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Underwater Fluxes of biogenic constituents and their Ecological Implications

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Spatial and temporal variations in water pCO₂ and atmospheric CO₂ exchanges over a temperate salt marsh system

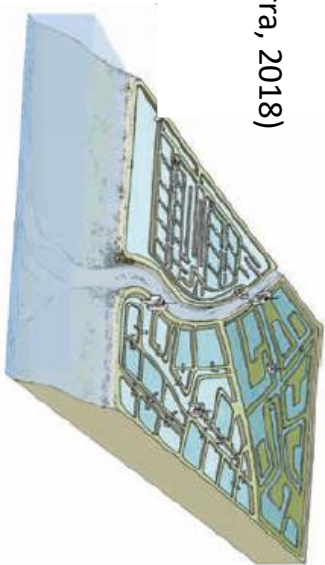
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SS25 - Underwater Fluxes of biogenic constituents
and their Ecological Implications – 6/27/2021

- « Salt marshes are coastal wetlands that are flooded and drained by salt water brought in by the tides. »
(National Oceanic and Atmospheric Administration)

(Acclimatterra, 2018)



Dyked salt marshes

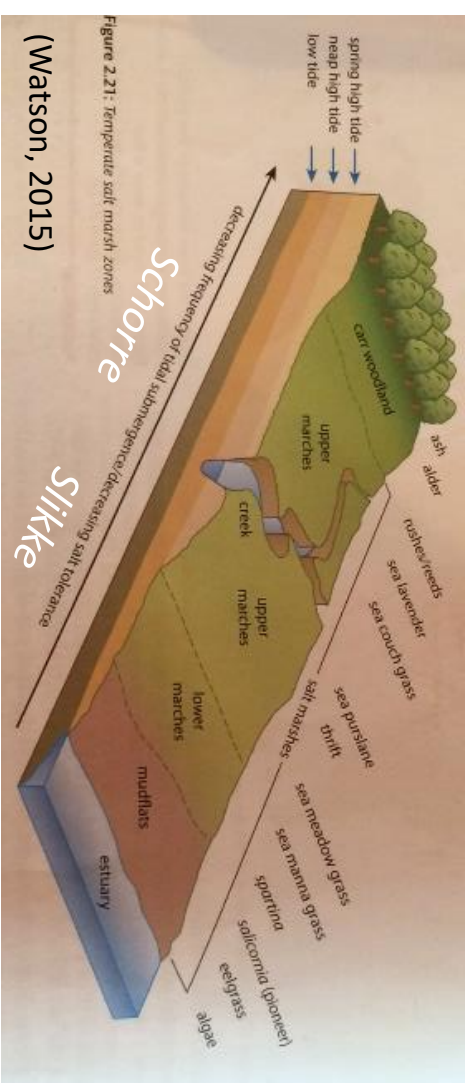
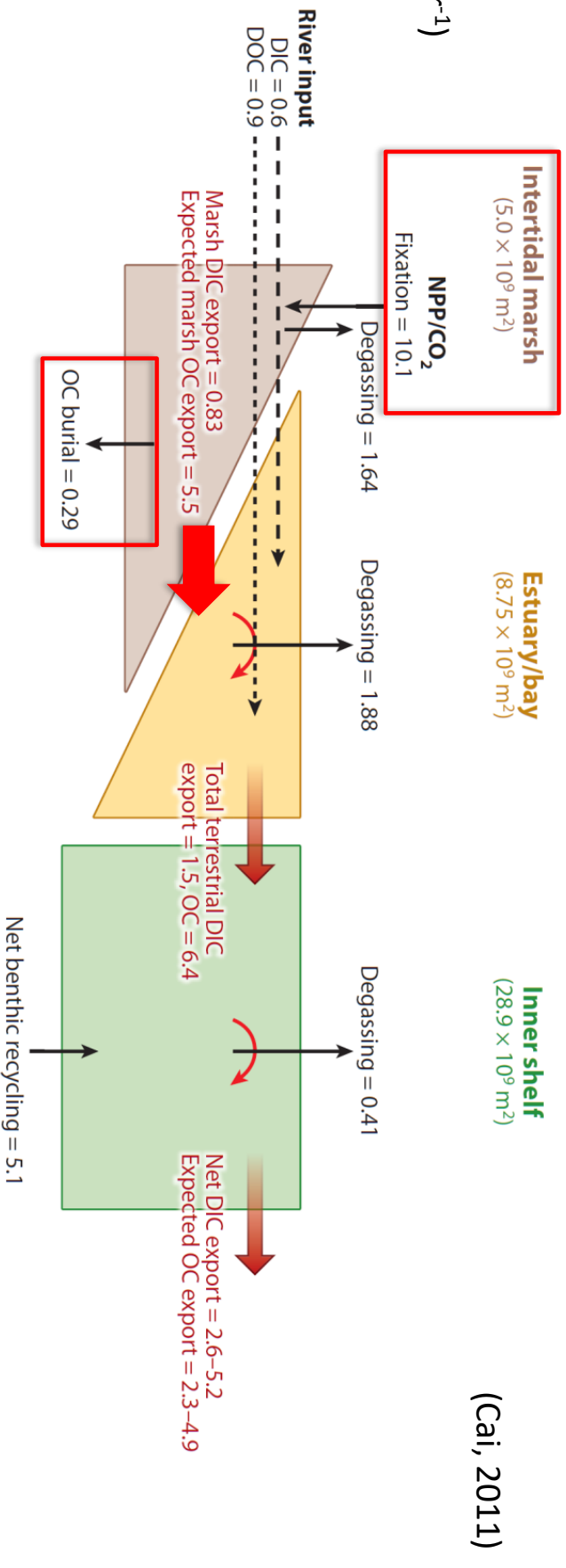


