

Choptank Tributary Model

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Major progress

1. Coupling with main bay model

- **Small model (original model) vs large model (current model)**

2. Low DO problem in Choptank

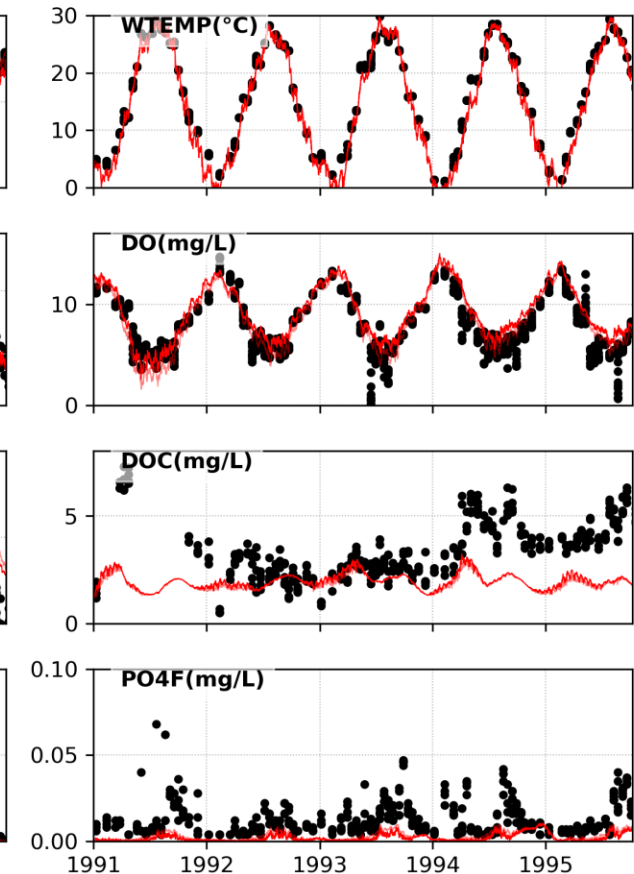
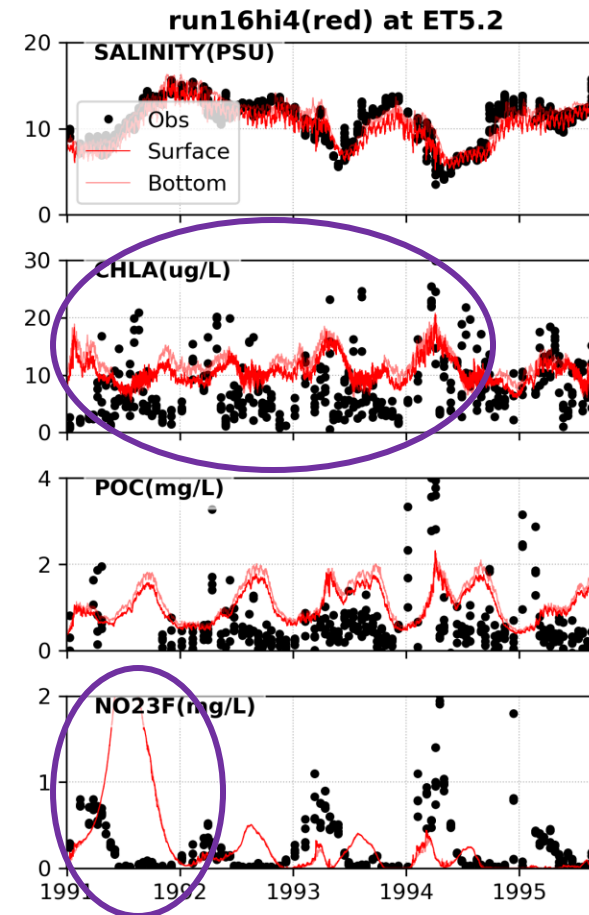
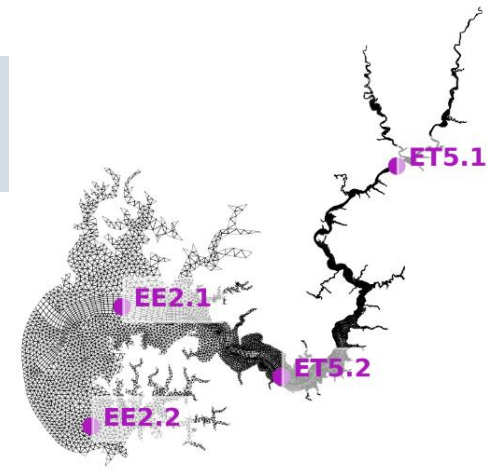
- **Stratification**
- **Bottom main bay water intrusion**

Coupling with main bay

Coupling with main bay:
Boundary condition from MBM

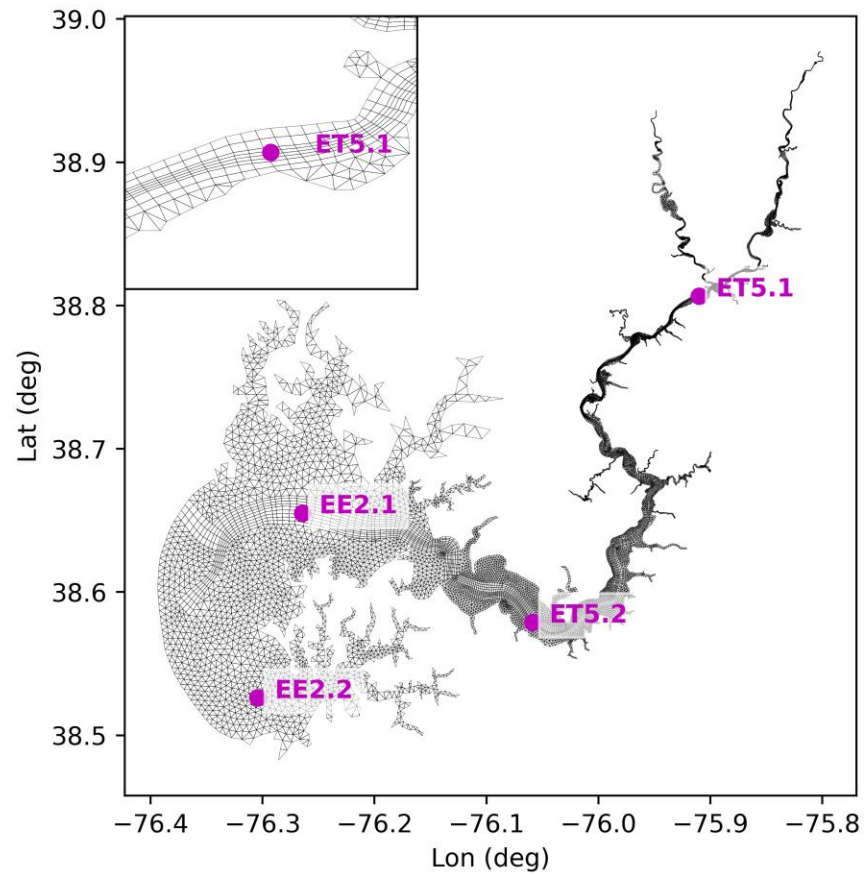
Previous problems

- High Chla variability not captured
- Abnormally high NO₂₃
- DOC magnitude not captured
- Finer resolution of grid does not make difference

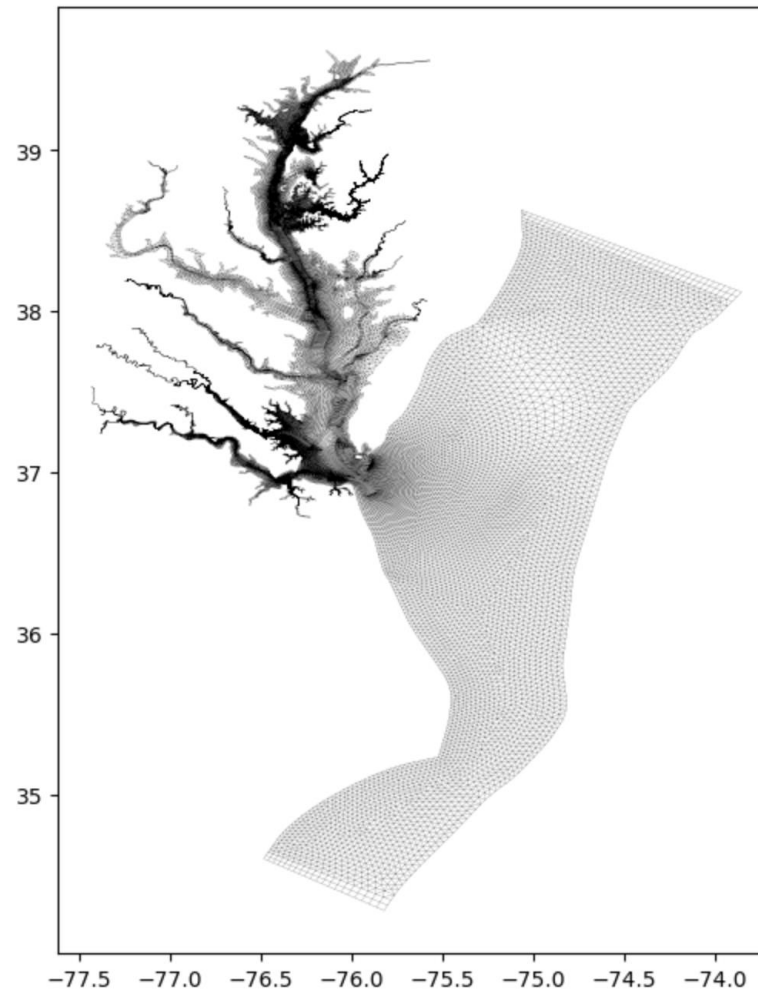


Coupling with main bay

Small model

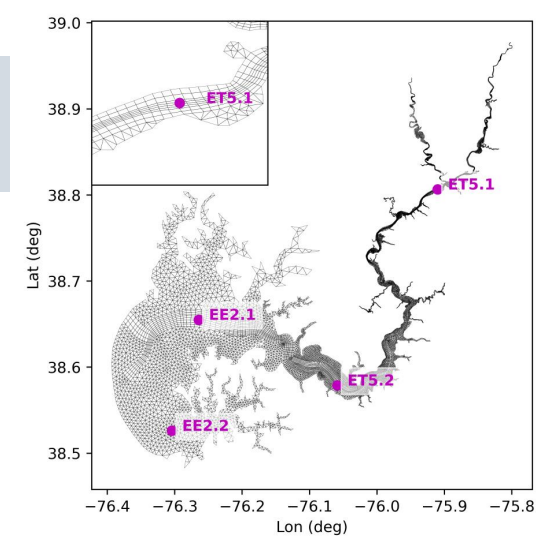
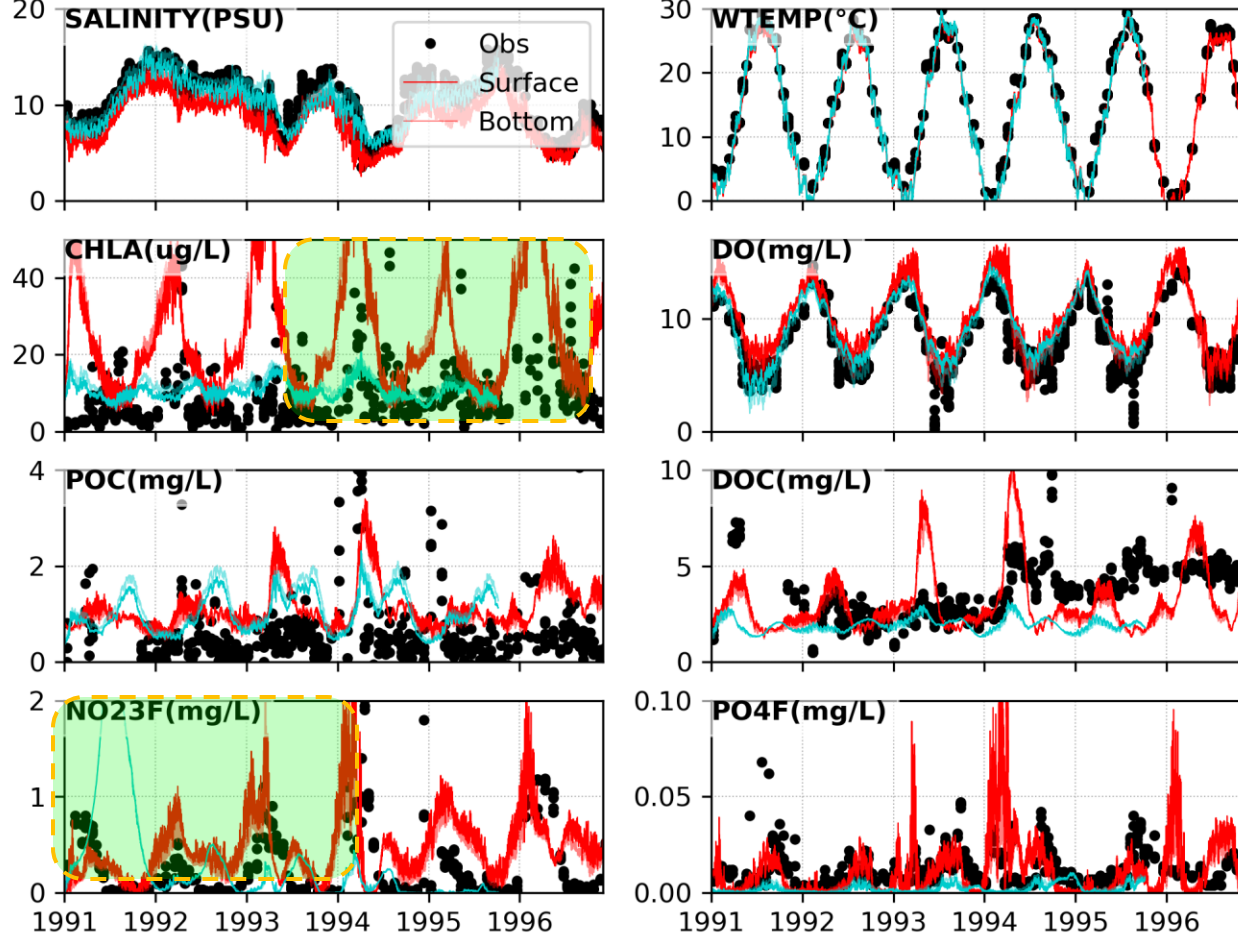


