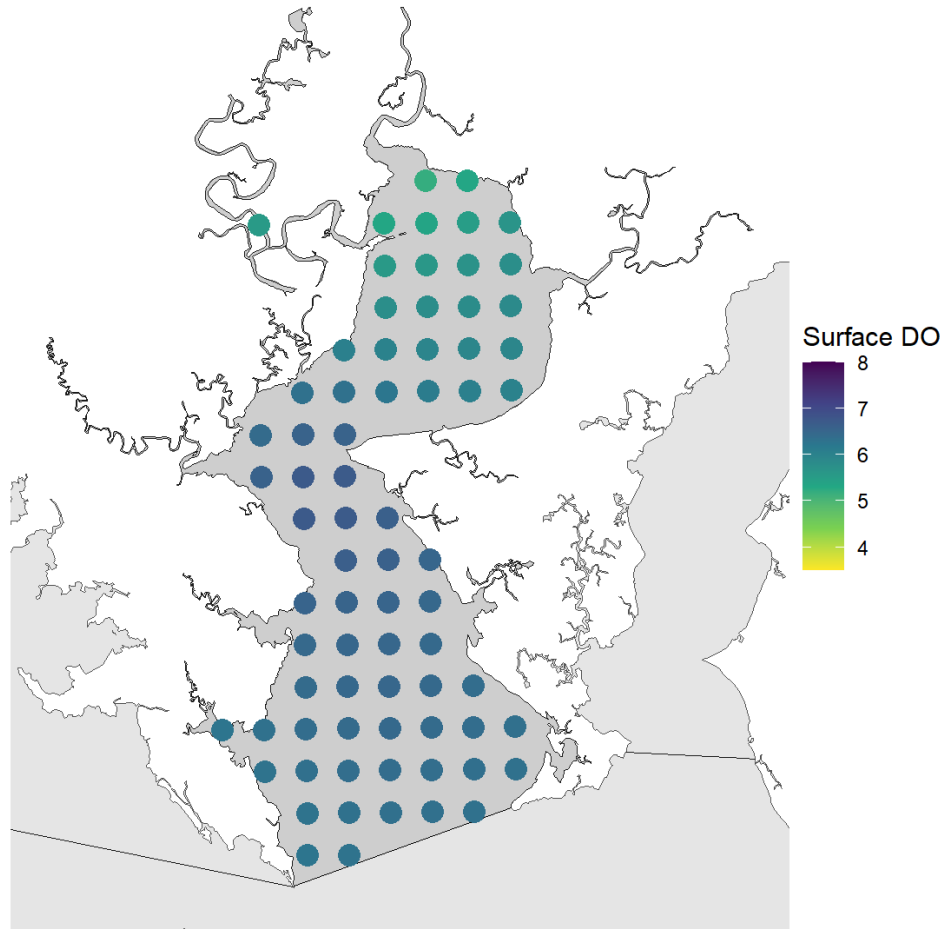


Result: When each cell is averaged between the “early” and “late” June 3D results, the result is lower overall estimates than is likely true. The 4D interpolator uses all data together and interpolates in time, avoiding this problem.

Compare spatial pattern: July

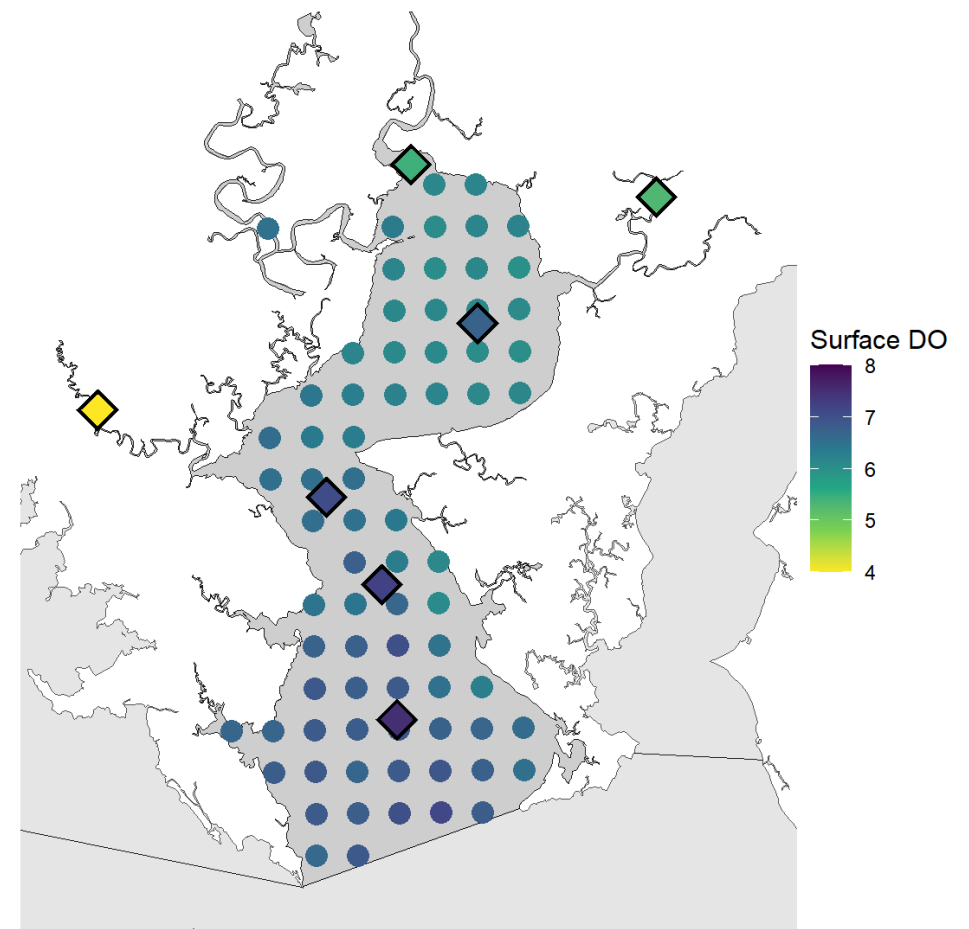
When DO data is evenly distributed in the month = Spatial pattern fairly similar between 3D and 4D.

