**RC1: 'Comment on egusphere-2025-335', Anonymous Referee #1, 14 Mar 2025**

We sincerely thank the Referee#1 for his/her review and for the time he/she spent on our submitted manuscript. We have considered all your remarks to improve the methodology, the precision, the limitations and the implications of our research.

Dear Authors,

This study entitled "Aquatic metabolism influences temporal variations of water carbon and atmospheric carbon dioxide fluxes in a temperate salt marsh" has several distinct strengths. Firstly, the author systematically observed changes across four seasons—spring, summer, autumn, and winter—and further examined diurnal variations within each season over 24-hour cycles, successfully capturing seasonal and daily fluctuations in carbon dioxide fluxes. Additionally, the author employed multiple measurement methods, including changes in atmospheric $CO_2$, water partial pressure of $CO_2$, nutrients, planktons, and biological parameters. However, further clarification of the study's scope, limitations, and implications will substantially enhance the research's logical coherence and completeness. My major comments are as follows.

We are grateful to Referee#1 for his/her positive feedbacks on our study. Referee#1 highlighted the importance of our findings to better understand the marsh carbon cycle investigating the fine temporal variations in water carbon concentrations and atmospheric $CO_2$ exchanges in a temperate salt marsh located between upstream artificial salt ponds and downstream continental shelf waters. Referee#1 also appreciated the multiple measurement methods employed in our study highlighting the influence of aquatic metabolism on water carbon and associated $CO_2$ fluxes. In the literature, very few studies have looked for the aquatic metabolism contribution on salt marsh carbon dynamics, using *in situ* carbon original samplings (seasonal 24-h cycles) and innovative methods (water $pCO_2$ probe and atmospheric Eddy Covariance). In blue carbon systems, like salt marshes, the strong heterogeneity of horizontal and vertical carbon fluxes caused by seasonal, diurnal and tidal rhythms requires simultaneous integrative measurements of net ecosystem $CO_2$ exchanges (NEE) and organic and inorganic carbon in tidal waters to better evaluate all marsh carbon processes and fluxes at the various temporal and spatial scales. Moreover, it is important to study more precisely the whole marsh metabolism integrating terrestrial and aquatic compartments at the different spatio-temporal scales and pinpointing their respective contributions to net ecosystem $CO_2$ exchanges (sink/source) to better take into account salt marshes in regional and global carbon balances. We believe our new results provide a better understanding of biotic and abiotic factors controlling water $pCO_2$ and atmospheric $CO_2$ fluxes in salt marshes where diurnal/tidal data are scarce to include these coastal systems in global carbon budgets and predict future marsh carbon sinks.

In consequence, we substantially modified the manuscript in accordance with the Referee's recommendations (see below) to improve the study's scope, limitations, and implications of our study and we hope our manuscript's revision will allow its publication in the Biogeosciences journal. We proposed a conceptual model to better organize and delimit the contribution of terrestrial and aquatic compartments to net ecosystem $CO_2$ exchanges (sink/source) according to the various measurements done at our study site (see Fig. 8 in the revised MS). Moreover, a new table was added in the revised MS to regroup similar articles studying inorganic carbon dynamics and water-air $CO_2$ emissions in temperate salt marsh systems to contextualize our findings and enhance the manuscript's scientific significance (see table 5 in the revised MS).

**Table 5. Seasonal/annual comparison of water inorganic carbon dynamics ($pCO_2$ in ppmv, DIC and TA in µmol kg$^{-1}$), total aquatic metabolism ($NEP_{tot}$ in mmol m$^{-2}$ h$^{-1}$) and water-air $CO_2$ fluxes ($FCO_2$ in mmol m$^{-2}$ h$^{-1}$) between the Bossys perdus salt marsh (this study, France) and other similar temperate salt marsh systems in the literature. Median values were done in bold and range values were done in brackets (min – max).**

| Reference | | Winter | Spring | Summer | Fall | Annual |
|---|---|---|---|---|---|---|
| This study | Water $pCO_2$ (ppmv) | **525**<br>(321 – 1461) | **221**<br>(106 – 416) | **158**<br>(89 – 597) | **411**<br>(311 – 541) | **382**<br>(89 – 1461) |
| | DIC (µmol kg$^{-1}$) | **2799**<br>(2354 – 3963) | **2173**<br>(2053 – 2530) | **2056**<br>(1587 – 2175) | **2584**<br>(2206 – 2762) | **2238**<br>(1587 – 3963) |
| | TA (µmol kg$^{-1}$) | **3076**<br>(2508 – 4016) | **2757**<br>(2379 – 2947) | **2385**<br>(2228 – 2812) | **2804**<br>(2351 – 3047) | **2617**<br>(2228 – 4016) |
| | $NEP_{tot}$ (mmol m$^{-2}$ h$^{-1}$) | **-2.35**<br>(-7.72 – 3.02) | **-15.80**<br>(-16.61 – -14.98) | **-16.43**<br>(-19.36 – -13.50) | **-5.45**<br>(-7.81 – -3.08) | **-10.01**<br>(-19.36 – 3.02) |
| | Water-air $FCO_2$ (mmol m$^{-2}$ h$^{-1}$) | **0.24**<br>(0.05 – 0.46) | **-0.25**<br>(-0.52 – -0.03) | **0.28**<br>(0.05 – 0.53) | **0.36**<br>(0.03 – 0.62) | **0.15**<br>(-0.52 – 0.62) |
| Wang et al. (2018) | Water $pCO_2$ (ppmv) | n.a.<br>(500 – 4000) | n.a. | n.a.<br>(1600 – 12000) | n.a. | n.a.<br>(500 – 12000) |
| | DIC (µmol kg$^{-1}$) | n.a.<br>(1500 – 2500) | n.a. | n.a.<br>(2250 – 4300) | n.a. | n.a.<br>(1500 – 4300) |
| | $NEP_{aquatic}$ (mmol m$^{-2}$ h$^{-1}$) | -0.83 | n.a. | -2.50 | n.a. | -1.60 |
| | Water-air $FCO_2$ (mmol m$^{-2}$ h$^{-1}$) | 0.60 | n.a. | 3.90 | n.a. | 2.05 |
| Reithmaier et al. (2023) | DIC (µmol kg$^{-1}$) | **2158**<br>(1610 – 3080) | **1941**<br>(1452 – 7895) | **2052**<br>(1450 – 4200) | **2210**<br>(1367 – 3740) | **2065**<br>(1367 – 7895) |
| | TA (µmol kg$^{-1}$) | **2262**<br>(1634 – 3296) | **1977**<br>(1376 – 8045) | **2083**<br>(1578 – 4191) | **2269**<br>(1330 – 3765) | **2104**<br>(1330 – 8040) |
| Song et al. (2023) | Water-air $FCO_2$ (mmol m$^{-2}$ h$^{-1}$) | n.a. | n.a. | **1.03** | **0.20** | n.a. |
| Gong et al. (2023) | Water-air $FCO_2$ (mmol m$^{-2}$ h$^{-1}$) | n.a. | **0.53** | **0.65** | **1.10** | **0.76** |
| Alongi (2020) | Water-air $FCO_2$ (mmol m$^{-2}$ h$^{-1}$) | n.a. | n.a. | n.a. | n.a. | **1.49** |

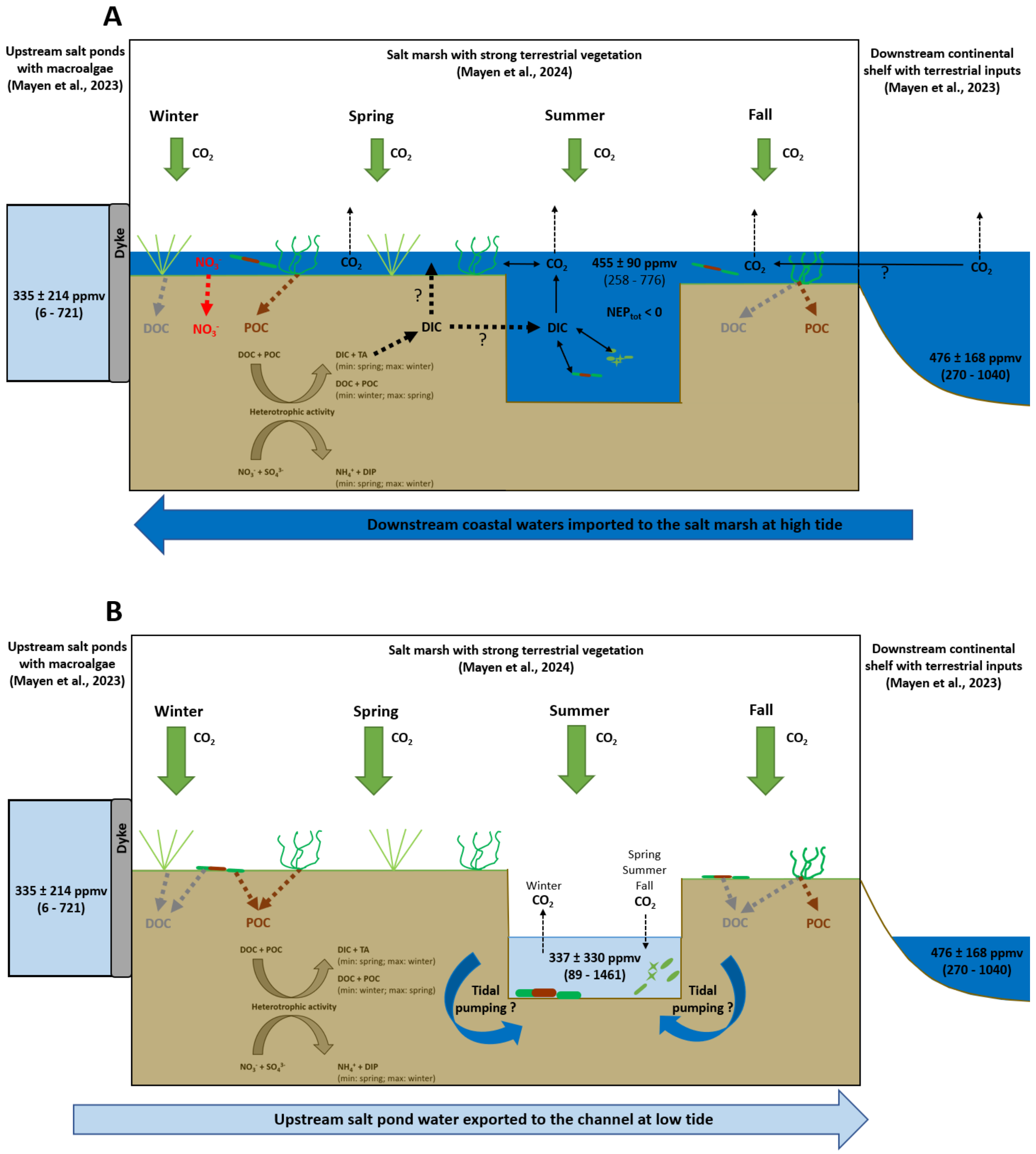

**Fig. 8.** Water carbon dynamics and atmospheric $CO_2$ fluxes at the Bossys perdus salt marsh over our 24-h cycles at two contrasted tidal periods: (A) high (flooding) tide (marsh immersion by downstream coastal waters) and (B) low (ebbing) tide (marsh emersion and channel water come from the marsh-drainage process by tidal forcing and the waterflow from the upstream salt ponds). Green arrows represent net atmospheric $CO_2$ sink measured at the ecosystem scale by eddy covariance. Negative $NEP_{tot}$ in the water column at high tide corresponds to aquatic heterotrophy (net carbon source for water).

1; The author emphasizes the study of "ecosystem carbon dioxide exchange" in the introduction, but the main discussion of the paper actually focuses on the water interface.

In the introduction section, we detailed the marsh carbon cycle focusing on the ecosystem carbon dioxide sinks and the major carbon fates. We described metabolic processes occurring in salt marshes inducing large exports of DIC and TA by the tide at the sediment-water interface and large $CO_2$ emissions at the water-air interface (see section 2.1, p2, L52-62). In the discussion section, we highlighted intense tidal variations in water $pCO_2$ due to strong water mixing processes in the salt marsh (upstream marsh and downstream coastal endmembers). During low tide, intense anaerobic respiration in winter induced the highest increases in DIC and water $pCO_2$ in the channel at night whereas in spring/summer, intense aquatic primary production induced $CO_2$-depleted and DOC-concentration channel waters. Finally, the contribution of aquatic metabolism on NEE fluxes were investigated in an integrative way within the Eddy Covariance footprint during 24-h periods. In our revised manuscript, we think that the introduction and discussion sections were consistent to answer the objectives of the study.

The authors also used "air-water $CO_2$ exchange" later for the measurement in the water. Further, NEE and air-water gas exchange actually measured at different locations. The authors can use a conceptual model to organize the role of each in this study area and also indicate the physical or theoretical boundaries and limitations of this study.

Over each 24-h cycle, net ecosystem $CO_2$ exchanges (NEE) were continuously measured every 10 minutes by atmospheric Eddy Covariance (EC). In intertidal systems, like salt marshes, the major advantage of the EC method is to measure NEE fluxes at the ecosystem scale, coming from all habitats inside the footprint, at short timescales and at both the sediment-air and water-air interfaces (i.e. low and high tides, respectively) (Mayen et al., 2024). Inside the EC footprint, water-air $CO_2$ fluxes were estimated at each high tide from *in situ* water $pCO_2$ and gas transfer velocity parametrisation. Thus, water-air $CO_2$ fluxes estimated from water $pCO_2$ could be compared with NEE fluxes measured simultaneously by EC to go further on the contribution of aquatic metabolism on uptake/emission fluxes at the ecosystem scale (Table 2). We followed the fair recommendation of the Referee#1 and proposed a conceptual model to organize and better delimit the contribution of terrestrial and aquatic compartments to net ecosystem $CO_2$ exchanges (sink/source) according to the various measurements done at our study site (see above and see the revised MS in figure 8).

Upon closer inspection of the methods and results, the study shows unclear definitions regarding its spatial scope and scale. The author claims to have conducted "vertical and horizontal surveys," yet in practice, the vertical survey is essentially limited to the air-water interface. The so-called horizontal survey is restricted to observations from a single point, where the author assumes tidal movements bringing upstream and downstream waters into the sampling area over a 24-hour period suffice as horizontal analysis. This approach, however, is highly limited since single-point sampling cannot represent the actual spatial variations throughout the salt marsh region. What is the role of this study site on this whole area, including the evaporation ponds all over the island?

Referee#1 is right and he/she has highlighted an important limit of our study. Here, vertical carbon fluxes were not limited to diffusive $CO_2$ fluxes at the water-air interface since, at the same time, we continuously measured net ecosystem $CO_2$ exchanges (NEE) inside the footprint (both at high and low tides) by the atmospheric eddy covariance (see above). At a single point in the main channel following the water mixing between upstream salt ponds and downstream continental shelf (Fig. 1), we measured the temporal dynamics of water carbon and nutrient concentrations at the diurnal/tidal scales through continuously water samplings over 24-hours (Fig. S1 in the Supplements). Very few studies performed seasonal 24-h cycles in blue carbon systems, such as salt marshes, to sample all water carbon forms from high to low tide including all intermediate tidal situations both the day and the night. In our study, horizontal carbon flux measurements (tidal DIC, DOC and POC outwelling in g C day$^{-1}$) along with carbon sequestration data should be added to our approach to better constrain the carbon budget of the studied salt marsh system over other regional/global carbon cycles. Referee#1 is right, the single-point sampling in the channel (inside the EC footprint; Fig. 1) might not represent the actual spatial carbon variations throughout the salt marsh region.

In consequence, we modified the revised MS specifying all these aspects and indicating only water sampling at a single point in the main channel was made to study water carbon dynamics in the salt marsh. Along with the new conceptual scheme, a new table was also added in the revised MS to regroup other similar articles studying inorganic carbon dynamics and water-air $CO_2$ emissions in temperate salt marsh systems to contextualize our findings and enhance the manuscript's scientific significance (see table 5 in the revised MS and see above). In addition, we modified the introduction, section 2.2, and the conclusion to show clear definitions regarding the spatial scope and scale of the study (see below).