Big model



Coupling with main bay

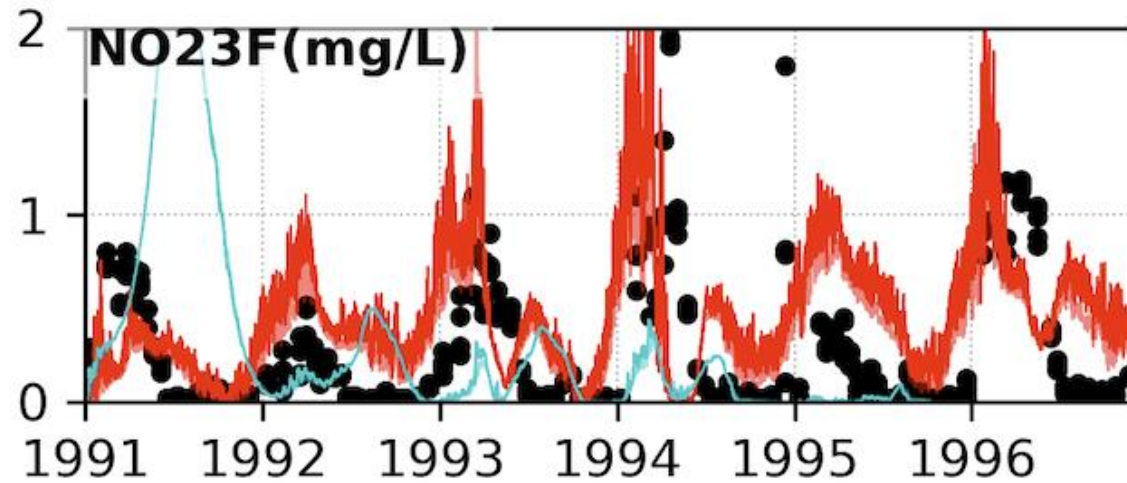
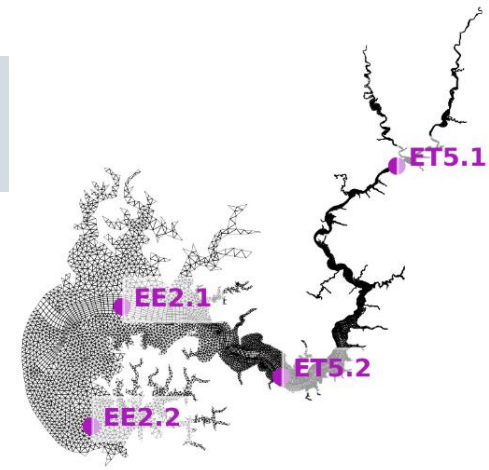
run17c (red) vs run16hi4 (cyan): at ET5.2



Improvements:

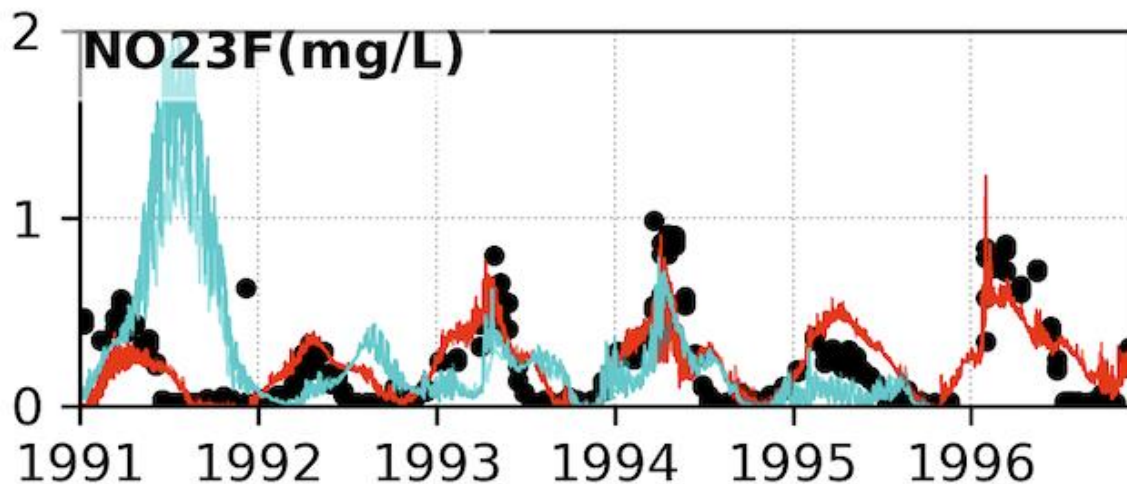
- No issue for wind wave boundary
- Larger variability of Chla
- No abnormal value of NO23
- Better seasonality and magnitude for NO23

Coupling with main bay



At station ET5.2

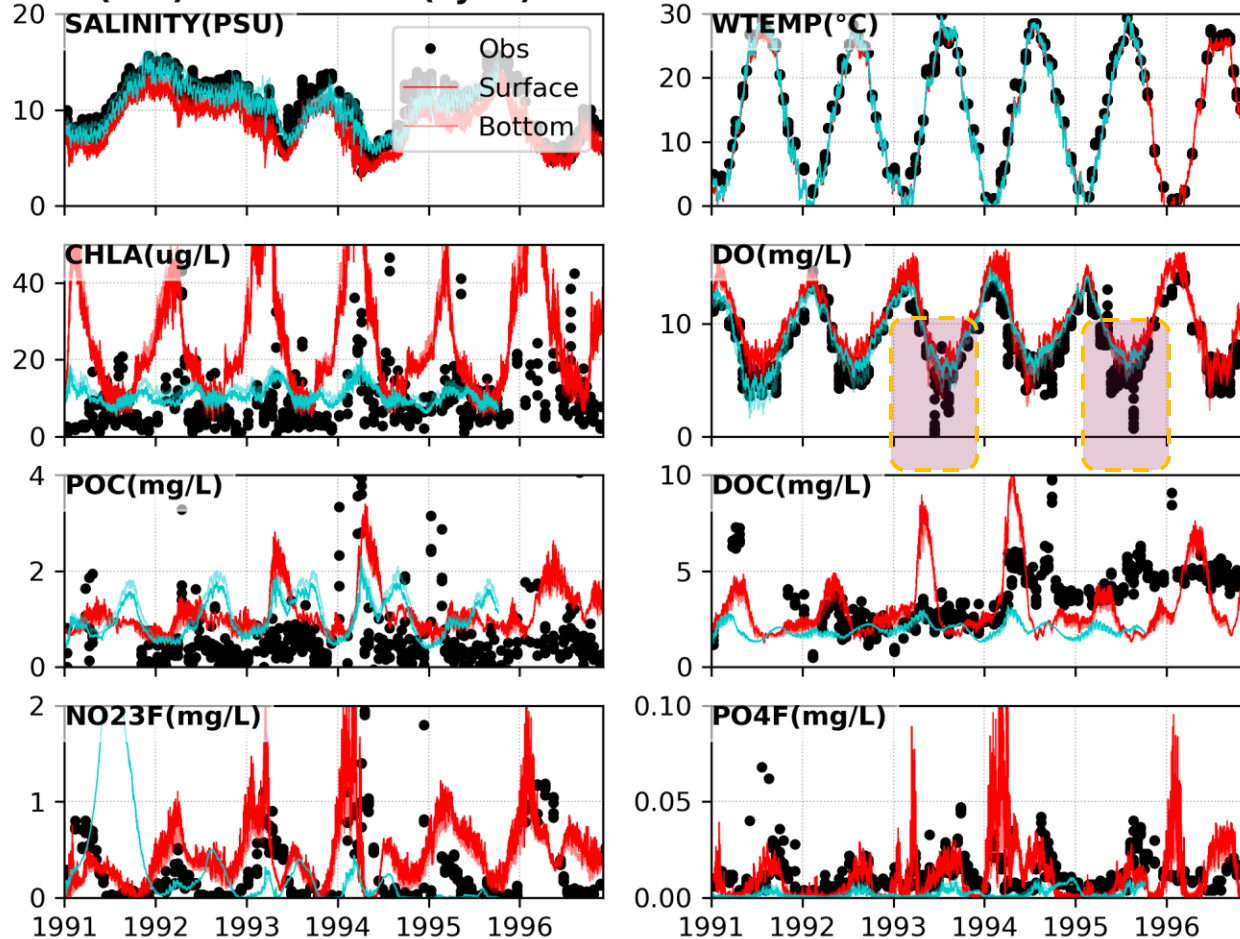
In small model (cyan color)
Abnormal appears in the lower
estuary at EE2.1.



At station EE2.1

Coupling with main bay

run17c (red) vs run16hi4 (cyan): at ET5.2



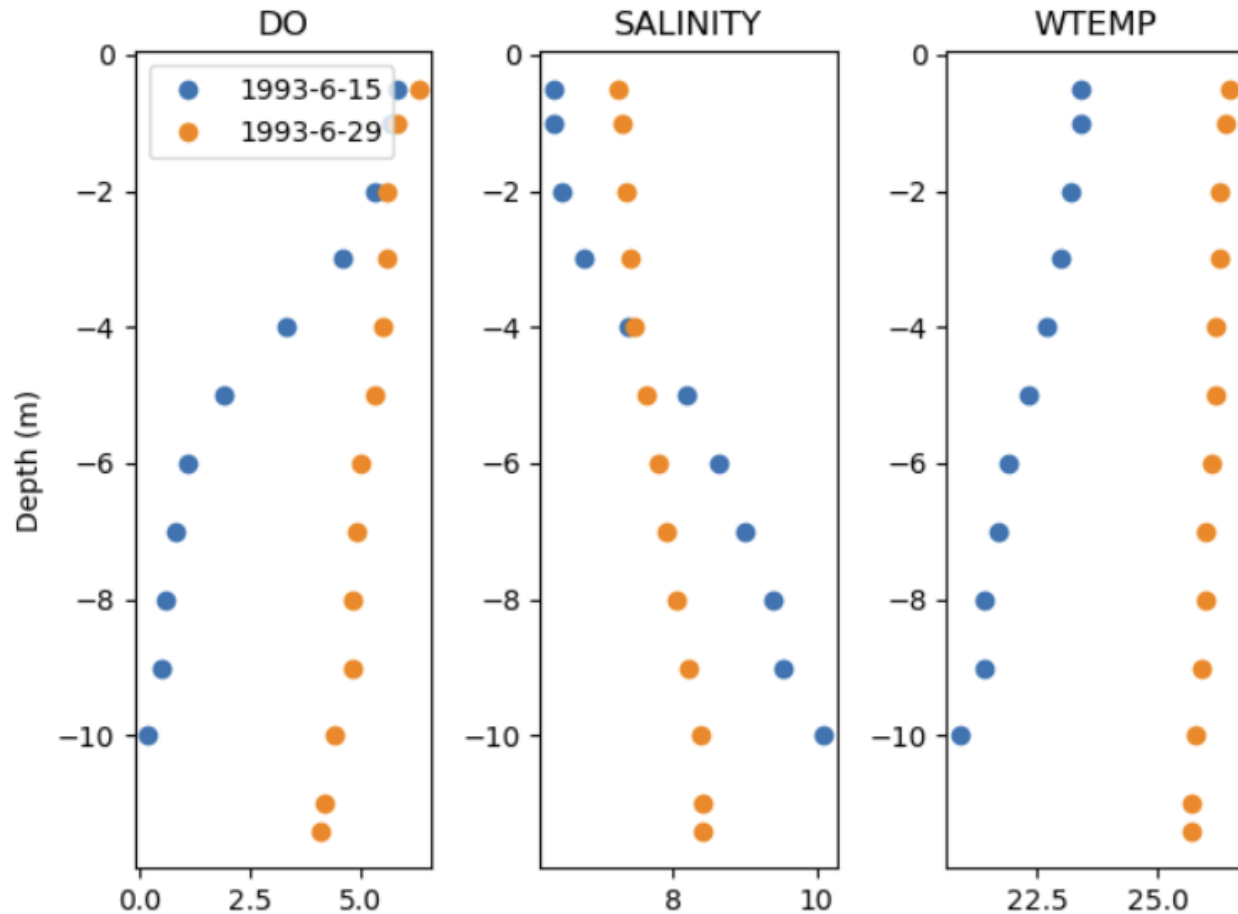
Problems persists:

Low DO in summer of 1993 and 1995 not resolved.

What happened in the summer of 1993 and 1995?

Summer hypoxia in 1993

June 1993

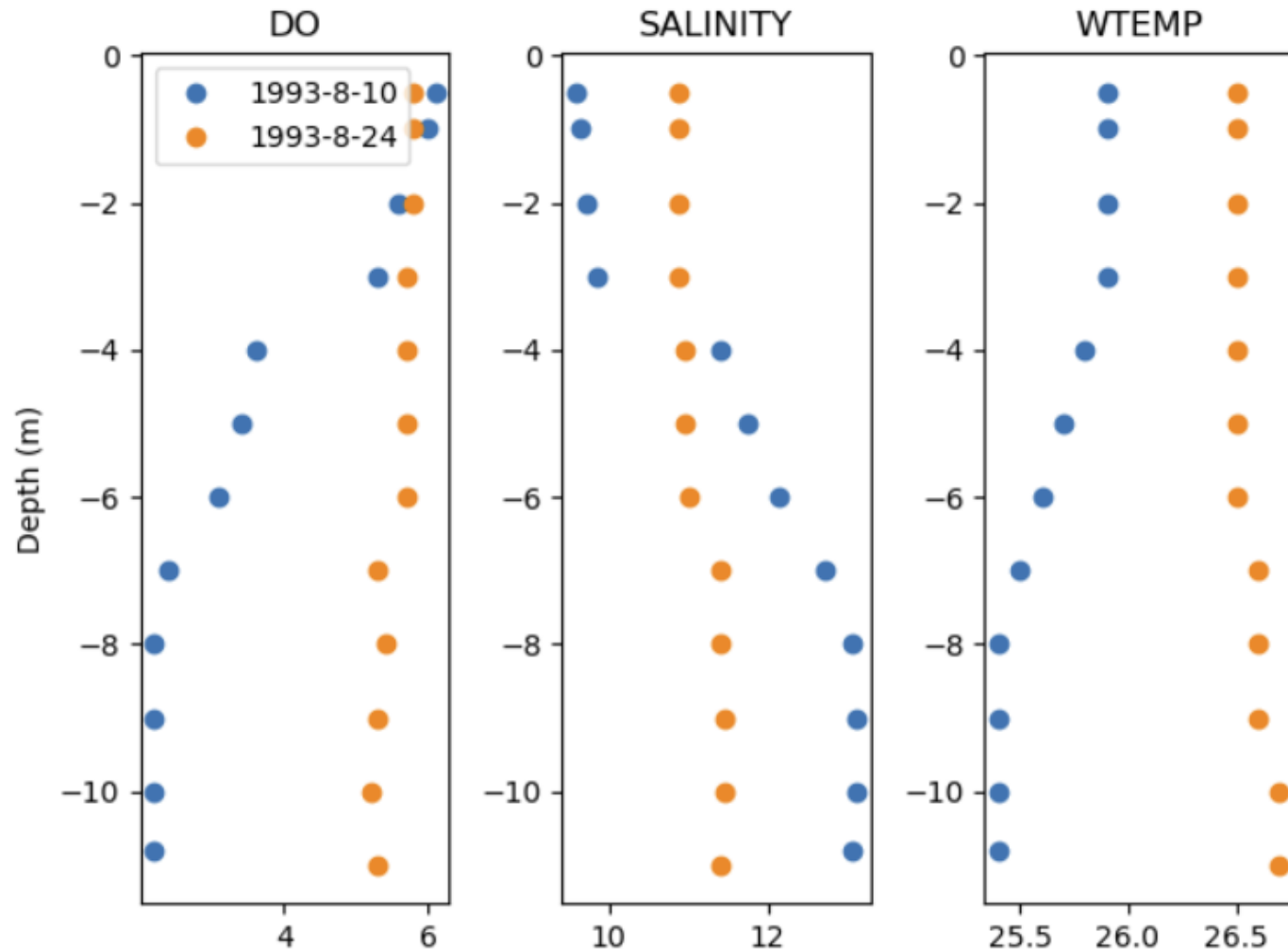


Two surveys in June of 1993 show distinctly different DO and salinity profile.