3D: July average of two “cruises”*



Interpolation: 3D IDW with grab sample data only

4D: 30 day rolling average on July 15



Interpolation: 4D, data are monthly avg of all surface obs

*For 3D: Data was split into “early” and “late” and is not shown here. But July had more equal station distribution than June.

CFD result

Exceedance					Allowed exceedance			
Designated use	EE3.0	EE3.0+calibration	EE3.0+calibration+average	Sensor average only	EE3.0	EE3.0+calibration	EE3.0+calibration+average	Sensor average only
MSN	0.00%	0.00%	0.00%	0.00%	3.85%	4.12%	3.85%	4.61%
OW8	0.00%	0.00%	0.00%	0.00%	2.27%	2.27%	2.00%	2.17%
OWsum	0.00%	0.00%	0.00%	0.00%	3.85%	3.85%	3.90%	4.01%

(1) Average to avoid dominance of local sensor data.
(2) Sensor data extend to 4m deep, thanks to the profiler data.

This would be the standard result set

- Using the 4D results in a CFD is coming soon (not done here).
- But based on the data and the interpolation results, I suspect the same conclusion will occur with the 4D interpolator → because 30-day mean DO rarely falls below 5 mg/L.

Note MSN: applied the 6 mg/L, 7-day mean DO criterion as a 30-day mean for Feb-May

Summary and next steps

- The 4D interpolator is acting as expected with the FSBMH data, interpolating within the range of the observed DO and reproducing annual and short-term variability.
- We will be doing some comparisons to data in other segments as well.

Criteria-related analyses:

- Thank you for the document about a Fishing Bay comparison (*Fishing Bay Analysis – BORG.pdf*) and the discussion we already had on email.
- Also thank you to CAP team and Tish for the CFD-related options presented in July at CAP.
- We'll be coming back to both teams with questions as we implement the CFD options with 4D output.
- We will wrap up this summary of FSBMH for 2022-2024 by generating the CFD results for all criteria that apply.

extras

Table 1. Chesapeake Bay dissolved oxygen criteria.

Designated Use	Criteria Concentration/Duration	Protection Provided	Temporal Application
Migratory fish spawning and nursery use	7-day mean $\geq 6 \text{ mg liter}^{-1}$ (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 $\geq 5 \text{ mg liter}^{-1}$	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 $\geq 5.5 \text{ mg liter}^{-1}$ (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 $\geq 5 \text{ mg liter}^{-1}$ (tidal habitats with >0.5 ppt salinity)	Growth of larval, juvenile and adult fish and shellfish; protective of threatened/endangered species.	
	7-day mean $\geq 4 \text{ mg liter}^{-1}$	Survival of open-water fish larvae.	
	Instantaneous minimum $\geq 3.2 \text{ mg liter}^{-1}$	Survival of threatened/endangered sturgeon species. ¹	
Deep-water seasonal fish and shellfish use	30-day mean $\geq 3 \text{ mg liter}^{-1}$	Survival and recruitment of bay anchovy eggs and larvae.	June 1 - September 30
	1-day mean $\geq 2.3 \text{ mg liter}^{-1}$	Survival of open-water juvenile and adult fish.	
	Instantaneous minimum $\geq 1.7 \text{ mg liter}^{-1}$	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 $\geq 1 \text{ mg liter}^{-1}$	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.

