

Interactive comment on “Enhanced carbon overconsumption in response to increasing temperatures during a mesocosm experiment” by J. Taucher et al.

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Air-water gas exchange and loss of organic matter

1. Without gas exchange, the amount of total carbon (DIC+POC+DOC) should not increase, as biological processes only lead to shifts between the different pools. Therefore any change in this mass balance is attributable to gas exchange, assuming no loss of carbon e.g. through sinking. The temporal development of total carbon (DIC+POC+DOC) in the mesocosms suggests a net carbon uptake of ~ 200 , 310 and 420 $\mu\text{mol C L}^{-1}$ at low, intermediate and high temperatures, respectively, over the course of the experiment (Fig. 4B). To account for this increase, wind speed was ad-

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justed and a value of 6 m s^{-1} was assumed, yielding the best fit to the observed net carbon uptake in the mesocosms at different temperatures.

The temporal development of total nitrogen (PON+DON+DIN), which decreased in all mesocosms over the course of the experiment, indeed suggests a loss of organic matter in our experiment. Assuming that gas exchange began with the onset of the bloom, when pCO_2 levels rapidly decreased, the amount of total carbon in the mesocosms would have been expected to start increasing at the same time. However, the amount of total carbon was more or less constant in all mesocosms during the first half of the experiment and a substantial increase in total carbon could be observed only after day t14. We assume that the uptake of DIC through air-water CO_2 flux was approximately balanced by the loss of organic matter during this bloom phase (until day t14). In our experiment, there are three mechanisms that may potentially lead to a loss of carbon and nitrogen: sinking of organic matter to the bottom of the mesocosms, wall growth or mesozooplankton dynamics. It is difficult to quantify the proportional effect of the above mechanisms for the observed loss in our experiment. However, both wall growth and grazing effects cannot explain the observed large loss of organic matter. Therefore we reckon that sinking of particles is the most likely reason for the observed loss of organic matter during the bloom phase. Previous studies have shown, that sinking of organic matter can lead to a considerable loss of biomass from the surface layer in mesocosm experiments [Keller et al., 1999; Wohlers et al., 2009]. Since high concentrations of POC and PON were reached very rapidly in our experiment, it is possible that some of this newly produced biomass has sunken to the bottom of the mesocosms. Although mixing of the water column by the propeller should minimize particle settling, this can obviously not be excluded entirely.

However, neither gas exchange nor sinking of organic matter affect the main findings and conclusions of our study.

It is correct that gas exchange should be fastest with highest gradients of pCO_2 . However, POC and DOC data suggest high levels of carbon consumption for a long time

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after nutrients were exhausted. This counteracts the increase in pCO₂ due to gas exchange. When biological activity finally ceases, pCO₂ increases very quickly due to gas exchange.

It is correct, that the estimated increase in DIC due to CO₂ uptake from the atmosphere seems quite high for an indoor experiment. However, high rates of gas exchange are facilitated through continuous mixing of the water column by propellers attached to the mesocosms. Thereby, the boundary layer, which is exchanging gas with the atmosphere, is constantly renewed and rapid air-water gas exchange is facilitated even at virtually zero wind speed. Furthermore, the positive effect of temperature on gas transfer velocity resulted in higher rates of gas exchange at higher temperatures. In fact, the magnitude of gas exchange in our mesocosms setup has been tested in a follow-up experiment (data not published yet) and supports rates of gas exchange in the same magnitude as observed in the presented experiment.

2. We emphasize, that the data is presented in its uncorrected form (DIC concentrations). Only in figure 4A (carbon budget, dashed line) the estimated gas exchange is taken into account for the calculated DIC uptake. Furthermore, the main results and conclusions in our study are not affected by potential gas exchange. This is why the discussion of these aspects was kept short. Observed dynamics in POM and DOM and their respective C:N ratios clearly support the hypothesis of carbon overconsumption and an associated temperature effect.

Technical corrections:

1. the depth of the mesocosms is ~100 cm
2. the mesozooplankton population survived in all treatments, however, the number of individuals was different in the different treatments (will be examined in a separate paper). However, copepod densities were not high enough to have a significant impact on carbon and nitrogen cycling.

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3. The maximum irradiance was calculated according to [Brock, 1981] ("calculating solar radiation for ecological studies") for the respective latitude and time of the year. Maximum daily irradiance of 600-700 W m⁻² are common at higher latitudes in summertime.

4. As described in the "Materials and Methods" Section (2.2) DOC samples were filtered through precombusted GF/F filters.

5. Following [Eppley, 1972], phytoplankton growth and photosynthesis usually have a Q₁₀ value between 1 and 2. Thus a Q₁₀ value of ~2 would correspond to the upper end for common Q₁₀ estimates.

6. We are aware of the fact, that temperature varied between the mesocosms in one treatment. However, the maximum variation is only up to 1.5 °C. Of course it is arguable whether this can be considered true replicates or not. We chose to treat them as replicates for the figures of the temporal development. The figures with the linear regressions should make clear, that there was variation within the treatments, however much smaller than the variation among the treatments.

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