Stronger stratification on 06/15 accompanied with low DO

Summer hypoxia in 1993

August 1993

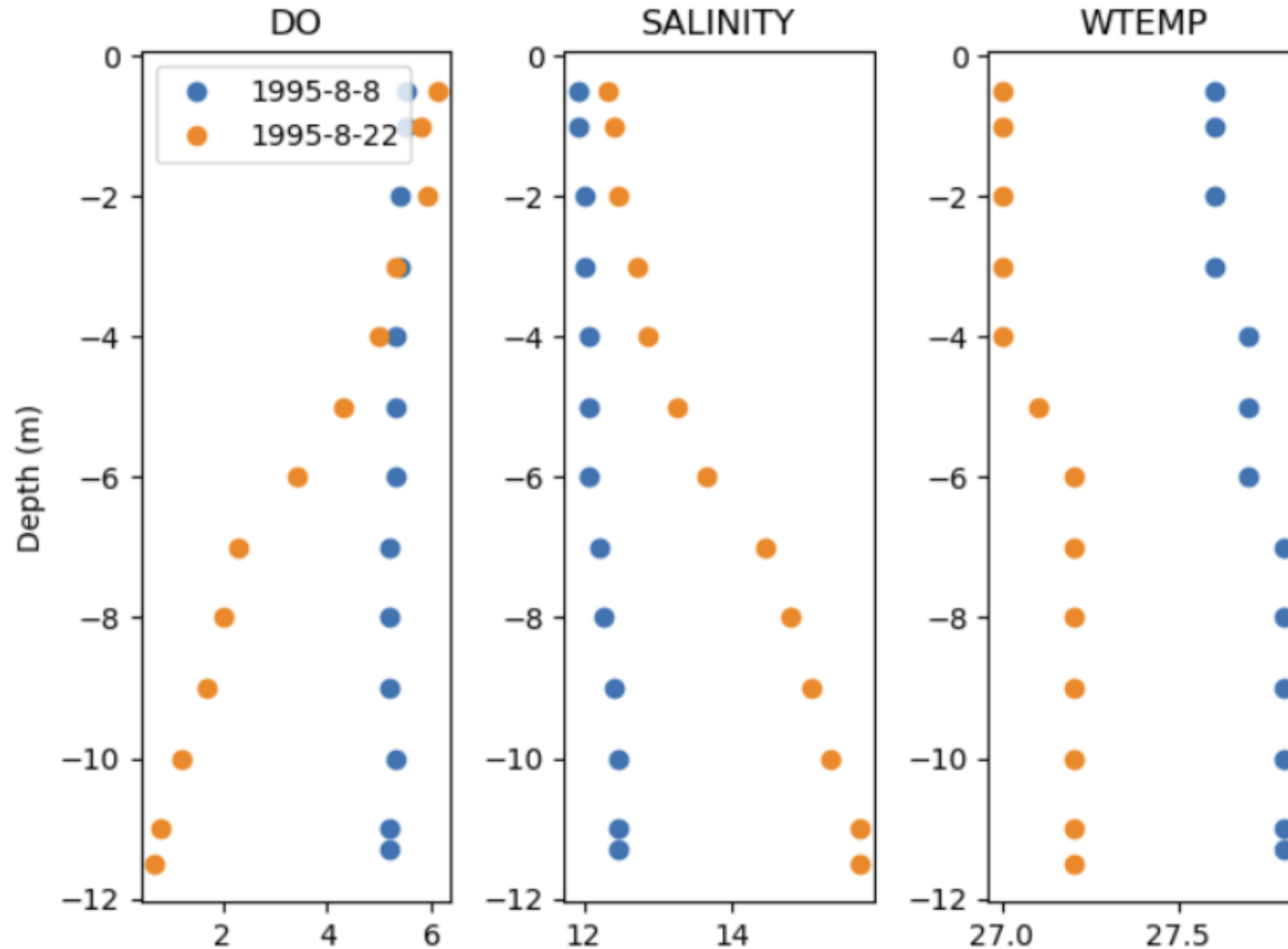


Two surveys in August of 1993 show distinctly different DO and salinity profile.

Stronger stratification on 08/10 accompanied with low DO

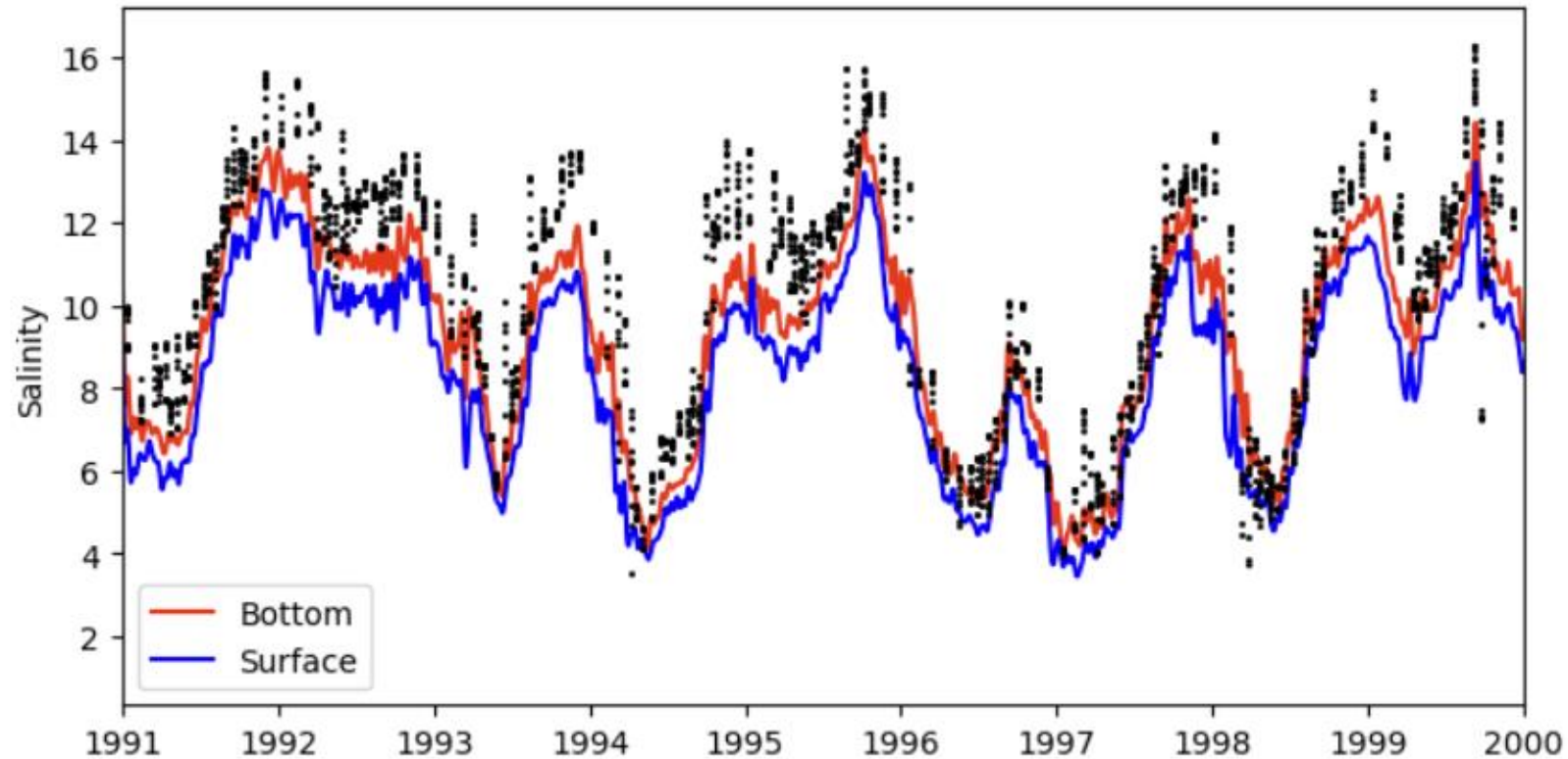
Similar cases happened in summer of 1995

August 1995



Bottom anoxic condition happened on 08/22. There was also a notable stratification (bottom-surface salinity about 4 psu)

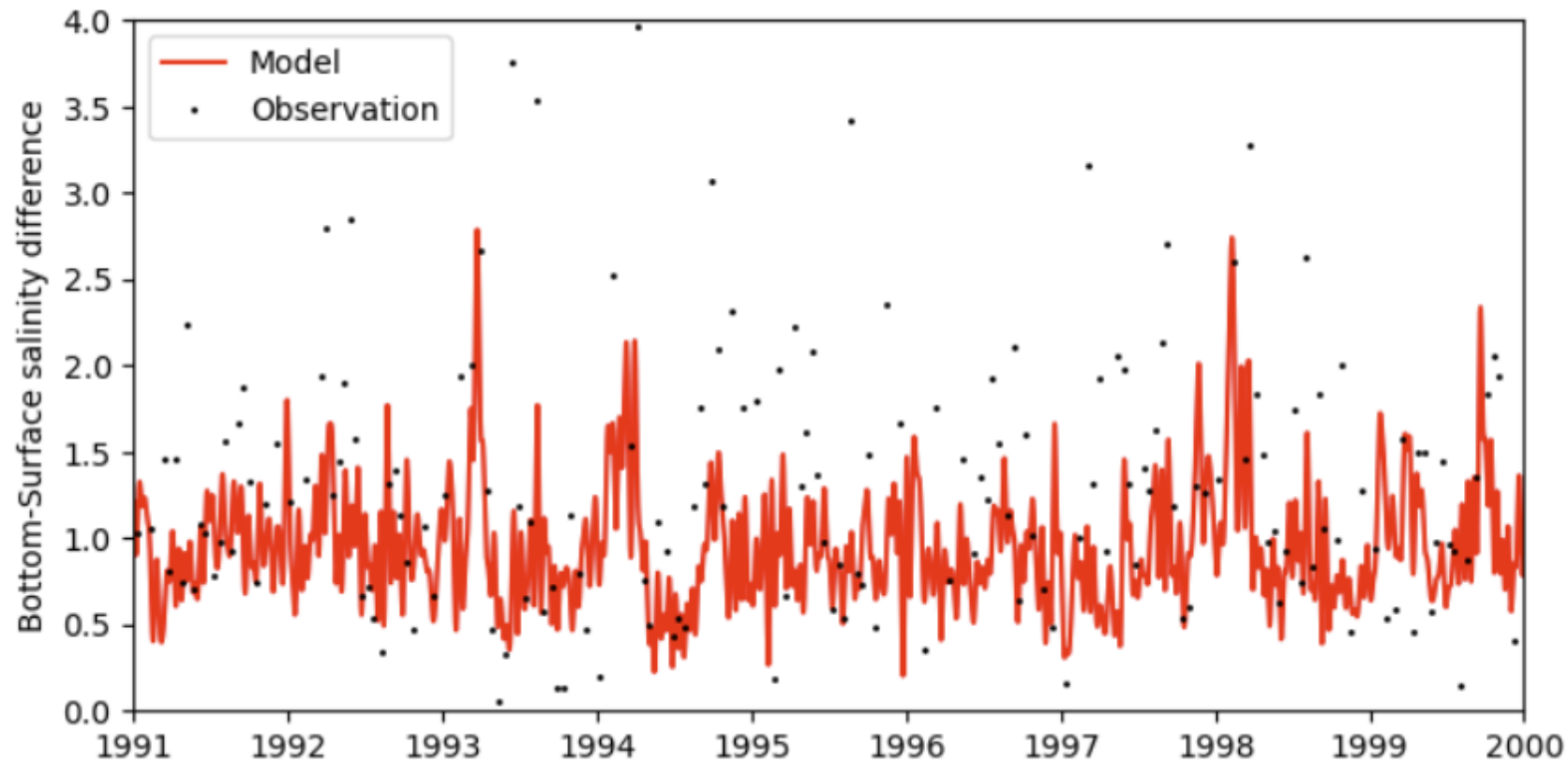
Salinity and stratification at ET5.2



Subtidal salinity (low-pass filtered) for bottom and surface is shown here.