EE3.0 in 2022 with 50 simulations at location

FSBMH | sg_004 | uidstr 4110004238000

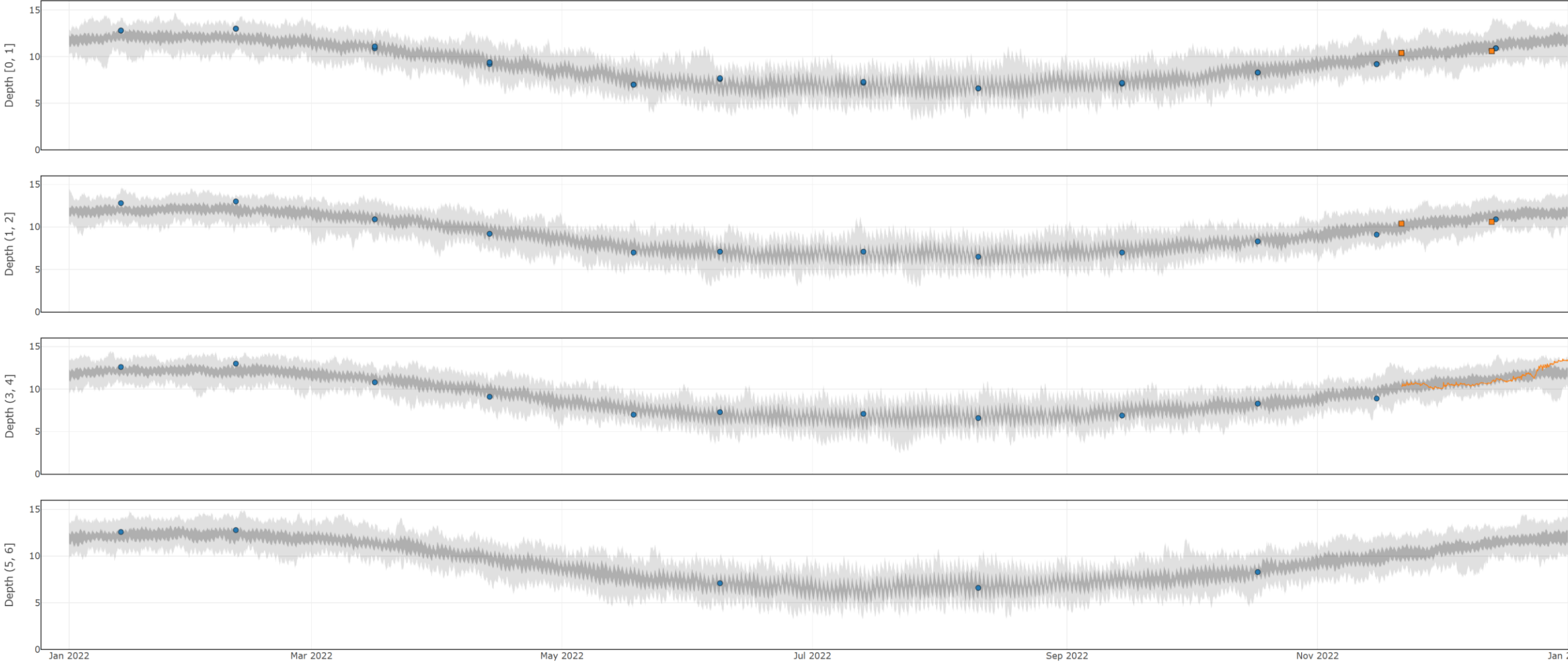
MC p00-p100 MC p25-p75 MC sims MC median EE3.0 XCH6891

X:

1w 2w 4w 8w all

Y:

Y: 0-4 Y: 0-8 Y: 0-16 Y: all



EE3.0 in 2022: showing just one simulation

FSBMH | sg_004 | uidstr 4110004238000

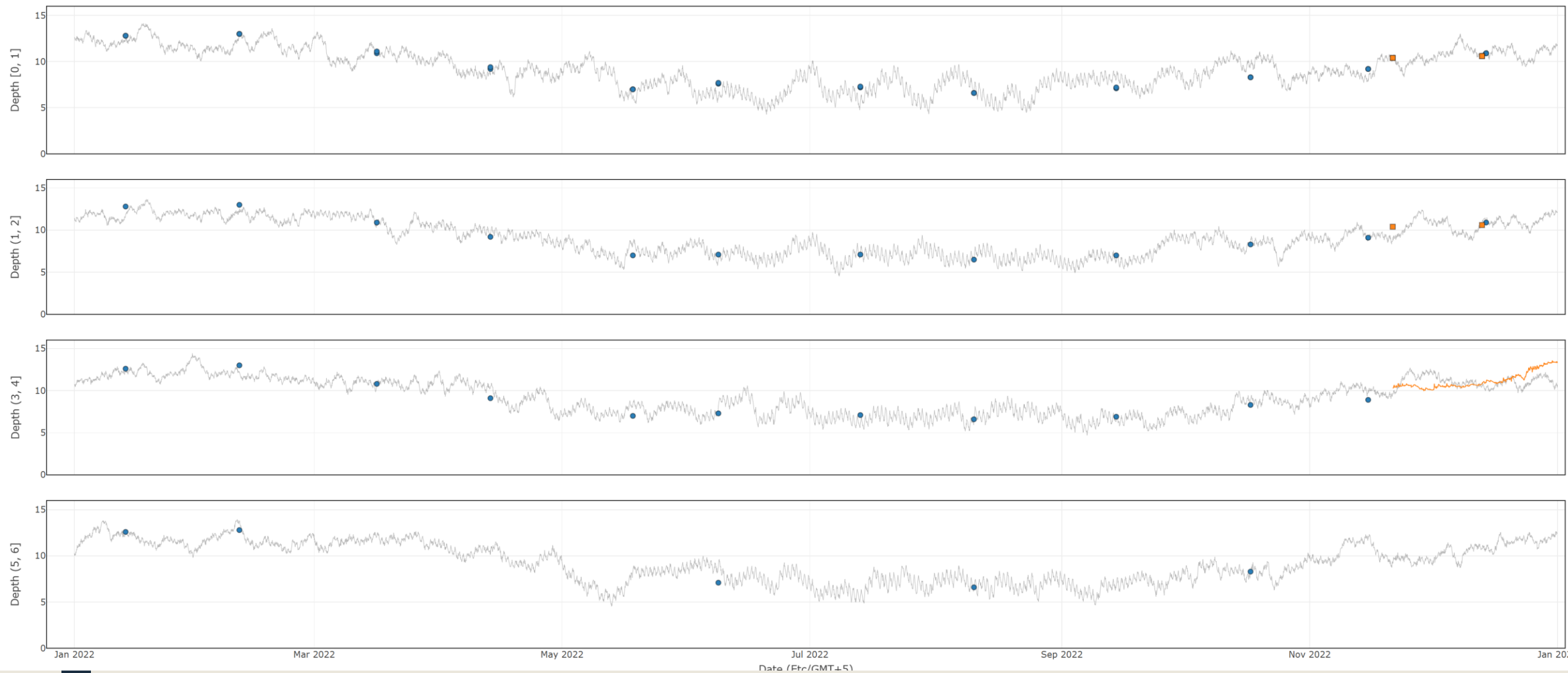
MC p00-p100 MC p25-p75 MC sims MC median EE3.0 XCH6891

