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Interactive Comment

Interactive comment on "Anthropogenic and natural CO_2 exchange through the Strait of Gibraltar" *by* I. E. Huertas et al.

I. E. Huertas et al.

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The paper Anthropogenic and natural CO2 exchange through the Strait of Gibraltar by Huertas and coworkers reports on a detailed study of the carbon cycle in the Strait of Gibraltar, which constitutes the link between the Mediterranean Sea and the North Atlantic Ocean. The study is based on an very extensive field data set and yields in assessments of carbon exchange between the two basins. The study moreover gives a detailed discussion of the results in the view of recent results from other researchers, which contributes to the comprehensive nature of the work by Huertas et al. I have some detailed comments, given below, and think that the work is well suited for publication in Biogeosciences.

Detailed comments:

In general I very much appreciated the comprehensive discussion of work found in literature. However sometimes I have had the feeling that it was difficult to recognize the original work by Huertas et al.. I recommend to introduce a brief recollection of the original findings (without discussion), for example right before the conclusions. In any way the own results need to be better discriminated against literature results.

Following the reviewer s recommendation, original findings have been better explained in different parts of the revised manuscript, including the abstract and the conclusions section. Efforts have been made to make explicit throughout the text which are the new contributions provided by our study and the comparisons with other values reported historically in this area.

Page 1024, line 11: A rather theoretical, conceptual application of the TTD method has been introduced by Thomas et al., GRL 2001.

INCLUDED

Page 1025, line 27: The statement due to carbonate sedimentation appears to be cryptic and unclear here. Please clarify.

CLARIFIED AS FOLLOWS:

"Moreover, results presented by Schneider et al. (2007) show that main alkalinity inputs come into the basin from the Black Sea along with river discharge, with carbonate sedimentation appearing to be the major sink for alkalinity."

Page 1041, lines 18-26: The section on Ca is entirely unclear to me. Also, I cannot identify the information, which should be shown in the plot. If Ca is a conservative water mass property, it should not be a surprise to see variations in Ca, when water masses mix. In my view an argument for biological changes in the Ca concentrations can only be made from deviations / anomalies relative to the conservative behaviour. The authors should make some efforts to shows this, if they think there were biological changes.

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The section has been clarified as follows:

"Therefore, if the alkalinity budget for the Mediterranean Sea described in Schneider et al. (2007) is taken into account, which considers a joint alkalinity entrance of 86 kmol s-1 into de basin from the Black Sea and rivers, and the alkalinity export through the Strait of Gibraltar obtained in our work is taken (-44 kmol s-1), 42 kmol s-1 of the alkalinity measured in the Mediterranean do not reach the Atlantic. Using the net export of nitrate through the Strait given by Dafner et al. (2003), a consumption of 4 kmol s-1 of alkalinity is expected to be associated to the remineralization of the organic matter present in the Mediterranean Sea, and the most likely candidate for the loss of the remaining 38 kmol s-1 of alkalinity would be CaCO3 sedimentation. Our results then imply a net carbonate sink of 19 kmol s-1 towards the seafloor. However, an export of -13$\pm$ 0.3 kmol s-1 of CaCO3 is observed to occur through Gibraltar (Table 2 and Fig. 7). This output of carbonate can be attributable to the contribution of the biological CaCO3 pump, which transports downward alkalinity by CaCO3 particulate from the upper surface layer to deep layer, providing an additional alkalinity gain equivalent to -26 kmol s-1. Although CaCO3 dissolution is not favoured thermodynamically, the increase of alkalinity can be produced in biological mediated environments (Milliman et al., 1999) or released back from the sediment to the water column (Berelson et al., 2006). The combination of all these processes would result in a gross CaCO3 formation of 32 kmol s-1. This budget is coherent with the high downward carbonate fluxes measured recently in the NW Mediterranean (Martin et al., 2006), who reported a mean annual flux of sink of 0.40 mol m-2 y-1 using sediment traps, which matches strongly our gross estimate. According to Schneider et al. (2007), the alkalinity loss via carbonate sedimentation corresponds to a surface calcification rate of 0.38 mol m-2 yr-1, which amounts to 32 kmol s-1 of a net CaCO3 precipitation. These authors, however, neglect carbonate dissolution and consider an alkalinity export through the Strait of -25 kmol s-1. In parallel, the gross CaCO3 formation (32 kmol s-1) in surface waters nearby coastal regions would favour a rise in the oceanic pCO2. Our estimates point to a CO2 outgassing of 21 kmol s-1 to the atmosphere due to settling of CaCO3

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particles, assuming that pCO2 is maintained in equilibrium with the atmospheric CO2 levels (Copin-Montégut, 1993)."

Page 1050, line 9-10: The term pump has to be clarified here. If the Mediterranean only pumps Co2 from the surface of the Atlantic into its deeper layer, this would be one aspect. But it would also be possible that the Med. absorbs anthro. CO2 on its own, which would constitute a different, complementary way of pumping CO2 into the deep Atlantic. The statement has been clarified as follows:

"Regardless of the approach used for CANT estimation, the data analysed and provided in our study indicate that the Mediterranean plays a fundamental role in the capture of anthropogenic carbon from the Atlantic, contributing to its storage in a dense layer which in the long term feeds back the deep circulation of the North Atlantic. Hence, the fact that the Mediterranean Sea gains CANT does not contradict its final function as an additional source of CANT within deeper Atlantic regions due to the downward entrainment (Rios et al., 2001; Alvarez et al., 2005)."

Interactive comment on Biogeosciences Discuss., 6, 1021, 2009.