Bottom-surface salinity difference

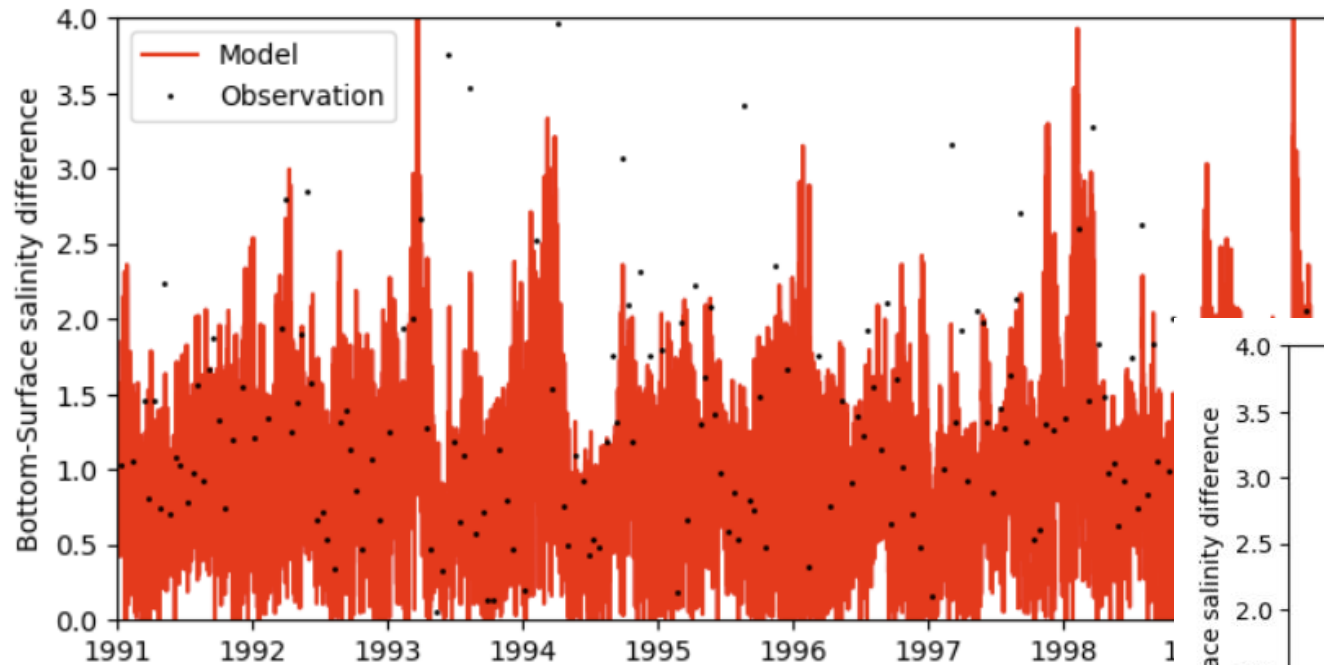
Subtidal salinity is shown here



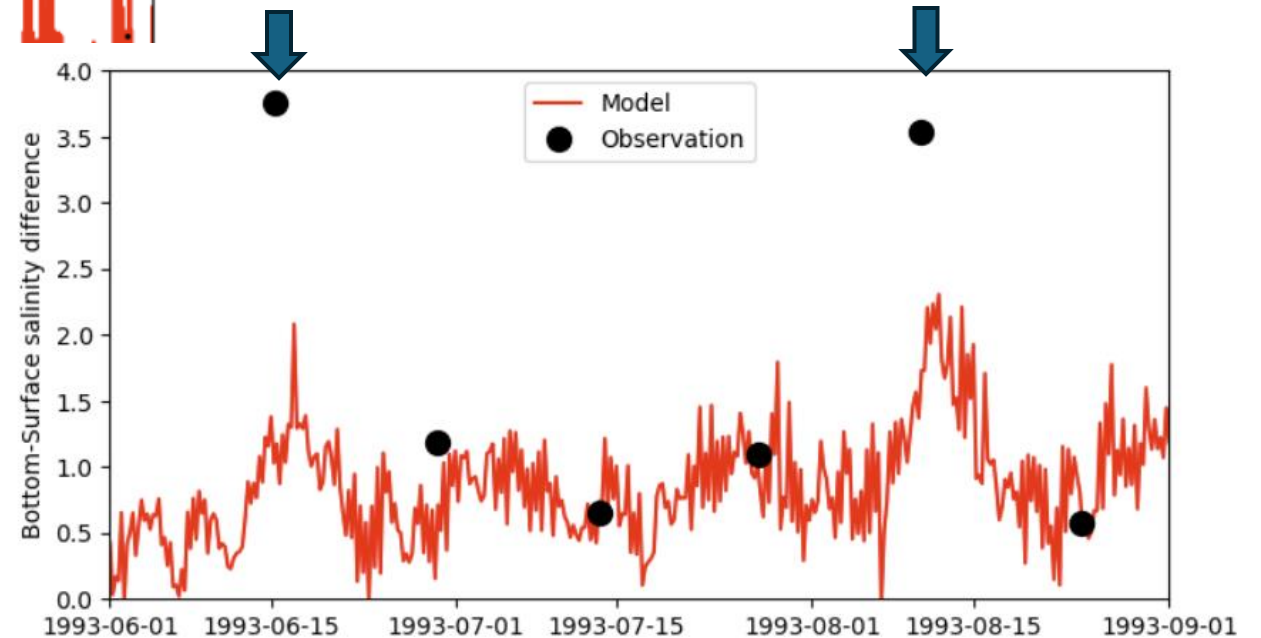
Model rarely captures
the stratification
peaks

Bottom-surface salinity difference (ΔS)

Due to tidal straining, the stratification will vary over tidal stage.
With full signal of ΔS , stronger stratification could happen.



However, in the summer of 1993, the peak stratification is still not well reproduced even with the full signal of ΔS



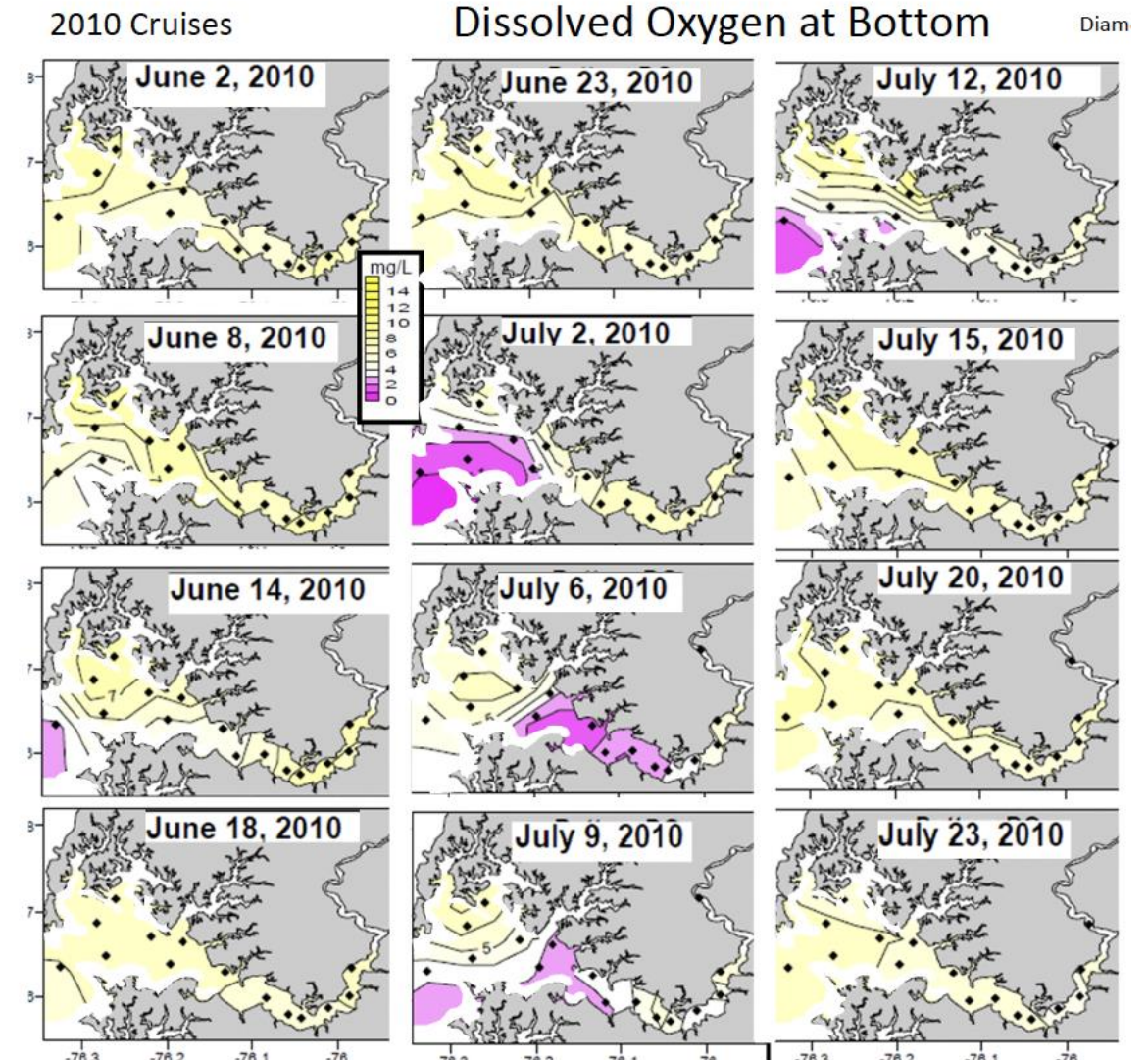
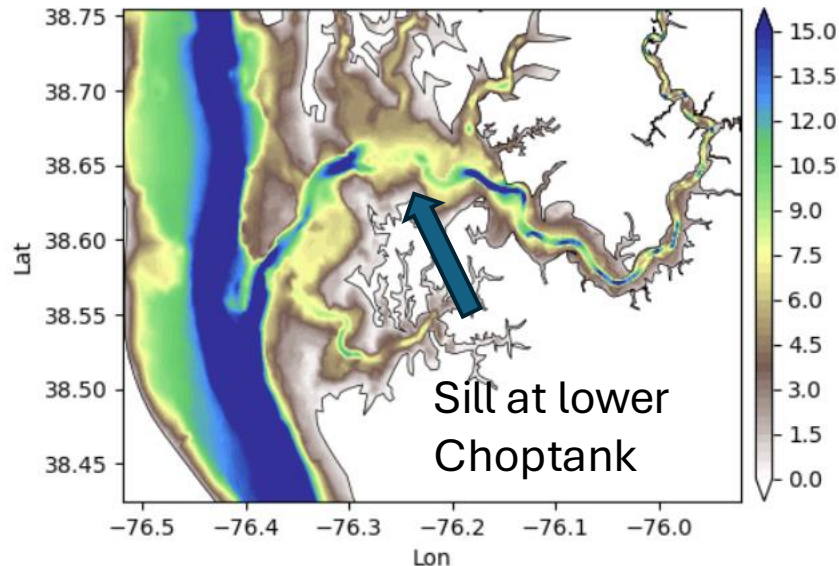
Stratification and salt intrusion is critically important

❑ Contribution from local process

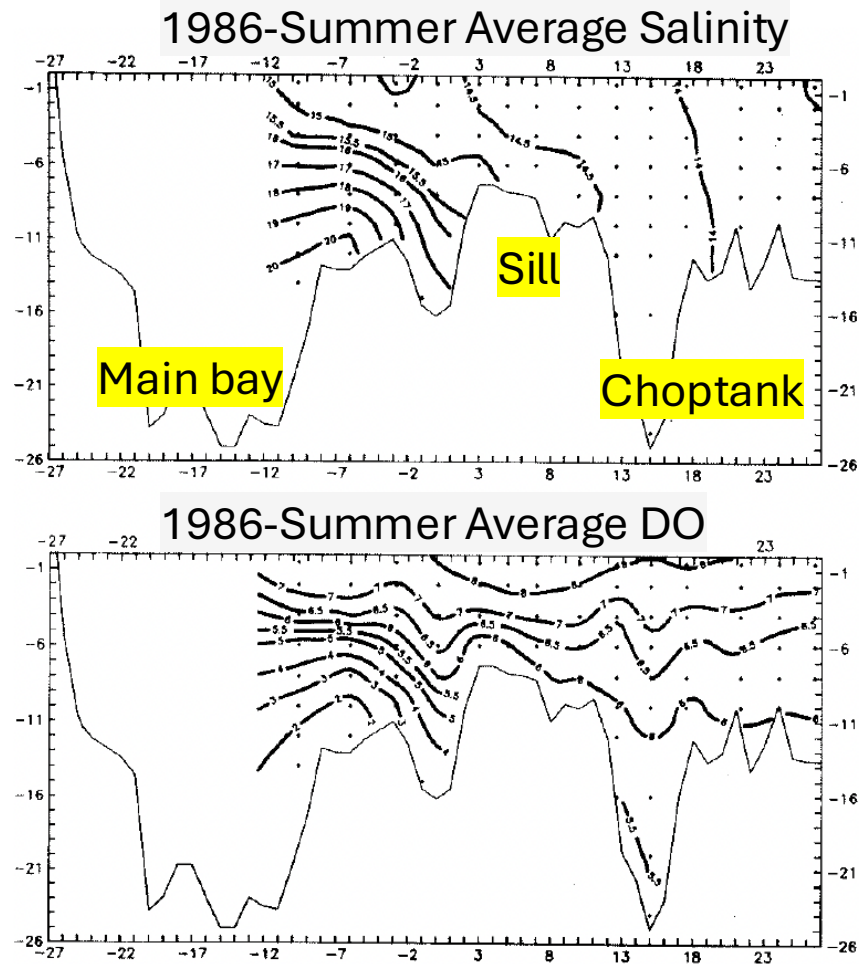
❑ Hypoxic water from main bay

Example in July 2010

- Notable hypoxic water move from main bay.
- The hypoxic water moved over the sill and stay in the lower Choptank Estuary.



Upwelling of bottom main bay water



Influence of sill:

Sill effectively block intrusion of main bay bottom water (salty and low DO)

“There is high inverse spatial correlation between averaged salt and average DO in the lower layer” - Sanford & Boicourt, 1990

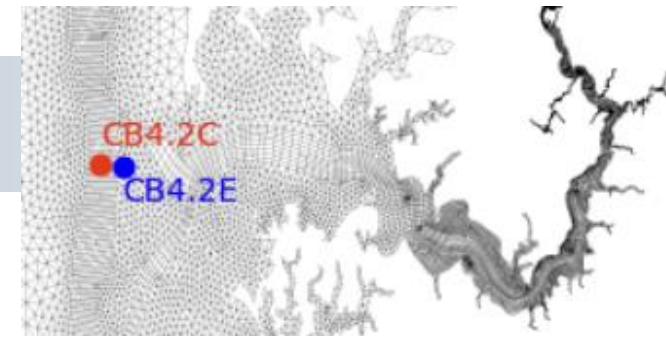
Sanford and Boicourt, 1990

Hypoxia at station CB4.2C and CB4.2E

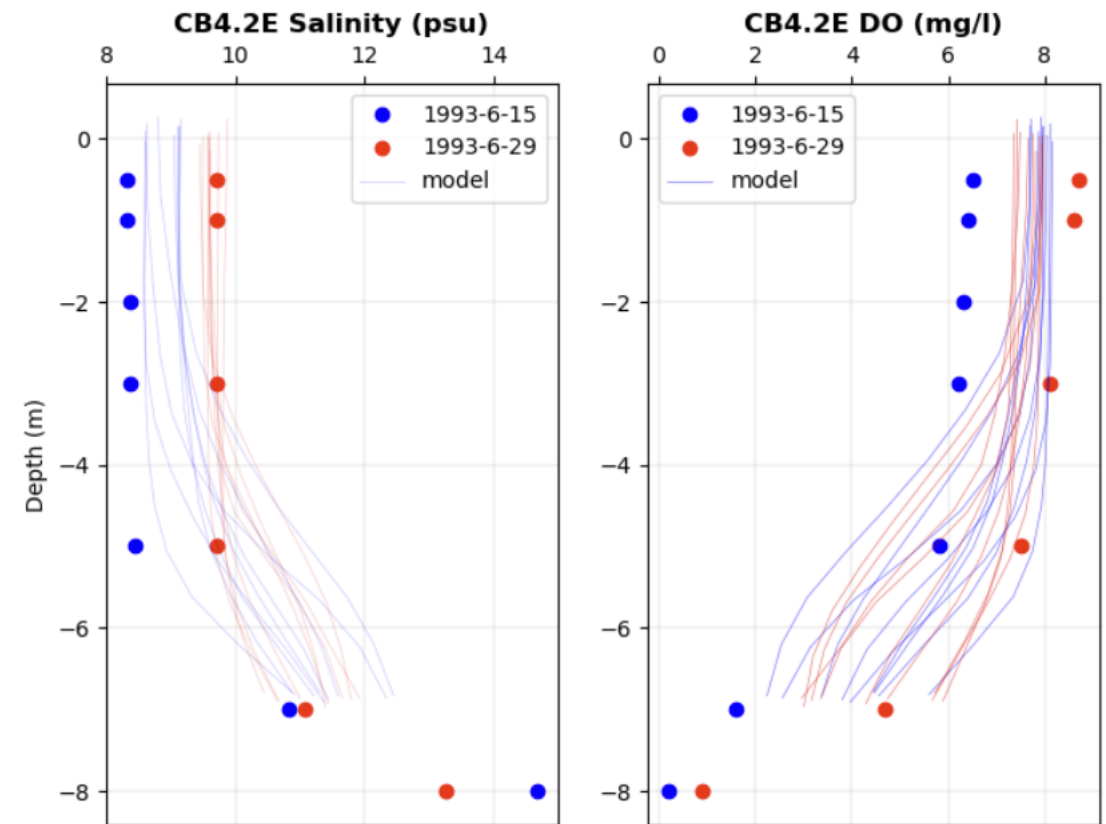
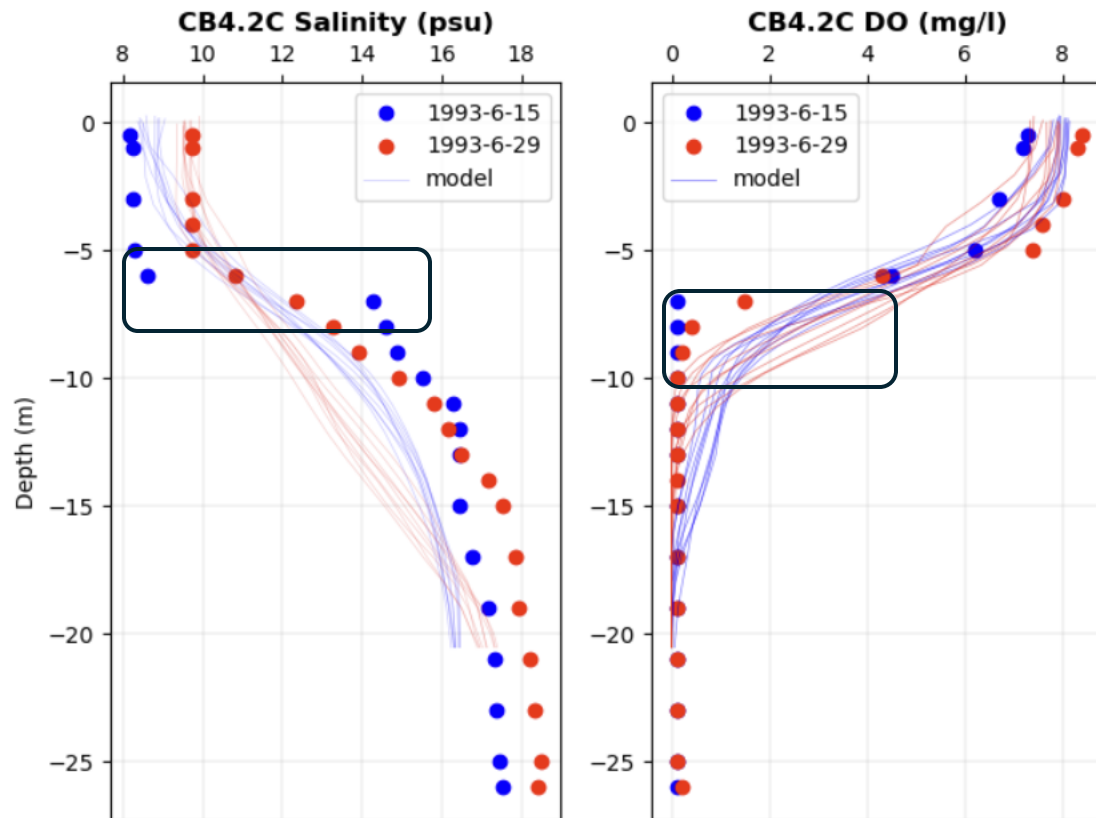
June 1993: Hypoxia occurred in the bay's main stem

