# SURFACE DISSOLVED INORGANIC CARBON DYNAMICS IN THE GULF OF BISCAY (JUNE 2006 – MAY 2007 – MAY 2008)

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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.

## 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, May 2007 and May 2008. We report the results from the surface measurements during the three 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). The 2008 was conducted at the same time as 2007, however no Seawifs data was available for that period.

During all cruises, Total Alkalinity (TA) values showed strong non-conservative behaviour, indicative of the impact of calcification (figure 5). TA anomalies were of similar amplitude during the 2006 and 2008 cruises, indicating that calcification affected markedly the dissolved inorganic carbon dynamics. Due to less primary productivity during the 2007 campaign, the overall $pCO_2$@13°C was higher than in 2006 and 2008 (figure 6).

Wind speeds were highest in 2007, which prevented the mixed layer to shoal sufficiently for the coccolithophorid bloom to flourish (figure 8). Where the Chl-a concentrations increased a decrease in $pCO_2$ was observed in the surface water ($pCO_2$@13°C is lower than the actual $pCO_2$). Overall, although the calcifying phase of the E.huxleyi bloom decreased the sink of atmospheric $CO_2$ (figure 5), it did not reverse the flux during the three campaigns (figure 8).

Fig. 1

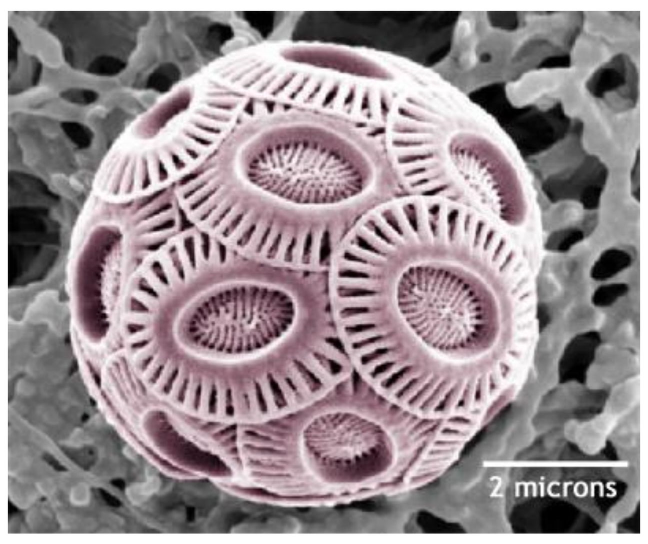


Fig. 2


Fig. 3

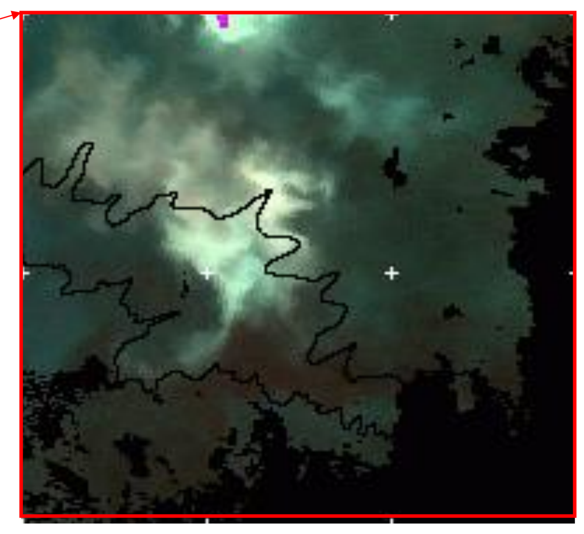

Figure 1 (left): Coccolithophorid *Emiliania huxleyi*. Figure 2 (middle): The study area: Gulf of Biscay. Figure 3 (right): Satellite image of the 1st of June 2006 (provided by Steve Groom, Remote Sensing Group, Plymouth Marine Laboratory, Plymouth, UK), where the high reflectance patch indicates the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

