SURFACE DISSOLVED INORGANIC CARBON DYNAMICS IN THE GULF OF BISCAY (JUNE 2006 – MAY 2007)

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Introduction

Coccolithophores, among which Emiliania huxleyi (*E.huxleyi*) (figure 1) is the most abundant and widespread species, are considered to be the most productive calcifying organisms on Earth. *E.huxleyi* often forms massive blooms in temperate and sub-polar oceans, and in particular at continental margins and shelf seas (figure 3).

The intrinsic coupling of organic matter production and calcification in coccolithophorid blooms underlines their biogeochemical importance in the marine carbon cycle. Primary production via photosynthesis in the photic zone and vertical export of organic matter to deep waters draws down CO_2:

$$CO_2 + H_2O \rightarrow CH_2O + O_2$$

this is the so-called "organic carbon pump".

In contrast, calcification and thus formation of biogenic calcium carbonate ($CaCO_3$), consumes total and carbonate alkalinity and releases CO_2:

$$Ca^{2+} + 2HCO_3^- \rightarrow CaCO_3 + H_2O + CO_2$$

this is often named the "carbonate counter-pump" because it counter-acts the effect on CO_2 fluxes. This intimate coupling of the two pumps in coccolithophores, together with other calcifying organisms (mainly planktonic foraminifera), has been considered to be responsible for generating and maintaining the ocean's vertical distribution of total alkalinity (TA) in seawater and for regulating the atmospheric pCO_2 since the Mesozoic era.

Fig. 1

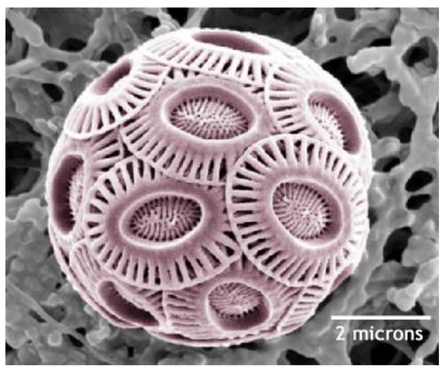

Fig. 2

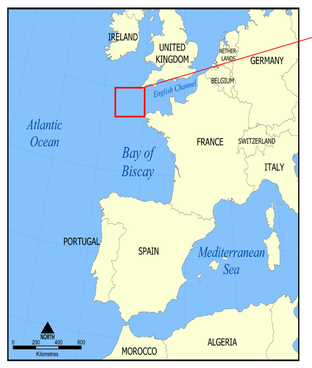

Fig. 3

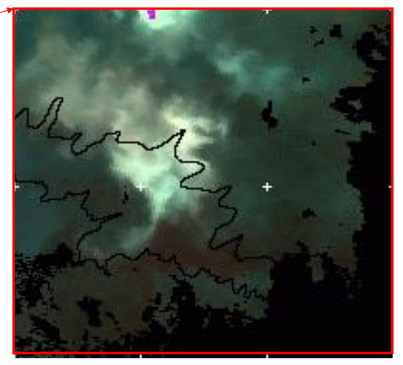

Figure 1 (left): Coccolithophorid *Emiliania huxleyi*. Figure 2 (middle): The study area: Gulf of Biscay. Figure 3 (right): Satellite image of the 1st of June 2006 (provided by Steve Groom, Remote Sensing Group, Plymouth Marine Laboratory, Plymouth, UK), where the high reflectance patch indicates the decline of the coccolithophorid bloom.

Results & discussion

The biogeochemical properties of an extensive bloom of the coccolithophore, *E.huxleyi*, at the shelf break in the northern Gulf of Biscay (figure 2) was investigated in June 2006 and May 2007. We report the results from the surface measurements during both cruises.

Seawifs Chlorophyll-a (Chl-a) values in the study area indicate that seasonal cycles of phytoplankton biomass were remarkably similar in 2006 and 2007 with a first peak in mid-April associated to diatoms and a second peak in late May associated to coccolithophorids (figure 4).

During both cruises, Total Alkalinity (TA) values showed strong non-conservative behaviour, indicative of the impact of calcification (figure 5). TA anomalies were positively related to the mixed layer depth, in agreement with the ecophysiology of coccolithophores, whereby these organisms flourish in nutrient depleted and high light availability conditions (figure 6).

The largest TA anomalies were observed in the high reflectance coccolith patch where we also observed an increase in the partial pressure of CO_2 normalized at a constant temperature of 13°C (pCO_2@13°C), in agreement with the transfer of CO_2 from the bicarbonate pool during calcification (figures 8 and 9). TA anomalies were of similar amplitude during both cruises, indicating that calcification affected markedly the dissolved inorganic carbon dynamics.