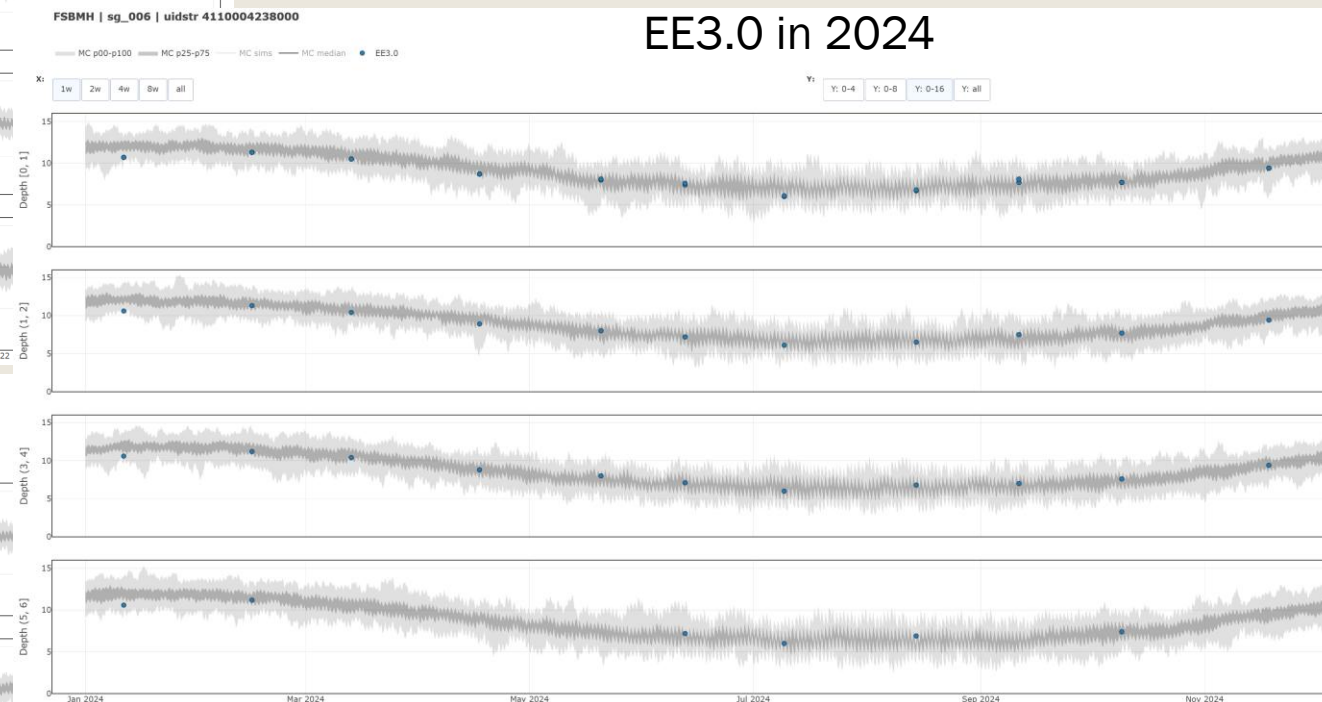
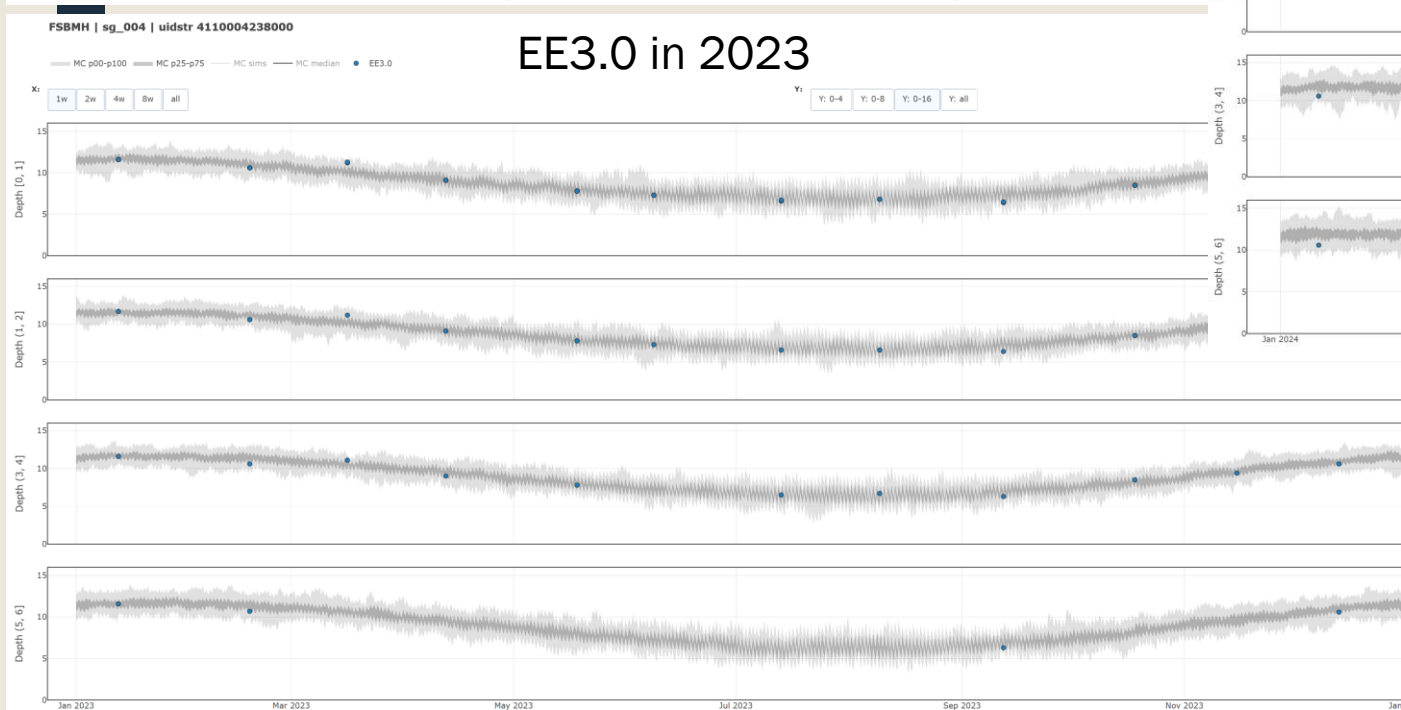