**Section 1. Introduction** (this paragraph was modified in the revised MS)

p3, L87-L97: "At a temperate salt marsh, this present study focuses on aquatic metabolism influence on water carbon dynamics and net ecosystem $CO_2$ exchanges at small timescales (diurnal and tidal) during the four seasons. The main aims of this paper are (1) to highlight biotic and abiotic controlling factors on water carbon variations, in particular water $pCO_2$, (2) to study the metabolic status of planktonic communities in the marsh as $CO_2$ sink or source and (3) to identify the contribution of water $pCO_2$ signatures and planktonic/water column metabolism on NEE. *To this purpose, we performed four seasonal 24-hour cycles (continuous samplings for 24 hours) measuring relevant water biogeochemical parameters ($pCO_2$, organic and inorganic carbon and nutrients), planktonic metabolism and water-air $CO_2$ fluxes at a single point in the main channel of the salt marsh connected to upstream salt ponds and* *downstream continental shelf. The novelty of this study was to look for marsh aquatic metabolism contribution on water carbon dynamics and water-air $CO_2$ fluxes, using in situ carbon original samplings through 24-h cycles at each season simultaneously with large scale and continuous atmospheric $CO_2$ exchange measurements (NEE by Eddy Covariance).”*

**Section 2.2. Sampling strategy and field samplings** (this paragraph was modified in the revised MS)

p5, L134-L142: “*At a single point in the main channel of the salt marsh* (Fig. 1-b), four seasonal 24-h cycles were performed from March to December 2021 (Fig. 2). For each 24-h cycle, our sampling strategy consisted of simultaneously measuring water biogeochemical parameters, planktonic metabolism and water-air $CO_2$ fluxes at diurnal (daytime and night-time) and tidal (*from high to low tides and all tidal phases in between*) scales through discrete samplings and continuous real-time measurements. At this station, samplings of sub-surface waters were performed continuously every one or two hours over the four 24-h cycles (n = 13 over C1-winter, n = 15 over C2-spring and C3-summer and n = 16 over C4-fall) encompassing a large variation in water heights (Hw): from the channel bottom at low tide (Hw = 0.5 m) to the full marsh immersion at high tide (Hw > 2.5 m) with all tidal intermediate situations in between (Fig. 2 and Fig. S1). *When repeated across seasons, it allows to sample the full tidal range, and hence the heterogeneity of the tidal height, residence time and water mixing.”*

**Section 5. Conclusions and limitations** (this paragraph was modified in the revised MS)

p30, L747-757: “In this study, the same diurnal/tidal synchronism (low and high tides at the same period of the day) was adopted during each 24-h cycle. However, due to the strong intraseasonal variability of meteorological (temperature, light, humidity, wind) and tidal (water level and immersion time) parameters, production and respiration rates in the marsh could strongly change from day to day and influenced the marsh carbon cycle differently. *Thus, several 24-hour cycles per season with different thermic and tidal conditions would allow to better take into account all temporal variabilities and to truly extrapolate at the seasonal scale our results on carbon dynamics in salt marshes. Direct measurements of heterotrophic respiration in marsh sediments could clearly highlight the contribution of autochthonous metabolic processes at the benthic interface in the channel DIC production in comparison with allochthonous processes/inputs. Moreover, subsequent to water mixing processes occurring in the sampling channel, lateral carbon exports from the salt marsh along with carbon sequestration rates should be measured (DIC, DOC and POC outwelling) to better constrain the carbon budget of this coastal intertidal wetland among other regional and global carbon cycles.”*

Consequently, the observed data might disproportionately reflect sedimentary and anoxic environmental influences from the upper or lower stream rather than the actual diurnal variations caused by photosynthesis and planktonic activity. Can this single selection inadvertently led the author to interpret tidal-driven signals as representative of the entire salt marsh ecosystem?

Over our 24-h cycles, observed data in the sampling channel at the diurnal/tidal scales reflected the water mixing processes between coastal and marsh endmembers but also the autochthonous/allochthonous metabolic processes. In winter, the low aquatic autotrophy during the day induced a small channel water $pCO_2$ decrease, whereas the intense aquatic heterotrophy during the night induced a large channel water $pCO_2$ increase. Over the winter 24-h cycle, the strong nDIC and nTA increases from high to low tide, especially at night, could relate to intense autochthonous heterotrophic respiration in the marsh sediments inducing the highest water $pCO_2$ values in the channel waters (Fig. 6). On the contrary, in spring and summer, lower tidal variations of DIC and TA were measured. The lowest nDIC and nTA were recorded at low tide associated with the lowest water $pCO_2$ values and the highest DOC concentrations indicating intense autochthonous and allochthonous primary production (phytoplankton, benthic microalgae and macroalgae). In the planktonic communities sampled at low tide, high abundances of pennate diatoms in spring and summer indicated the presence of autochthonous benthic microalgal mats resuspended in channel waters whose strong metabolism could promote the lowest water $pCO_2$. Moreover, the large autotrophy of the allochthonous macroalgae recorded in the upstream salt ponds could also largely contributed to the large $CO_2$ uptake and DOC production recorded in the sampling channel that receives all upstream salt pond waters at low and ebb tides. Thus, in some cases, it is difficult to distinguish the relative contribution of allochthonous and autochthonous metabolic processes to water carbon dynamics recorded in the channel as both process origins are involved. This difficulty was more discussed in the revised MS.

At the daily scale, planktonic communities could play a major role in the water inorganic carbon dynamics in spring only when the highest planktonic autotrophy ($NEP_{pk} = 0.25$ g C $m^{-2}$ $d^{-1}$) was associated with the lowest water $pCO_2$ values (239 ± 105 ppmv), especially at low tide (Fig. 5). On the contrary, the winter planktonic autotrophy ($NEP_{pk} = 0.11$ g C $m^{-2}$ $d^{-1}$) corresponded to the highest water $pCO_2$ values (669 ± 327 ppmv) due to a more intense autochthonous respiration at the benthic interface. In the same way, the summer planktonic heterotrophy ($NEP_{pk} = -0.06$ g C $m^{-2}$ $d^{-1}$) simultaneously measured with water $CO_2$ undersaturation (271 ± 182 ppmv) could indicate that the autochthonous planktonic respiration in the studied salt marsh was counterbalanced by the intense allochthonous macroalgae primary production in the upstream ponds.

Contrary to global findings on the marsh carbon cycle (large DIC and DOC outwelling; Santos et al., 2021), our study highlighted $CO_2$-depleted and DOC-concentrated water exportations from high to low tide in spring and summer confirming the major role of autochthonous/allochthonous primary production within all marsh compartments (terrestrial and aquatic) in the coastal carbon cycle. It could indicate lower aquatic heterotrophy and higher aquatic autotrophy at our studied marsh, especially in spring and summer, allowing simultaneously large $CO_2$ uptake and DOC production.

Santos, I. R., Burdige, D. J., Jennerjahn, T. C., Bouillon, S., Cabral, A., Serrano, O., Wernberg, T., Filbee-Dexter, K., Guimond, J. A., and Tamborski, J. J.: The renaissance of Odum's outwelling hypothesis in "Blue Carbon" science, Estuarine, Coastal and Shelf Science, 255, 107361, https://doi.org/10.1016/j.ecss.2021.107361, 2021.

To address these issues, the author should clearly define the limitations of the study, explicitly describing the representativeness of the sampling points within the salt marsh area. It is crucial to specify under which spatial conditions the observed results are applicable, distinguishing clearly between areas with longer or shorter water flow paths, and between flowing or stagnant water bodies.

Over our 24-h cycles, surface water was continuously sampled every hour of two hours at a single point in the studied salt marsh inside the EC footprint from the channel bottom at low tide (Hw = 0.5 m) to the full marsh immersion at high tide (Hw > 2.5 m) with all tidal intermediate situations in between (see above responses and revised section 2.2.). At high tide, water samples are mainly representative from the downstream coastal-endmember (i.e. the continental shelf). Indeed, we recorded similar salinity and water $pCO_2$ values between the immersed marsh and the Breton Sound continental shelf (Mayen et al., 2023). The Breton Sound continental shelf exchanges salt waters with the Atlantic Ocean to the west at each semi-diurnal tidal cycle and receives continental inputs through the Aiguillon Bay discharges to the east depending on hydrodynamic and meteorological conditions. The residence times of coastal waters in the Breton Sound continental shelf are generally above 85 days (Polsenaere et al., 2017). On the contrary, at low tide, water sampled at the bottom of the channel is representative of both the waterflow coming from the upstream salt ponds and the Bossys perdus marsh-drainage process by tidal forcing. During this time, salinity and $pCO_2$ measured in channel waters showed similar trends with the upstream salt ponds (Mayen et al., 2023). However, in some cases, it is difficult to distinguish the relative contribution of allochthonous and autochthonous metabolic processes to water carbon dynamics recorded in the channel. To better understand the representativeness of the sampling points within the salt marsh area, we completed the revised MS, especially in the section study site (see below), and we added a conceptual scheme to clearly distinguish water samplings at low tide and at high tide (see figure 8). Moreover, a new table was added in the revised MS to regroup similar articles studying inorganic carbon dynamics and water-air $CO_2$ emissions in temperate salt marsh systems to contextualize our findings and enhance the manuscript's scientific significance (see table 5).

Polsenaere, P., Soletchnik, P., Le Moine, O., Gohin, F., Robert, S., Pépin, J. F., ... & Goulletquer, P. (2017). Potential environmental drivers of a regional blue mussel mass mortality event (winter of 2014, Breton Sound, France). *Journal of Sea Research*, *123*, 39-50.

**Section 2.1. Study sites** (this paragraph was modified in the revised MS)

p3-4, L101-121: "The Bossys perdus salt marsh is a vegetated intertidal wetland (52.5 ha) located along the French Atlantic coast on Ré Island (Fig. 1-a). The salt marsh is located within the Fier d'Ars tidal estuary which receives coastal waters from the Breton Sound continental shelf during high tide periods (Fig. 1-a). This intercommunication enables (1) the immersion of the estuarine intertidal zone (including the studied salt marsh) and (2) the water supply for artificial salt marshes (i.e. salt ponds) upstream of the dyke. Water residence times in the salt ponds vary from a few hours to a fortnight depending on seasonal management practice. Generally, macroalgae blooms (*Ulva spp*.) colonize salt ponds from April to October each year (Mayen et al., 2023). *After an intensive land-use (salt harvesting and oyster farming), the Bossys perdus salt marsh is now protected within a National Natural Reserve to restore its natural hydrodynamics and vegetation while conserving the site's specific typology due to past human activities (channel networks, humps and dykes; Fig. 1-b) (Mayen et al., 2024). Two different substrata can be found in the soil of the salt marsh with sand-dominated sediments at bottom and mud-dominated sediments at top (transition depth at 33 cm). In the muddy section, dry bulk density and organic carbon content were 0.8 ± 0.1 g cm*$^{-3}$ *and 1.78 ± 0.19%, respectively (Amann et al., 2024).* The salt marsh is subject to semi-diurnal tides originating on the continental shelf allowing its immersion through channels differently in space, time and frequency depending on tidal periods. At high tide (HT), imported coastal waters gradually fill the sampling channel (Fig. 1-b) and immerse the salt marsh at variable water heights depending on tidal amplitudes and meteorological conditions. *Due to the site's specific typology, lowest marsh levels (mudflats and S. maritima) were quickly immersed (south), whereas the whole marsh immersion (all muds and plants) only occurred 0.75 h later at the highest water heights (Mayen et al., 2024). At low tide (LT), the channel empties and the salt marsh is emerged and exposed to the atmosphere. During this time, water remaining at the bottom of the channel come from (i) the Bossys perdus marsh-drainage process by tidal pumping and (ii) the waterflow from the upstream salt ponds to the downstream estuary (Fig. 1-b) at low water height situations (0.50 m maximum depth; see Fig. S1 in Mayen et al., 2024) fluctuating seasonally according to meteorological conditions and pond managements (Mayen et al., 2023).”*

**Section 5. Conclusions and limitations** (this paragraph was modified in the revised MS)

p30, L747-757: “In this study, the same diurnal/tidal synchronism (low and high tides at the same period of the day) was adopted during each 24-h cycle. However, due to the strong intraseasonal variability of meteorological (temperature, light, humidity, wind) and tidal (water level and immersion time) parameters, production and respiration rates in the marsh could strongly change from day to day and influenced the marsh carbon cycle differently. *Thus, several 24-hour cycles per season with different thermic and tidal conditions would allow to better take into account all temporal variabilities and to truly extrapolate at the seasonal scale our results on carbon dynamics in salt marshes. Direct measurements of heterotrophic respiration in marsh sediments could clearly highlight the contribution of autochthonous metabolic processes at the benthic interface in the channel DIC production in comparison with allochthonous processes/inputs. Moreover, subsequent to water mixing processes occurring in the sampling channel, lateral carbon exports from the salt marsh along with carbon sequestration rates should be measured (DIC, DOC and POC outwelling) to better constrain the carbon budget of this coastal intertidal wetland among other regional and global carbon cycles.”*

Furthermore, the author should further explore how air-water $CO_2$ fluxes are influenced by temperature and wind speed variations under different seasonal and diurnal conditions, and clearly state which factor has the more significant impact.

In marsh and coastal end-members, Mayen et al. (2023) highlighted the predominance of air-water $CO_2$ gradients in the control of flux directions either as a sink or a source. Indeed, in the present study, during all high tide periods (except in spring), sampled coastal waters were oversaturated in $CO_2$ compared to the atmosphere (water $pCO_2$ > air $pCO_2$) producing atmospheric $CO_2$ degassing. However, at the seasonal scale, turbulence processes measured at the air-water interface also played an important role in $CO_2$ flux variability and magnitude (see below). For instance, at high tide night between winter and summer, wind speed variability and associated $k_{660}$ gas transfer velocity produced significant water-air $CO_2$ emission variations although no significant air-water $CO_2$ gradients were measured (i.e. higher $CO_2$ emissions and $k_{660}$ values over C3-HT/Night than over C1-HT/Night whereas water $pCO_2$ values were similar; see below). Moreover, the methodological calculations and associated differences chosen for the exchange coefficient parameterizations may produce even more contrasts in the estimated air-water $FCO_2$ (see Polsenaere et al., 2022 and Mayen et al., 2023).

| | Tw (°C) | $NEP_{tot}$ (mmol $m^{-2}$ $h^{-1}$) | $pCO_2$ (ppmv) | $k_{660}$ (m $s^{-1}$) | $FCO_2$ (mmol $m^{-2}$ $h^{-1}$) |
|---|---|---|---|---|---|
| C1-winter-HT/Night | 9.8 ± 0.4 | -7.53 | 546 ± 51 | 7.39 ± 0.51 | 0.38 ± 0.05 |
| C3-summer-HT/Night | 20.3 ± 0.2 | -19.04 | 546 ± 49 | 9.64 ± 0.22 | 0.48 ± 0.07 |

2. The role of mixing. Moreover, since the study site is located at the river-sea interface, the dynamics of water mixing should be investigated in greater detail.

The Bossys perdus salt marsh is located within the Fier d'Ars tidal estuary at the interface between the upstream artificial salt ponds and the downstream Breton Sound continental shelf (see above responses) that were studied before from a carbon influenced-typology/management point of view (Mayen et al., 2023). At high tide, coastal waters imported from the estuary and the shelf by the tide can completely fill the sampling channel and immerse the salt marsh through variable water heights depending on tidal amplitudes and meteorological conditions. In contrast, at low tide, the marsh vegetation at the benthic interface is emerged into the atmosphere without any coastal waters and during this time, the channel allows drainage of upstream artificial salt ponds waters to the Fier d'Ars tidal estuary (Mayen et al., 2024).

The author should discuss how water mixing processes affect the study results, thereby enhancing the regional significance of the research.

We thank Referee#1 for this major comment about the role of water mixing in the study results. In the revised MS, we more investigated the water mixing processes occurring in the salt marsh and their influence in carbon dynamics (see below). During transient tidal phases, we showed that the mixing between two contrasted water masses (marsh-influenced endmember and shelf-influenced endmember) can significantly affect water $pCO_2$ dynamics in the sampling channel. During flooding tides (i.e. channel filling), water $pCO_2$ generally increased in response to $CO_2$-oversaturated coastal waters imported from the continental shelf whereas during ebbing tides (i.e. channel emptying), large water $pCO_2$ decreases could partly be recorded due to $CO_2$-depleted marsh waters exported from salt ponds, along with autochthonous carbon processes (production/respiration) involved at both tidal periods in channel waters (Fig. 2). In upstream artificial salt ponds with higher water residence times, a strong biological control on water $pCO_2$ was seen, inducing water $CO_2$ undersaturation in spring and summer due to intense aquatic autotrophy (135 ± 165 and 242 ± 116 ppmv, respectively) and water $CO_2$ oversaturation in fall due to heterotrophy (622 ± 57 ppmv; Mayen et al. 2023). On the contrary, in downstream estuarine waters, a strong seasonal compensation of thermal and non-thermal effects occurred throughout the year producing low seasonal water $pCO_2$ variations (from 441 ± 21 ppmv in winter to 385 ± 60 ppmv in summer; Mayen et al. 2023). Thus, $CO_2$ source/sink status of the sampling channel can instantaneously change during the water mixing between two contrasted endmembers.