Figure 2.21: Temperature salt marsh zones

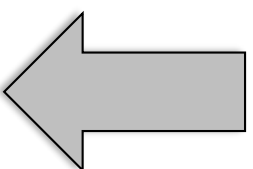
(Watson, 2015)

- CO₂ sink, organic carbon burial and C export by the tide :

Tg C yr⁻¹ (10¹² g C yr⁻¹)



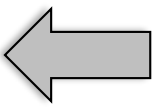
- Study the dynamics of (i) water pCO₂ and (ii) atmospheric CO₂ exchanges in relation to biotic and abiotic controlling factors along an intertidal bay – channel – salt marshes continuum at seasonal, diurnal and tidal scales



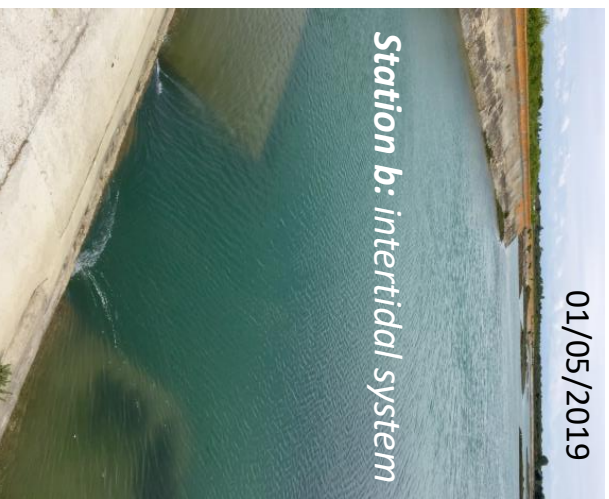
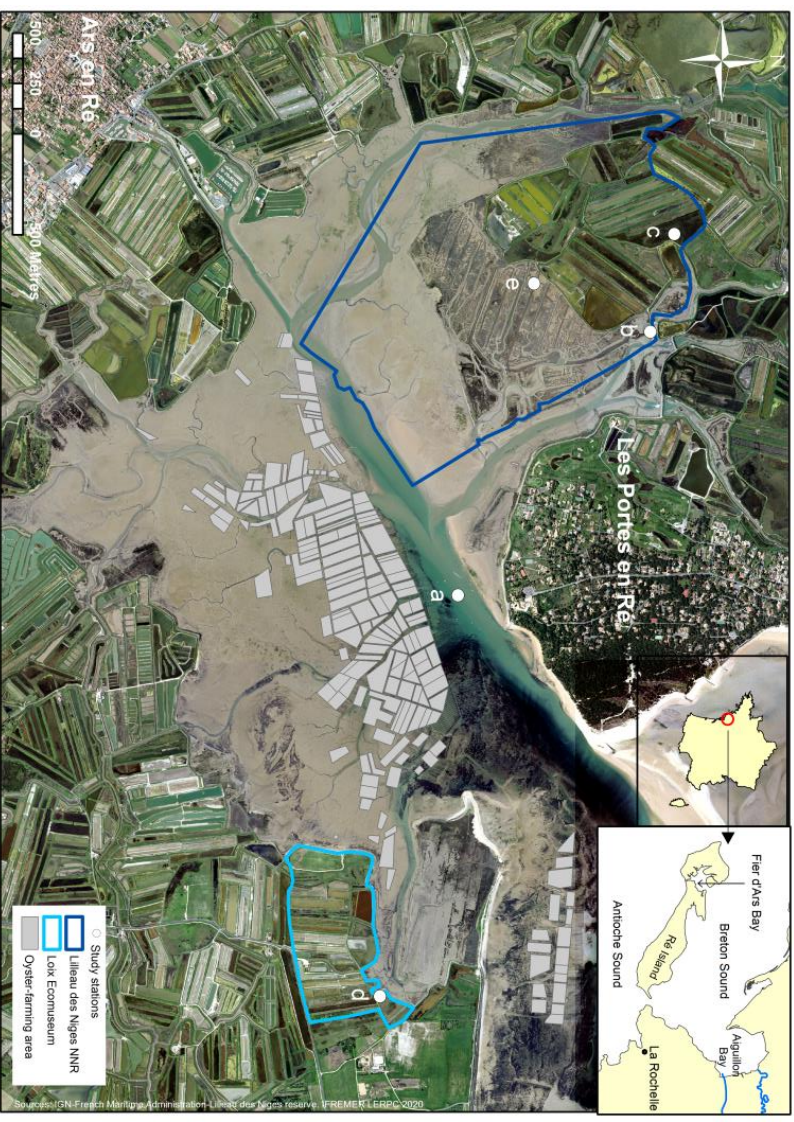
Understanding the evolution of the ecological functions of coastal wetlands (CO₂ sinks, C sequestration in sediments) in the face of global change.



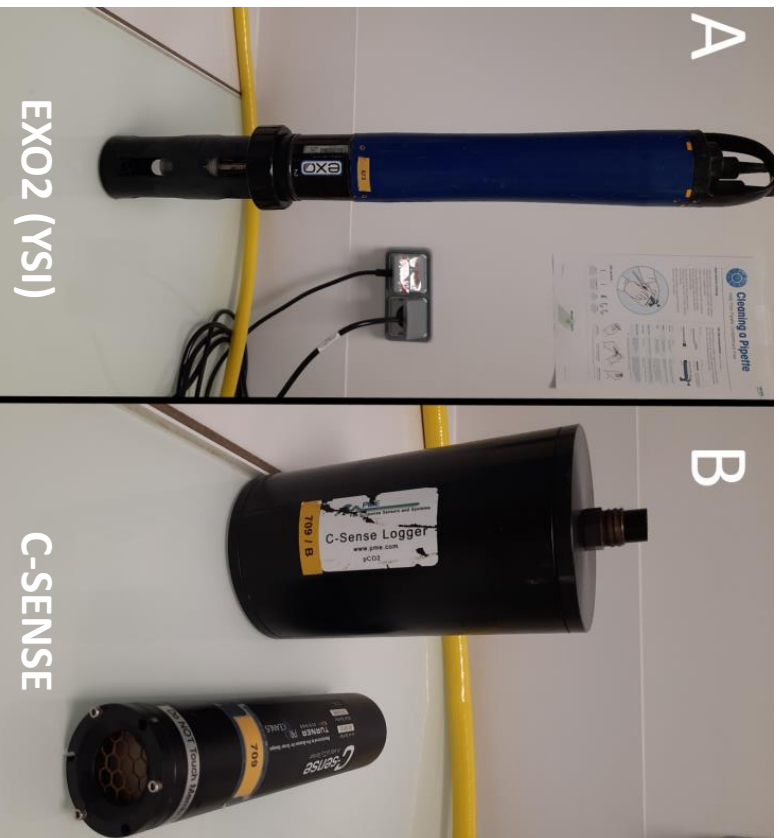
- Intertidal bay on the Ré island – France
- Complex of salt marshes and anthropised mudflats (1,200 ha): **coastal wetland**
- Bay – channel – salt marshes continuum