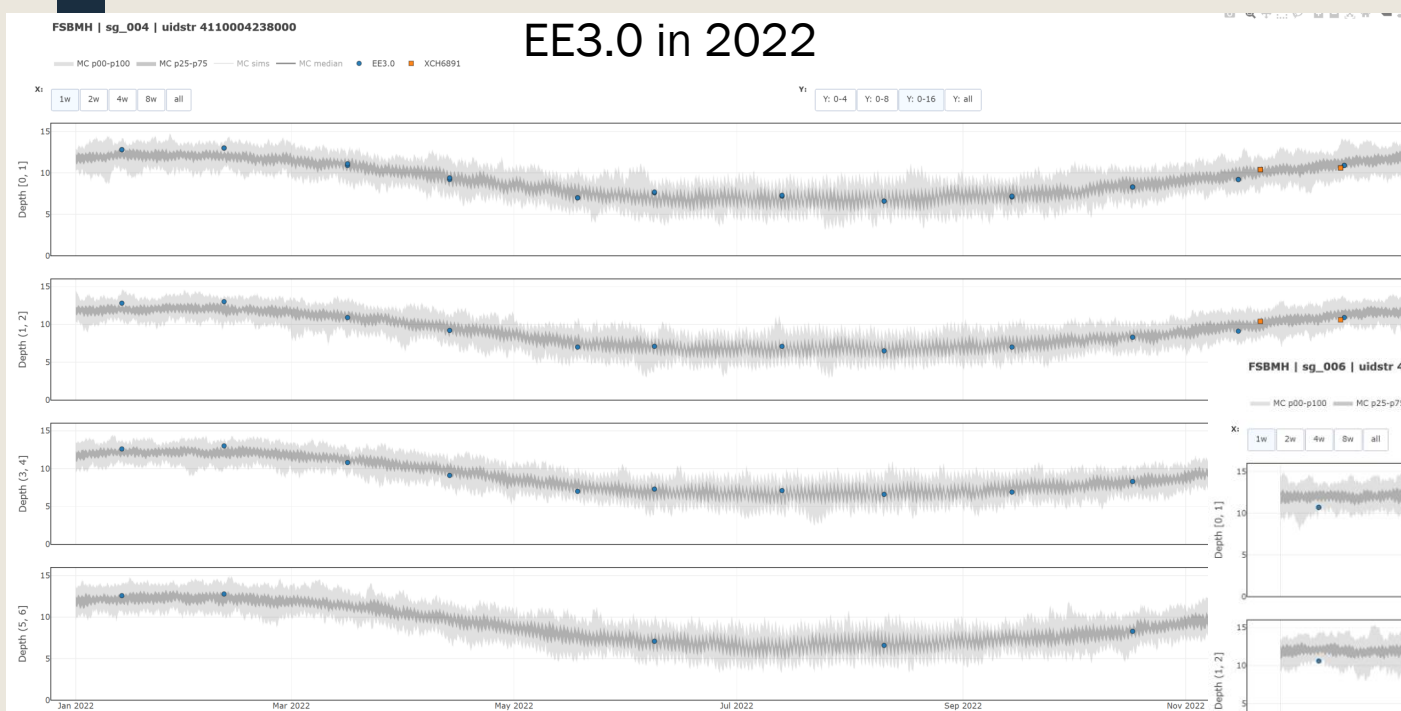
X:

1w 2w 4w 8w all

Y:

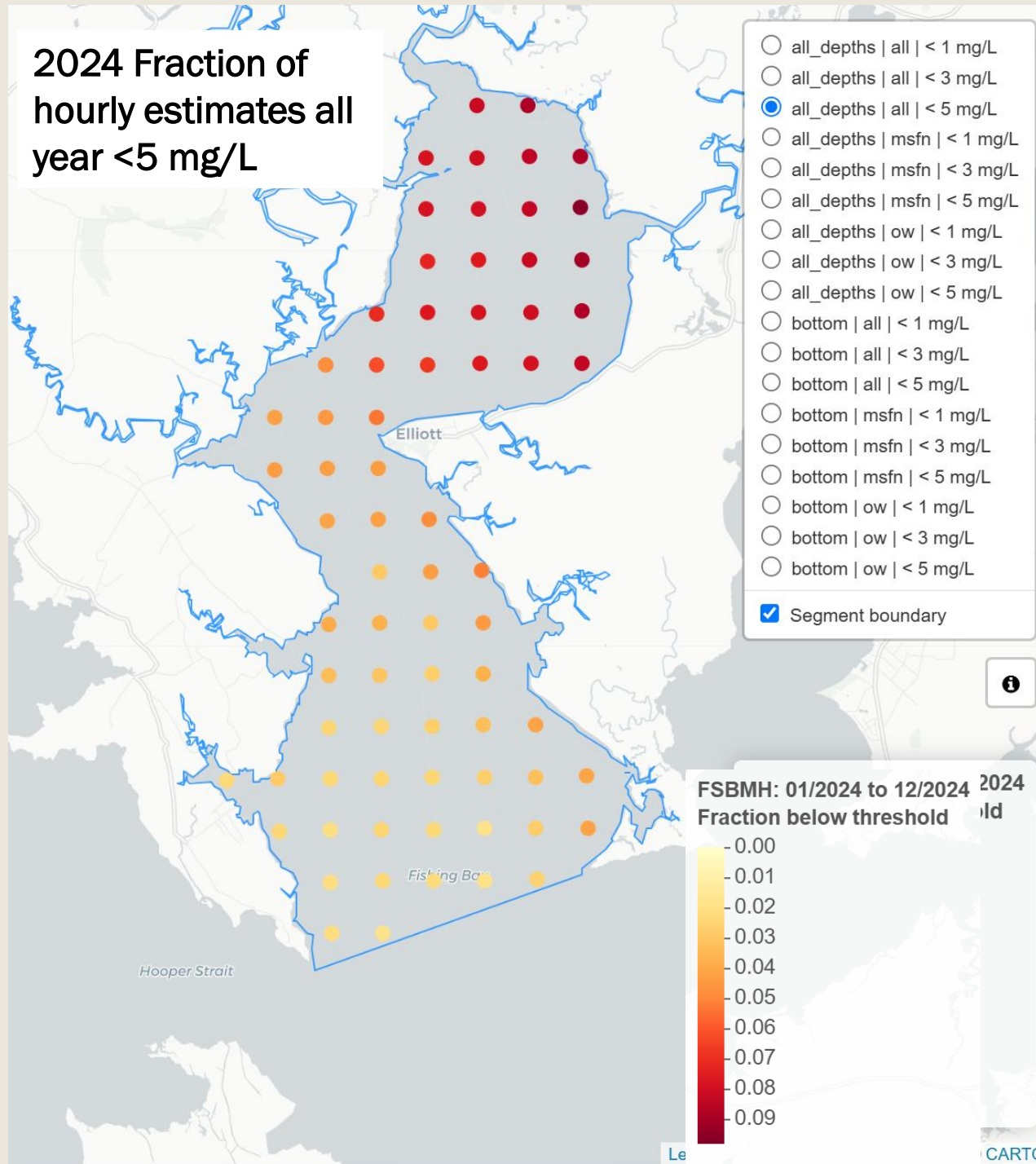
Y: 0-4 Y: 0-8 Y: 0-16 Y: all





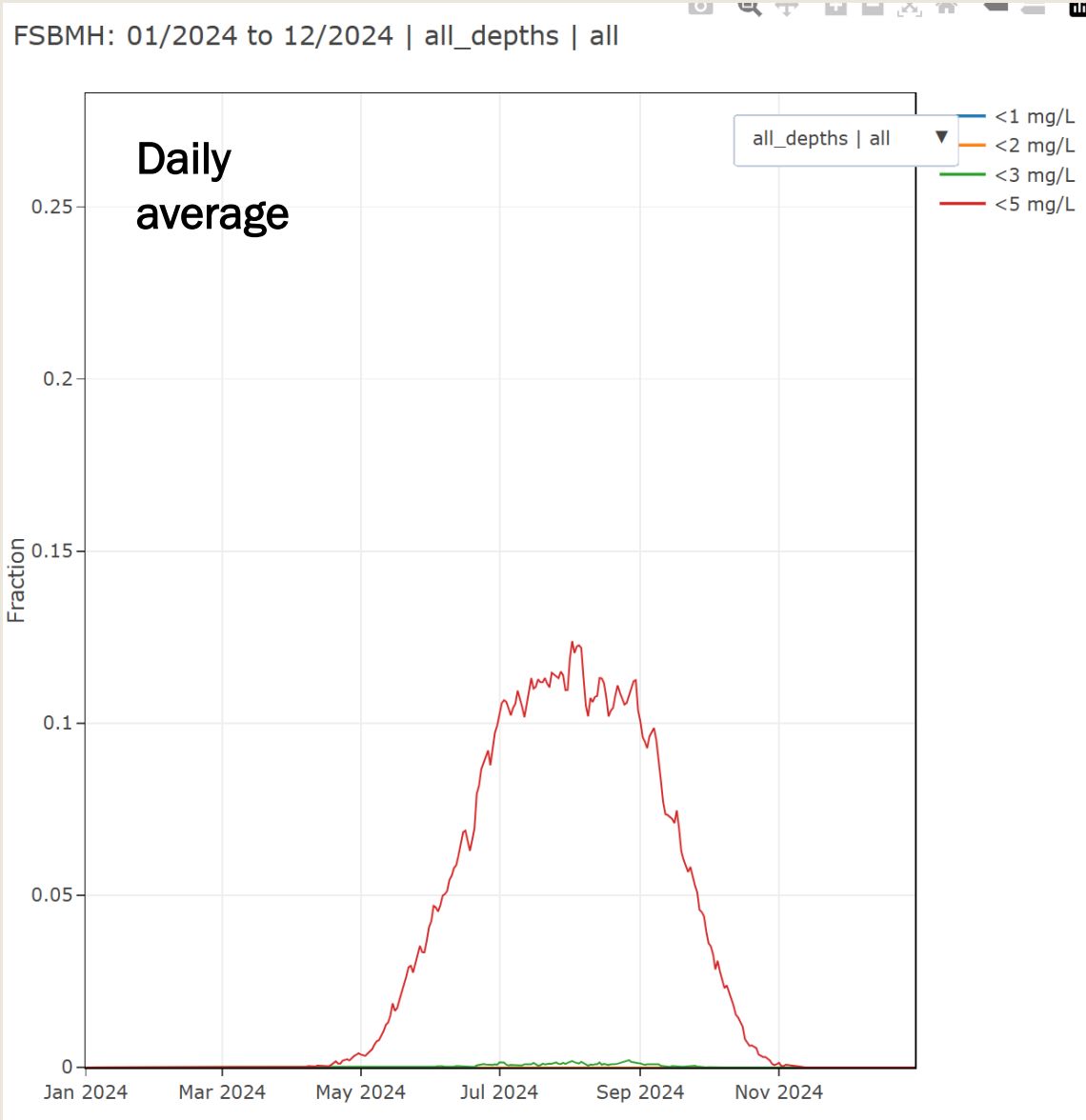