Moreover, the strong DIC and TA variations in the channel during salinity changes also indicated a major influence of water mixing processes in marsh carbonate chemistry (Fig. 6). Over the four sampling 24-h cycles ($n = 59$), mean TA:DIC ratios were 1.15 ± 0.11 in surface waters confirming mixing between marsh waters and seawater following Reithmaier et al. (2023). In coastal systems, water mixing processes strongly controlled inorganic carbon dynamics, especially in tidal salt marsh (Wang et al., 2016), in seagrass tidal bay (Polsenaere et al., 2023) and in mangrove (Cabral et al., 2024). We completed the revised MS in the section 4.1. and 4.3 accordingly to discuss how water mixing processes can affect water $pCO_2$ and DIC variations (see below).

**Section 4.1. Temporal variations of water $pCO_2$ in salt marshes** (these sentences were modified in the revised MS)

p22, L533-L541: "*Thus, during transient tidal phases, lateral exchanges with adjacent down- and upstream waters instantaneously produced intense channel water $pCO_2$ variations, leading to 1) increases during flood tides (i.e. channel filling) in response to $CO_2$-oversaturated coastal waters imported from the shelf, and 2) decreases during ebb tides (i.e. channel emptying) in response to $CO_2$-depleted marsh waters exported from salt ponds (Mayen et al., 2023), along with autochthonous carbon processes (production/respiration) involved at both tidal periods. These tidal water $pCO_2$ variations over our 24-h cycles were observed and confirmed during the longer in situ measurement periods up to 5 days per season encompassing our 24-h sampling measurements. These intense tidal variations confirmed that water mixing processes occurring in the channel induced large changes in carbonate chemistry mainly related to contrasted coastal and marsh endmembers (Fig. 8).*"

**Section 4.3. Marsh aquatic respiration as DIC source** (these sentences were added in the revised MS)

p26, L629-630: "Large tidal variations of DIC and TA were recorded along the salinity gradient (Fig. 6) *confirming a strong control of water mixing processes occurring in the channel on the carbonate chemistry (Reithmaier et al., 2023).*"

p27, L641-L655: "*During low tide (marsh emersion), the largest DIC and TA increases were measured in channel waters, especially in winter, highlighting a strong control of tidal forcing on water carbonate chemistry (Fig. 8). In similar salt marsh systems, the same tidal DIC pattern was recorded over all seasons with highest concentrations at low tide and lowest ones at high tide (Table 5).* In most intertidal systems, such as salt marshes and mangroves, intense respiration processes occur in sediments inducing high DIC and TA concentrations in surface waters, especially at low tide through porewater exports driven by the tide (Nakamura et al., 2024; Reithmaier et al., 2023). In winter, during low biological activity of *S. maritima* (Mayen et al., 2024), the highest POC:PON and POC:Chl*a* ratios measured at low tide (Fig. 7) suggested predominant detrital organic matter from decaying vegetation (Savoye et al., 2003). The highest POC-$\delta^{13}$C values measured in winter at low tide (-14.6 ± 0.9‰; unpublished data) could confirm the presence of terrestrial C4 plants in channel waters, like *S. maritima* (Amann et al., 2024). This could constitute an energy source for microbial activity in sediments inducing, in turn, the largest increase of DIC and $pCO_2$ measured at low tide night (up to 3963 µmol $kg^{-1}$ and 1461 ppmv, respectively; Fig. 6) due to a strong winter tidal forcing. *During this period, DIC increased faster than TA until reaching very close concentrations (Table 1). This could indicate that most of carbonate ions ($CO_3^{2-}$) in channel waters were converted into bicarbonate ions ($HCO_3^-$) by the large addition of $CO_2$ and $H^+$ from marsh respiration processes, such that carbonate species in the exported channel waters mostly consisted of $HCO_3^-$ and dissolved $CO_2$.*"

Moreover, we discussed the potential influence of riverine and anthropogenic inputs from the continental shelf in the marsh carbon cycle. The Breton Sound continental shelf exchanges salt waters with the Atlantic Ocean to the west at each semi-diurnal tidal cycle and receives continental inputs through the Aiguillon Bay discharges to the east depending on hydrodynamic and meteorological conditions (Mayen et al., 2023). During high tide in winter, the large terrestrial inputs of $NO_3^- + NO_2^-$ in coastal waters from the Aiguillon Bay (Fig. 1) could supply the anaerobic processes in the marsh sediments and induced the large export of dissolved $CO_2$ in channel waters during low tide. More precisely, over the winter 24-h cycle, we simultaneously recorded a large $NO_3^- + NO_2^-$ decrease (sink) and a large $NH_4^+$ increase (source) from high to low tide and could highlight a dissimilatory nitrate reduction to ammonium (DNRA) in marsh sediments which is an intense respiration process producing DIC and TA (Giblin et al., 2013; Hopkinson and Giblin, 2008). These terrestrial inputs could constitute an energy source for heterotrophic activity in marsh sediments inducing, in turn, the largest increase of DIC and $pCO_2$ measured at low tide (up to 3963 µmol $kg^{-1}$ and 1461 ppmv, respectively; Fig. 6) due to a strong winter tidal forcing. However, direct measurements of anaerobic processes especially at the benthic interface, should be realized to confirm the significance of these metabolic processes in the winter DIC production. We completed the revised MS in the section 4.3. to discuss how terrestrial inputs affect the study results (see below).

**Section 4.3. Marsh aquatic respiration as DIC source** (these sentences were modified in the revised MS)

p27-28, L665-675: “However, nutrient variations over our 24-h cycles could highlight other anaerobic processes, particularly at benthic interface, involving DIC and TA production in channel waters. *In winter at high tide, we recorded the highest concentrations of* $NO_3^-$_$NO_2^-$ *in coastal waters derived from riverine and anthropogenic inputs (Belin et al., 2021).* Over this 24-h cycle, the large $NO_3^-$_$NO_2^-$ decrease (sink) from high to low tide was significantly related to the large $NH_4^+$ increase (source) ($R^2 = 0.90$, $p < 0.001$). This strong relationship could highlight a dissimilatory nitrate reduction to ammonium (DNRA) in sediments which is known to be an important metabolic process in salt marshes producing DIC and TA (Giblin et al., 2013; Hopkinson and Giblin, 2008). In low winter autotrophy conditions, $NO_3^-$_$NO_2^-$ was not consumed by primary producers and could diffuse through sediments during immersion (Boynton et al., 2018) where it could be reduced in $NH_4^+$ by DNRA (Koop-Jakobsen and Giblin, 2010) before diffusing to channel waters through tidal pumping (Zheng et al., 2016). *Direct measurements of anaerobic processes at the benthic interface, such as sulfate reduction and DNRA, should be assessed to confirm the significance of these metabolic processes in the winter DIC production.”*

3. A few sentences can be modified to improve the reading.

Line, 675-676. The authors may change the sequence of presentations for the season. For example, “inducing water CO2 undersaturation in spring/summer and water $CO_2$ oversaturation in fall/winter.” This may be applied to the entire article.

The conclusion section was revised to highlight the tidal forcing importance in the water $pCO_2$ variation (see below).

**Section 5. Conclusions and limitations** (this paragraph was modified in the revised MS)

p29, L732-734: “*Over the seasonal 24-h cycles, water* $pCO_2$ *dynamics was partly controlled by the tidal forcing inducing intense variations in the channel during transient tidal phases due to contrasted end-members (coastal water* $CO_2$ *oversaturation versus marsh water* $CO_2$ *undersaturation).”*

Line, 682-684. This sentence is hard to read and can be spectacular. The Reviewer suggests splitting this sentence into two sentences and clarifying each sentence. Similar sentences can be found in the abstract, making this sentence difficult to interpret.

Both in the abstract and the conclusion of the revised MS, we modified the text concerning the contribution of planktonic communities in the marsh carbon cycle to improve the clarifying and the reading. We split the information into two sentences as suggested by Referee#1. We highlighted that phytoplankton communities can affect the $pCO_2$ variations in the channel waters during the low tide periods due to intense aquatic metabolism but planktonic metabolism did not control the marsh atmospheric carbon uptake at the ecosystem scale in the integrative way measured by eddy covariance.

**Section 5. Conclusions and limitations** (these sentences were modified in the revised MS)

p29, L740-743: "*The spring/summer phytoplanktonic bloom in channel waters and the associated aquatic autotrophy led to $CO_2$-depleted water exportations downstream. However, at the daily scale, planktonic metabolism did not play a significant role in marsh atmospheric carbon balance measured by Eddy Covariance at the ecosystem scale (within the footprint).*"

4. Uncertainties induced by k is unclear, Line 257. The authors should justify the reason to use this k in one or two sentences.

We completed the revised MS and we justified the use of the *k*-wind parametrization of Van Dam et al. (2019). Currently, there is no consensus on the *k* value parameterization in shallow coastal systems, such as salt marshes, mainly because *k* depends on several drivers acting at the same time: wind, current, water depth, friction at the bottom, heating and cooling. In this study, we have used the *k* parameterization of Van Dam et al. (2019) as a function of wind speed, that was determined from concomitant $pCO_2$ and $FCO_2$ eddy covariance data in an estuarine system with characteristics very similar with our study site: similar water/air temperature ranges, similar tidal amplitude ($0.50 < \text{depth} < 2.80$ m), similar depth (average depth: 1 m) and similar wind speed range ($0.93 < U_{10} < 6.79$ m $s^{-1}$ and average $U_{10}$: 3.85 m $s^{-1}$). Moreover, other studies in salt marsh systems also used this model for *k* calculation (Song et al., 2023).

**Section 2.5.1. Water-air $CO_2$ fluxes** (this paragraph modified in the revised MS)

p9-10, L277-287: "Water $pCO_2$ (ppmv) were measured by the C-sense$^{TM}$ probe, while air $pCO_2$ (ppm) were measured by the EC station at a height of 3.15 m. $FCO_2 > 0$ (i.e. water $pCO_2$ > air $pCO_2$) indicates a $CO_2$ source from water to atmosphere and $FCO_2 < 0$ (i.e. water $pCO_2$ < air $pCO_2$) indicates an atmosphere $CO_2$ sink by the water column. *We used the k-wind parametrization of Van Dam et al. (2019), which is a coefficient specific to shallow and microtidal estuaries but can be adapted to salt marsh systems (Song et al., 2023). Currently, there is no consensus on the k value parameterization in shallow coastal systems, such as salt marshes, mainly because k depends on several drivers acting at the same time: wind, current,* *water depth, friction at the bottom, heating and cooling. In this study, we used the k parameterization of Van Dam et al. (2019) as a function of wind speed, that was determined from concomitant $pCO_2$ and $FCO_2$ eddy covariance data in an estuarine system with characteristics very similar with our study site. The gas transfer coefficient, normalized to a Schmidt number of 600 ($k_{600}$) obtained from Van Dam et al. (2019), were converted to the $CO_2$ transfer velocity according to in situ temperature and salinity (k or $k_{660}$) following Jähne et al. (1987).”*

5. Implication: Most importantly, it is suggested that the author explicitly articulate the global or regional implications of this research clearly in the final sentence of the abstract to underscore its significance. Since this study employs both atmospheric and aquatic $CO_2$ measurement methods, the author should consider comparing and discussing the differences and relationships between these two measurement methods, potentially providing predictions or assessments regarding regional variations. Establishing a clear conceptual model based on such comprehensive and systematic observations would greatly enhance the research's academic value and influence.

We followed the recommendation of the Referee#1 and we completed the abstract in the revised MS to highlight the regional implication of this study in the coastal carbon cycle (see below). Also, we established a clear conceptual model based on our findings to greatly enhance the research's academic value and influence.

**Abstract** (these sentences were added in the revised MS)

p1-2: *“This study suggests that the horizontal exchanges of coastal waters with the salt marsh significantly participate to measured water carbon dynamics and associated channel water $CO_2$ sink/source status, through strong biological activity in the salt marsh (production and respiration). At the daily scale, plant and phytoplankton metabolisms played a major and a minor role, respectively, to the marsh atmospheric $CO_2$ sink measured at the ecosystem scale (NEE), even during low immersion where emerged plants located on the highest marsh levels can maintain net $CO_2$ uptake despite aquatic heterotrophy and shelf-contributed $CO_2$ emissions.”*

Minor comments:

Regarding presentation, it is recommended that the author rectify the inconsistent font sizes in the figures. For example, the term "$pCO_2$" is excessively large while other text is too small, causing readability issues. All text should be consistently sized and easily readable. Additionally, the labeling of "$pCO_2$" should remain uniform throughout the paper.

In the revised MS, we modified the font sizes in all figures as suggested by Referee#1 so that the text is of a uniform size and easily readable.

**RC2: 'Comment on egusphere-2025-335', Anonymous Referee #2, 17 Mar 2025**

We sincerely thank the Referee#2 for his/her work and the time he/she spent in reviewing our manuscript. We have considered all your remarks to improve the methodology, the precision, the limitations and the implications of our research study.

Title: Aquatic metabolism influences temporal variations of water carbon and atmospheric carbon dioxide fluxes in a temperate salt marsh by Mayen et al.

**General Comments:**

This manuscript presents valuable insights into the metabolic dynamics of a temperate salt marsh ecosystem, with a focus on temporal variations in DIC and $CO_2$ fluxes. The study is thorough in its approach and provides meaningful data across seasonal and tidal cycles. However, addressing the points below—especially those related to external influences, methodological clarity, and data interpretation—will improve the manuscript's clarity and impact.

We are grateful to Referee#2 for his/her positive feedbacks on our manuscript. Referee#2 highlighted the importance of our findings on the temporal variations of water carbon concentrations and atmospheric $CO_2$ fluxes in a temperate salt marsh using *in situ* carbon original samplings (seasonal 24-h cycles) and innovative methods (water $pCO_2$ probe and atmospheric Eddy Covariance). We believe our innovative results provide a better understanding of metabolic processes controlling water $pCO_2$, DIC and atmospheric $CO_2$ fluxes in salt marshes where diurnal/tidal data are still scarce. We considered all rightly-suggested Referee's recommendations (see below) and we hope that this revision will allow a final publication in the Biogeosciences journal. The manuscript has thereby been substantially revised, especially the external input influences on the study results, the methodology and the limitations of the study.

**Contextualization with broader literature:**

While the study provides localized data on carbon dynamics, its relevance to broader regional or global trends is not fully explored. Including references to similar studies or integrating global estimates would help contextualize the findings and enhance the manuscript's scientific significance.

We followed the recommendation of the Referee#2. In the revised MS, we added other similar studies to contextualize our findings and enhance the manuscript's scientific significance. A new table was specifically added in the revised MS to regroup similar articles studying inorganic carbon dynamics and water-air $CO_2$ emissions in temperate salt marsh systems (see table 5). In the revised MS, we compared our results with the literature (Table 5) to contextualize our findings.