4 interconnected stations with different management practices and configurations



- *In situ* measurements of pCO_2 , [Chl a] and biogeochemical parameters (oxygen, salinity, temperature ...)
- 24-hour cycles of *in situ* measurements at the seasonal and spatial scales → high frequency (1 minute)
- 5 multiparameter and specific probes (autonomous) in sub-surface waters:
 - C-SENSE (X2): pCO_2 measurements (0-2000 ppmv + 0-4000 ppmv, %Er = 3% of range)
 - EXO2 (YSI): biogeochemical parameter measurements (T, S, TU, pH, O_2)
 - Aquatic MinipAR (PME)
 - C3-fluorimeter: chlorophyll- a concentration



EXO2 (YSI)

C-SENSE

C3-fluorimeter
(Turner)

C-Sense (x2)
(PME/Turner)

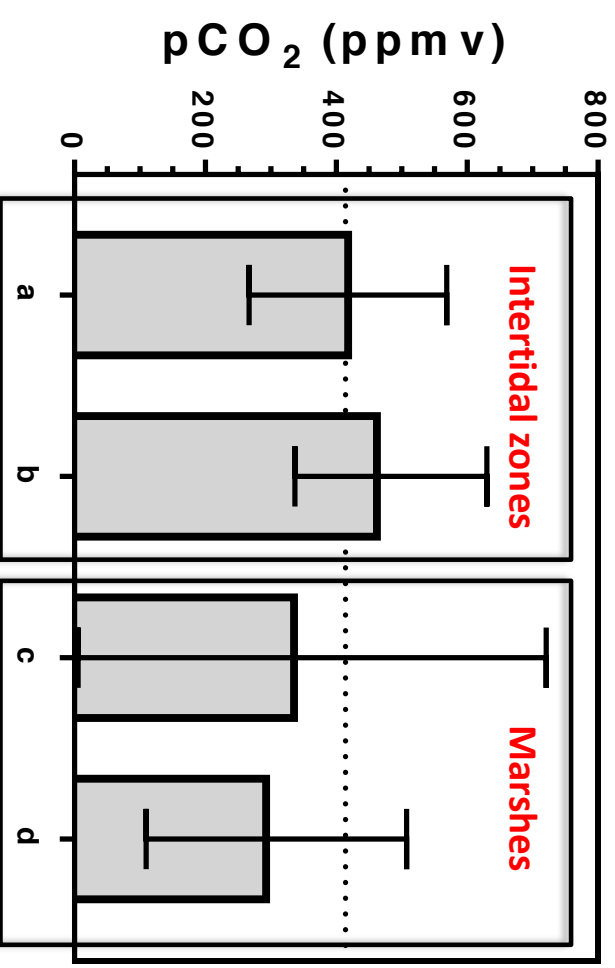
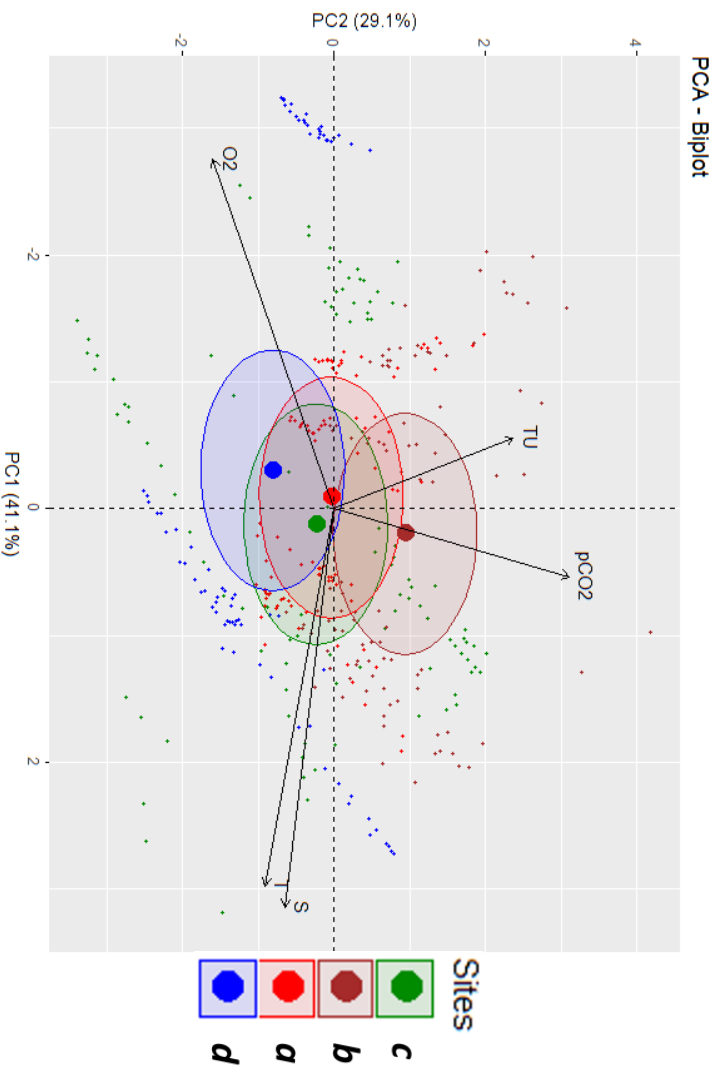
EXO (YSI)