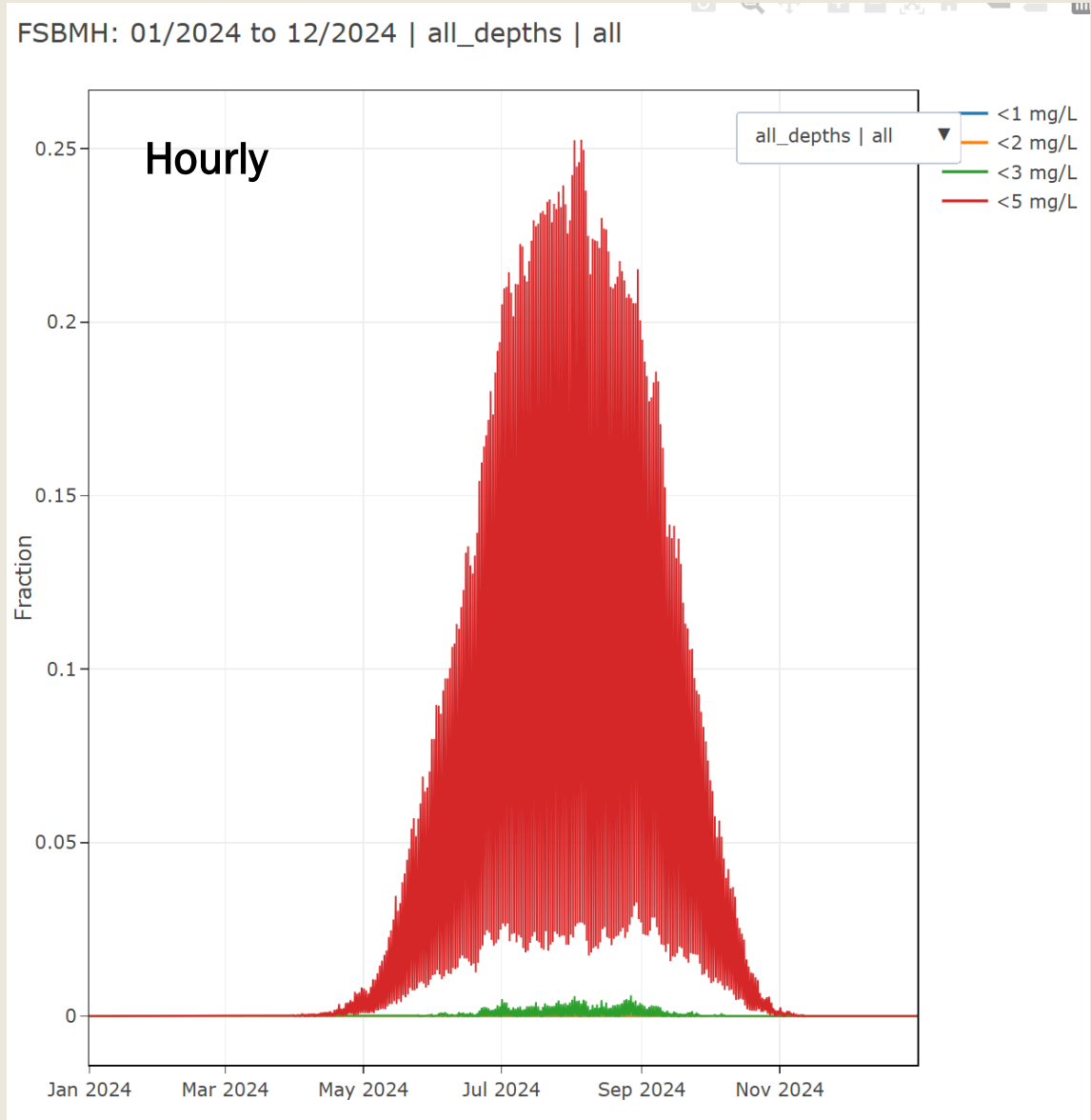
- Data falls within the simulations' values across years and depths.
- Not much difference year-to-year at this station.