Observation: anoxia at depth of 7m.

Model: anoxia at depth of 10-20m; also failed to capture the sharp pycnocline

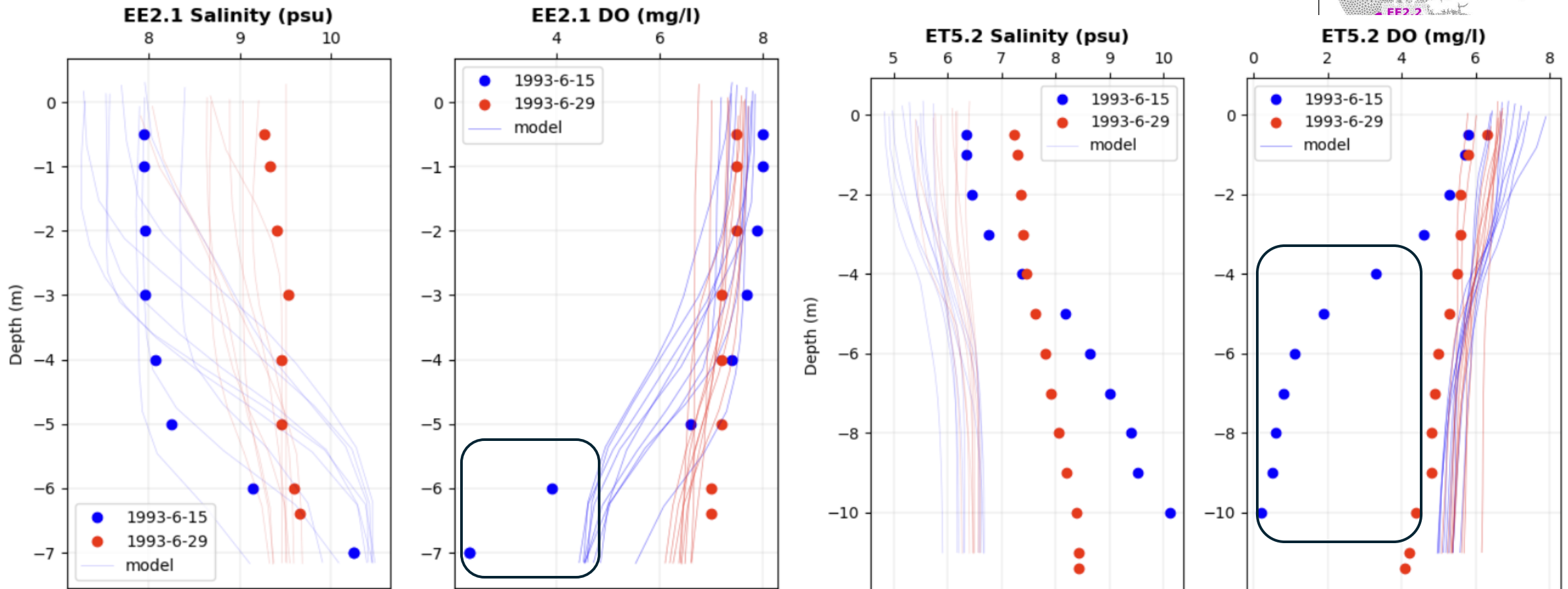
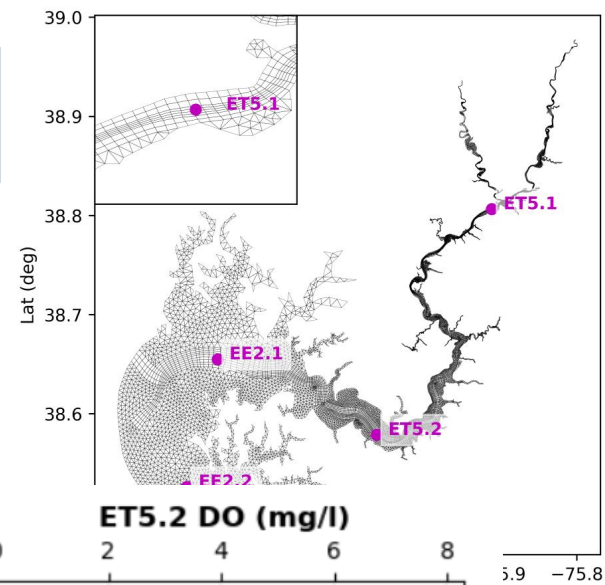


It spread to station CB4.2E



The hypoxia in June 1993

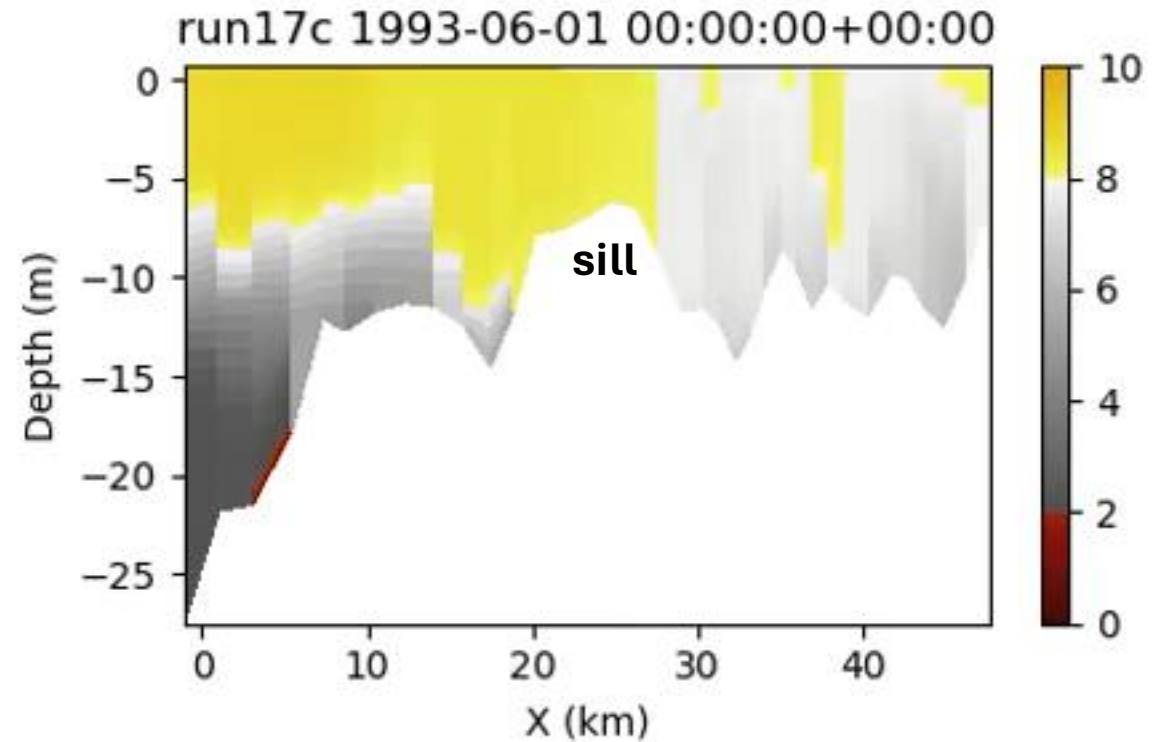
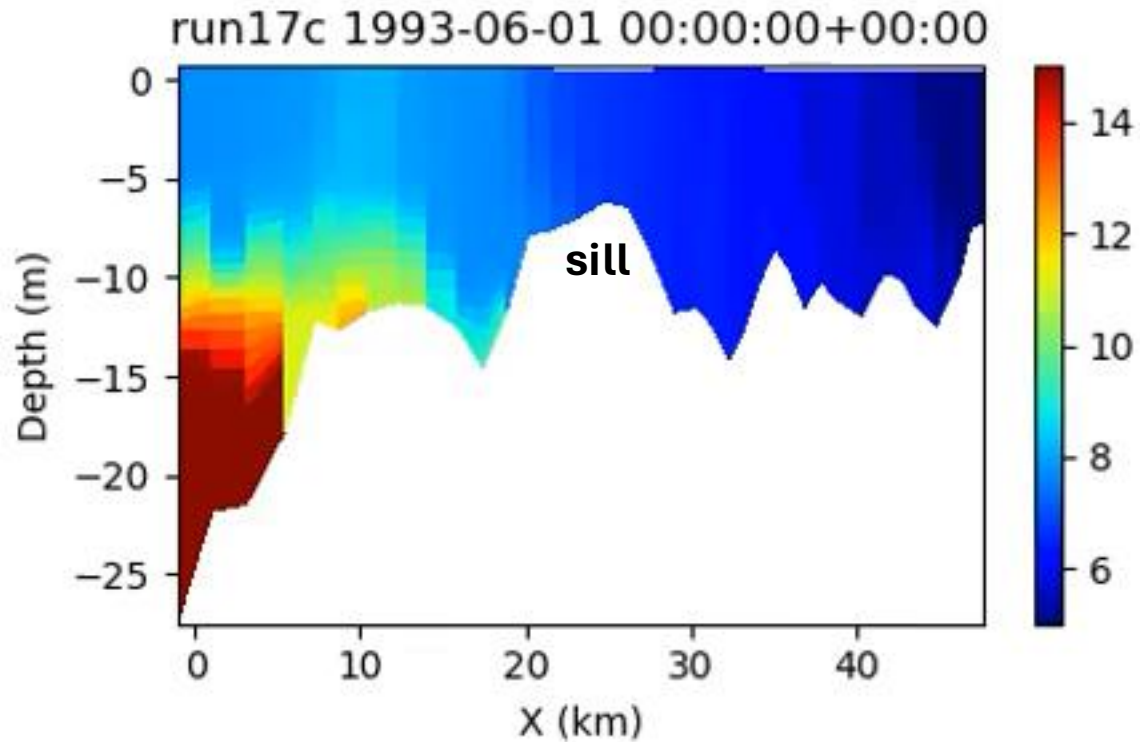
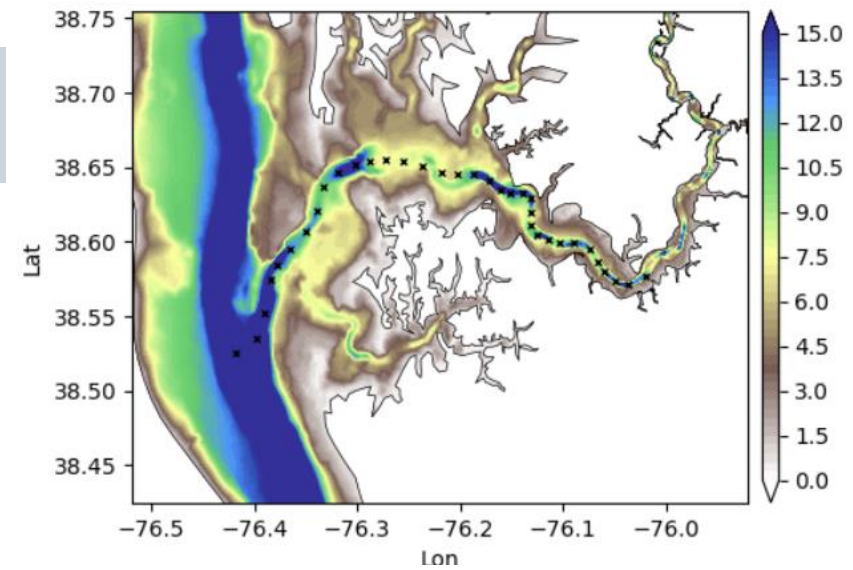
- The hypoxic water is also observed at EE2.1 and ET5.2 on 1993-6-15, but not on 06-29.
- Model failed to capture the intrusion of bottom main bay