**Table 5. Seasonal/annual comparison of water inorganic carbon dynamics ($pCO_2$ in ppmv, DIC and TA in µmol kg$^{-1}$), total aquatic metabolism ($NEP_{tot}$ in mmol m$^{-2}$ h$^{-1}$) and water-air $CO_2$ fluxes ($FCO_2$ in mmol m$^{-2}$ h$^{-1}$) between the Bossys perdus salt marsh (this study, France) and other similar temperate salt marsh systems in the literature. Median values were done in bold and range values were done in brackets (min – max).**

| Reference | | Winter | Spring | Summer | Fall | Annual |
|---|---|---|---|---|---|---|
| This study | Water $pCO_2$ (ppmv) | **525**<br>(321 – 1461) | **221**<br>(106 – 416) | **158**<br>(89 – 597) | **411**<br>(311 – 541) | **382**<br>(89 – 1461) |
| | DIC (µmol kg$^{-1}$) | **2799**<br>(2354 – 3963) | **2173**<br>(2053 – 2530) | **2056**<br>(1587 – 2175) | **2584**<br>(2206 – 2762) | **2238**<br>(1587 – 3963) |
| | TA (µmol kg$^{-1}$) | **3076**<br>(2508 – 4016) | **2757**<br>(2379 – 2947) | **2385**<br>(2228 – 2812) | **2804**<br>(2351 – 3047) | **2617**<br>(2228 – 4016) |
| | $NEP_{tot}$ (mmol m$^{-2}$ h$^{-1}$) | **-2.35**<br>(-7.72 – 3.02) | **-15.80**<br>(-16.61 – -14.98) | **-16.43**<br>(-19.36 – -13.50) | **-5.45**<br>(-7.81 – -3.08) | **-10.01**<br>(-19.36 – 3.02) |
| | Water-air $FCO_2$ (mmol m$^{-2}$ h$^{-1}$) | **0.24**<br>(0.05 – 0.46) | **-0.25**<br>(-0.52 – -0.03) | **0.28**<br>(0.05 – 0.53) | **0.36**<br>(0.03 – 0.62) | **0.15**<br>(-0.52 – 0.62) |
| Wang et al. (2018) | Water $pCO_2$ (ppmv) | n.a.<br>(500 – 4000) | n.a. | n.a.<br>(1600 – 12000) | n.a. | n.a.<br>(500 – 12000) |
| | DIC (µmol kg$^{-1}$) | n.a.<br>(1500 – 2500) | n.a. | n.a.<br>(2250 – 4300) | n.a. | n.a.<br>(1500 – 4300) |
| | $NEP_{aquatic}$ (mmol m$^{-2}$ h$^{-1}$) | -0.83 | n.a. | -2.50 | n.a. | -1.60 |
| | Water-air $FCO_2$ (mmol m$^{-2}$ h$^{-1}$) | 0.60 | n.a. | 3.90 | n.a. | 2.05 |
| Reithmaier et al. (2023) | DIC (µmol kg$^{-1}$) | **2158**<br>(1610 – 3080) | **1941**<br>(1452 – 7895) | **2052**<br>(1450 – 4200) | **2210**<br>(1367 – 3740) | **2065**<br>(1367 – 7895) |
| | TA (µmol kg$^{-1}$) | **2262**<br>(1634 – 3296) | **1977**<br>(1376 – 8045) | **2083**<br>(1578 – 4191) | **2269**<br>(1330 – 3765) | **2104**<br>(1330 – 8040) |
| Song et al. (2023) | Water-air $FCO_2$ (mmol m$^{-2}$ h$^{-1}$) | n.a. | n.a. | **1.03** | **0.20** | n.a. |
| Gong et al. (2023) | Water-air $FCO_2$ (mmol m$^{-2}$ h$^{-1}$) | n.a. | **0.53** | **0.65** | **1.10** | **0.76** |
| Alongi (2020) | Water-air $FCO_2$ (mmol m$^{-2}$ h$^{-1}$) | n.a. | n.a. | n.a. | n.a. | **1.49** |

**Discussion of study limitations:**

The manuscript would benefit from addressing potential limitations, particularly the absence of direct measurements of anaerobic respiration. Since both aerobic and anaerobic respiration pathways are key drivers of DIC and TA generation, a discussion on the lack of direct data and its implications would improve the transparency and robustness of the study.

Referee#2 is right, anaerobic respiration processes as other benthic processes/fluxes were not measured over our marsh site, which constituted a limitation in our study. In our case, the importance of anaerobic respiration in the marsh carbon cycle was revealed by the large and simultaneously DIC and TA increases measured from high to low tide, especially over the winter 24-h cycle (Fig. 6 and Fig. S1 in the Supplements). Indeed, in intertidal systems, the strong relationship between nTA and nDIC suggested a major contribution of anaerobic respiration in water inorganic carbon dynamics (Borges et al., 2003; Koné et Borges, 2008, Nakamura et al., 2024). In most intertidal systems, such as salt marshes and mangroves, intense anaerobic respiration processes occur in sediments inducing the highest DIC and TA concentrations in surface waters, especially at low tide through porewater exports driven by the tide (Nakamura et al., 2024; Reithmaier et al., 2023). Moreover, during our winter 24-h cycle, the strong nutrient increases (DIP and $NH_4^+$) from high to low tide could confirm microbial respiration of organic matter in marsh sediments and, in turn, lateral exports of DIC from porewaters to channel waters by tidal pumping as observed in other tidal systems (Cabral et al., 2024; Deborde et al., 2008; Santos et al., 2019). However, direct measurements of anaerobic respiration pathways in marsh sediments, such as sulfate reduction, denitrification and DNRA (dissimilatory nitrate reduction to ammonium), would have provided valuable information to conclude about the main biological drivers of DIC and TA increases during low tide periods in particular. We modified the manuscript accordingly to highlight this limitation in our study (see below).

**Section 4.3. Marsh aquatic respiration as DIC source** (this sentence was modified in the revised MS)

p28, L673-675: "*Direct measurements of anaerobic processes at the benthic interface, such as sulfate reduction and DNRA, should be assessed to confirm the significance of these metabolic processes in the winter DIC production.*"

**Section 5. Conclusions and limitations** (this sentence was added in the revised MS)

p30 L752-754: "*Direct measurements of heterotrophic respiration in marsh sediments could clearly highlight the contribution of autochthonous metabolic processes at the benthic interface in the channel DIC production in comparison with allochthonous processes/inputs*"

**Influence of external inputs and confounding factors:**

The potential influence of riverine and anthropogenic inputs—especially given the proximity to upstream dykes and salt ponds—is not thoroughly discussed. River inputs can introduce organic and inorganic materials, impacting gas concentrations and leading to supersaturation conditions for $O_2$ and $pCO_2$. As noted in Line 515, transient tidal phases cause considerable $pCO_2$ variability due to lateral exchanges. More explicit discussion on these confounding factors is necessary to support the conclusion that observed variations are predominantly driven by marsh primary production.

We thank Referee#2 for this comment. At our studied site, allochthonous inputs can significantly impact water $pCO_2$ dynamics measured in the sampling channel along with autochthonous processes as mentioned in our submitted MS. At high tide, the salt marsh is immersed by coastal waters imported from the continental shelf, this latter being under influence of riverine inputs to the East depending on seasons (Mayen et al., 2023); whereas at low tide, the salt marsh is emerged into the atmosphere and remaining water in the channel is drained from upstream salt ponds. In the revised MS, we more discussed the potential influence of downstream and upstream end-members in the marsh carbon cycle (water carbon dynamics and associated $CO_2$ fluxes).

Firstly, during high tide both the day and the night, imported coastal waters were generally oversaturated in $CO_2$ with respect to the atmosphere inducing atmospheric $CO_2$ emissions during the marsh immersion, except in spring (Table 2). Indeed, Mayen et al. (2023) and Coignot et al. (in prep.) showed that the coastal end-member (i.e. the continental shelf) behaved as a $CO_2$ source throughout the year, especially in winter during the highest river water flows from the Aiguillon Bay (Fig. 1). Thus, at high tide, coastal waters imported to the studied marsh could degas the excess of anthropogenic-derived $CO_2$ into the atmosphere during the marsh immersion (see section 4.1 in the revised MS). At the same time, the riverine and anthropogenic nutrient inputs by coastal waters from the continental shelf could supply the anaerobic respiration processes in the marsh sediments and, in turn, induced the large exports of dissolved $CO_2$ in channel waters (large oversaturation). In fact, over the winter 24-h cycle, the large $NO_3^-$ decrease (sink) from high to low tide was significantly related to the large $NH_4^+$ increase (source). This relationship could highlight a dissimilatory nitrate reduction to ammonium (DNRA) in sediments which is an intense respiration process producing DIC and TA in water (see section 4.3 in the revised MS).

On the contrary, the upstream salt ponds connected with the studied salt marsh through a lock during low tide periods only could strongly influence the water carbon dynamics measured in the sampling channel. Indeed, from spring, the intense primary production of floating macroalgae and phytoplankton bloom in the upstream salt ponds can influence the water inorganic carbon inducing large water $CO_2$ undersaturations at low tide in channel waters. Mayen et al. (2023) confirmed that the fast-growing macroalgae recorded in the upstream salt ponds induced and maintained large water $CO_2$ undersaturation at both day and night during warm and bright periods, inducing low diurnal variations of water $pCO_2$. Thus, in our case, the catchment area constituted of artificial salt ponds and associated anthropogenic dykes strongly influence water $pCO_2$ dynamics in the studied salt marsh (see section 4.2 in the revised MS).

**Role of emergent vegetation:**

Section 4.2 focuses heavily on planktonic primary production, yet emergent vegetation such as Spartina maritima likely plays a significant role in carbon cycling. Data in Tables 2 and 3 suggest that marsh plant metabolism (NEEmarsh) has a greater influence than planktonic NEP. The manuscript should provide a more detailed discussion on how emergent plants contribute to DOC production and GPP.

During low tide, phytoplankton and benthic microalgae recorded in the sampling channel could strongly control water carbon dynamics inducing large water $CO_2$ undersaturation and large DOC production as measured in spring, summer and fall. At the same time, the intense autotrophy of emerged plants strongly controlled NEE promoting a marsh atmospheric carbon sink during daytime immersion (Mayen et al., 2024). The metabolism of emerged plants can also contribute to a DOC production through above-ground and belowground litter loss and root exudations.

In the section 4.2, we firstly highlighted the role of planktonic communities in the $CO_2$-depleted and DOC-concentrated water exportations from high to low tide. Indeed, a large part of inorganic carbon was fixed by primary producer photosynthesis (negative correlation between Chla and water $pCO_2$; Table 3) including mainly phytoplankton, benthic microalgae and macroalgae, processed by metabolic processes and then exported from/to channel waters as organic carbon (negative correlation between DOC and water $pCO_2$; Table 3). In the second time, we discussed the potential contribution of the emerged plants, especially in spring and summer, in the large DOC production measured in the channel waters. Indeed, the large $GPP_{marsh}$ rate estimated by Eddy Covariance at low tide day indicate an intense autotrophy of emerged plants (Fig. 2) and confirmed by Mayen et al. (2024). Thus, these latter could produce large amounts of DOC in the marsh sediments, which are exported to the surface water of the channel by tidal pumping at low tide. In a temperate salt marsh, Schiebel et al. (2018) confirmed strong DOC production by plant biomass following by a leaching of DOC to surface water by tidal pumping. Thus, in some cases, it is difficult to distinguish the relative contribution of allochthonous and autochthonous metabolic processes to water carbon dynamics recorded in the channel as both process origins are involved. Over our 24-h cycles, the daily carbon balances of marsh plant metabolism ($NEE_{marsh}$) and the planktonic metabolism ($NEP_{pk}$) indicated a minor contribution of planktonic communities and a major one of emerged plants to marsh atmospheric carbon balances at the ecosystem and daily scales (Table 4). We have now modified section 4.2 and section 4.4 to provide a more detailed discussion on how emergent plants contribute to DOC production and GPP as follow:

**Section 4.2. Marsh primary producer metabolism influence on water $pCO_2$ and DOC** (this paragraph was completed in the revised MS)

p26, L612-L626: "*Finally, at our salt marsh, the strong primary production of emerged plants, especially in spring and summer (high daytime $GPP_{marsh}$ rates over C3-summer; Fig. 2) and confirmed by Mayen et al. (2024), could also induce DOC production through above-ground and belowground litter loss and root exudations (Kristensen and Alongi, 2006; Schiebel et al., 2018), then exported to surface waters by tidal pumping (Santos et al., 2019) inducing the highest DOC concentrations measured at low tide (Fig. 7).* Most of the DOC leached from marsh plants, like S. maritima, is labile and biodegradable through bacterial activity, especially polysaccharides. *However, because of its long residence time, lignin-derived DOC is a potentially important source of recalcitrant humic substances in marsh-influenced waters (Arnaud et al., 2024; Moran and Hodson, 1990; Wang et al., 2014). Thus, over our spring and summer 24-h cycles, the $CO_2$-depleted and DOC-concentrated water exportations from high to low tide could highlight the major role of autochthonous/allochthonous marsh primary production within all compartments (terrestrial and aquatic) in the coastal carbon cycle. However, in some cases, it is difficult to distinguish the relative contribution of allochthonous and autochthonous metabolic processes to water carbon dynamics recorded in the channel as both process origins are involved (Fig. 8). Contrary to our study, Santos at al. (2021) indicated large DIC and DOC outwelling from salt marshes over all seasons; it could indicate lower aquatic heterotrophy and higher aquatic autotrophy at our studied marsh, especially in spring and summer, allowing simultaneously large $CO_2$ uptake and DOC production."*

## Section 4.4. Influence of aquatic and benthic metabolisms on NEE

p28, L690-697: "For an integrative study of the planktonic community contribution to marsh $CO_2$ uptake including both high and low tide periods, daily C balances were computed from planktonic aquatic metabolism ($NEP_{pk}$) and net ecosystem $CO_2$ exchanges (NEE) within the EC footprint (Table 4). Over our 24-h cycles, planktonic metabolism was net autotrophic in winter and spring due to higher daytime $CO_2$ uptake than night-time $CO_2$ source in waters, whereas it was net heterotrophic in summer and fall due to lower daytime $CO_2$ uptake than night-time $CO_2$ source (Fig. 5-a). Simultaneously, NEE measurements indicated an intense autotrophy of the whole salt marsh from winter to summer (Mayen et al., 2024) allowing a large atmospheric C uptake with a major contribution from marsh plants ($NEE_{marsh}$) and a minor one from planktonic communities ($NEP_{pk}$) (Table 4)."

**Clarity through visual aids:**

A conceptual figure illustrating the pathways of TA, DIC, and DOC generation—and their respective effects on $pCO_2$—would help clarify the interactions and enhance the reader's understanding of the discussed processes.

In the revised MS, we added a conceptual figure (see figure 8) as suggested by Referee#2 to illustrate TA, DIC and DIC generation in the studied salt marsh and their contribution on water $pCO_2$ in the channel.

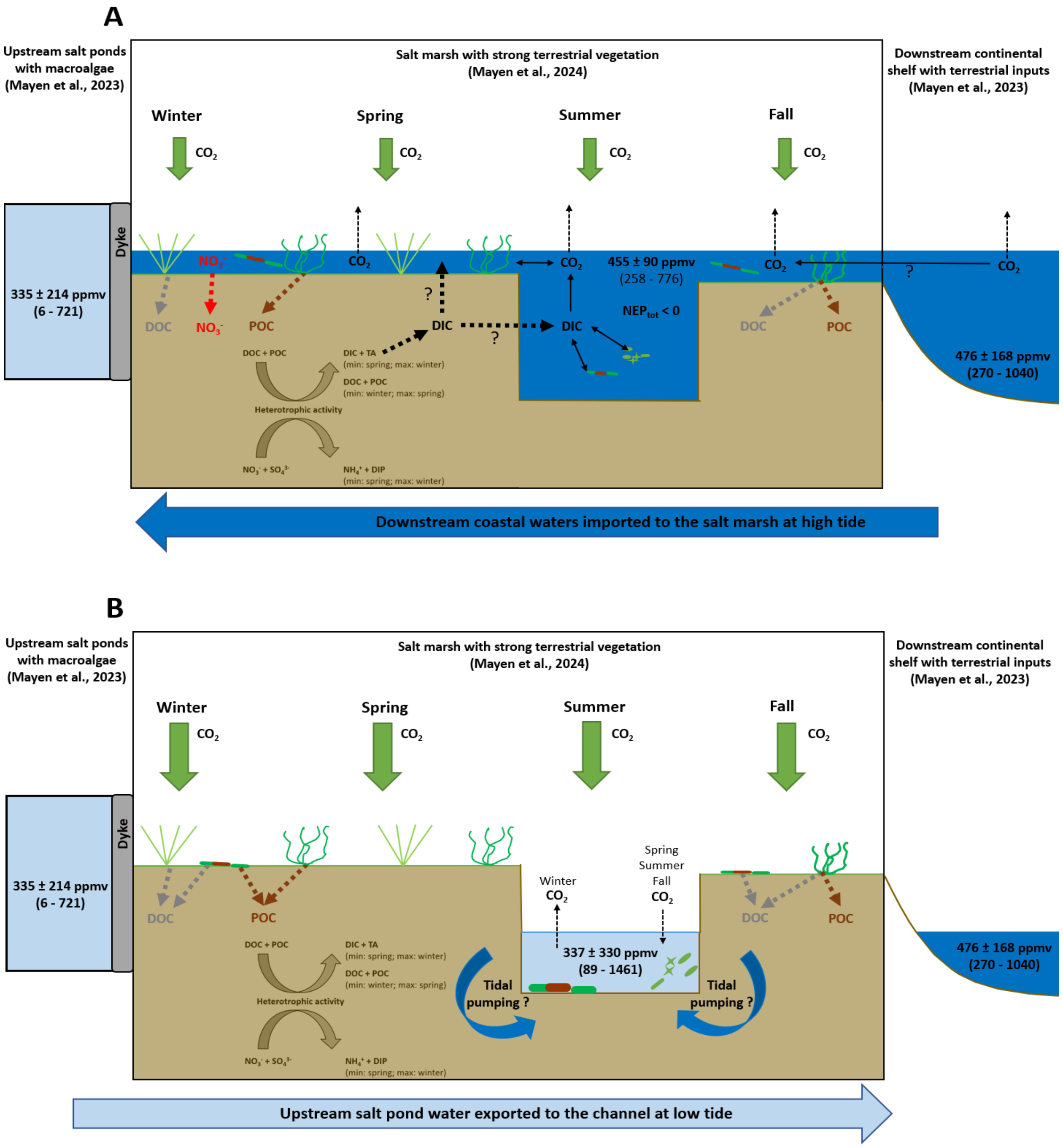

**Fig. 8. Water carbon dynamics and atmospheric CO2 fluxes at the Bossys perdus salt marsh over our 24-h cycles at two contrasted tidal periods: (A) high (flooding) tide (marsh immersion by downstream coastal waters) and (B) low (ebbing) tide (marsh emersion and channel water** come from the marsh-drainage process by tidal forcing and the waterflow **from the upstream salt ponds). Green arrows represent net atmospheric CO2 sink measured at the ecosystem scale by eddy covariance. Negative NEP$_{tot}$ in the water column at high tide corresponds to aquatic heterotrophy (net carbon source for water).**

**Specific Comments:**

L95: Provide sediment type information at the study sites, which is relevant for interpreting diagenetic processes. This can be added to the Methods or Results section.