2024 Fraction of hourly estimates all year <5 mg/L

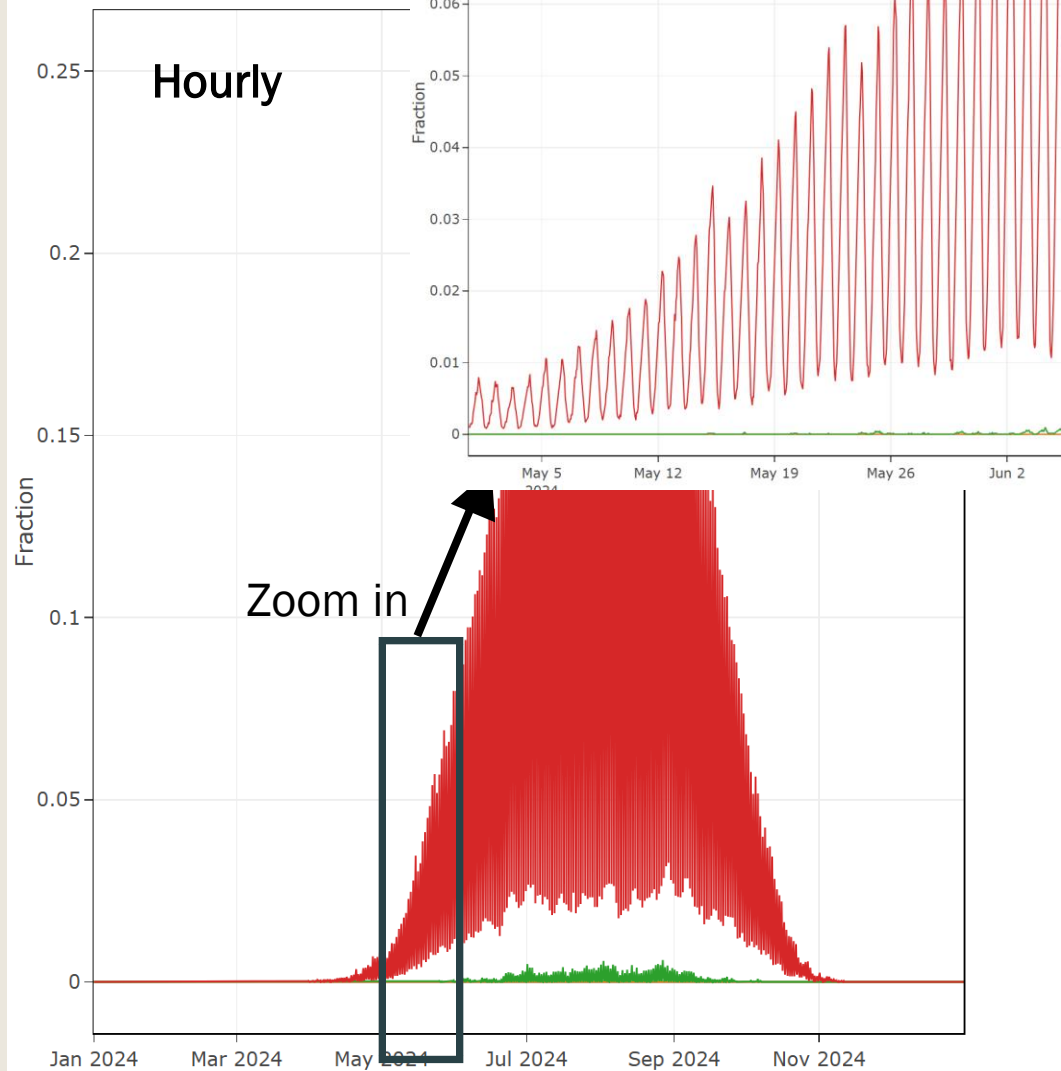


- These are very small fractions (max 8.09%).

Fraction of volume less than DO thresholds: Hourly and daily average segment-wide summaries
2024: 50 simulations for FSBMH



FSBMH: 01/2024 to 12/2024



FSBMH: 01/2024 to 12/2024