Main bay water intrusion

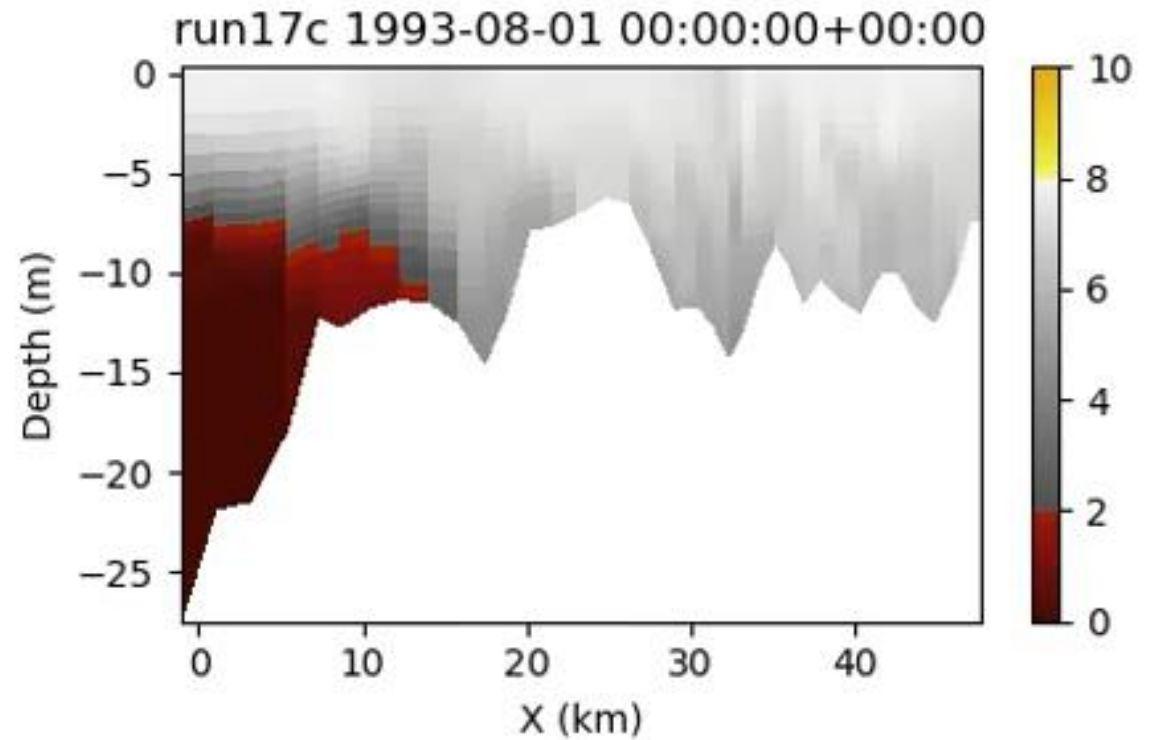
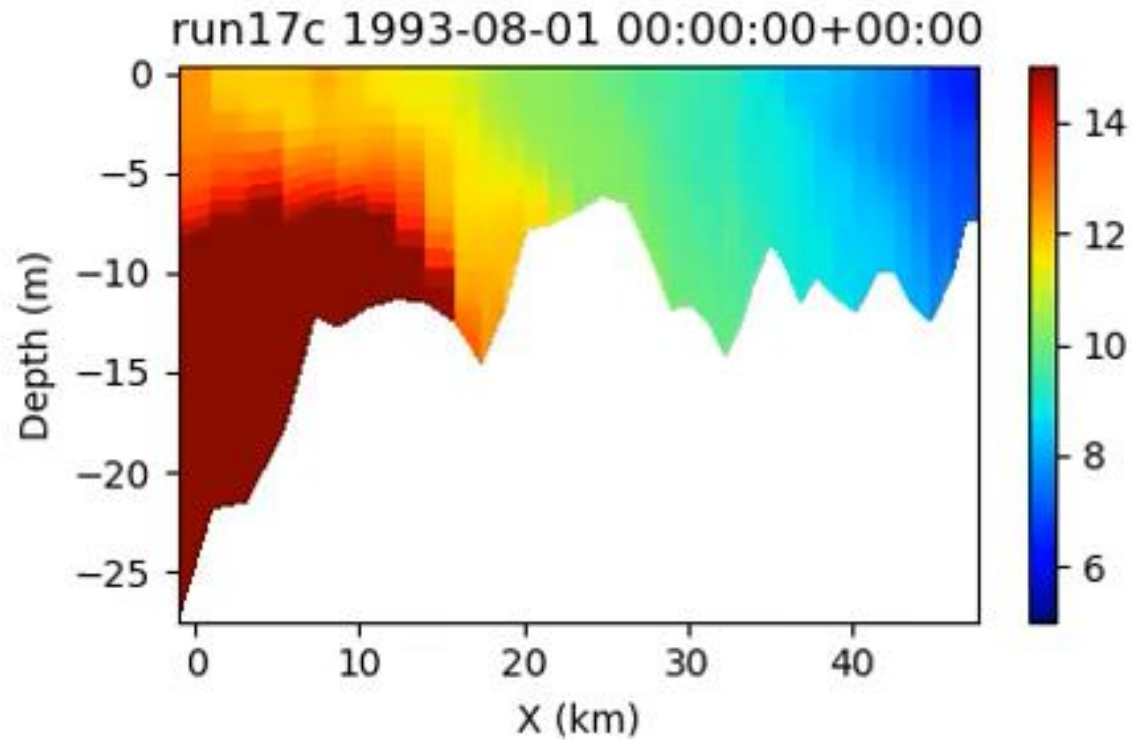
1993-June

Hypoxic water from main bay did not spill over the sill.



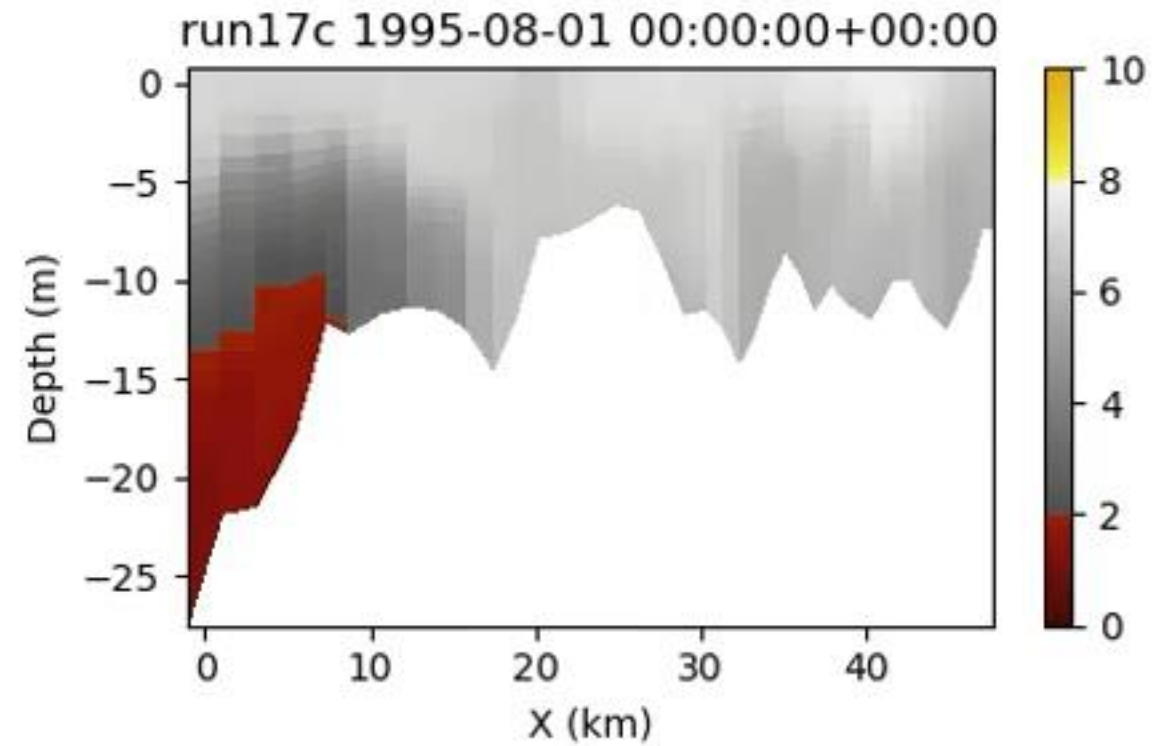
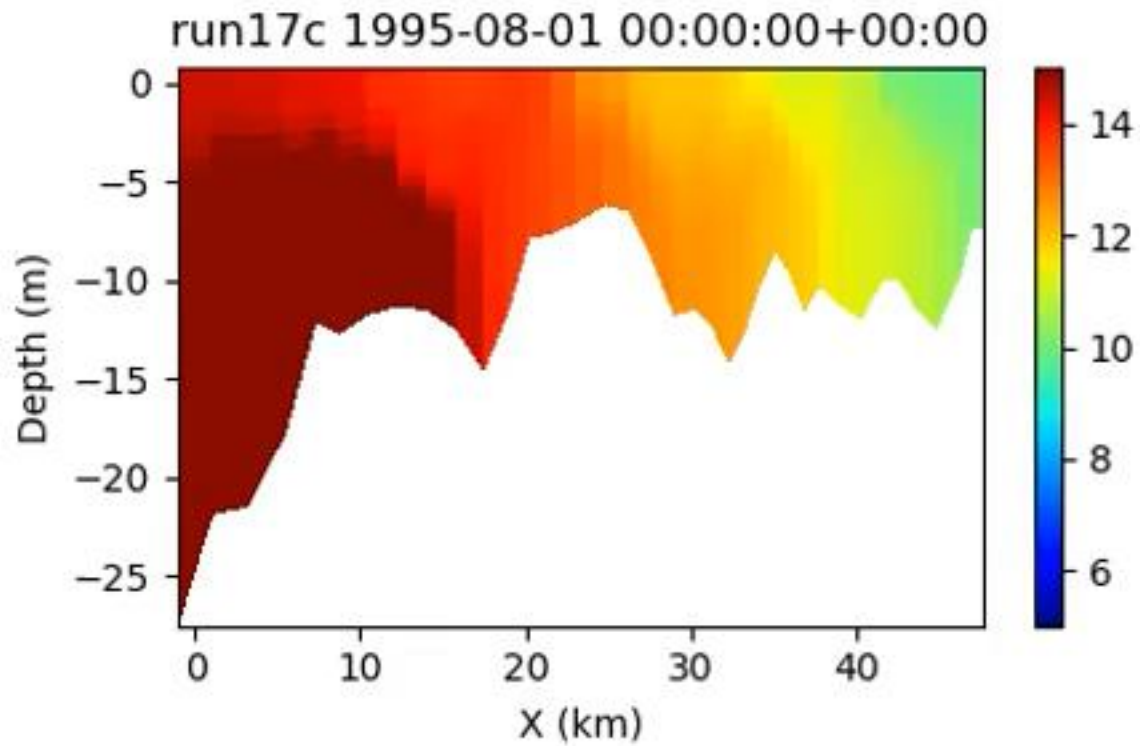
Main bay water intrusion