In the revised MS, we completed the description of the study site to add information concerning the marsh sediment composition (see below). At top, sediments are dominated by a sandy substrate whereas at bottom, sediments were composed by muds.

**Section 2.1. Study sites** (these sentences were added in the revised MS)

p4, L109-L112: "*Two different substrata can be found in the soil of the salt marsh with sand-dominated sediments at bottom and mud-dominated sediments at top (transition depth at 33 cm). In the muddy section, dry bulk density and organic carbon content were 0.8 ± 0.1 g cm*$^{-3}$ *and 1.78 ± 0.19%, respectively (Amann et al., 2024).*"

L160: Standardize the y-axis scaling for $CO_2$ in Fig. 2 to ensure comparability across plots.

The figure 2 was modified and we standardized the y-axis scaling for water $pCO_2$ (between 0 and 1600 ppmv) to ensure comparability across the plots.

L178–179: Clarify whether the listed plant species percentages are based on biomass, coverage, or another metric. Also, indicate whether vegetation composition varies seasonally, and how this might impact $CO_2$ fluxes.

As suggested by Referee#2, we completed the revised MS in the Eddy Covariance section and we indicated that the plant percentages inside the studied footprint are based on a habitat coverage survey fully described in Mayen et al. (2024). A land-use map was created from geo-referenced IGN BD orthogonal images with a resolution of 20 cm (2019) using ArcGIS 10.2 (ESRI). The spatial analysis tool of ArcGIS 10.2 was used to perform an unsupervised classification of the BD orthogonal images. We checked the resulting map by selecting 20 random locations within the footprint of the studied salt marsh and compared their land use on the ground and on the map (Mayen et al., 2024). Also, we added supplementary information concerning seasonal life cycle of the marsh plants and their potential impact on atmospheric $CO_2$ fluxes (see below). *H. portulacoides* and *S. vera* are evergreen plants throughout the year whereas, the growing season for *S. maritima* was shorter (only in spring and summer).

**Section 2.3.2. Atmospheric Eddy Covariance and footprint** (these sentences were added in the revised MS)

p6, L181-L186: "*A habitat covering map showed that the studied footprint was occupied mainly by halophytic plants including Halimione portulacoides (37%), Spartina maritima (22%) and Suaeda vera (7%) whereas, mudflats and channels occupied 34% of the footprint area (Mayen et al., 2024). H. portulacoides and S. vera are evergreen plants throughout the year whereas, the growing season for S. maritima was shorter (from spring to late summer). During winter and fall, S. maritima persists only in the form of rhizomes and its low metabolism could induce lower marsh CO2 uptake rate (Mayen et al., 2024).*"

L194–195: The reported uncertainties are appreciated. Specify whether they were determined through replicate analyses, CRM comparisons, or another quality control method.

In our study, the uncertainties of nutrient measurements were obtained from certified reference material (CRM) comparisons. The revised MS was completed in the method section (see below).

**Section 2.4.1. Discrete parameters** (this sentence was added in the revised MS)

p8, L212-213 "Measurement uncertainties were 4% for DSi and 8% for $NO_3^-$_$NO_2^-$, $NH_4^+$ and DIP *and were obtained from certified reference material comparisons within interlaboratory studies (the Dutch Accreditation Council, ISO 17043:2010*)."

L245: It is noted that water samples were collected for DIC analysis, yet DIC concentrations were calculated rather than directly measured. Clarify this apparent inconsistency.

For each hourly water sample, DIC was analysed using a TOC meter in laboratory (Shimadzu TOC-$_{\text{LCPH/CPN}}$$^{\text{TM}}$) after water acidification to convert all DIC into $CO_2$. However, this method can have large uncertainties since water samples were filtered directly in the field and large $CO_2$ amounts could evade into the atmosphere, especially during the water $CO_2$ oversaturation periods in winter, inducing potentially underestimated DIC values. Thus, in this study, we decided to calculate DIC concentrations from the measured total alkalinity (TA) and water $pCO_2$ using the $CO_2$ system calculation program $CO_2SYS$ (Lewis and Wallace, 1998) as fully described in the 2.5 section of the submitted MS. Other studies in shallow coastal systems estimated DIC from the pair TA-$pCO_2$ (Sippo et al., 2016; Cotovicz Jr. et al., 2021; Koné et Borges, 2007). In the revised MS, we modified the method section to clarify this apparent inconsistency.

L270: The formula presented appears incorrect. (TA1 - TA2) should be multiplied by a factor of 0.5, and DIC and TA should be referred to as NDIC and NTA.

In this study, we calculated the net ecosystem production of the water column ($NEP_{tot}$, eq. 2) as follows:

$$NEP_{tot} = ((nDIC_1 - nDIC_2)\rho d) / \Delta t - ((nTA_1 - nTA_2)\rho d) / \Delta t - FCO_2$$

where $nDIC_1$ and $nDIC_2$ are DIC concentrations (mmol $kg^{-1}$) normalized to salinity between two samplings, $nTA_1$ and $nTA_2$ are TA concentrations (mmol $kg^{-1}$) normalized to salinity between two samplings, ρ is the water density (kg $m^{-3}$), d is the water depth (m), Δt is the time interval (h) between the two discrete samplings and $FCO_2$ is the water-air $CO_2$ flux (mmol $m^{-2}$ $h^{-1}$). We used the method proposed by Cotovicz et al. (2021) in which (nTA1 – nTA2) was not multiplied by 0.5. We modified the revised MS to indicate that DIC concentrations and TA concentrations between two samplings were normalized to salinity (see above). However, we propose not to change this formula and to keep the results in the submitted MS (see Table 2).

Cotovicz, L. C., Knoppers, B. A., Régis, C. R., Tremmel, D., Costa-Santos, S., and Abril, G.: Eutrophication overcoming carbonate precipitation in a tropical hypersaline coastal lagoon acting as a $CO_2$ sink (Araruama Lagoon, SE Brazil), Biogeochemistry, 156, 231–254, https://doi.org/10.1007/s10533-021-00842-3, 2021.

L530: The manuscript discusses seasonal shifts in metabolic status, but the role of light (PAR) across seasons and tidal phases is underexplored. If PAR data were collected, integrating it into the analysis would enhance the interpretation.

Over our sampling 24-h cycles, atmospheric PAR was continuously measured by the Eddy Covariance system and the seasonal variations of PAR were fully described in the 3.1. section (meteorological and environmental settings). We showed that C2-spring and C3-summer were the brightest periods with no significant variation in daytime PAR values (Mann-Whitney test, $p = 0.10$). Over C2-spring and C3-summer, the medians of daytime PAR values were 1236 and 1135 µmol $m^{-2}$ $s^{-1}$, respectively. Thus, we concluded that the seasonal shift in planktonic metabolic status from spring to summer was rather related to an increase in air temperature and a change in abundance and diversity of planktonic communities than a PAR variation (see below and see Fig. 4).

## Section 4.2. Marsh primary producer metabolism influence on water $pCO_2$ and DOC

p24, L579-L583: "During daytime low tide, the highest planktonic $CO_2$ uptake ($NEP_{pk} > 0$) was recorded in spring (high PAR and temperate Tw) through a significant autotrophic activity of pennate diatoms and nanophytoplankton, whereas the decrease in planktonic $CO_2$ uptake towards summer (high PAR and Tw) was concomitant to higher temperatures, leading to increased community respiration, and more generally, dominant heterotrophic processes."

L540: The use of POC stable isotope ratios is mentioned; briefly explain the methodology and analysis in the Methods section.

We followed the recommendation of Referee#2 and briefly explain the methodology and analysis of POC stable isotope ratio in the material and method section (see below).

**Section 2.4.1. Discrete parameters** (this sentence was added in the revised MS)

p8, L228-L229: "*The analysis of POC stable isotope ratios ($\delta^{13}$C-POC) was performed using an Elemental Analyser Isotope Ratio Mass Spectrometer (EA-IRMS: Thermo Flash HT/EA and Delta V Advantage) following Razanamahandry et al. (2024).*"

L675: The statement "Over the seasonal 24-h cycles, water $pCO_2$ was mainly controlled by biological activity..." is not supported by the data. Fig. 2 indicates that $pCO_2$ variation corresponds closely with Hw, suggesting tidal forcing as the main driver. This should be addressed.

Referee#2 is right, tidal forcing is a major controlling factor of marsh water carbonate chemistry (Fig. 6), especially water $pCO_2$. In the figure 2, we can see that water $pCO_2$ variations were strongly related to water height measured in the sampling channel. During transient tidal phases, lateral exchanges with adjacent down- and upstream waters instantaneously produced intense channel water $pCO_2$ variations, leading to increases during flood tides (i.e. channel filling) mainly due to buffered coastal waters imported from the shelf, except in winter at night, and decreases during ebb tides (i.e. channel emptying), mainly due to $CO_2$-depleted marsh waters exported from the marsh system. The revised MS was modified accordingly (see below).

**Section 4.1. Temporal variations of water $pCO_2$ in salt marshes** (these sentences were modified in the revised MS)

p22, L528-L539: "*During high tide both at day and night, imported coastal waters were oversaturated in $CO_2$ inducing atmospheric emissions during marsh immersion (except in spring; Table 2). Indeed, Mayen et al. (2023) confirmed that the coastal end-member behaved as a $CO_2$ source, especially in winter during the highest river water flows from the Aiguillon Bay. Thus, coastal waters advected to the studied salt marsh could degas the excess of anthropogenic-derived $CO_2$ into the atmosphere (Fig. 8). In the salt marsh, strong water $pCO_2$ variations were recorded from high to low tide due to more intense biological activity (production and respiration) at low tide in channel waters influenced by the marsh than at high tide in more buffered coastal waters as shown elsewhere by Wang et al. (2018).* In winter at low tide, the net marsh autotrophy during the day induced a small channel water $pCO_2$ decrease, whereas the net marsh heterotrophy during the night induced a large channel water $pCO_2$ increase. In contrast, during spring and summer, the intense autotrophy in channel waters induced the lowest $pCO_2$ values both at day and night (Fig. 2). *Thus, during transient tidal phases, lateral exchanges with adjacent down- and upstream waters instantaneously produced* *intense channel water $pCO_2$ variations, leading to 1) increases during flood tides (i.e. channel filling) in response to $CO_2$-oversaturated coastal waters imported from the shelf, and 2) decreases during ebb tides (i.e. channel emptying) in response to $CO_2$-depleted marsh waters exported from salt ponds (Mayen et al., 2023), along with autochthonous carbon processes (production/respiration) involved at both tidal periods.* These tidal water $pCO_2$ variations over our 24-h cycles were observed and confirmed during the longer in situ measurement periods up to 5 days per season *encompassing our 24-h sampling measurements. These intense tidal variations confirmed that water mixing processes occurring in the channel induced large changes in carbonate chemistry mainly related to contrasted coastal and marsh endmembers (Fig. 8).*"

**Section 4.3. Marsh aquatic respiration as DIC source** (theses sentences were modified in the revised MS)

p27, L641-646: "*During low tide (marsh emersion), the largest DIC and TA increases were measured in channel waters, especially in winter, highlighting a strong control of tidal forcing on water carbonate chemistry (Fig. 8). In similar salt marsh systems, the same tidal DIC pattern was recorded over all seasons with highest concentrations at low tide and lowest ones at high tide (Table 5).* In most intertidal systems, such as salt marshes and mangroves, intense respiration processes occur in sediments inducing high DIC and TA concentrations in surface waters, especially at low tide through porewater exports driven by the tide (Nakamura et al., 2024; Reithmaier et al., 2023)."

**Section 5. Conclusions and limitations** (these sentences were modified in the revised MS)

p29-30, L732-741: "*Over the seasonal 24-h cycles, water $pCO_2$ dynamics was partly controlled by the tidal forcing inducing intense variations in the channel during transient tidal phases due to contrasted end-members (coastal water $CO_2$ oversaturation versus marsh water $CO_2$ undersaturation).* In general, at high tide, water column $CO_2$ oversaturation due to heterotrophic metabolism was able to significantly reduce atmospheric $CO_2$ uptake measured at the ecosystem scale (NEE) during the highest immersion levels only. From high to low tide, the salt marsh acted as a source of DIC, TA and $NH_4^+$, especially in winter, related to intense anaerobic respiration processes in waters and sediments inducing a significant increase in water $pCO_2$. On the contrary, in spring and summer, intense autochthonous and allochthonous primary production, including phytoplankton, benthic microalgae and macroalgae, induced the lowest water $pCO_2$ in the channel both at day and night, coupled with high DOC production. *The spring/summer phytoplanktonic bloom in channel waters and the associated aquatic autotrophy led to $CO_2$-depleted water exportations downstream.*"

**Figures and Tables:**

Fig. 2: In winter, high salinity occurs during high Hw, whereas in spring and fall, high salinity coincides with low Hw. Additionally, no clear relationship between salinity and Hw is observed in fall. These seasonal differences warrant further discussion.

At our studied salt marsh, no clear relationship between salinity and water height was observed between the seasons (Fig. 2), contrary to the river-dominated coastal systems (Wang et al., 2018; Polsenaere et al., 2023). In our case, the winter/fall low tide periods correspond to the lowest salinity values whereas the spring/summer low tide periods correspond to the highest salinity values (Fig. 2). This seasonal difference in channel water salinity at low tide was related to dilution and evaporation occurring in the upstream salt ponds due to seasonal changes in meteorological conditions and associated upstream dyke marsh water managements. Over C1-winter and C4-fall, salt water in these upstream ponds was diluted by the rain decreasing salinity whereas over the hottest periods (C2-spring and C3-summer), evaporation processes occur in the salt ponds inducing large salinity increases, especially during neap tide periods. These winter/fall dilution and spring/summer evaporation processes in the upstream salt ponds were fully described by Mayen et al. (2023). We completed the revised MS to added this explanation in the discussion section (see below).

These upstream artificial ponds are supplied with salt waters from the estuary during high tide through a lock management practice to promote biodiversity protection. The water residence time in these artificial ponds varied from a few hours to fifteen days according to the management practices before being discharged to the downstream estuary through the Bossys perdus channel during low tide. Thus, according to the weather, the pond geomorphology, the complex circulation of salt waters and management practices, there is no correlation between water heights and salinity values at low tide in the sampling channel.

**Section 4.3. Marsh aquatic respiration as DIC source** (these sentences were modified in the revised MS)

p26, L629-L635: "*Large tidal variations of DIC and TA were recorded along the salinity gradient (Fig. 6) confirming a strong control of water mixing processes occurring in the channel on the carbonate chemistry (Reithmaier et al., 2023). However, the slope of this relationship was negative in C1-winter/C4-fall and positive in C2-spring/C3-summer due to a seasonal shift in channel salinity (Fig. 2). More precisely, in the upstream salt ponds supplying the studied marsh channel during low tide, large seasonal variations of salinity can occur due to different meteorological conditions and water managements inducing low salinity in winter/fall due to salt water dilution by the rain and high salinity in spring/summer due to salt water evaporation by the hot (Mayen et al., 2023).*"

Moreover, $pCO_2$ does not exhibit significant diurnal variation during low Hw periods, which diverges from typical diurnal patterns. This anomaly requires explanation.

