

Response to Editor and Reviewers Regarding Manuscript Revisions

We sincerely appreciate the constructive feedback provided by the reviewers, which has greatly enhanced the clarity, focus, and overall quality of our manuscript. Below, we summarize the key changes made to the manuscript in response to the reviewers' comments:

1. Revised Selection of Endmembers for $\text{DIC}_{\text{excess}}$, $\text{TA}_{\text{excess}}$ and TA_p Calculations

- The choice of "endmembers" for the calculations of $\text{DIC}_{\text{excess}}$, $\text{TA}_{\text{excess}}$, and TA_p has been adjusted. Specifically, we now define $\text{DIC}_{\text{NorthSea}}$ and $\text{TA}_{\text{NorthSea}}$ based on data from station CAR_S_076, located farthest offshore behind Spiekeroog and Wangerooge. This station, experiencing the highest salinities during almost every season, better represents the North Sea influence without significant estuarine input.
- This adjustment ensures that our mixing model accurately reflects North Sea contributions while normalizing for salinity effects at each station (see section 6 for details on the salinity normalization process).
- To estimate the contributions of estuarine DIC and TA in the Western and Eastern EFWS, we used DIC measurements from the lowest salinity station in the Estuary where the Ems enters the Wadden Sea, with considerable influence of freshwater (Table 1). These values ($\text{DIC}_{\text{estuary}}$; $\text{TA}_{\text{estuary}}$) were used to calculate the $\text{DIC}_{\text{mixing w/R}}$ and $\text{TA}_{\text{mixing w/R}}$ (equation 5) for the different regions. By utilizing seasonal data instead of previous averages from earlier measurements, the model now better captures the seasonal variability of the North Sea and estuary influence.

2. Removal of the Ems Data to Streamline the Manuscript

- To enhance clarity and focus, we have removed data from the Ems River from the main manuscript. This decision was made to streamline the discussion and maintain a stronger emphasis on the East Frisian Wadden Sea (EFWS).
- Additional data from the Ems River will be presented in a subsequent publication.

3. Exclusion of $p\text{CO}_2^{\text{therm}}$ and $p\text{CO}_2^{\text{bio}}$ Analyzes

- We have removed the $p\text{CO}_2^{\text{therm}}$ and $p\text{CO}_2^{\text{bio}}$ analyses because $p\text{CO}_2^{\text{bio}}$ encompasses not only biological processes such as photosynthesis but also other processes like mixing and remineralization.
- Additionally, we removed the plot displaying the thermal and non-thermal components of $p\text{CO}_2$, as it did not contribute significantly to the main focus of the manuscript. Its exclusion helps streamline the presentation of results.

4. Clarification Regarding CaCO_3 Dissolution and Oversaturation

- We have removed references to CaCO_3 dissolution in relation to calcite saturation, as our data consistently show calcite oversaturation. This change avoids potential misinterpretations and misquotations in future citations.

5. Streamlining of the Manuscript to Improve Readability

- In response to the reviewers' concerns about the manuscript's length and complexity, we have significantly streamlined the text by:
 - Moving extensive results and certain spatial maps (e.g., Figures 2, 3, 7, 12) to the supplementary materials.
 - Simplifying methodological descriptions to avoid redundancy, particularly for well-established analytical procedures.

- Improving sentence structure and overall readability through thorough proofreading.
- In addition, we have restructured the manuscript and discussion to ensure that the focus of the manuscript is maintained and clearly communicated throughout.
- The discussion of [TA-DIC] as a proxy for ecosystem metabolic status has been better integrated into the manuscript and now appears earlier (Material and Methods, Results) for improved coherence.
- Sections 4.3 and 4.4, which were deemed less essential, have been condensed or removed to enhance focus.

6. Salinity Normalization and Clarification of Mixing Approach

- We have revised the manuscript to clarify the salinity normalization of DIC and TA, addressing the reviewers' suggestions. Our approach now explicitly frames DIC_{excess} , TA_{excess} , and TA_p as normalized for salinity to better separate estuarine mixing from biogeochemical processes.
- The ratio $S_i/S_{NorthSea}$ normalizes the influence of the salinity at the specific station by the salinity of the North Sea ($S_{NorthSea}$). This normalization adjusts the mixing model, ensuring that the contributions from the North Sea waters are appropriately balanced according to the salinity at each individual station. When S_i is smaller than $S_{NorthSea}$, the $DIC_{NorthSea}$ and $TA_{NorthSea}$ are weighted more strongly.

Explanation of Outliers

- Outliers have been properly explained in the manuscript, along with the rationale for their exclusion.

These revisions ensure that the manuscript is more concise, better structured, and clearer in its key messages. We appreciate the reviewers' valuable feedback and believe these changes significantly enhance the quality and readability of the study.

Sincerely,

Julia Meyer