Same to 1993 August

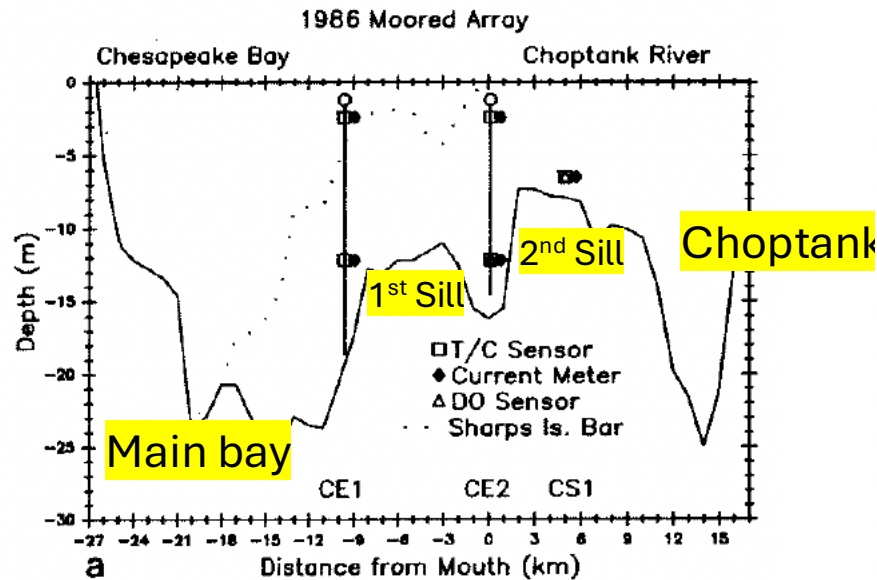


Main bay water intrusion

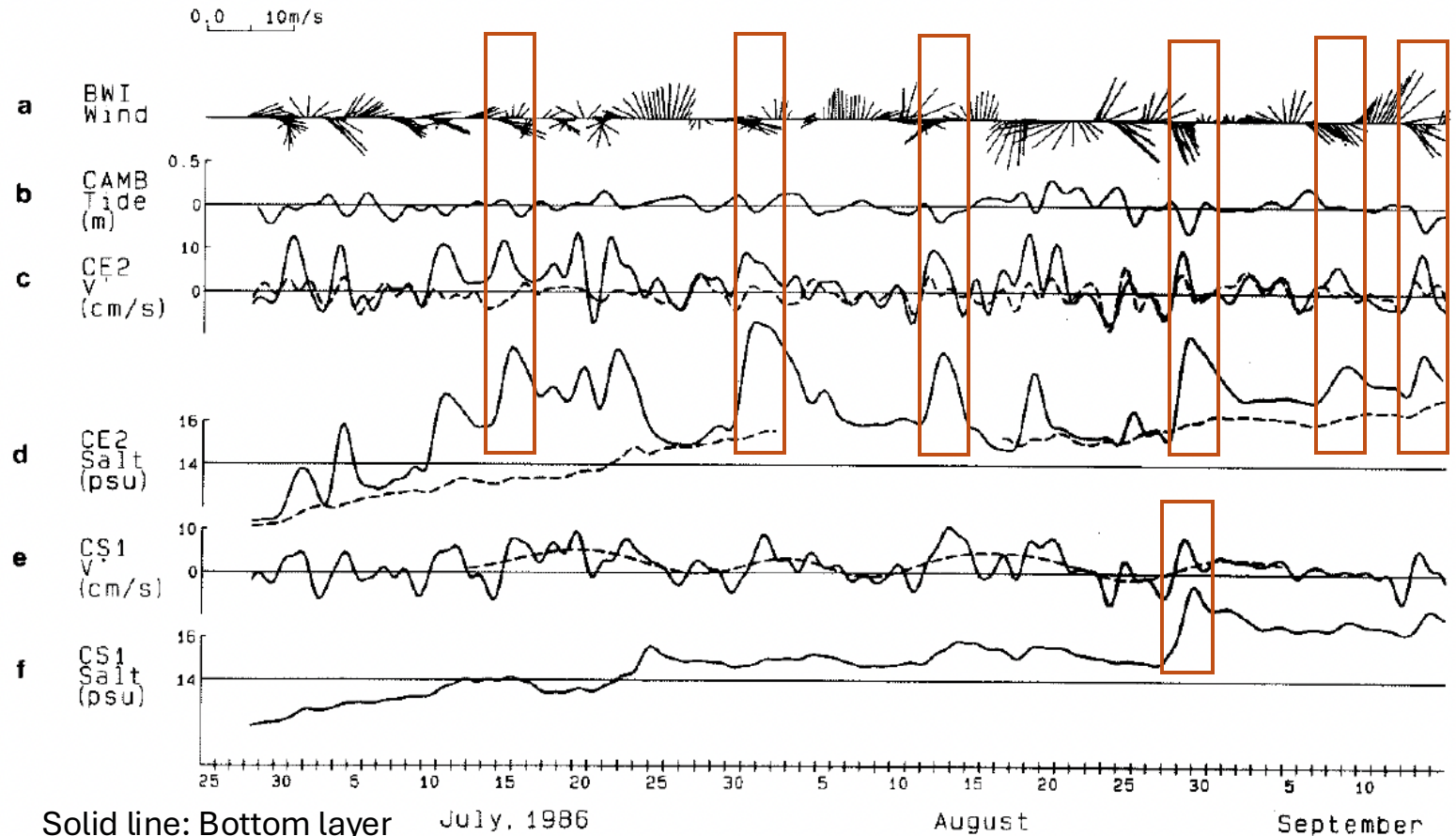
Same to 1995 August



Upwelling/intrusion of bottom main bay water

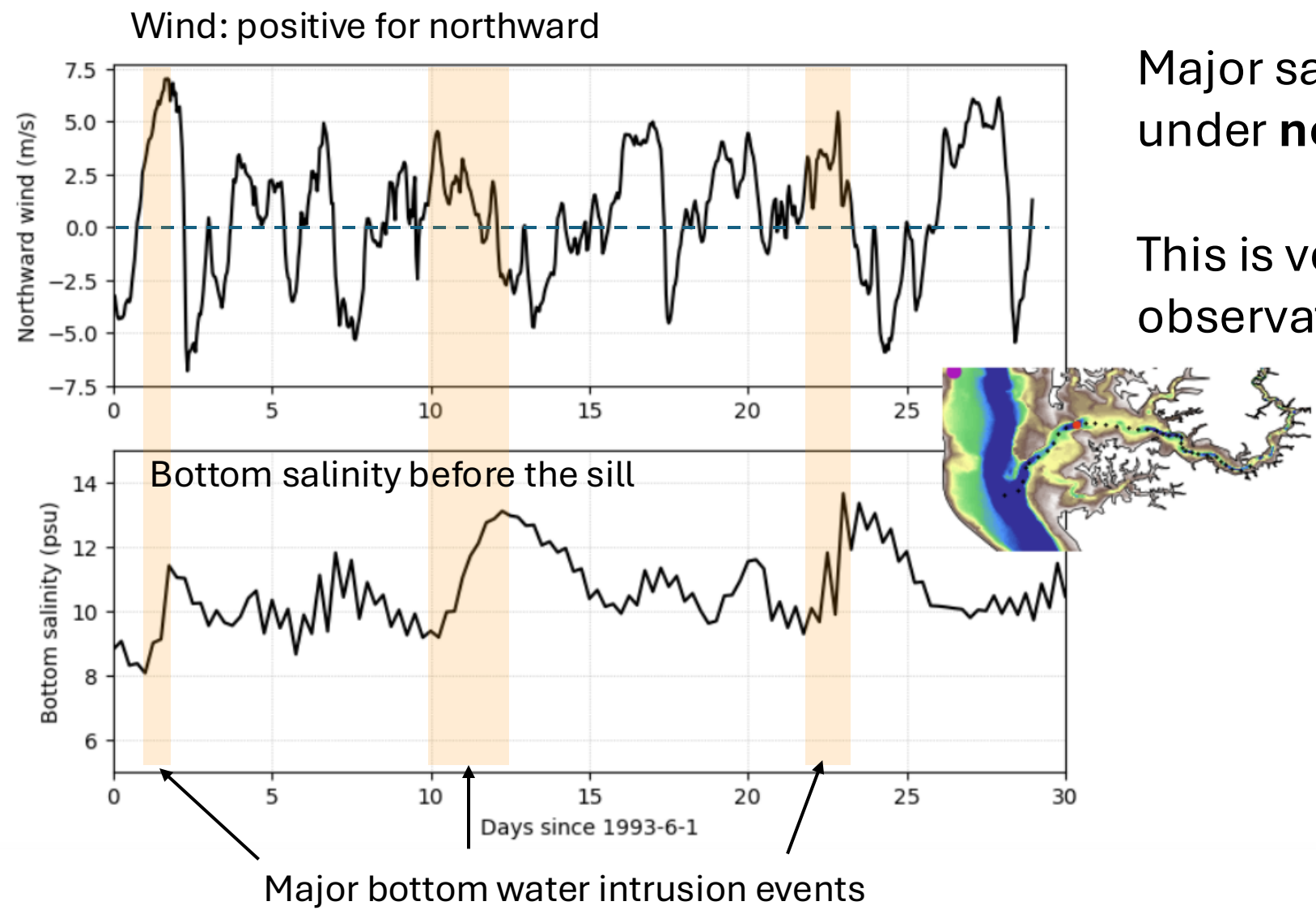


- “Intrusions are always preceded by a southward wind pulse”
- Southward wind pulse led to landward bottom velocity and bottom salinity increase.
- More frequent intrusions happened at station CE2 (before the first sill) than at station CS1 (before the second sill)

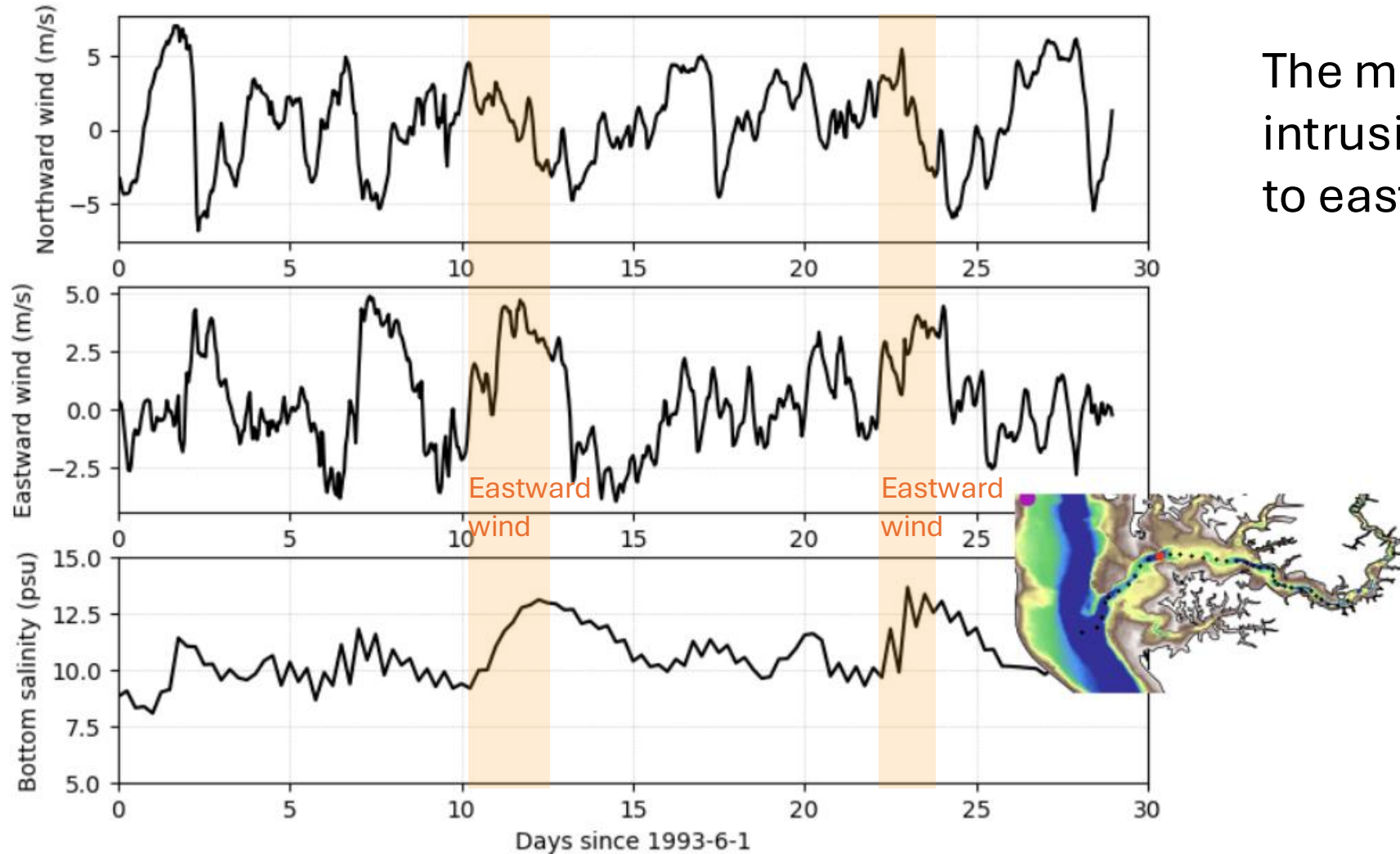


Sanford and Boicourt, 1990

Does our model reproduce such response?

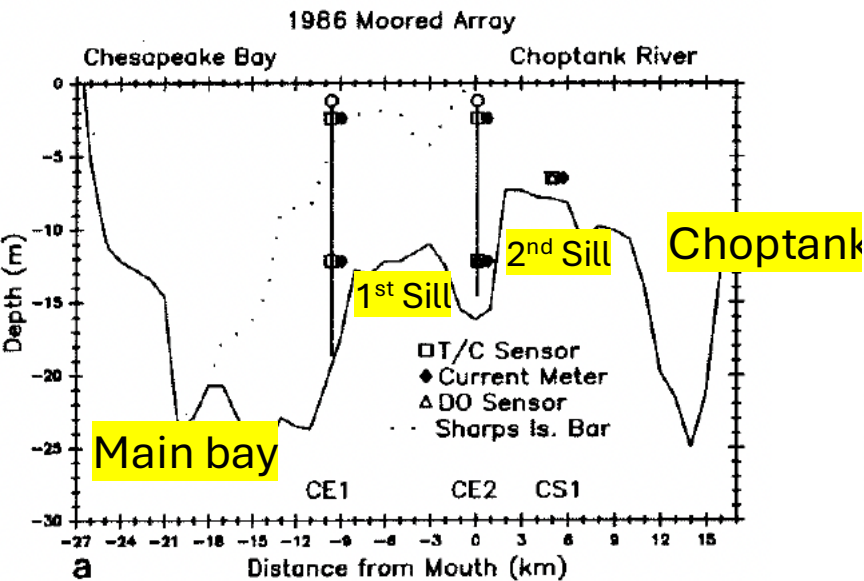


Does our model reproduce such response?

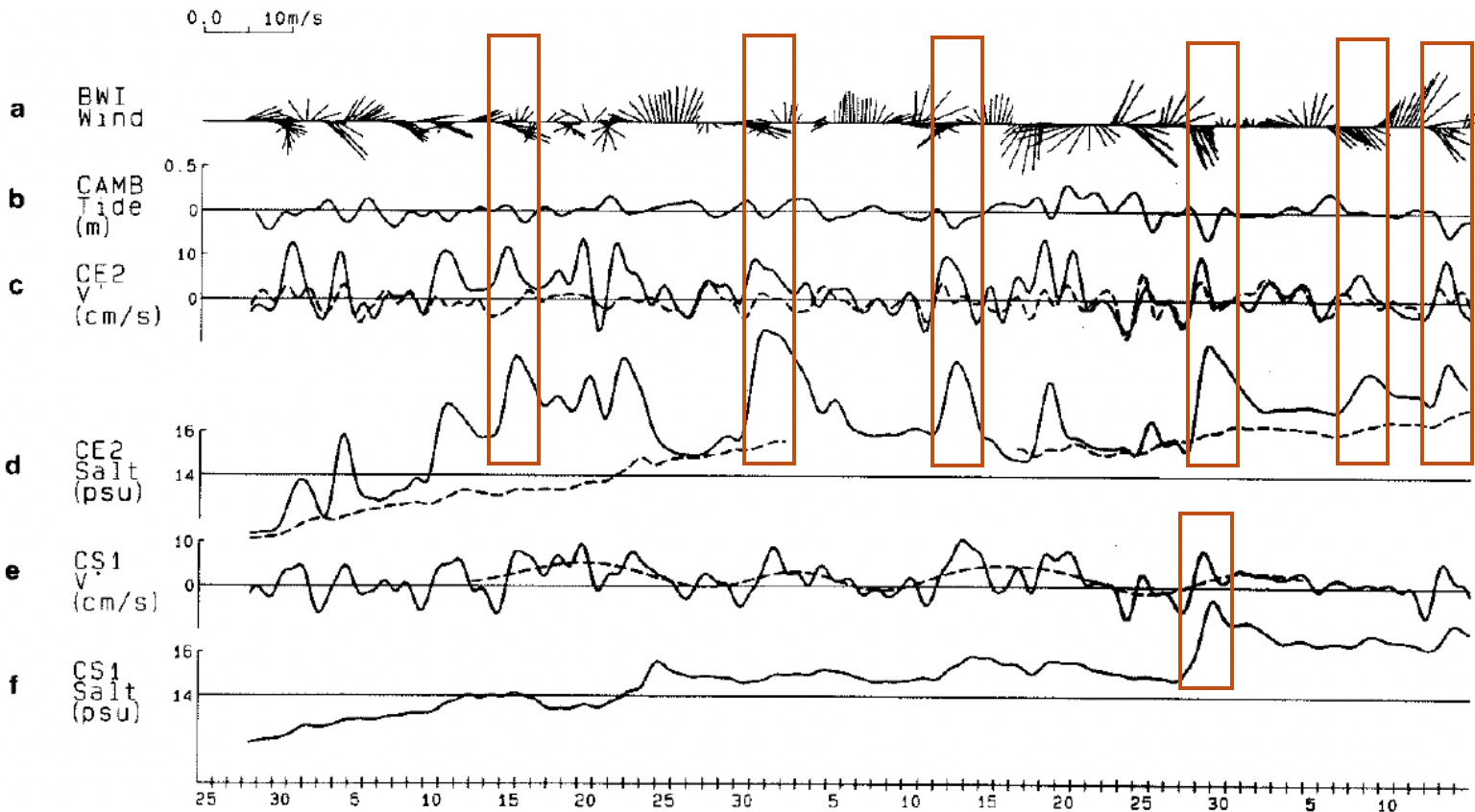


The major bottom salt intrusion seems to response to eastward wind.

Upwelling of bottom main bay water



This may be right too.
There are also notable eastward
wind during major salt intrusions.