Fig. 4

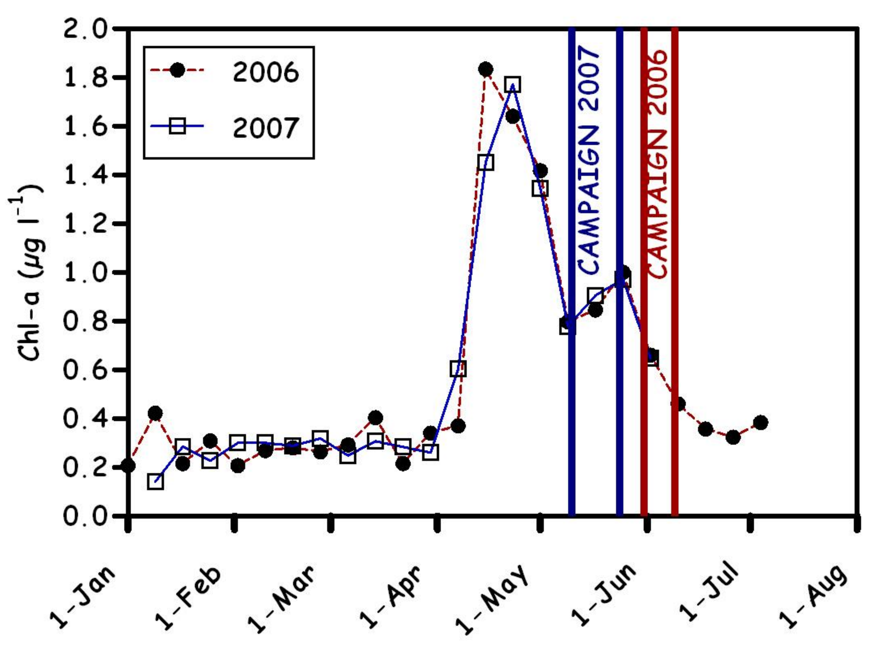


Fig. 5

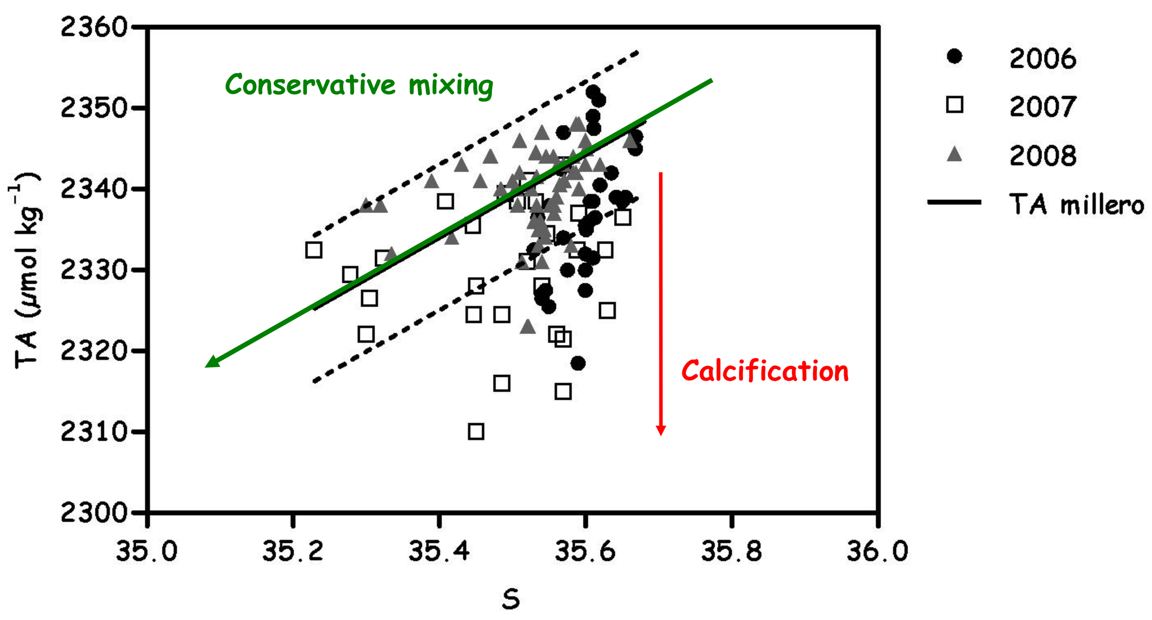


Figure 4 (left): SeaWifs weekly remotely sensed Chl-a, spatially averaged over lat = [47°N, 49°N], long = [9°W, 6°W]. Campaign periods are indicated with vertical lines in red for 2006 and blue for 2007. Figure 5 (right): Surface water TA (µmol kg⁻¹) versus salinity. For 2006 in black circles, 2007 in black squares and 2008 in grey triangles.