1. Major influence of station typologies on pCO₂

- a*: Fier d'Ars intertidal bay
- b*: Vieux port channel
- c*: A1 salt marsh (nature reserve)
- d*: Loix salt marsh (salt-farming activity)

- Intertidal bay and channel (*a* and *b*)**
 - Strong tidal influences → High turbidity → **limited phytoplankton activity**
 - Few aquatic vegetation

- Salt marshes (*c* and *d*)**
 - **Photosynthesis of primary producers** (macroalgae/ phytoplankton/*Ruppia maritima*)



2. Major influence of management practices on pCO₂

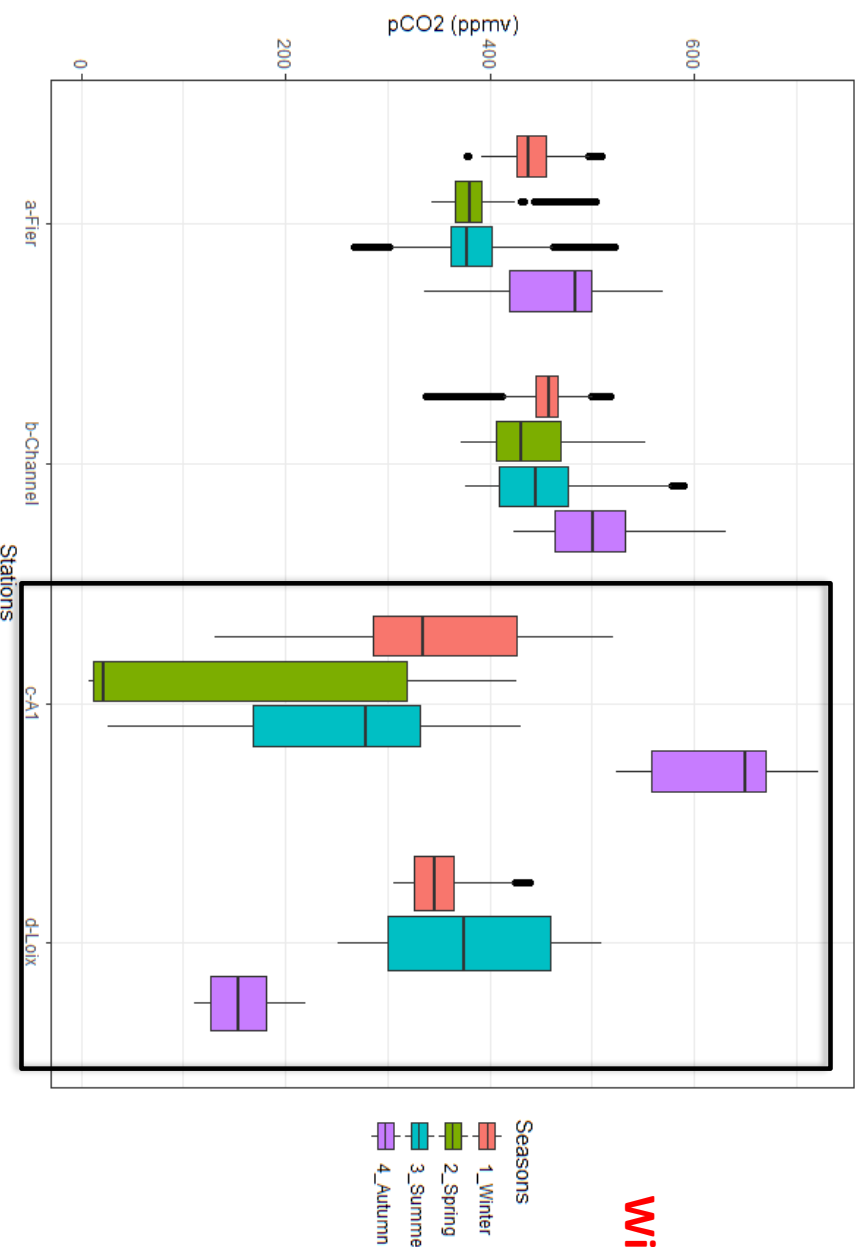
Summer 2019:

- **c:** photosynthesis activity of aquatic macroalgae
- **d:** zooplankton bloom → phytoplankton cell degradation



Autumn 2019:

- **c:** Macroalgae degradation → Organic matter mineralisation → high pCO₂



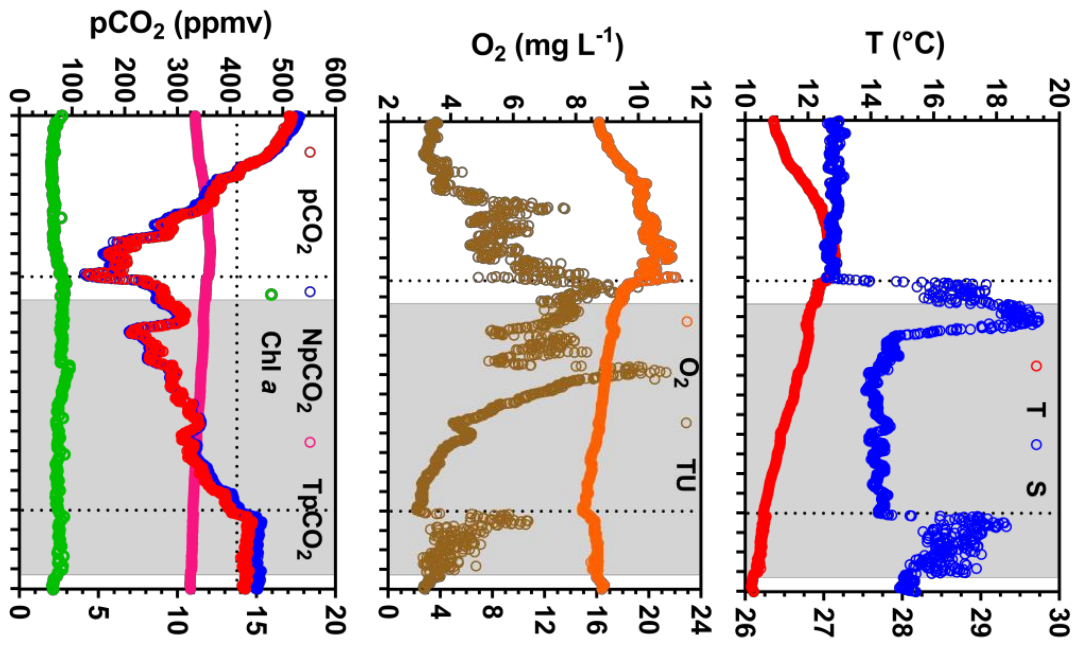
Winter 2020: no significant difference on pCO₂

pCO₂ (c) > pCO₂ (d)

