FINAL REPORT PROGRAM LEFE

Program LEFE/CYBER	DYCIDEMAIM (Carbon dynamic at exchange interfaces of temperate tidal marshes)	Years 2021-2022
Pierre POLSENAERE, Pierre.Polsenaere@Ifremer.fr, IFREMER LER-PC La Tremblade, Littoral Unit, France. Participating Laboratories : IFREMER, INRAe, BRGM		Contribution to Pampanino (2018), ANR PAMPAS (2019-2024), LRTZC (2019-2027). Other funding sources: Ifremer (scientific direction) doctorate and post-doctorate scholarships.

Context: Salt marshes are among the most productive ecosystems in the biosphere. The majority of this marsh primary production is generally respired and exported from the system by horizontal tidal advection, depending on seasonal, diurnal and tidal time scales.

Objectives / scientific questions: The DYCIDEMAIN project addressed the following scientific questions through a seasonal 24-hour cycle sampling strategy: (i) which relevant biotic and abiotic factors control variations in water carbon (pCO_2) and (ii) what is the contribution of aquatic (planktonic) metabolism to the net ecosystem exchange (atmospheric CO_2 fluxes) in temperate salt marshes?

Main results:

In the studied temperate Bossys salt marsh (Fig. 1.A), water pCO_2 was mainly controlled by biological activity, resulting in water CO_2 oversaturation in winter and autumn (669 ± 327 and 422 ± 73 ppmv, respectively) due to heterotrophic processes, and water CO_2 undersaturation in spring and summer (239 ± 105 and 271 ± 182 ppmv, respectively) due to autotrophic processes (Fig. 2.C). Water pCO_2 also varied significantly during each 24-h cycle, depending on diurnal and tidal scales with, generally, (1) pCO_2 decreasing and increasing during the day and night, respectively, and (2) lower pCO_2 values at low tides (salinity values ranging from 21.4 in winter to 44.2 in summer) than at high tides (Fig. 2.A,C) (i.e. 321 at LT/Day to 1461 ppmv at LT/Night in winter, Fig. 2.C).

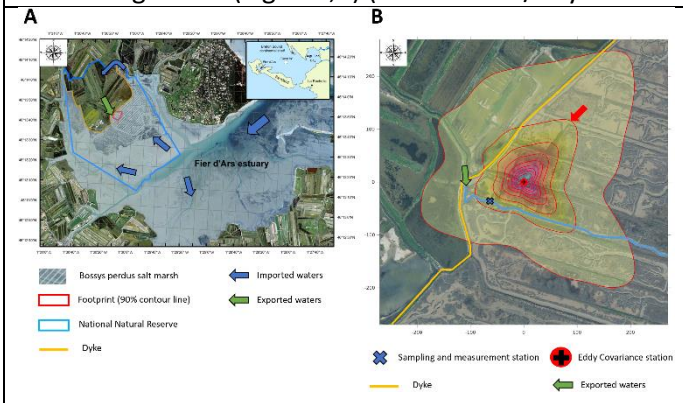

Fig. 1. (A) The studied Bossys perdus salt marsh located on the French Atlantic coast within the National Nature Reserve on the Ré Island. The dike (orange line) separates the terrestrial and marine marsh areas. The blue and green arrows represent coastal water inflows at high tide and exported waters at low tides from the upstream artificial salt marshes, respectively. (B) The location and setup of the atmospheric Eddy Covariance (EC) system within the salt marsh (at emersion) and the corresponding mean annual footprint (2021) (Kljun et al. 2015) representative of the measured fluxes. The red arrow indicates the 80 % contour line encompassing the 24-hour cycle water sampling location (blue cross).

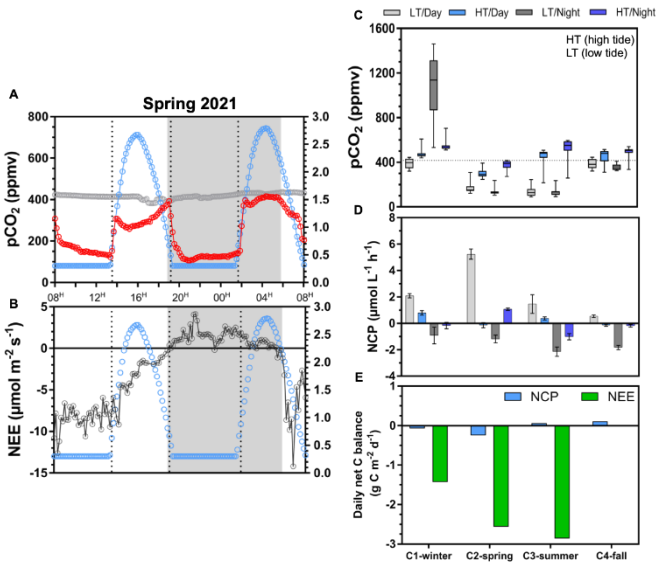

Fig. 2. Simultaneous time series of (A) water partial pressure of CO_2 (pCO_2, red) and (B) Net Ecosystem Exchange (NEE, black) measured over 24 hours at the studied salt marsh in spring 2021. Air pCO_2 (grey), water level (blue) values and day (white) and night (grey) periods are also shown. Box plots of water pCO_2 (C), Net planktonic Community Production (NCP, D) and Daily Net Carbon Balance (NCP and NEE, E) measured in each season and tidal period. Positive and negative NCP values correspond to planktonic autotrophy and heterotrophy, respectively. Positive and negative NEE values correspond to atmospheric CO_2 source and sink, respectively.