Fig. 6

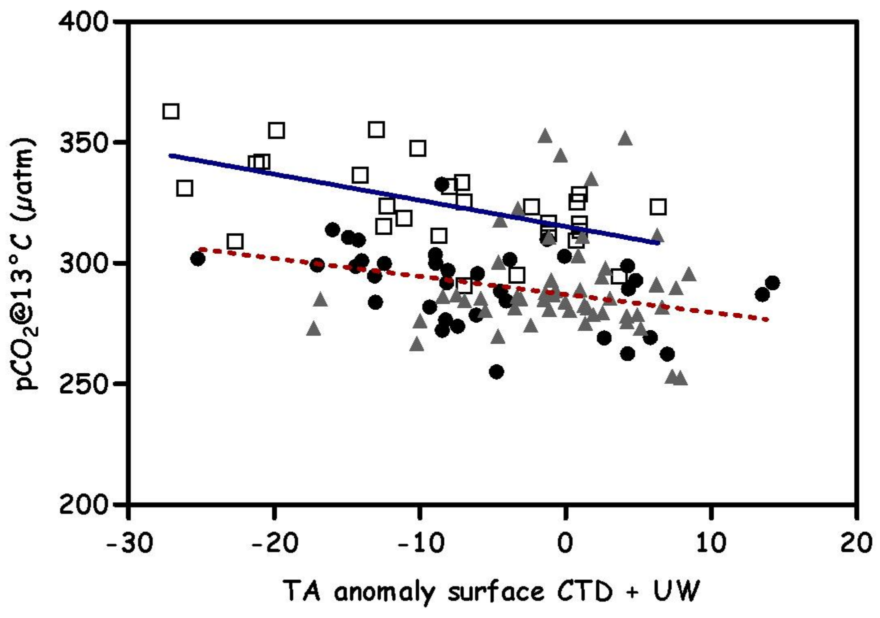


Fig. 7

Figure 6 (left): 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 black circles, 2007 in black squares and 2008 in grey triangles. Figure 7 (right): Preparing for a CTD cast on board the RV Belgica.

Fig. 8

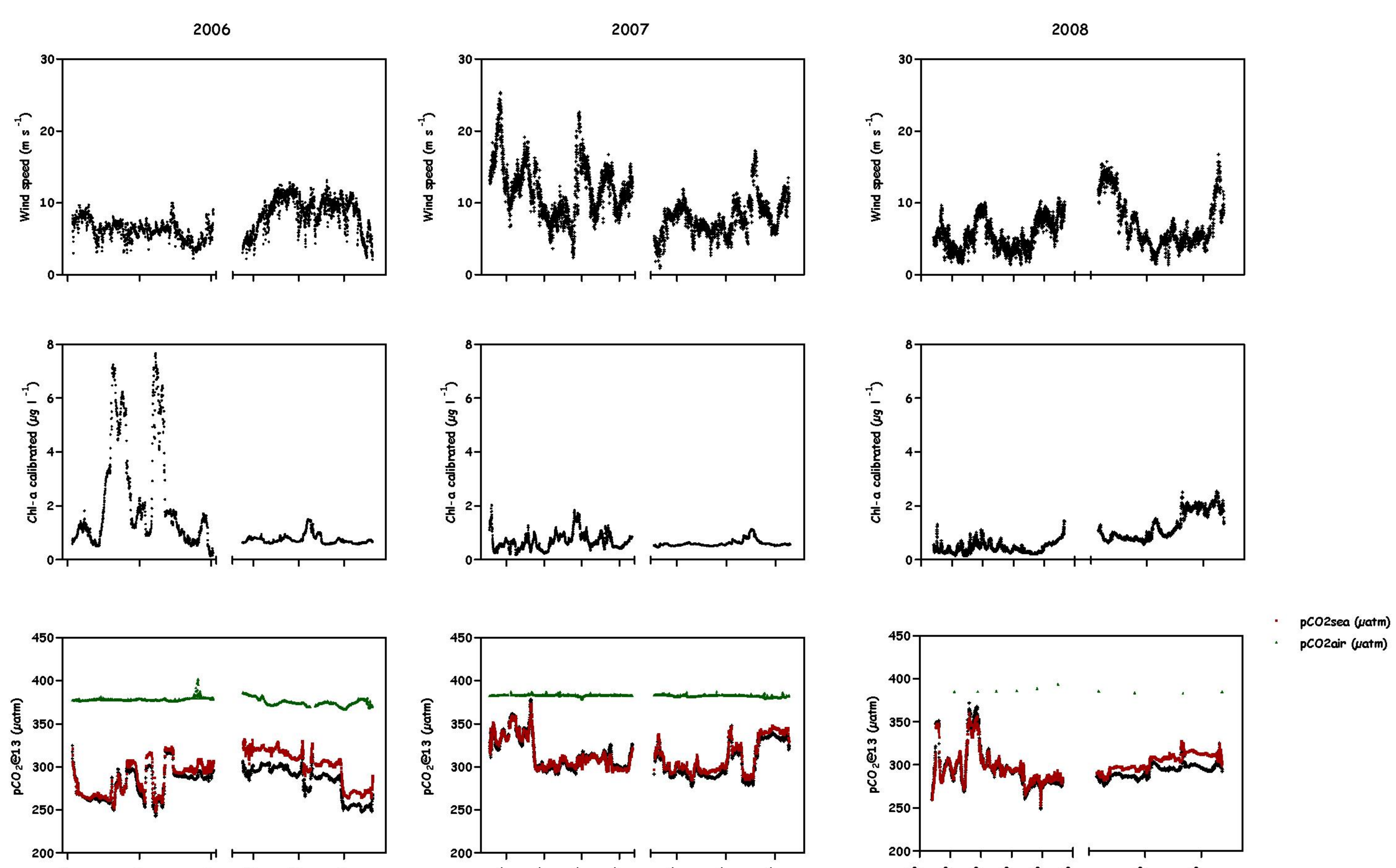


Figure 8 (left): On top wind speeds (m s⁻¹), in the middle Chl-a concentrations (µg l⁻¹) and at the bottom $pCO_2$@13°C (ppm) in black, actual sea surface $pCO_2$ in red and $pCO_{2\ atmosphere}$ in green.

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