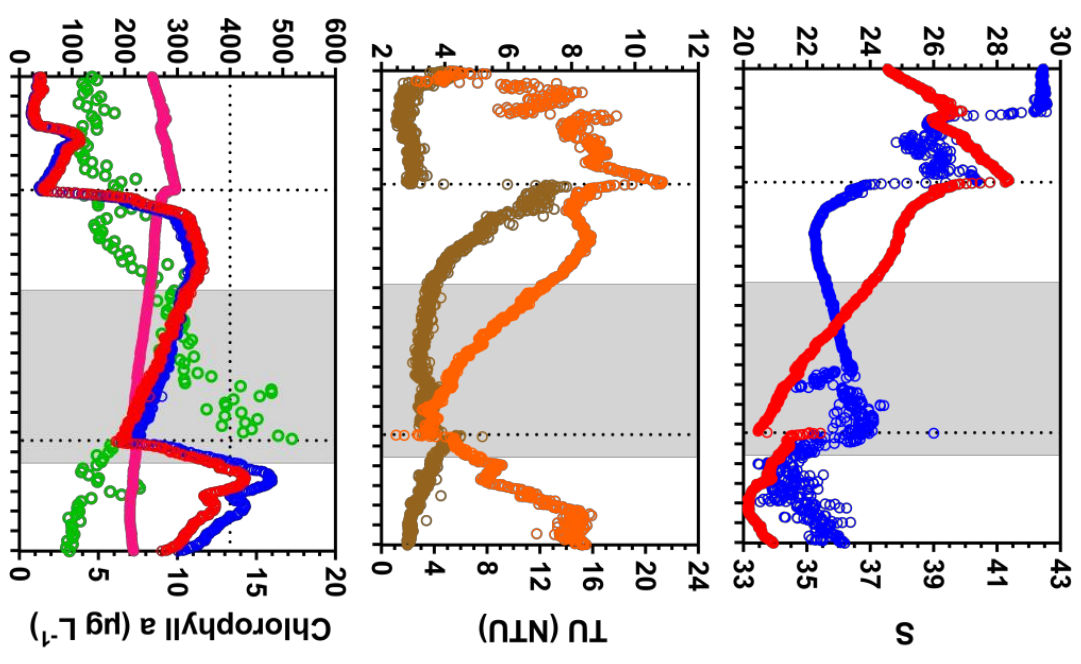
- a:** Fier d'Ars intertidal bay
- b:** Vieux port channel
- c:** A1 salt marsh (nature reserve)
- d:** Loix salt marsh (salt-farming activity)

- Indigenous biological activity (primary production/respiration) at the diurnal scale
- Coastal water incomings (tidal advection): increase pCO₂ in winter, spring and summer

Station c - Winter 2020



Station c - Summer 2019



pCO₂/salinity = -0.93
 pCO₂/water level = 0.85

- Large diurnal and tidal variations on pCO₂

Winter: 130 < pCO₂ < 519 ppmv

Summer: 25 < pCO₂ < 430 ppmv

- Estimated water-air CO₂ flux (mmol CO₂ m⁻² h⁻¹): **FCO₂ = α k (pCO₂eau – pCO₂air)**

(Takahashi et al., 2002)