Referee#2 is right, low diurnal variations in channel water $pCO_2$ was recorded during low tide periods. In winter at low tide, the weak autochthonous/allochthonous aquatic autotrophy during the day induced a small channel water $pCO_2$ decrease, whereas the intense autochthonous/allochthonous aquatic heterotrophy during the night induced a large channel water $pCO_2$ increase. On the contrary, in spring and summer, large water $CO_2$ undersaturations were induced and maintained in the channel both during the day and the night mainly due to the intense autotrophy of the allochthonous macroalgae and autochthonous benthic microalgae (Mayen et al., 2023). Thus, in some cases, it is difficult to distinguish the relative contribution of allochthonous and autochthonous metabolic processes to water carbon dynamics recorded in the channel as both process origins are involved. To illustrate, over the C2-spring and C3-summer, water $pCO_2$ decreased of 100 and 140 ppmv, respectively, during the low tide day and increased of 30 and 50 ppmv, respectively, during the low tide night. These low diurnal variations of channel water $pCO_2$ were explained in the section 4.2 of the revised MS (see below).

At the daily scale, planktonic communities could play a major role in the water inorganic carbon dynamics in spring only when the highest planktonic autotrophy ($NEP_{pk} = 0.25$ g C $m^{-2}$ $d^{-1}$) was associated with the lowest water $pCO_2$ values (239 ± 105 ppmv), especially at low tide (Fig. 5). On the contrary, the winter planktonic autotrophy ($NEP_{pk} = 0.11$ g C $m^{-2}$ $d^{-1}$) corresponded to the highest water $pCO_2$ values (669 ± 327 ppmv) due to a more intense autochthonous respiration at the benthic interface. In the same way, the summer planktonic heterotrophy ($NEP_{pk} = -0.06$ g C $m^{-2}$ $d^{-1}$) simultaneously measured with the water $CO_2$ undersaturation (271 ± 182 ppmv) could indicate that the autochthonous planktonic respiration in the salt marsh was counterbalanced by the intense allochthonous macroalgae primary production in the upstream ponds.

**Section 4.2. Marsh primary producer metabolism influence water $pCO_2$ and DOC** (these sentences were completed in the revised MS)

p26, L602-L611: "In spring and summer at low tide, the strong daytime increases (up to 190%) and night-time decreases (down to 10%) of DO in channel waters (Fig. 2) could indicate an intense biological activity of *allochthonous* aquatic macroalgae and/or *autochthonous* benthic microalgae which have higher rates of production and respiration than phytoplankton per unit area (Borum and Sand-Jensen, 1996; Hill et al., 2015). The fast-growing macroalgae recorded in the upstream salt ponds induced and maintained large water $CO_2$ undersaturation at both day and night, especially during warm and bright periods, *inducing low diurnal variations of water* $pCO_2$ (Mayen et al., 2023). Thus, these *allochthonous* macroalgae could also largely contributed to the large $CO_2$ uptake and DOC production recorded in the sampling channel that receives all upstream salt pond waters at low and ebb tides (Fig. 8). Previous studies have reported that macroalgae primary production favours tidal DOC exportations, a part of which can be sequestered in marine sediments (Hill et al., 2015; Krause-Jensen and Duarte, 2016; Raven, 2018)."

Table 1: The highest Chl a concentration is reported in fall, which contradicts the data shown in Fig. 4. Clarify this inconsistency.

In the submitted MS, a representation error of Chl*a* concentration was made in the figure 4. At each diurnal/tidal phase (LT/Day, HT/Day, LT/Night and HT/Night), the Chl*a* concentration value reported in green corresponded to one sample only, associated to sampled planktonic community. In the revised MS, we modified the figure 4 and the Chl*a* concentrations reported in green correspond to the Chl*a* median value for each diurnal/tidal phase. The caption of the figure 4 was also modified.

Fig. 4: Chl a concentrations are high in fall, but both microphytoplankton and pico-nanophytoplankton abundances are low. This discrepancy should be addressed in the discussion.

Referee#2 reported a valuable comment. Over C4-fall at low tide, the highest Chl*a* concentrations were recorded while, at the same time, the microphytoplankton and pico-nanophytoplankton abundances were low. This discrepancy could be related to the presence of benthic microalgal mats (microphytobenthos) resuspended in the channel over C4-fall inducing high phytoplankton biomasses (high Chl*a* concentrations) and low phytoplankton abundances in surface waters. Indeed, over C4-fall at low tide, the diatom community sampled in channel waters was constituted of 71% of marine benthic diatoms (39% of *Nitzschia longissima* and 32% of *Pleurosigma* + *Gyrosigma*). This information has already been mentioned and discussed in section 4.2. (see below).

### Section 4.2. Marsh primary producer metabolism influence water $pCO_2$ and DOC

p24, L570-578: “During the 24-h cycles, the large phytoplankton abundance increases from high to low tide, especially in spring and summer (Fig. 4), indicated a development of planktonic communities in the salt marsh under nutrient-rich conditions and low water levels. At low tide (except in winter), POC:PON ratios were close to the Redfield value (Redfield, 1958) suggesting living phytoplanktonic biomass in channel waters. Moreover, phytoplankton was highlighted as the dominant C source at low tide using POC stable isotope ratios ($\delta^{13}C$ of -18.3 ± 1.0‰, -17.4 ± 0.4‰ and -20.6 ± 0.9‰ in spring, summer and fall, respectively; unpublished data) according to Gearing et al. (1984). In the sampled planktonic communities, high abundances of pennate diatoms indicated the presence of resuspended benthic microalgal mats (microphytobenthos: MPB) whose strong metabolism could promote the lowest water $pCO_2$ measured in the channel (Fig. 2) as observed elsewhere (Polsenaere et al., 2022).”

Fig. 5a and Table 2: NEPpK > 0 is shown during Ht/Night in spring; however, NEPpK cannot logically be positive during nighttime. An explanation for this abnormal result is necessary.

We thank Referee#2 for this abnormal result. In the submitted MS, a sign error was made in the spring planktonic metabolism at the HT/Night in the figure 5a et the table 2. Referee#2 is right, $NEP_{pk} > 0$ (i.e. autotrophy of planktonic communities) is not possible during the night (no light, PAR < 10 µmol $m^{-2}$ $s^{-1}$). In the revised MS, the correction was made in the figure 5a et in the Table 2. We checked all other calculations of metabolism rates and no error was found.

Fig. 6: TA and DIC show a negative correlation with salinity in winter and fall, but a positive correlation in spring and summer. The reason for this seasonal shift needs to be discussed.

Over the sampling 24-h cycles, DIC and TA were significantly related to salinity but the slope of this relationship was negative in winter/fall and positive in spring/summer, as the Referee#2 rightly noted (Fig. 6-A). Indeed, over C1-winter and C4-fall, channel waters at low tide had the lowest salinity values and the highest DIC and TA concentrations (negative slopes) whereas C2-spring and C3-summer, channel waters had both the highest salinity values and the highest DIC and TA concentrations (positive slopes). This shift was related to a seasonal change in the channel salinity, especially in water exported from the upstream salt ponds, due to dilution and evaporation processes (Mayen et al., 2023). We completed the revised MS to added this explanation in the discussion section (see below).

**Section 4.3. Marsh aquatic respiration as DIC source** (these sentences were added in the revised MS)

p26, L629-L635: "*Large tidal variations of DIC and TA were recorded along the salinity gradient (Fig. 6) confirming a strong control of water mixing processes occurring in the channel on the carbonate chemistry (Reithmaier et al., 2023). However, the slope of this relationship was negative in C1-winter/C4-fall and positive in C2-spring/C3-summer due to a seasonal shift in channel salinity (Fig. 2). More precisely, in the upstream salt ponds supplying the studied marsh channel during low tide, large seasonal variations of salinity can occur due to different meteorological conditions and water managements inducing low salinity in winter/fall due to salt water dilution by the rain and high salinity in spring/summer due to salt water evaporation by the hot (Mayen et al., 2023).*"

**RC3**: 'Comment on egusphere-2025-335', Anonymous Referee #3, 17 Mar 2025

We thank the Referee#3 for his/her work and for the time he/she spent in reviewing our manuscript. We have considered all your remarks to ameliorate the methodology, the precision, the limitations and the implications of our research. A new table was added in the revised MS to regroup similar articles studying inorganic carbon dynamics and water-air $CO_2$ emissions in temperate salt marsh systems to contextualize our findings and enhance the manuscript's scientific significance (see table 5 below). In that respect, we noticed that the referee ranked the scientific significance of our MS as "poor", unlike the two other referees that ranked it as "excellent" and "good". However, Referee 3 did not provide any reference of previous works that report same findings as ours. Consequently, we based our revisions on our own knowledge of the literature, hoping that we did not miss any key paper on the topic. Finally, to further discuss our finding in a broader context, we propose in the revised MS a conceptual model to better organize and delimit the contribution of terrestrial and aquatic compartments to net ecosystem $CO_2$ exchanges (sink/source) according to the various measurements done at our study site (see Fig. 8 below).

The main goal of this paper is to show that tidal floodwater when over the marsh alters $CO_2$ gas flux between the tidal marsh and the atmosphere, that the biogeochemistry of the tidal water is altered when it floods and drains from the marsh, and that the $CO_2$ flux magnitude and direction from flood water when it totally inundates all marsh vegetation is controlled by $CO_2$ levels somewhat controlled by pelagic metabolism. The approach appears to be designed primarily just to prove these points – not to quantify the seasonal/annual pattern of any of the processes that can contribute to these patterns. I say this because water chemistry was only sampled on 4 days during an entire year (seasonally) and with the exception of $pCO_2$, which was measured by continuous probe, other parameters (nutrients OC, IC, etc) were sampled only twice on either side of high tide and low tide. The interval between samplings at high and low tide were not mentioned, best I can tell.

Salt marshes play a major role in the global carbon (C) cycle allowing atmospheric $CO_2$ uptake and blue C sequestration due to intense plant primary production. This present study was built to better understand the influence of marsh aquatic metabolism on water $pCO_2$ and net ecosystem $CO_2$ exchanges (NEE) at short timescales (diurnal/tidal rhythms). In a salt marsh, we performed bi-hourly water samplings over each 24-hour cycle ($n = 13$) to measure continuously water biogeochemical parameters (organic carbon, inorganic carbon, phytoplankton abundances and nutrients) at the diurnal/tidal scales (see figure S1 in the Supplements). Moreover, for planktonic metabolism, water samples were collected every six hours during each 24-h cycle ($n = 4$) successively at low tide and high tide. Finally, these water samplings were performed simultaneously with NEE fluxes measured by atmospheric Eddy Covariance inside the footprint. To our best knowledge, this is the first time so many parameters are quantified simultaneously at a same study site to better study the marsh carbon cycle. In the literature, very few studies have looked for the aquatic metabolism influence in water carbon dynamics and atmospheric carbon exchanges from an integrative manner, using *in situ* carbon original samplings (through intense seasonal 24-h cycles) and innovative methods (autonomous water $pCO_2$ probe and atmospheric Eddy Covariance). In this way, our original results provide a better understanding of biotic and abiotic factors controlling water $pCO_2$ and atmospheric $CO_2$ fluxes in salt marshes where diurnal/tidal data are scarce. The novelty of this study and the original findings were fully highlighted in the revised MS.

In our study, water $pCO_2$ were mainly controlled by biological activity inducing water $CO_2$ oversaturation at low tide in winter due to heterotrophic processes (DIC, TA, $NH_4^+$ and $PO_4^{3-}$ increases). In a new way in the literature, we recorded large water $CO_2$ undersaturation coupled with DOC production in spring/summer at low tide due to autochthonous/allochthonous autotrophic processes from phytoplankton, benthic microalgae and macroalgae. Contrary to global findings on the marsh carbon cycle (large DIC and DOC outwelling; Santos et al., 2021), our study highlighted $CO_2$-depleted and DOC-concentrated water exportations from high to low tide in spring and summer confirming the major role of marsh primary production within all compartments (terrestrial and aquatic) in the coastal carbon cycle. It could indicate lower aquatic heterotrophy and higher aquatic autotrophy at our studied marsh, especially in spring and summer, allowing simultaneously large $CO_2$ uptake and DOC production.

Santos, I. R., Burdige, D. J., Jennerjahn, T. C., Bouillon, S., Cabral, A., Serrano, O., Wernberg, T., Filbee-Dexter, K., Guimond, J. A., and Tamborski, J. J.: The renaissance of Odum’s outwelling hypothesis in “Blue Carbon” science, Estuarine, Coastal and Shelf Science, 255, 107361, https://doi.org/10.1016/j.ecss.2021.107361, 2021.

The sampling conducted here was done in a tidal creek that connects a marsh to open bay water and the ocean. The creek and sampling point were within the footprint of an ongoing eddy covariance tower study. However, the footprint of the tidal creek and its flooding watershed were never indicated. Indeed, when I look at a google earth image of the study site, it seems to be an extremely human altered marsh/estuary, with ponds, ditches, spoil banks, etc all over the place. The flooding pattern seems impossible to describe by looking at an aerial image.

Referee#3 is right, the Bossys perdus salt marsh is located on the intertidal area of the Fier d’Ars tidal estuary at the interface between the upstream salt ponds and the downstream continental shelf (Fig. 1). As fully described in Mayen et al. (2024), the Bossys perdus salt marsh experienced successive periods of intensive land use (salt harvesting and oyster farming) and returned to natural conditions before becoming a permanent part of the national natural reserve since 1981 for the biodiversity protection without major restoration work. It is currently managed to restore its natural hydrodynamics while conserving the site’s specific typology due to past human activities (channel networks, humps and dykes; Fig. 1). Past human activities and water management practices for salt farming have shaped the marsh typology (channel network, humps and dykes), producing a time-delayed immersion of plants and muds between high and low marsh areas during spring tides. Thus, due to this emersion/immersion heterogeneity, mud flats and *S. maritima* were quickly immersed by coastal waters, whereas the whole immersion of marsh habitats only occurred during the highest tidal amplitudes favouring a higher atmospheric $CO_2$ uptake by *H. portulacoides* and *S. vera* (Mayen et al., 2024). We have now added in the description of the study the following to make clear that the Bossys Perdus hydrology is the results of natural and anthropogenic conditions (as in many coastal wetlands worldwide):

**Section 2.1. Study sites** (these sentences were completed in the revised MS)

p3-4, L101-109: “The Bossys perdus salt marsh is a vegetated intertidal wetland (52.5 ha) located along the French Atlantic coast on Ré Island (Fig. 1-a). The salt marsh is located within the Fier d’Ars tidal estuary which receives coastal waters from the Breton Sound continental shelf during high tide periods (Fig. 1-a). This intercommunication enables (1) the immersion of the estuarine intertidal zone (including the studied salt marsh) and (2) the water supply for artificial salt marshes (i.e. salt ponds) upstream of the dyke. Water residence times in the salt ponds vary from a few hours to a fortnight depending on seasonal management practice. Generally, macroalgae blooms (*Ulva spp.*) colonize salt ponds from April to October each year (Mayen et al., 2023). *After an intensive land-use (salt harvesting and oyster farming), the Bossys perdus salt marsh is now protected within a National Natural Reserve to restore its natural hydrodynamics and vegetation while conserving the site’s specific typology due to past human activities (channel networks, humps and dykes; Fig. 1-b) (Mayen et al., 2024)”*

The Bossys perdus salt marsh, located upstream of the estuary, is subjected to semi-diurnal tides from the Breton Sound continental shelf (Fig. 1) allowing the marsh immersion by two main channels differently in space, time and frequency according to the tidal periods. At high tide, coastal waters advected from the continental shelf can completely fill channels and immerse the marsh through variable water heights depending on tidal amplitudes and meteorological conditions as described in Mayen et al. (2023, 2024). The Breton Sound continental shelf exchanges salt waters with the Atlantic Ocean to the west at each semi-diurnal tidal cycle and receives continental inputs through the Aiguillon Bay discharges to the east depending on hydrodynamic and meteorological conditions (Fig. 1). The residence time of coastal waters in the Breton Sound continental shelf is long, generally above 85 days (Polsenaere et al., 2017). In contrast, at low tide, the marsh vegetation at the benthic interface is emerged into the atmosphere without any coastal water input. During this time, Bossys perdus channels allow drainage of upstream salt pond waters to the downstream estuary with low water heights. In the revised MS, the flooding pattern by downstream coastal waters at high tide and by upstream pond waters at low tide was fully described in the section 2.1 (see below). This present study was conducted following on 1) from Mayen et al (2023) who studied the water $pCO_2$ dynamics in the two contrasted end-members (i.e. in upstream artificial salt ponds and downstream tidal estuary and continental shelf) and 2) from Mayen et al. (2024) who detailed temporal dynamics and controlling factors of NEE fluxes at the Bossys perdus salt marsh.