During both cruises, pCO_2 values ranged form 250 to 375 µatm and the area was found to act as a sink for atmospheric CO_2. pCO_2@13°C in the water column was negatively related to TA anomalies in agreement with an overall production of CO_2 related to calcification (figure 7). Hence, the calcifying phase of the *E.huxleyi* bloom decreased the sink of atmospheric pCO_2, but did not reverse the direction of the flux. pCO_2@13°C values in June 2006 lie below the values in May 2007, due to the cumulated impact of primary production on pCO_2, since the 2006 cruise was carried out later in the year than the 2007 cruise (figure 7).

Fig. 4

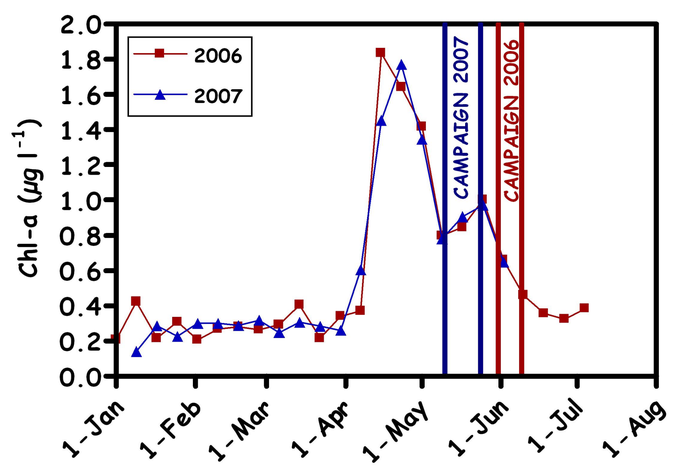

Fig. 5

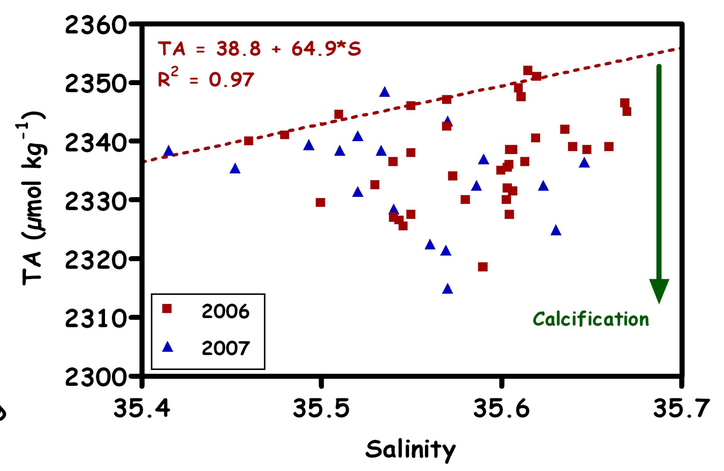

Figure 4 (left): SeaWifs weekly remotely sensed Chl-a, spatially averaged over lat = [47°N, 49°N], long = [9°W, 6°W] for 2006 in red squares and 2007 in blue triangles. Campaign periods are indicated with vertical lines in red for 2006 and blue for 2007. Figure 5 (right): Surface water TA (µmol kg-1) versus salinity.