Solid line: Bottom layer
Dashed line: surface layer

July, 1986 August September
Sanford and Boicourt, 1990

Summary

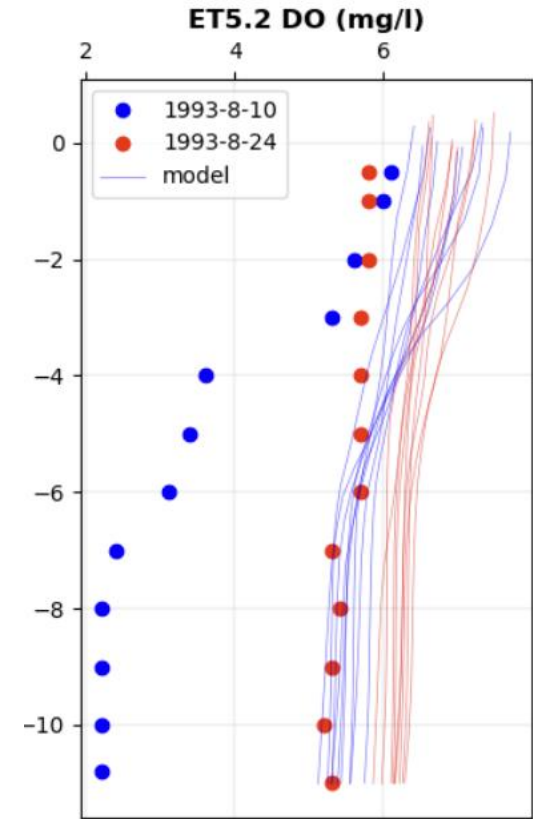
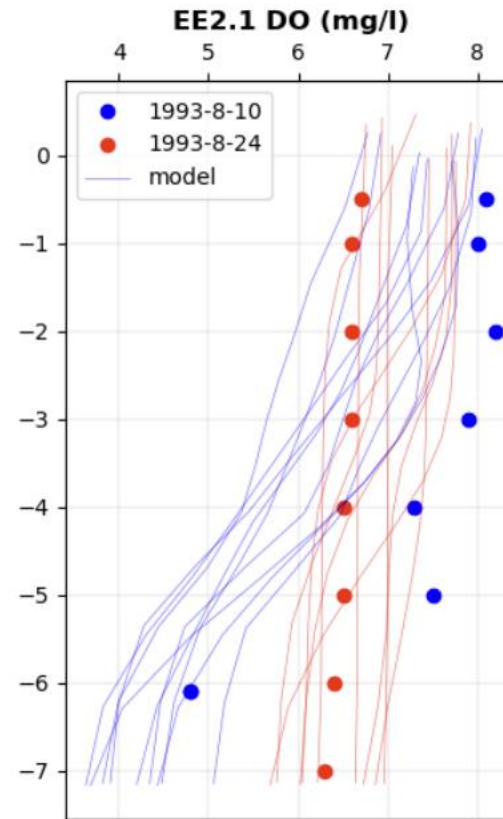
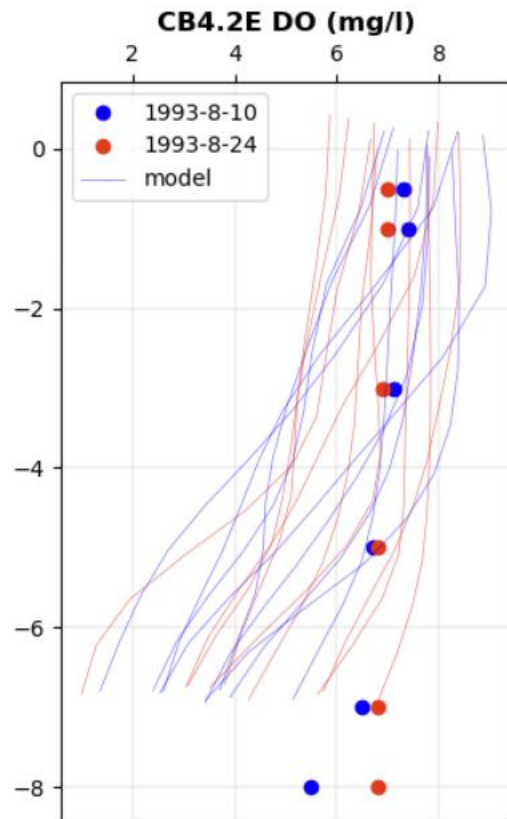
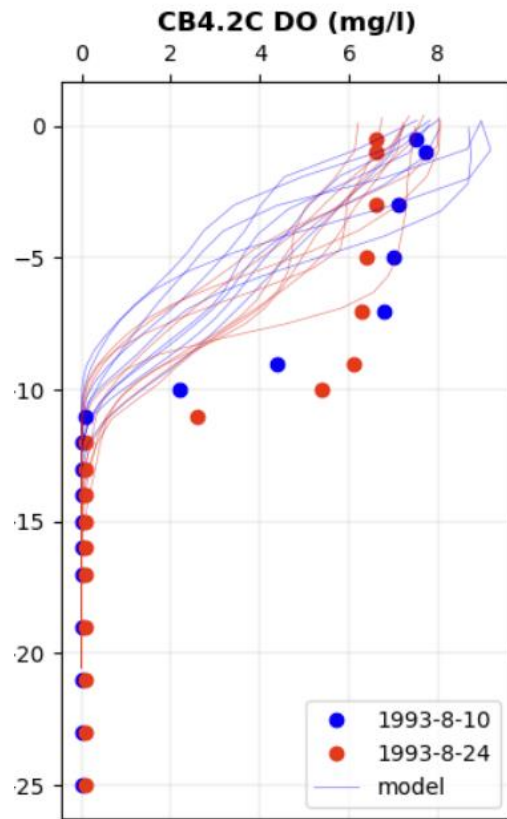
- ❑ Big model is better, providing more reasonable results in water quality
- ❑ Intrusion of bottom salty and hypoxic water from main bay control/module the DO condition in the lower Choptank.
- ❑ The fjord like bathymetry, specifically the sills at the mouth of Choptank, complicate the bottom water intrusion.

Future directions

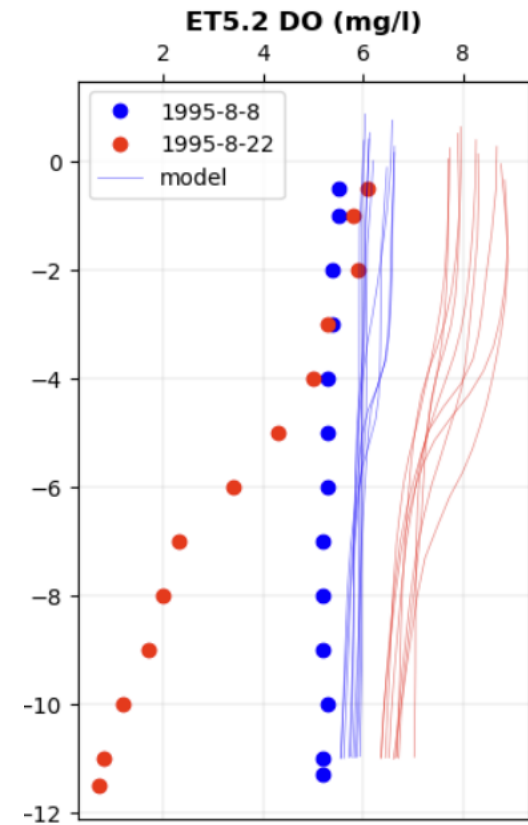
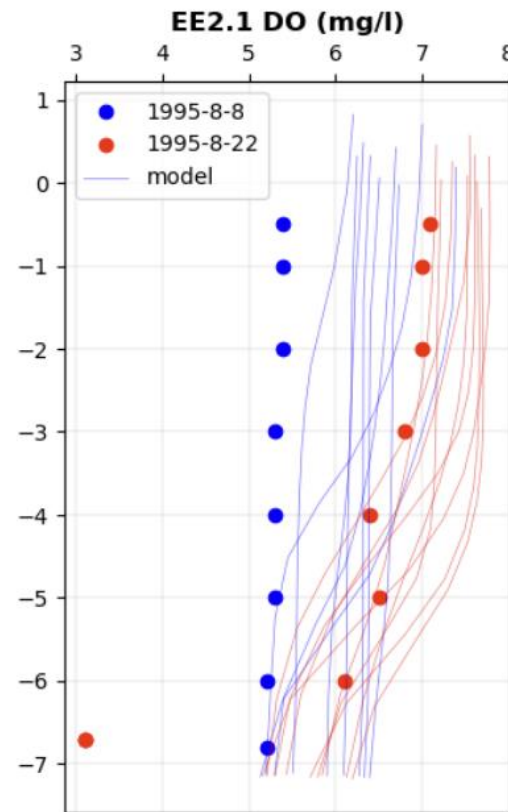
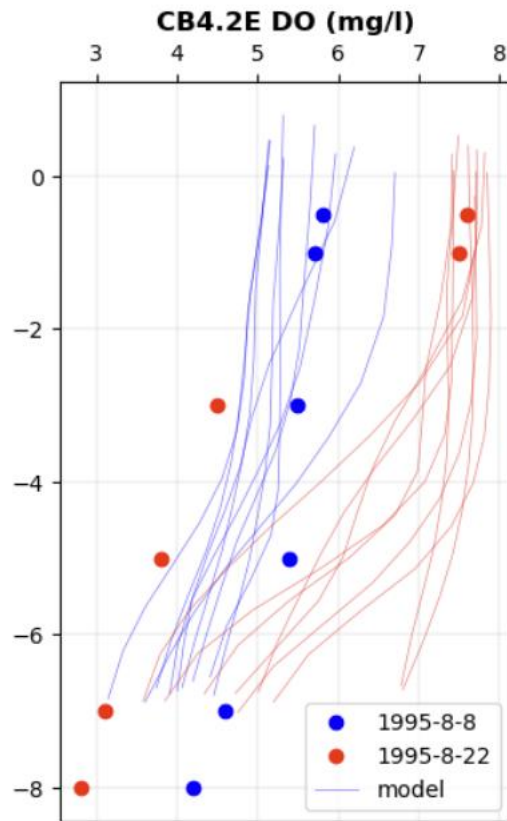
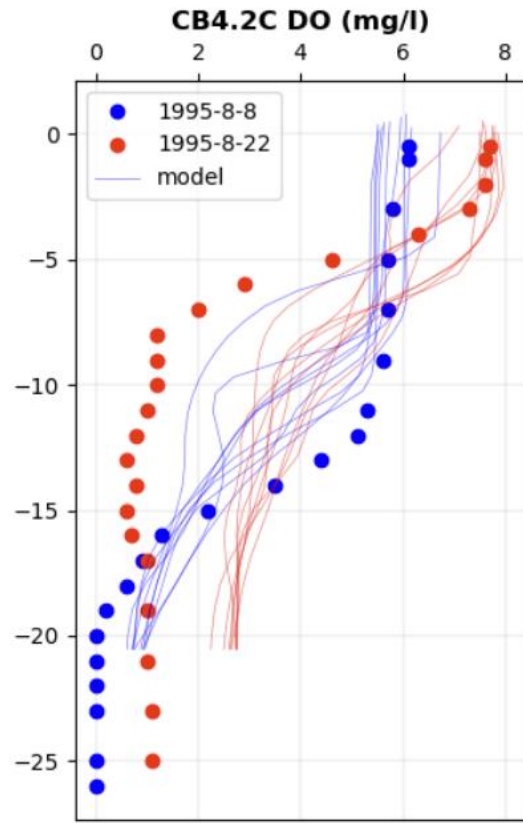
- ❑ More in-depth understanding of upwelling and bottom water intrusion
- ❑ Hindcast simulation for year 2010, during which a notable bottom hypoxic water intrusion was observed.

Supplemental

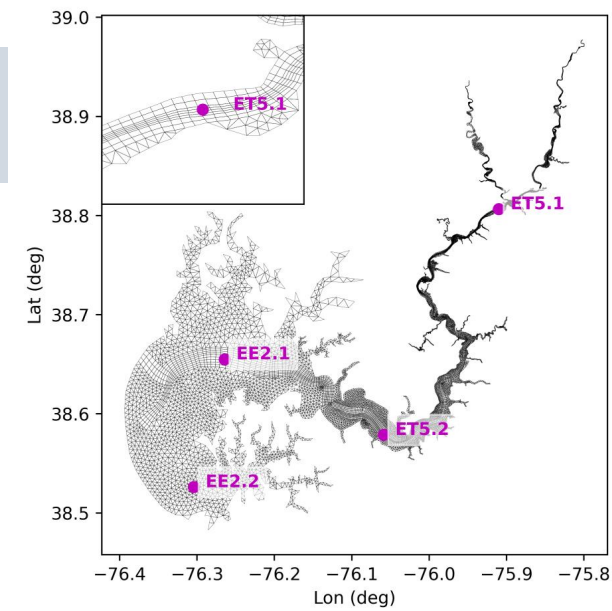
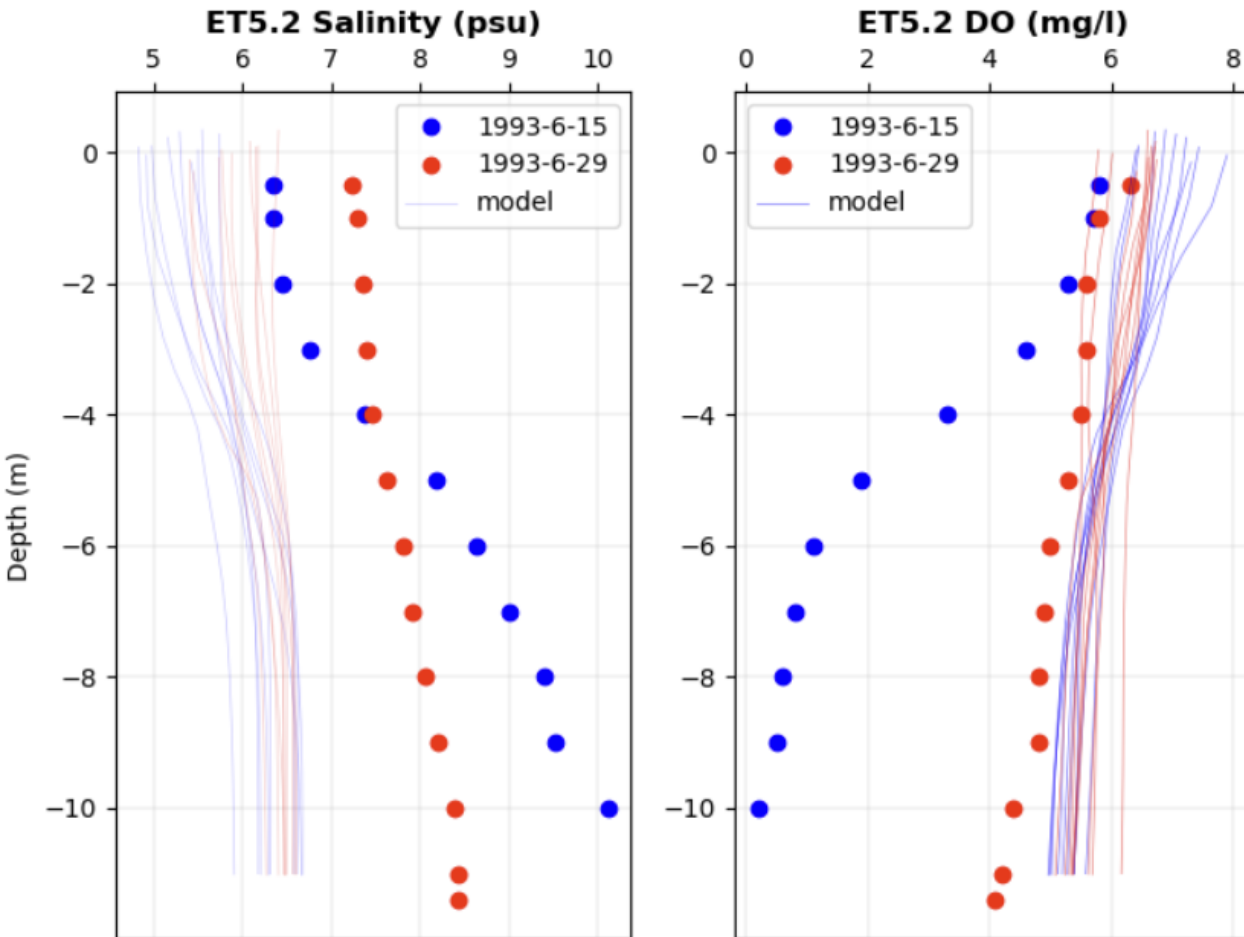
The hypoxia in August 1993



The hypoxia in August 1995



The hypoxia in June 1993



Summary for June 1993

On 06-15: Hypoxic water spread from main bay into Choptank. Model fails to capture this intrusion

On 06/29: Hypoxia develop in main bay, but not spread into Choptank