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Biogeosciences Discussions

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

Anonymous Referee #1

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General Comments

This paper describes an experiment to test the response of a pelagic community to elevated temperatures. This is a timely experiment because relatively few studies have considered the effect of rising temperature on marine biogeochemistry and productivity – even though rising temperature will be a major consequence of climate change. The approach taken was to use 9 large volume mesocosms (1400L each) and to modify the temperature after filling the enclosures with water taken from Kiel Fjord in June 2010. The aim of the experiment was to manipulate the environment to investigate how natural assemblages, ranging in size from viruses to mesozooplankton, might respond

to changing temperature during a phytoplankton bloom and how that might be reflected in variations in biogeochemical processes.

The approach taken was to measure all of the components of the carbon cycle – dissolved inorganic carbon (DIC), dissolved organic carbon (DOC), total dissolved nitrogen (TDN), particulate organic carbon (POC) and nitrogen (PON). These measurements allowed other components of the carbonate system (e.g. pCO2) to be calculated. With this comprehensive set of measurements, the authors expected to be able to construct a balanced total carbon-system budget for the period of the experiment. However, this was not the case and they could not balance the budget using the data from their measurements. They concluded that there must have been significantly more gas exchange than would be expected for an in-door experimental system, and they applied corrections for gas exchange. Unfortunately, the magnitude of the correction is not clear, nor is it possible to determine how many of the conclusions of the study depend directly on the correction.

For that reason, few of the conclusions in the paper are justifiable. The original, uncorrected data must be shown in the paper.

Specific Comments

1. Air-sea CO2 exchange correction

The decision to apply a strong gas exchange correction appears to have been made because the authors could not balance the carbon budget. However, it is impossible for the reader to determine the magnitude of the correction. Indeed, the decision to apply a correction is questionable because of data presented in the paper. Firstly, the nitrogen budget raises questions about the assumption that every variable in the carbon budget has been adequately measured because the nitrogen budget also does not balance. Comparing the concentration of nitrate added to initiate the phytoplankton bloom, with increase in PON and DON (Fig 2) shows a loss of about 25% of total nitrogen throughout the experimental period of 30 days. Since denitrification is unlikely

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to be a significant process in these (presumably well-mixed, well-oxygenated systems), then a substantial amount of nitrogen is not accounted for in the nitrogen budget. Is this the same magnitude as the unaccounted carbon? If so, then the most likely explanation is that the measurements that were made do not account for all of the carbon or for all of the nitrogen in the mesocosms. That is, both the carbon and nitrogen budgets are incomplete. Applying a "correction" to air-sea CO2 exchange is therefore not justified – and cannot address the nitrogen budget anomaly.

A second doubt about whether air-sea gas exchange should be corrected comes from the data in Fig. 4c, which shows pCO2 in the water in the mesocosms. If the increase in pCO2 after day 10 had been a diffusive process, then the shape of the curve would be different. Rates of diffusion depend on concentration gradients. When the concentration difference is greatest (i.e. steep gradient), then diffusion rate is fastest; when the gradient is shallowest, diffusion rate is slower. Yet, Fig. 4c shows the slowest change pCO2 when the gradient is greatest (around day 10), but acceleration when the gradient is shallowest around day 30. So the data and the shape of the curve are not consistent with the contention that air-sea gas exchange estimates were in error. Thirdly, it seems implausible that this experimental design, of indoor mesocosms that were "gentle mixed" would result in surface roughness equivalent to that obtained with a wind speed of 6 m s-1. There have to be real doubts about the assumption that gas exchange was significantly underestimated and about the justification for applying a correction.

2. Consequences for budget calculations

If justification for a correction to air-sea exchange has not been convincingly made, then all of the conclusions from the study must be in doubt. The authors need to provide the uncorrected data so that readers can determine to their own satisfaction what has happened in the experiment. Was there really "overconsumption" of carbon? How robust are the estimates of unusually high C:N ratios? How much of the temperature effect was a consequence of the gas exchange correction? This can only be determined

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if the authors supply the uncorrected rates.

It is also important to apply appropriate timescales to budget calculations. The experiment had basically 2 phases- an autotrophic phase and a heterotrophic phase – and it is important to separate those phases when constructing budgets.

Technical corrections

1. What is the depth of the mesocosm?

2. Acartia was added at a density of 10 animals L-1. Did this population survive throughout the experiment and how was the number of zooplankton estimated.

3. It is implausible that the maximum light supplied from the artificial light sources was 690 W m-2. The solar constant is 1360 W m-2 and it is unlikely that this much light could be supplied to a mesocosm; indeed, it is not clear why such intense light would be required.

4. Was water filtered before DOC concentration was determined? Make this clear.

5. On page 3499, line 19-21 – "the Q10 value of 2.0 .... lies at the upper end of estimates for ... photosynthesis". This is incorrect. A Q10 of 2 is typical of biological process at this temperature range.

6. A large different in temperate in the replicate mesocosms is shown in Fig 3 D. E and F. In some cases, replicates appear to vary by 2 or 3âĎČ. With such a large deviation from the target temperatures, it is inappropriate to say that these are replicate mesocosms. It is inappropriate to use data from such variable temperatures to calculate error bars on the figures.

Interactive comment on Biogeosciences Discuss., 9, 3479, 2012.