DISSOLVED INORGANIC CARBON DYNAMICS IN THE BAY OF BISCAY

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Introduction

Based on the talk in session V entitled “The importance of the carbon cycle in climate change and ocean acidification”.

The current ocean has already absorbed 48% of anthropogenic CO_2 (Sabine *et al.*, 2004) with a consequent ocean acidification of 0.1 pH units. The surface ocean is further expected to decrease at a rate 3 times higher than what was experienced during glacial-interglacial periods (Falkowski *et al.*, 2000) with important repercussions on the chemistry and equilibrium of the oceanic carbonate system. The decreasing $[CO_3^{2-}]$ as a result of ocean acidification makes it more difficult for marine organisms to produce $CaCO_3$ structures, such as for example coccolithophorids (Riebesell *et al.*, 2000). But the precipitation of $CaCO_3$ is one of the main minerals transporting C to the deep ocean and hence buffering CO_2 uptake at the ocean surface. Coccolithophores, among which Emiliania huxleyi (*E.huxleyi*) (Fig. 1) is the most abundant and widespread species, are assumed to be the single most pelagic calcifier in the ocean (Balch *et al.*, 2007; Milliman *et al.*, 1999; Lee, 2001).

E.huxleyi often forms massive blooms in temperate and sub-polar oceans, and in particular at continental margins and shelf seas (Fig. 3). The intrinsic coupling of organic matter production and calcification in coccolithophorid blooms underlines their biogeochemical importance in the marine carbon cycle.

Materials and methods

Three cruises were carried out in the northern Bay of Biscay in June 2006, May 2007 and May 2008. Sampling of pH, oxygen (O_2), total alkalinity (TA) and phosphate (PO_4) was carried out with a rosette of 12 Niskin bottles (12L) coupled to a Conductivity-Temperature-Depth probe (Seabird SBE SBE21) (Fig. 4). Depths of sampling were chosen to cover surface waters, thermocline, and bottom waters down to the seafloor over the continental shelf and down to maximum 1400 m over the continental slope (Fig. 2). Twenty undisturbed sediment cores were collected with a boxcorer (Fig. 5) from which 4 cores were subsampled (Fig. 8) for benthic incubations over 24 to 48 h. Water-sediment fluxes of O_2, TA, silicate (Si) and nitrate (NO_3^-) were computed from the changes in concentration between the start and end of the incubation. Particulate inorganic carbon (PIC), particulate organic carbon (POC), chlorophyll-a, pheaopigments as well as ^{234}Th and ^{210}Pb was sampled from the sediments at a 1 cm interval.

Aims

To evaluate the relative effect of phytoplankton calcification to organic carbon production (NCC:NCP) on seawater carbonate chemistry and related air-sea CO_2 fluxes.

Results & discussion

The effect of net community production (NCP) on total dissolved inorganic carbon (DIC) and on partial pressure of CO_2 (pCO_2) was much higher than the effect of net community calcification (NCC) on DIC and pCO_2 (Fig. 6 and 7 respectively). The effect of sea surface temperature (SST) on pCO_2 was also higher then the effect of NCC on pCO_2 (fig. 7). Hence, the overall effect of NCC in decreasing the CO_2 sink during the cruises was low (on average ~12% of total air-sea CO_2 flux) (Fig. 7). Therefore, the influence of increasing pCO_2 in seawater due to increasing atmospheric CO_2 is probably minor on NCC compared to NCP. If this is a general feature in naturally occurring phytoplankton blooms in the northern North Atlantic Ocean, and in the global ocean, then the potential feedback of increasing atmospheric CO_2 on the surface ocean sink would be mainly due to NCP.

However, laboratory experiments carried out during the project suggest a reduced deep-ocean export of organic and inorganic matter due to a decreasing PIC to POC ratio with increasing pCO_2.

$CaCO_3$ dissolution rates represented ~1% of the pelagic calcification rates and were low compared to other studies in continental slope and deep ocean sites (Fig. 9) due to a much higher $CaCO_3$ saturation state (Ω_{Ca}) of the bottom waters overlying the continental shelf stations in the northern Bay of Biscay.