**Section 2.1. Study sites** (these sentences were modified in the revised MS)

p4, L114-121: “At high tide (HT), imported coastal waters gradually fill the sampling channel (Fig. 1-b) and immerse the salt marsh at variable water heights depending on tidal amplitudes and meteorological conditions. *Due to the site’s specific typology, lowest marsh levels (mudflats and S. maritima) were quickly immersed (south), whereas the whole marsh immersion (all muds and plants) only occurred 0.75 h later at the highest water heights (Mayen et al., 2024). At low tide (LT), the channel empties and the salt marsh is emerged and exposed to the atmosphere. During this time, water remaining at the bottom of the channel come from (i) the Bossys perdus marsh-drainage process by tidal pumping and (ii) the waterflow from the upstream salt ponds to the downstream estuary (Fig. 1-b) at low water height situations (0.50 m maximum depth;*

*see Fig. S1 in Mayen et al., 2024) fluctuating seasonally according to meteorological conditions and pond managements (Mayen et al., 2023).”*

As in most estuaries there seems to be strong spatial gradients in water chemistry (and metabolism) with two end-members – way into the marsh and the ocean/bay. The authors took 2 samples at low tide, after water had drained from the marsh surface and apparently sat around still in a tidal creek until the next tide came in. why the water level never drained completely such that water level went to zero was never mentioned. The water at low tide was sampled presumably about ½ way before the current went slack and then picked up again. Water was sampled again at high tide – presumably, the water was in the bay only minutes before and therefore showing little to no immediate effect of being on the marsh (of course the estuarine water at high tide presumably had been influenced by previous flood tides – but we don’t know what the water residence time was and what its time course trajectory was.

In this study, strong water mixing processes occurred in the channel due to contrasted shelf and marsh endmembers (see above). At low tide, the trickle of water flow occurring continuously at the bottom of the channel come from (i) the marsh-drainage processes by tidal forcing and (ii) the flow from the upstream salt ponds to the downstream estuary (Fig. 1-b). At high tide, coastal waters advected from the continental shelf can completely fill the channels and immerse the marsh through variable water heights depending on tidal amplitudes and meteorological conditions. Emersion and immersion periods at the studied salt marsh was fully described in Mayen et al. (2024). For instance, on average in 2020, the daily immersion durations ranged between 5.7 h d$^{-1}$ (winter) and 6.5 h d$^{-1}$ (fall). Moreover, as the water residence time in the Breton Sound continental shelf was above 85 days (Polsenaere et al., 2017), imported coastal waters to the salt marsh could be similar from one high tide to another.

Over the 24-hour periods, we intensively and continuously sampled every hour or two hours all carbon forms and nutrients in surface waters (with water filtrations and other sample work in between) taking into account all marsh tidal phases with different water depths (from 0.50 m at the bottom of the channel at low tide up to 2.50 m at high tide with all intermediate tidal situations in between). Thus, at low tide, at least eight samples were collected in channel waters over each 24-h cycle (see figure S1 in the Supplements). Moreover, we sampled and incubated surface water in Winkler bottles every six hours during each 24-h cycle (n = 4) successively at low tide and high tide to measure planktonic aquatic metabolism simultaneously with all other biogeochemical parameters. This sampling strategy allows to measure multiples parameters simultaneously for a typical full tidal cycle, representing all the water heights founding in the salt marsh. When repeated across seasons, it allows to sample the full tidal range, and hence the heterogeneity of the tidal height, residence time and water mixing. We have amended the section 2.2 as follow:

**Section 2.2. Sampling strategy and field samplings** (these sentences were modified in the revised MS)

p5, L134-L142: “*At a single point in the main channel of the salt marsh (Fig. 1-b*), four seasonal 24-h cycles were performed from March to December 2021 (Fig. 2). For each 24-h cycle, our sampling strategy consisted of simultaneously measuring water biogeochemical parameters, planktonic metabolism and water-air $CO_2$ fluxes at diurnal (daytime and night-time) and tidal (from high to low tides and all tidal phases in between) scales through discrete samplings and continuous real-time measurements. At this station, samplings of sub-surface waters were performed continuously every one or two hours over the four 24-h cycles (n = 13 over C1-winter, n = 15 over C2-spring and C3-summer and n = 16 over C4-fall) encompassing a large variation in water heights (Hw): from the channel bottom at low tide (Hw = 0.5 m) to the full marsh immersion at high tide (Hw > 2.5 m) with all tidal intermediate situations in between (Fig. 2 and Fig. S1). *When repeated across seasons, it allows to sample the full tidal range, and hence the heterogeneity of the tidal height, residence time and water mixing."*

We also don't know how deep the water was when it flooded the marsh during the different times samples were collected.

At low tide, all water samplings were performed in the studied channel with 0.50 m of depth (see figure S1 in the Supplements). At that time, water remaining at the bottom of the channel results from (i) the marsh-drainage processes by tidal pumping and (ii) the flow from the upstream salt ponds to the downstream estuary through low water heights. At high tide, water samplings were performed with depths ranging between 0.60 m and 2.50 m from the beginning of the rising tide until the full marsh immersion to take into account all marsh tidal phases (the water depth associated to each sample was done in Fig. S1 in the Supplement). See above responses.

We don't know if the vegetation was completely flooded or not.

Over our 24-h cycles, the marsh vegetation was completely emerged during low tide periods, partially immersed in coastal waters during all tidal intermediate situations between high and low tide (0.50 < Hw < 2.00 m; Fig. 2 and Fig. S1) and fully immersed at the highest water depths (Hw > 2.00 m; Fig. 2 and Fig. S1). The Bossys perdus salt marsh is subject to semi-diurnal tides allowing its immersion through channels differently in space, time and frequency depending on tidal periods. Mayen et al. (2024) fully described the immersion/emersion marsh heterogeneity. At incoming tide, when coastal waters begin to fill the channel and then overflow over the marsh (from 0.5 h in spring tides to 2.5 h in neap tides; data not shown), the SSW sector was first immersed. However, although some marsh sectors were simultaneously immersed, others were still emerged. Indeed, lowest marsh levels (56% of the footprint area), mainly composed of mudflats and *S. maritima*, were quickly immersed (south), whereas the whole marsh immersion (muds and plants) only occurred 0.75 h later at high tide during spring tide. Thus, the highest marsh levels (44% of the footprint area), mainly composed of *H. portulacoides* and *S. vera*, were still emerged during the beginning of the tidal immersion. Conversely, at neap tide, this footprint immersion *versus* emersion marsh heterogeneity could still be present even at high tide due to insufficient water levels (Mayen et al., 2024). We completed our revised MS in the section 2.1. to better understand the plant flooding during high tide periods (see below).

**Section 2.1. Study sites** (these sentences were modified in the revised MS)

p4, L112-117: "The salt marsh is subject to semi-diurnal tides originating on the continental shelf allowing its immersion through channels differently in space, time and frequency depending on tidal periods. At high tide (HT), imported coastal waters gradually fill the sampling channel (Fig. 1-b) and immerse the salt marsh at variable water heights depending on tidal amplitudes and meteorological conditions. *Due to the site's specific typology, lowest marsh levels (mudflats and S. maritima) were quickly immersed (south), whereas the whole marsh immersion (all muds and plants) only occurred 0.75 h later at the highest water heights (Mayen et al., 2024).*"

We don't know if the tidal creek was influenced by the many ponds on the marsh which apparently had dense macroalgae. We do know that there was extensive salt accumulation in the summer, presumably reflecting evaporation in the many ponds, which may or may not have flooded and drained on a regular basis.

At low tide, water remaining at the bottom of the channel come from (i) the marsh-drainage processes by tidal pumping and (ii) the flow from the upstream salt ponds with low water heights (see section 2.1 Study site). Generally, macroalgae blooms (*Ulva* spp.) colonize these upstream salt ponds from April to October each year and can influence the sampling channel according to the seasonal marsh water managements (Mayen et al., 2023). Moreover, in these upstream salt ponds supplying the studied salt marsh during low tide, large seasonal variations of salinity can occur due to different meteorological conditions with low salinity in winter/fall due to dilution of salt waters by the rain and high salinity in spring/summer due to evaporation of salt waters by the hot (Mayen et al., 2023). In this study, the influence of the upstream marsh end-member (i.e. artificial salt ponds) on our findings were more discussed in the revised MS.

We learned – that the flux of $CO_2$ from the tidal marsh to/from the marsh surface and its plants was shut off at high tide. We also know this from just about every flux tower study that's been conducted that I'm aware. So nothing new was learned here.

Indeed, tidal immersion strongly affected NEE fluxes measured by atmospheric Eddy Covariance by decreasing daytime $CO_2$ uptake and night-time $CO_2$ emissions at the ecosystem scale from a certain water height level as deeply explained in Mayen et al. (2024). We don't know what study the referee is aware of. However, to our best knowledge, such tidal pattern on marsh $CO_2$ exchanges was reported in salt marshes (Mayen et al., 2024; Moffett et al., 2010; Forbrich and Giblin, 2015, Weiss et al., 2020), in brackish marshes (Knox et al., 2018) and in a vegetated (seagrass) tidal flat lagoon (Polsenaere et al., 2012). However, in our study, water-air $CO_2$ fluxes estimated from water $pCO_2$ could be compared for the first time with NEE measured simultaneously by Eddy Covariance to go further into the contribution of aquatic metabolism on uptake/emission fluxes at the ecosystem scale (Table 2). Thanks to these original data in the literature, we highlighted that at high tide during the day, water column $CO_2$ oversaturation due to heterotrophic metabolism was able to significantly reduce marsh atmospheric $CO_2$ uptake during the highest immersion levels only when all marsh plants were immersed by coastal waters. For the first time, we showed that NEE at high tide remained strongly controlled by marsh vegetation, since emerged plants located on the highest levels can maintain daytime and night-time atmospheric $CO_2$ uptake or emission, respectively, in the presence of coastal water oversaturated or undersaturated in $CO_2$ (see section 4.4., p28-29). This novelty and these original findings were fully detailed in the section 4.4. of the submitted MS.

We learned that the remaining $CO_2$ flux from the marsh surface when it was completely covered by water reflected not processes occurring in/on the salt marsh, but metabolism of the water itself. This means that the $p\mathrm{CO}_2$ levels were entirely due to the metabolism – planktonic and benthic, which were not completely separated. Light-dark bottles were used to simulate the pelagic metab and everything else plus plankton were measured by the time course change near high tide or low tide. However, the water at high tide wasn't over the marsh – it was in the tidal creek. So it doesn't reflect the marsh surface sediment fluxes, as they authors didn't say they sampled water out in the middle of the marsh after it had traversed the marsh surface flooding away from the tidal creek.

For planktonic metabolism measurements, water samples were collected every six hours during each 24-h cycle (n = 4) successively at low tide and high tide. At low tide, planktonic communities were sampled in light and dark bottles at the bottom of the studied channel when water is drained from upstream salt ponds with a low flow. On the contrary, at high tide, planktonic communities were sampled after the studied channel was fully filled by imported coastal water and the marsh surface was mostly flooded by water. At high tide, when the marsh is fully flooded, horizontal homogenization of water masses occurs, due to surface water flows induced by complex tidal circulation and wind action. So, light-dark bottles sampled at high tide reflected the marsh surface sediment fluxes and all the sediment organic matter put back into suspension in water by the tide. The revised MS was completed to take into account this precision (see below).

During high tide (marsh immersion), total aquatic metabolism was heterotroph ($\mathrm{NEP}_{tot} < 0$) both during day and night (except in winter at daytime), inducing net DIC and $p\mathrm{CO}_2$ increases in water (Table 2). At the same time, the low contribution of planktonic aquatic metabolism ($\mathrm{NEP}_{pk}$) to total aquatic metabolism ($\mathrm{NEP}_{tot}$) suggested a major influence of immersed plant respiration and/or benthic processes on the water inorganic carbon pool and air-water $CO_2$ fluxes. Previous studies in intertidal wetlands showed that benthic respiration produces strong sediment-to-water DIC fluxes through diffusion during immersion inducing water $CO_2$ oversaturation (see section 4.3, p27, L635-640).

**Section 2.2. Sampling strategy and field samplings** (this sentence was completed in the revised MS)

p5, L147-L150: "*For planktonic metabolism measurements, water samples were collected every six hours during each 24-h cycle (n = 4) successively at low tide (LT; water remaining at the channel bottom) and high tide (HT; water flooding mostly marsh surface).*"

While light-dark bottles can give some measure of pelagic metabolism, were they suspended at multiple light levels – I don't think so.

For planktonic metabolism measurements, the light-dark Winkler bottles were incubated for six hours in surface waters of the sampling channel under *in situ* water temperature and aquatic PAR and at the same depth of sampling. So, the light-dark Winkler bottles were incubated in close environmental conditions as all the planktonic communities in surface waters. However, the bottles have not been suspended at multiple light levels as suggested by Referee#3. As planktonic aquatic metabolism ($NEP_{pk}$) played a minor role in the total aquatic metabolism ($NEP_{tot}$) during marsh immersion (Table 2), the absence of multiple light levels in the planktonic metabolism measurements is, in our opinion, not crucial. Again, this is the first attempt to account for planktonic metabolism in a marsh carbon budget, probably because the light-dark bottles technique is time-consuming and difficult. We acknowledge that methodological can further be improved.

Was shading from marsh plants imitated – I don't think so. There was some metabolism as the authors documented it. The level of $pCO_2$ in the floodwater was related to the direction of flux seen by the flux tower. When floodwater at high tide was supersaturated – there was an escape of $CO_2$ to the atmosphere and vice versa.

For planktonic metabolism measurements, the shading from marsh plants was not tested as suggested by Referee#3. So, our measurements of planktonic metabolism might overestimate autotrophy *versus* heterotrophy. Nevertheless, $NEP_{pk}$ played a minor role in the total aquatic metabolism during marsh immersion (Table 2), and thus the absence of shading from marsh plants in the planktonic metabolism measurements is unlikely to alter significantly our results.

We learned therefore that flux direction and magnitude from a marsh can change when the marsh is flooded. But we don't know whether the magnitude calculated bears any semblance to reality and how it really compared to what the flux tower saw. Actually it could have been interesting to see what k value should be used to calculate flux from the water surface when it is over the marsh, as the flux tower doesn't rely on a k. Presumably the k value at a particular wind speed differs when the marsh vegetation sticks above the surface or alters water turbulence. This is a big unknown, but unfortunately the authors didn't measure this.

Referee#3 is right, the gas transfer velocity ($k$) could have been calculated from water $pCO_2$ and NEE fluxes measured at the same time in the EC footprint during marsh immersion periods. However, this approach and calculation would have significantly increased the quantity of results and the length of the manuscript. In this study, we have chosen to use the $k$ parameterization of Van Dam et al. (2019) as a function of wind speed, that was determined from concomitant $pCO_2$ and $FCO_2$ eddy covariance data in an estuarine system with characteristics very similar with our study site. Currently, there is no consensus on the $k$ value parameterization in shallow coastal systems, such as salt marshes, mainly because $k$ depends on several drivers acting at the same time: wind, current, water depth, friction at the bottom, heating and cooling. In the revised MS, the $k$ values obtained the parameterization of Van Dam et al. (2019) were recorded in the table 2 for each high tide period (from 4.44 to 7.74 cm $h^{-1}$ in winter, from 5.89 to 9.93 cm $h^{-1}$ in spring, from 9.25 to 10.85 cm $h^{-1}$ in summer and from 4.81 to 10.85 cm $h^{-1}$ in fall).

I don't think we really learned by comparing light-dark incubations with whole water DIC changes the true contribution of pelagic vs all other processes that control DO or DIC concentrations in a water column in contact with sediments, plants, the air, etc.

We could not find which factual basis supports this referee's comment and what was the exact concern of the reviewer here. In original way in the literature, at each high tide, total aquatic metabolism ($NEP_{tot}$) was estimated by changes in DIC concentrations between two discrete samplings and was compared at the same time to planktonic aquatic metabolism ($NEP_{pk}$) and water-air $CO_2$ fluxes ($FCO_2$) to better understand the aquatic metabolism contribution on $CO_2$ emissions during marsh immersion.