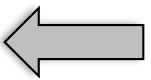
- Channel:** CO₂ source

→ **b:** +0.16 ± 0.24 mmol m² h⁻¹

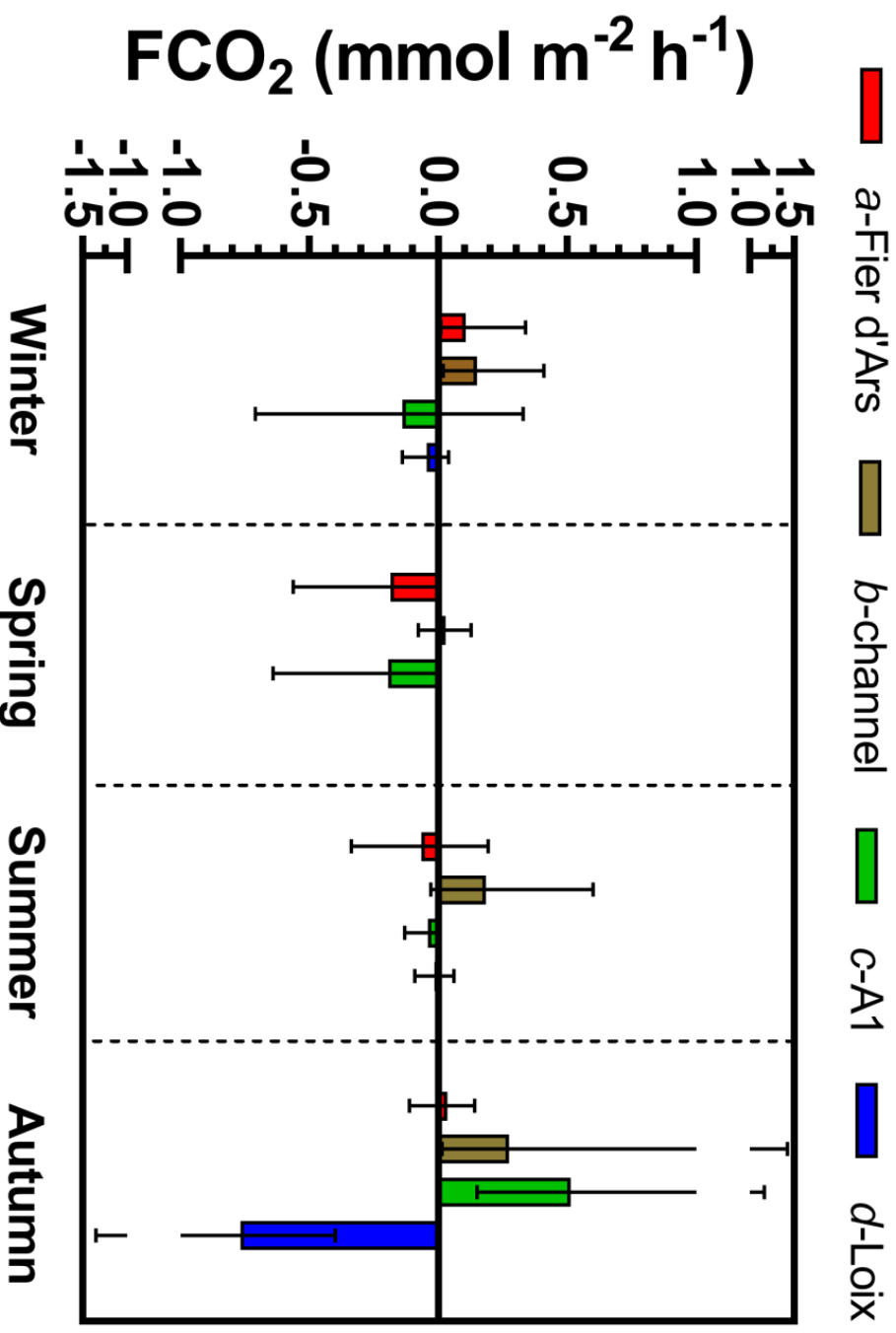
- Marshes:** CO₂ sink

→ **c:** +0.04 ± 0.36 mmol m² h⁻¹

→ **d:** -0.28 ± 0.38 mmol m² h⁻¹



Strong variations in autumn



a: Fier d'Ars intertidal bay

b: Vieux port channel

c: A1 salt marsh (nature reserve)

d: Loix salt marsh (salt-farming activity)



- **Significant influences of $p\text{CO}_2$ dynamics:**
 - ✓ Station typologies within the coastal zone (Bay, channel, marsh)
 - ✓ Management practices: water turnover
- Diurnal and tidal scales: **non-temperature effects on $p\text{CO}_2$ dynamics**
 - ✓ Biological activity (photosynthesis/respiration)
 - ✓ Different tidal effects according to water column CO_2 saturation
- **Métabolism:**
 - ✓ **Channel:** CO_2 source to atmosphere
 - ✓ **Salt marshes:** CO_2 sink
- Study: (1) the atmospheric CO_2 fluxes by Eddy Covariance (*in situ* measurements)
(2) the salt marsh aquatic metabolism

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Thank you for your attention !

