

Reply to the interactive comment of G. Abril

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The criticism of G. Abril on computing net community production of seagrass during immersion from CO₂ fluxes is mainly mirrors his criticism (Abril, 2009) on method described in Da Silva et al. (2009), who actually used, in contrast to us, a static and not a dynamic chamber. The main concern outlined there is that in closed chamber system pCO₂ is an inadequate measure of changes in the DIC pool and thus of net primary production. It should be noted that the method of Da Silva provides reasonable net community production rates when compared to other methods. We agree with Abril, that an unambiguous determination of the net community production requires a comprehensive assessment of changes in the DIC system in particular when calcification and carbonate dissolution are of importance. This can in future be done by monitoring the pH inside the chamber and total alkalinity or DIC at the beginning and end of the incubation.

The continuous purging of the dynamic chamber with ambient air forces the carbonate system into equilibrium with the atmospheric pCO₂. Any loss of DIC regardless of carbon species will result in an uptake of CO₂ from the ambient air till the equilibrium is reached and vice versa benthic respiration will result in a loss of CO₂ till the equilibrium is reached again. The response time of our chamber (e.g. the time required to reduce a perturbation to 37% of its initial value) depends on the pH and ranges from 49 to 63 minutes for a pH range of 7.80 to 8.40. For illustrative purposes, when assuming a constant assimilation rate and a response time of 60 min., 37% of the assimilated carbon will be replenished after 1h and 80% after 6h of incubation. Thus dynamic chamber can in principal capture changes in the DIC pool over longer incubations times. One uncertainty of course arises from attributing the observed CO₂ flux to primary production. In the Ria Formosa calcification and carbonate dissolution are negligible (Dos Santos, 2009). Thus the main processes affecting the DIC pool inside the chamber are exchange with the atmosphere, benthic respiration and assimilation, with the latter being the only process capable of lowering the pCO₂ inside the chamber below equilibration with the atmosphere. Thus we found it reasonable to attribute CO₂ uptake to primary production. It should further be noted that CO₂ rather than bicarbonate is the preferred carbon species taken up by the seagrass. As the rate constant of CO₂ hydration is in

the order of tenth of seconds to minutes and the response time of our chamber to CO₂ disequilibria is on a similar time scale, the response time of the chamber towards assimilatory uptake of CO₂ is expected to be much faster than towards changes in the DIC pool. However this is subject to ongoing variations of the chamber. A second source of uncertainties arises from the water exchange through the open port of the chamber during submersion. We have tentatively estimated this bias to 12 to 18%. Thus without accounting for these processes we might slightly underestimate the net primary production

Clavier et al. (2011) have recently reported a net community production of about 3 mmol m⁻² h⁻¹ under aerial conditions and of about 20 mmol m⁻² h⁻¹ under submerged conditions with the latter being derived from DIC and oxygen measurements. The respective gross primary production rates in the study of Clavier et al. (2011) from a *Zostera noltii* seagrass bed in the Banc d'Arguin were 6 and 42.7 mmol m⁻² h⁻¹. From our CO₂-flux measurements we have estimated a net community production of 9.1 mmol m⁻² h⁻¹ under aerial conditions and of 16.4 mmol m⁻² h⁻¹ under submerged conditions. As a first rough estimate of the gross community production in our study, we can simply add the observed respiration fluxes measured during night to the net community production resulting in an estimated gross community production of 17.5 mmol m⁻² h⁻¹ under aerial conditions and of 36.5 mmol m⁻² h⁻¹ under submerged conditions whereas the peak occurring at the transition from air exposure to immersion has not been included. In particular under submerged conditions the net and gross community production rates from both studies agree quite well. Under aerial conditions our production rates were about three times higher than those reported in Clavier et al. (2011) When including the carbon evolution from the sediment we can estimate a gross primary production to 4.3 g C m⁻² d⁻¹ being close to that (~ 5 g C m⁻² d⁻¹) reported by Cabaço et al. (2012) for established meadows of *Z. noltii* in the Ria Formosa for this time (late spring) of the year that has been computed from changes in the living biomass. Thus in conclusion, despite the uncertainties from the lacking DIC measurements we feel confident with the data and in particular with our statement that the net primary production during submersion exceed that during air exposure. However we would like to point out that the main focus of our manuscript is to show the strong imprint of tidal cycles on trace gas fluxes in intertidal systems. With respect to the magnitude of the measured fluxes we have clearly stated that these are still uncertain.

References

Cabaço, S., Santos, R., and Sprung, M. 2012. Population dynamics and production of the seagrass *Zostera noltii* in colonizing versus established meadows. *Marine Ecology*, 33, 280-289, doi: 10.1111/j.1439-0485.2011.00494.x, 2012.

Clavier, J., Chauvaud, L., Carlier, A., Amice, E., Van der Geest, M., Labrosse, P., Diagne, A., Hily, C. 2011. Aerial and underwater carbon metabolism of a *Zostera noltii* seagrass bed in the Banc d'Arguin, Mauritania. *Aquatic Botany*, 95, 24 - 30