During daytime high tides, total aquatic metabolism was weakly autotrophic ($NEP_{tot} > 0$) in winter and strongly heterotrophic ($NEP_{tot} < 0$) in spring, summer and fall indicating a weak photosynthesis of immersed plants and a low biological use of marine DIC (Table 2) (see section 4.2, p24, L562-564). Total aquatic metabolism was heterotroph ($NEP_{tot} < 0$) both during day and night (except in winter at daytime), inducing net DIC and $pCO_2$ increases in water (Table 2). At the same time, the low contribution of planktonic aquatic metabolism ($NEP_{pk}$) to total aquatic metabolism ($NEP_{tot}$) suggested a major influence of immersed plant respiration and/or benthic processes on the water inorganic carbon pool. Previous studies in intertidal wetlands showed that benthic respiration produces strong sediment-to-water DIC fluxes through diffusion during immersion inducing water $CO_2$ oversaturation (Gong et al., 2023; Song et al., 2023) (see section 4.3, p27, L635-640).

We also learned that aquatic metabolism isn't always greatest in the hot summer, as this study showed the highest and greatest range in DOC during the winter – the coldest month. But of course this result wasn't strictly a function of temperature.

In the submitted MS, we showed that the highest DOC concentrations were recorded over the summer 24-h cycle (Table 1), especially at low tide (Fig. 7) probably due to intense autochthonous and allochthonous aquatic primary production (benthic microalgae, phytoplankton, and macroalgae). Moreover, at our salt marsh, the strong primary production of emerged plants, especially in spring and summer ($-14.3 <$ daytime $GPP_{marsh} < -2.6$ µmol $CO_2$ $m^{-2}$ $s^{-1}$ over C3-summer; Fig. 2) and confirmed by Mayen et al. (2024), could also induce DOC production through above-ground and belowground litter loss and root exudations (Kristensen and Alongi, 2006; Schiebel et al., 2018), then exported to surface waters of the sampling channel. DOC can also come from the heterotrophic degradation of organic matter in the sediments and be transferred to channel waters by tidal pumping during ebbing tide. The high spring/summer DOC concentrations in channel water could have different various sources in our studied site and were fully described in the section 4.2. of the revised MS.

An extensive set of observations was presented here. The authors justified many flux trajectories by mentioning one of many processes previously studied in marshes. For example, they showed that through a particular DIC-DIN flux ratio and NH4:NO3 ratios that there may have been DNRA. They also showed via the slope of the DIC/TA change could have been explained by sulfate reduction. But they showed it being greatest in winter, when there is often less sulfate reduction and more pyrite reoxidation – changing the $O_2$ to DIC flux ratio of metabolism.

Referee#3 is right, the highest DIC outwelling from overall salt marshes was generally observed in summer since the highest temperature values promote intense heterotrophic respiration in sediments (Wang et al., 2016, 2018). In our case, the highest increases of DIC (from 2354 to 3963 µmol $kg^{-1}$), TA (from 2508 to 4016 µmol $kg^{-1}$) and DIN (from 27.7 to 68.4 µM) were measured in winter at low tide night probably due to intense anaerobic respiration processes in channel waters and/or sediments resulting in the highest water $pCO_2$ (up to 1461 ppmv). This large winter DIC production by the studied salt marsh could be explained by dominant detrital organic matter in the channel (see high POC:PON and POC:Chl*a* ratios; Fig. 7) coupled with large river-derived nutrient inputs during high tide periods (see high $NO_3^-$_$NO_2^-$ concentrations in coastal waters; Fig. 7) supplying anaerobic respiration in sediments (see below).

**Section 4.3. Marsh aquatic respiration as DIC source** (this paragraph was modified in the revised MS)

p27, L641-659: "*During low tide (marsh emersion), the largest DIC and TA increases were measured in channel waters, especially in winter, highlighting a strong control of tidal forcing on water carbonate chemistry (Fig. 8). In similar salt marsh systems, the same tidal DIC pattern was recorded over all seasons with highest concentrations at low tide and lowest ones at high tide (Table 5).* In most intertidal systems, such as salt marshes and mangroves, intense respiration processes occur in sediments inducing high DIC and TA concentrations in surface waters, especially at low tide through porewater exports driven by the tide (Nakamura et al., 2024; Reithmaier et al., 2023). In winter, during low biological activity of *S. maritima* (Mayen et al., 2024), the highest POC:PON and POC:Chla ratios measured at low tide (Fig. 7) suggested predominant detrital organic matter from decaying vegetation (Savoye et al., 2003). The highest POC-$\delta^{13}$C values measured in winter at low tide (-14.6 ± 0.9‰; unpublished data) could confirm the presence of terrestrial C4 plants in channel waters, like S. maritima (Amann et al., 2024). This could constitute an energy source for microbial activity in sediments inducing, in turn, the largest increase of DIC and $pCO_2$ measured at low tide night (up to 3963 µmol $kg^{-1}$ and 1461 ppmv, respectively; Fig. 6) due to a strong winter tidal forcing. *During this period, DIC increased faster than TA until reaching very close concentrations (Table 1). This could indicate that most of carbonate ions ($CO_3^{2-}$) in channel waters were converted into bicarbonate ions ($HCO_3$-) by the large addition of $CO_2$ and $H^+$ from marsh respiration processes, such that carbonate species in the exported channel waters mostly consisted of $HCO_3^-$ and dissolved $CO_2$.* In mangroves, Cabral et al. (2024) confirmed a strong control of tidal forcing in water $pCO_2$ dynamics with highest values recorded a low tide during the highest tidal amplitudes. In addition, in our case, the strong DIP and $NH_4^+$ increases from high to low tide could confirm microbial respiration of organic matter in marsh sediments and, in turn, lateral export of DIC from porewaters to channel waters by tidal pumping (Fig. 8) as observed in other tidal systems (Cabral et al., 2024; Deborde et al., 2008; Santos et al., 2019)."

While there is a lot of data presented here – I see little that’s new. It’s from an extensively altered salt marsh so extrapolation of results to anywhere else is dubious – except for saying some of the same marsh processes occur there as everywhere else. I don’t see that we are any closer to understanding the magnitude and direction of DIC flux to/from a regularly flooded marsh. Nor are we any closer to quantifying the $CO_2$ sequestration rate of this salt marsh system.

In the literature, very few studies have looked for the aquatic metabolism influence in water carbon dynamics and atmospheric carbon exchanges from an integrative manner, using *in situ* carbon original samplings (through intense seasonal 24-h cycles) and innovative methods (autonomous water $pCO_2$ probe and atmospheric Eddy Covariance). In this way, our original results provide a better understanding of biotic and abiotic factors controlling water $pCO_2$ and atmospheric $CO_2$ fluxes in salt marshes where diurnal/tidal data are scarce. In our study, water $pCO_2$ were mainly controlled by biological activity inducing water $CO_2$ oversaturation at low tide in winter due to heterotrophic processes (DIC, TA, $NH_4^+$ and $PO_4^{3-}$ increases). In a new way in the literature, we recorded large water $CO_2$ undersaturation coupled with DOC production in spring/summer at low tide due to autotrophic processes from phytoplankton, benthic microalgae and macroalgae. Contrary to global findings on the marsh carbon cycle (large DIC and DOC outwelling; Santos et al., 2021), our study highlighted $CO_2$-depleted and DOC-concentrated water exportations from high to low tide in spring and summer confirming the major role of autochthonous/allochthonous primary production within all marsh compartments (terrestrial and aquatic) in the coastal carbon cycle. It could indicate lower aquatic heterotrophy and higher aquatic autotrophy at our studied marsh, especially in spring and summer, allowing simultaneously large $CO_2$ uptake and DOC production. The novelty of this study and the original findings were fully highlighted in the revised MS.

A new table was added in the revised MS to regroup similar articles studying inorganic carbon dynamics and water-air $CO_2$ emissions in temperate salt marsh systems to contextualize our findings and enhance the manuscript’s scientific significance (see table 5). Moreover, to further discuss our finding in a broader context, we propose in the revised MS a conceptual model to organize the contribution of terrestrial and aquatic compartments to net ecosystem $CO_2$ exchanges (see figure 8). Although we think we made a literature survey as complete as possible, we would be very happy to learn about additional literature we could refer to in our MS.

**Table 5. Seasonal/annual comparison of water inorganic carbon dynamics ($pCO_2$ in ppmv, DIC and TA in µmol $kg^{-1}$), total aquatic metabolism ($NEP_{tot}$ in mmol $m^{-2}$ $h^{-1}$) and water-air $CO_2$ fluxes ($FCO_2$ in mmol $m^{-2}$ $h^{-1}$) between the Bossys perdus salt marsh (this study, France) and other similar temperate salt marsh systems in the literature. Median values were done in bold and range values were done in brackets (min – max).**

| Reference | | Winter | Spring | Summer | Fall | Annual |
|---|---|---|---|---|---|---|
| This study | Water $pCO_2$ (ppmv) | **525**<br>(321 – 1461) | **221**<br>(106 – 416) | **158**<br>(89 – 597) | **411**<br>(311 – 541) | **382**<br>(89 – 1461) |
| | DIC (µmol $kg^{-1}$) | **2799**<br>(2354 – 3963) | **2173**<br>(2053 – 2530) | **2056**<br>(1587 – 2175) | **2584**<br>(2206 – 2762) | **2238**<br>(1587 – 3963) |
| | TA (µmol $kg^{-1}$) | **3076**<br>(2508 – 4016) | **2757**<br>(2379 – 2947) | **2385**<br>(2228 – 2812) | **2804**<br>(2351 – 3047) | **2617**<br>(2228 – 4016) |
| | $NEP_{tot}$ (mmol $m^{-2}$ $h^{-1}$) | **-2.35**<br>(-7.72 – 3.02) | **-15.80**<br>(-16.61 – -14.98) | **-16.43**<br>(-19.36 – -13.50) | **-5.45**<br>(-7.81 – -3.08) | **-10.01**<br>(-19.36 – 3.02) |
| | Water-air $FCO_2$ (mmol $m^{-2}$ $h^{-1}$) | **0.24**<br>(0.05 – 0.46) | **-0.25**<br>(-0.52 – -0.03) | **0.28**<br>(0.05 – 0.53) | **0.36**<br>(0.03 – 0.62) | **0.15**<br>(-0.52 – 0.62) |
| Wang et al. (2018) | Water $pCO_2$ (ppmv) | n.a.<br>(500 – 4000) | n.a. | n.a.<br>(1600 – 12000) | n.a. | n.a.<br>(500 – 12000) |
| | DIC (µmol $kg^{-1}$) | n.a.<br>(1500 – 2500) | n.a. | n.a.<br>(2250 – 4300) | n.a. | n.a.<br>(1500 – 4300) |
| | $NEP_{aquatic}$ (mmol $m^{-2}$ $h^{-1}$) | -0.83 | n.a. | -2.50 | n.a. | -1.60 |
| | Water-air $FCO_2$ (mmol $m^{-2}$ $h^{-1}$) | 0.60 | n.a. | 3.90 | n.a. | 2.05 |
| Reithmaier et al. (2023) | DIC (µmol $kg^{-1}$) | **2158**<br>(1610 – 3080) | **1941**<br>(1452 – 7895) | **2052**<br>(1450 – 4200) | **2210**<br>(1367 – 3740) | **2065**<br>(1367 – 7895) |
| | TA (µmol $kg^{-1}$) | **2262**<br>(1634 – 3296) | **1977**<br>(1376 – 8045) | **2083**<br>(1578 – 4191) | **2269**<br>(1330 – 3765) | **2104**<br>(1330 – 8040) |
| Song et al. (2023) | Water-air $FCO_2$ (mmol $m^{-2}$ $h^{-1}$) | n.a. | n.a. | **1.03** | **0.20** | n.a. |
| Gong et al. (2023) | Water-air $FCO_2$ (mmol $m^{-2}$ $h^{-1}$) | n.a. | **0.53** | **0.65** | **1.10** | **0.76** |
| Alongi (2020) | Water-air $FCO_2$ (mmol $m^{-2}$ $h^{-1}$) | n.a. | n.a. | n.a. | n.a. | **1.49** |

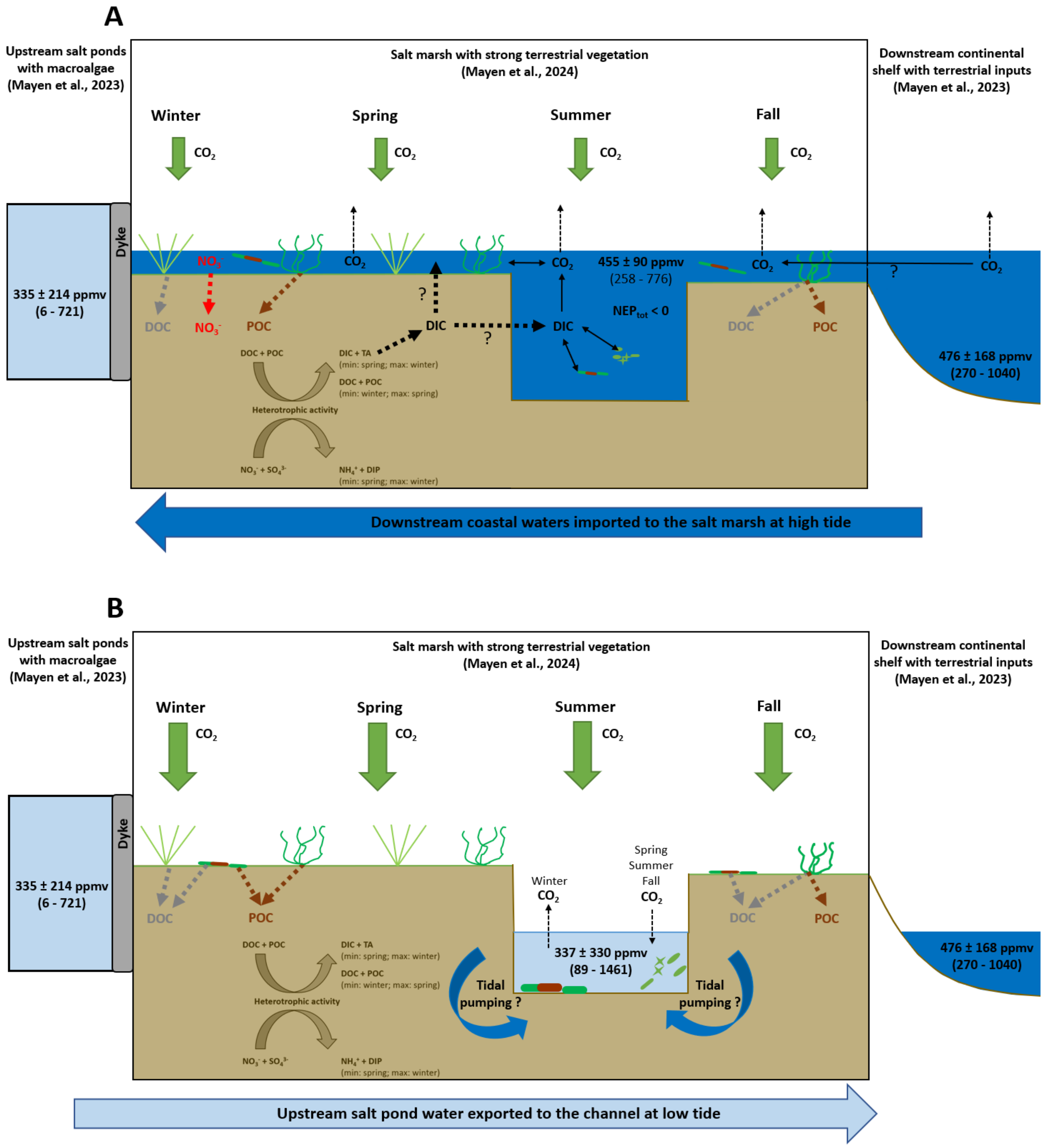

**Fig. 8. Water carbon dynamics and atmospheric CO$_2$ fluxes at the Bossys perdus salt marsh over our 24-h cycles at two contrasted tidal periods: (A) high (flooding) tide (marsh immersion by downstream coastal waters) and (B) low (ebbing) tide (marsh emersion and channel water** come from the marsh-drainage process by tidal forcing and the waterflow **from the upstream salt ponds). Green arrows represent net atmospheric CO$_2$ sink measured at the ecosystem scale by eddy covariance. Negative NEP$_{tot}$ in the water column at high tide corresponds to aquatic heterotrophy (net carbon source for water).**