Fig. 6

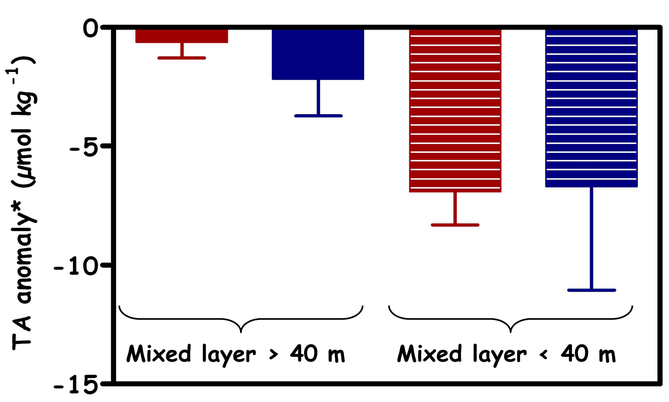

Fig. 7

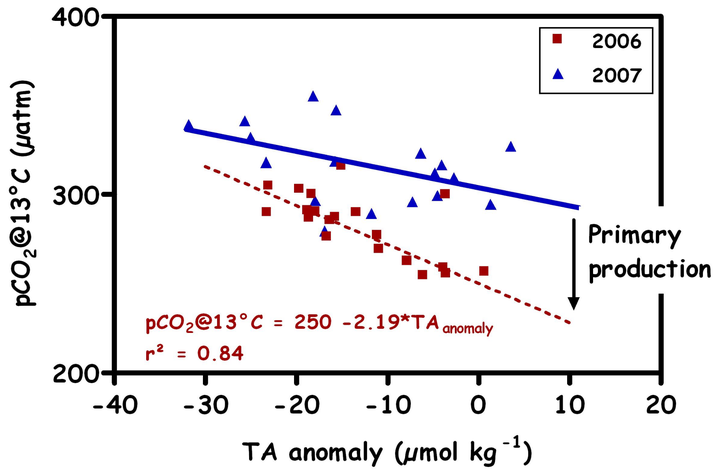

Figure 6 (left): TA anomaly (µmol kg-1) for data with a mixed layer depth deeper than 40m on the left and in striped colors for data with a mixed layer shallower than 40m on the right, for 2006 in red and 2007 in blue. Figure 7 (right): Surface water pCO_2@13°C (ppm) versus TA anomaly (µmol kg-1) over the top 50 m of the water column for 2006 in red squares and 2007 in blue triangles.

Fig. 8

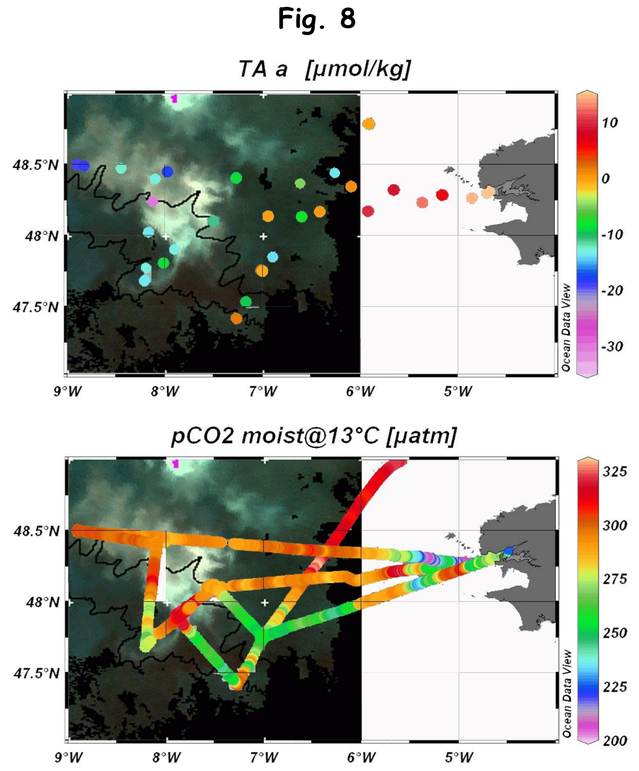

Fig. 9

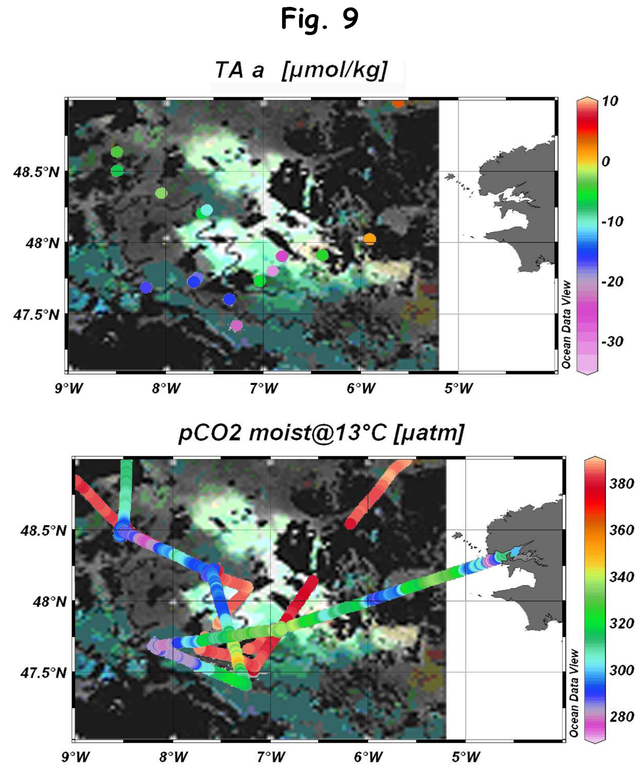

Figure 8 (left): On top TA anomalies (µmol kg-1) and at the bottom pCO_2@13°C (ppm), plotted on the remote sensing image of the 1st of June for 2006. Figure 9 (right): On top TA anomalies (µmol kg-1) and at the bottom pCO_2@13°C (ppm), plotted on the remote sensing image of the 14th of May for 2007.

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