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Interactive comment on "The carbon budget of the North Sea" *by* H. Thomas et al.

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We very much appreciate the interactive comment by Andersson et al, which sheds light on our manuscript in a highly interesting way. Traditionally, the trophic state of coastal areas has been relied on as an indicator to assess or estimate at least the direction of the CO_2 air-sea fluxes, since on a global scale, the knowledge on the coastal nutrient conditions is much more profound that those of the carbon cycle. However in the past decade an increasing number of studies have been carried out in coastal environment, which include notably inorganic carbon cycle parameters. It has turned out that the trophic state not necessarily serves as a reliable indicator for the direction of the CO_2 air-sea fluxes, rather the CO_2 air sea flux is determined by a variety of physical, chemical and biological factors. In the view of our present manuscript, it might be worth noticing that both the North Sea and the adjacent Baltic Sea act as sinks for atmospheric CO_2, still both show heterotrophic characteristics (Thomas et al., 2003; Thomas et al., 2004). Note that in some cases the direction of the air-sea CO_2 fluxes and ecosystem trophic state agree: the Galician upwelling system is a sink for atmospheric CO_2 and net autotrophic (Borges and Frankignoulle, 2002); the US South Atlantic Bight is a source of CO_2 and net heterotrophic (Cai et al., 2003). A further com-

plicating factor is the rise of the atmospheric CO_2, which causes in turn an increase in the surface DIC as nicely argued by Andersson et al. in their comment. However, if re-equilibration of CO_2 occurs during winter then the increase of atmospheric CO_2 should not be a major source of discrepancy between trophic state and air-sea CO_2 fluxes in highly biologically active areas as the North Sea (unlike the BATS site). It thus appears that the application of expressions (autotrophic vs. heterotrophic), originally applied on individual species, on a full ecosystem scale needs a careful consideration of the complexity of the system. A fully valid and scientifically challenging point is the authors' remark on a possible temporal variability of the system, here the North Sea. Since our study intends to provide the first ever comprehensive carbon budget, currently we do not have a tool nor data available to address this question. Moreover, we have to assume that also from the hydrographic point of view the system is in a steady state. We thus fully agree that one should consider a term describing the temporal changes of the system, when establishing carbon budgets. However, in the present case we can only assume that it is zero. An argument, which tends to support our steady state assumption, might be seen in the short flushing times of the North Sea. For the largest part of the North Sea, these are less than a year, and we feel that if one assumes an accumulation of organic carbon in the water column of the North Sea, this accumulation should be visible/detectable in our budget. With other words, any accumulation of organic carbon in the North Sea should cause and increase of DOC in the outflowing waters compared to the inflowing waters. Obviously, this argument might be weakened by longer residence times in other marine areas, but here, we feel that the observed decrease of the DOC concentrations from inflowing to outflowing waters allows ignoring any DOC accumulation within the North Sea on an annual scale. Moreover, the good match of the assessment of the CO2 air-sea exchange using the closing term assessment with the air-sea flux approach based on pCO_2 field data (Thomas et al., 2004) seems to underpin the assumption that the North Sea is at steady state (or very close to it) over an annual scale. In 2005 and 2009 we will repeat the North Sea survey in order to gain first information on the temporal variability of the carbon and related

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nutrient cycles.

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