The observed pattern, contrary to what is generally observed in other marsh systems, is certainly due to the intense primary production of the microphythobenthic community in the channel and the CO_2 undersaturated waters advected from the upstream artificial marshes at low tide.

Regarding planktonic metabolism (NCP, measured by the Winkler method, Fig. 2.D) and its potential influence on the water pCO_2 and atmospheric fluxes (NEE) measured by EC (Fig. 1.B and Fig. 2.B,C,E), water autotrophy and heterotrophy were generally observed during day and night with higher NCP rates in channel waters at low tide (from 0.54 ± 0.10, C4-LT/Day to 5.24 ± 0.39 µmol L^{-1} h^{-1}, C2-LT/Day, Fig. 2.D) than in coastal waters at high tide, confirming diurnal water pCO_2 dynamics. In winter, the highest concentrations of DIC, TA and nutrients (NH_4^+ and PO_4^{3-}) measured at low tide reflected sediment heterotrophy exported to channel waters by tidal pumping. In spring (LT/Day), planktonic autotrophic metabolism was the highest and decreased towards the summer season due to an increase in respiration with water temperature associated with a dinoflagellate bloom. During these seasons, the significant decrease in water pCO_2 and increase in DOC from high to low tide could be related to a strong marsh primary production including plants, macroalgae and phytoplankton.

Overall, planktonic metabolism (together with microphytobenthic communities) contributes significantly to CO_2 undersaturated water exports. The associated horizontal water exchange in these environments has a strong influence on carbon (pCO_2) dynamics and NEE, especially at the daily scale (Fig. 2.B). However, the contribution of planktonic metabolism (NCP) to atmospheric CO_2 uptake (NEE) by the whole marsh ecosystem remains small (Fig. 2.E).

Future of the project:

The DYCIDEMAIN project gave rise to further research i) in the studied salt marsh (post-doctorate of Marie Arnaud (2021-2022) on the quality and decomposition of salt marsh litter under sea-level rise scenarios) and the COMICA project (2022-2024, Ifremer LER-PC and ASIM) on potential links between microbial communities and carbon processes and fluxes both funded by the Ifremer scientific direction and ii) at other marsh sites (freshwater and salt marshes) in the Charentais Sounds in the framework of larger projects (LRTZC 2019-2027, LIENSs and TETRAE MAVI 2023-27, INRAe) focusing on (blue) carbon budgets and food webs versus carbon process/flux relationships.

Publications:

Mayen J, Polsenaere P, Regaudie de Gioux A, Deborde J, Collin K, Le Merrer Y, Foucault E, Ouisse V, André L, Arnaud M, Kostyrka P, Lamaud E, Souchu P. (2024) Influence of aquatic metabolism on temporal marsh carbon dynamics and associated atmospheric CO_2 fluxes, in prep. for *Limnology and Oceanography*

Mayen J, Polsenaere P, Regaudie De Gioux A, Dupuy C, Vagner M, Lemesle J-C, Poitevin B, Souchu P (2023) Influence of typology and management practices on water pCO_2 and atmospheric CO_2 fluxes over two temperate shelf – estuary – marsh water continuums. *Regional Studies in Marine Science*, 67, 103209 (17p.). https://doi.org/10.1016/j.rsma.2023.103209.

Oral communications:

Mayen J, Polsenaere P, Regaudie de Gioux A, Deborde J, Collin K, Le Merrer Y, Foucault E, Ouisse V, André L, Arnaud M, Kostyrka P, Lamaud E, Souchu P. Influence of aquatic metabolism on marsh carbon dynamics and associated atmospheric CO_2 fluxes. AGU Meeting, San Francisco, 11-15 December 2023.

Mayen J, Polsenaere P, Regaudie de Gioux A, Deborde J, Arnaud M, Kostyrka P, Collin K, Le Merrer Y, Foucault E, Ouisse V, André L, Lemesle J-C, Lelong V, Vagner M, Souchu P. Influence du métabolisme planctonique sur la dynamique du carbone des marais. Colloque de restitution finale du projet ANR PAMPAS, 9-10 nov. 2023, La Rochelle.

Mayen J., Polsenaere P, Geairon P, Chabirand J-M, Deborde J, Grizon J, Lemesle J-C, Poitevin B, Dupuy C, Vagner M**.** Spatial and temporal variations in water pCO_2 and atmospheric CO_2 exchanges over a temperate salt marsh system. ASLO Aquatic Sciences Meeting, 22-27 June 2021.

Theses:

October 2020-Feb 2024: Thèse Jérémy Mayen, Ifremer, ED VAAME. Échanges de CO_2 atmosphérique dans les marais charentais : processus, dynamique et facteurs de contrôle associés. Dir. Souchu P, codir. : Polsenaere P., Regaudie de Gioux A.

Data availablility