References

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Fig. 1

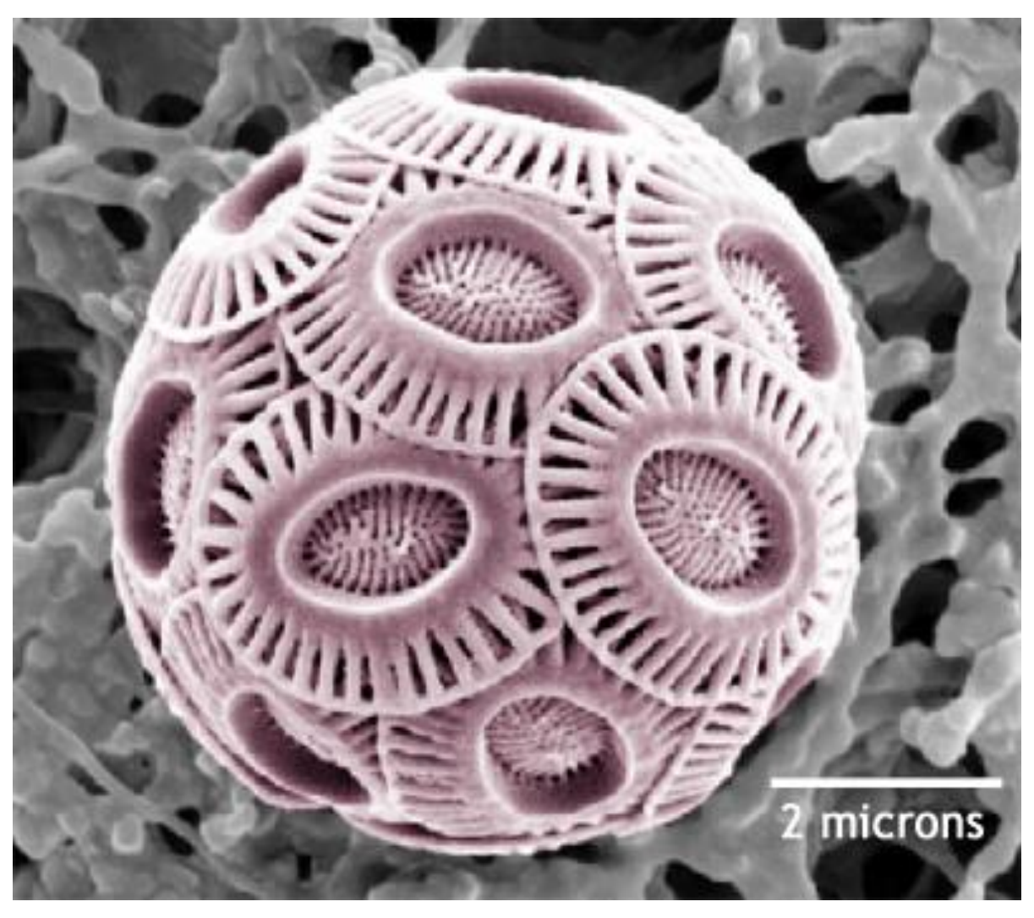

Fig. 2

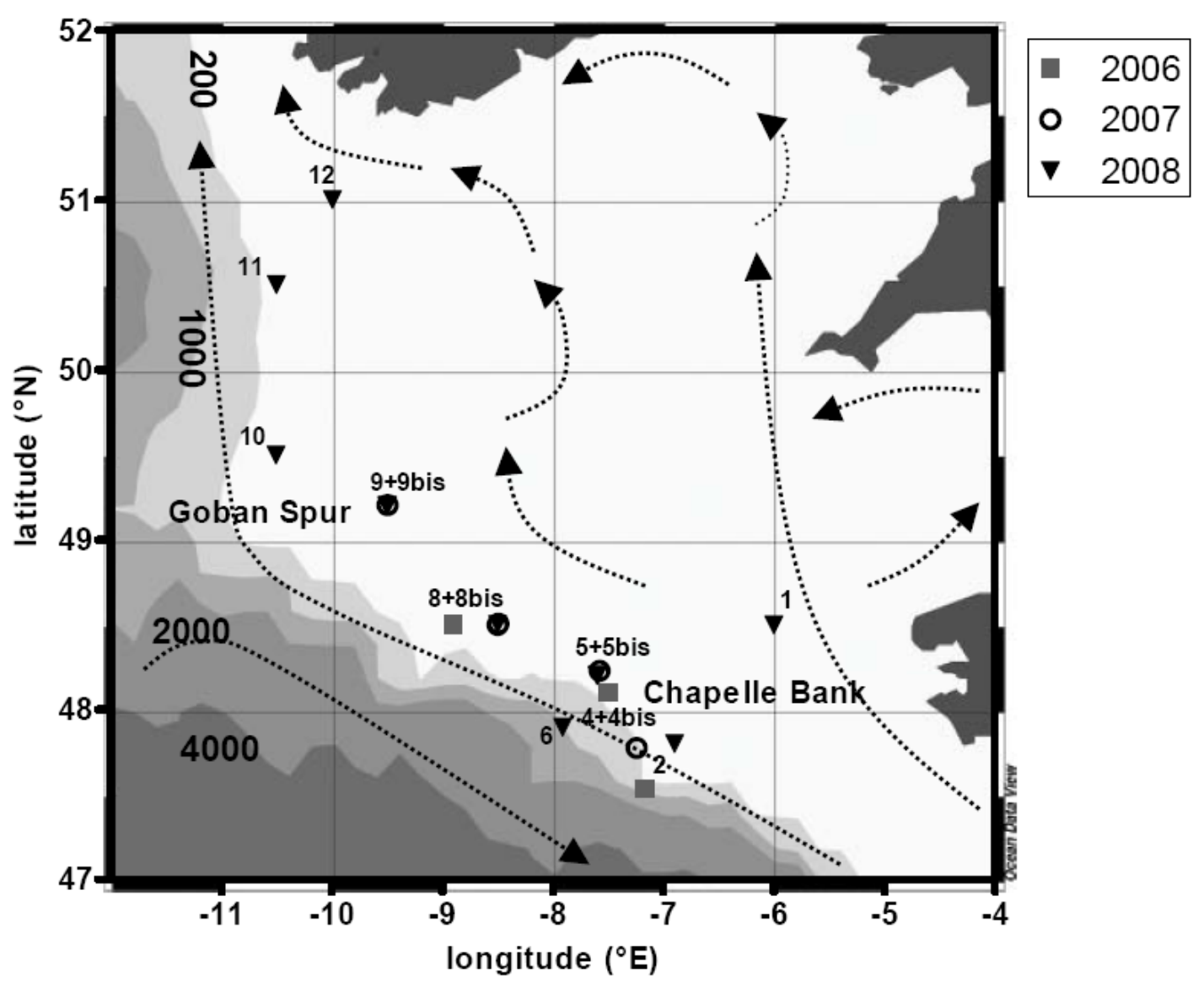

Fig. 3

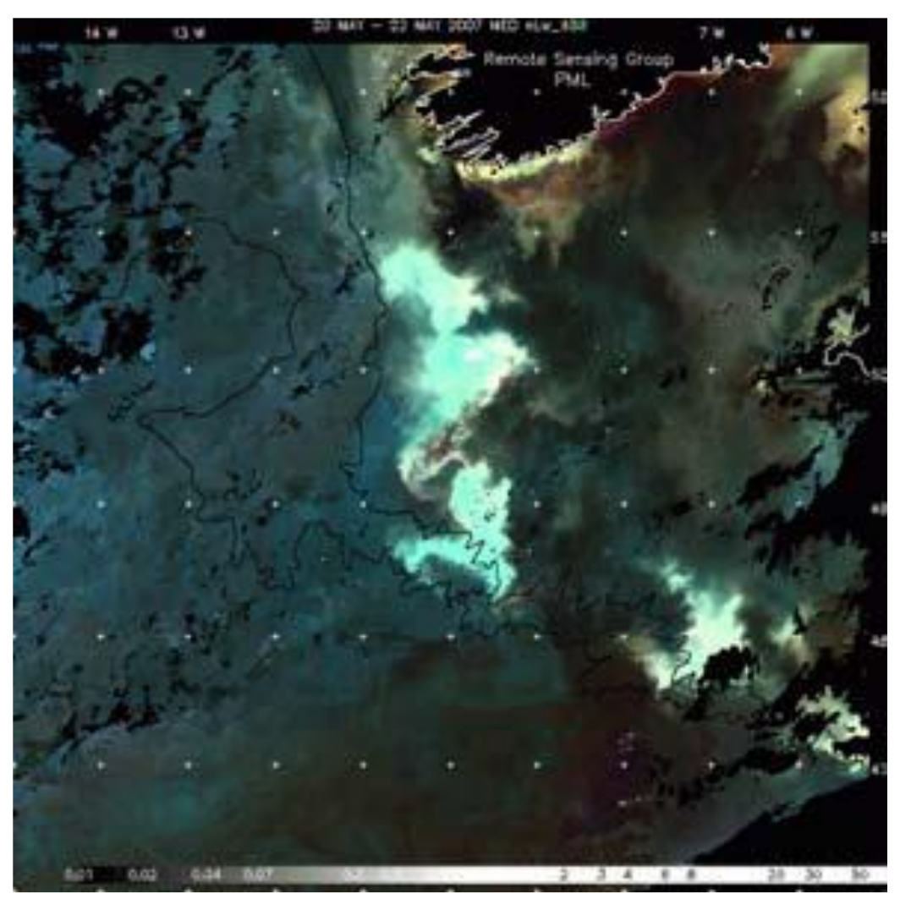

Figure 1: Coccolithophorid *Emiliania huxleyi*. Figure 2: The study area: Bay of Biscay. Arrows indicate the general current pattern. Figure 3: Composite satellite image of May 2007 (provided by Steve Groom, Remote Sensing Group, Plymouth Marine Laboratory, Plymouth, UK), where the high reflectance patch indicates the decline of the coccolithophorid bloom.

Fig. 4

Fig. 5

Figure 4: Rosette of 12 Niskin bottles. Figure 5: Boxcore.

Fig. 6

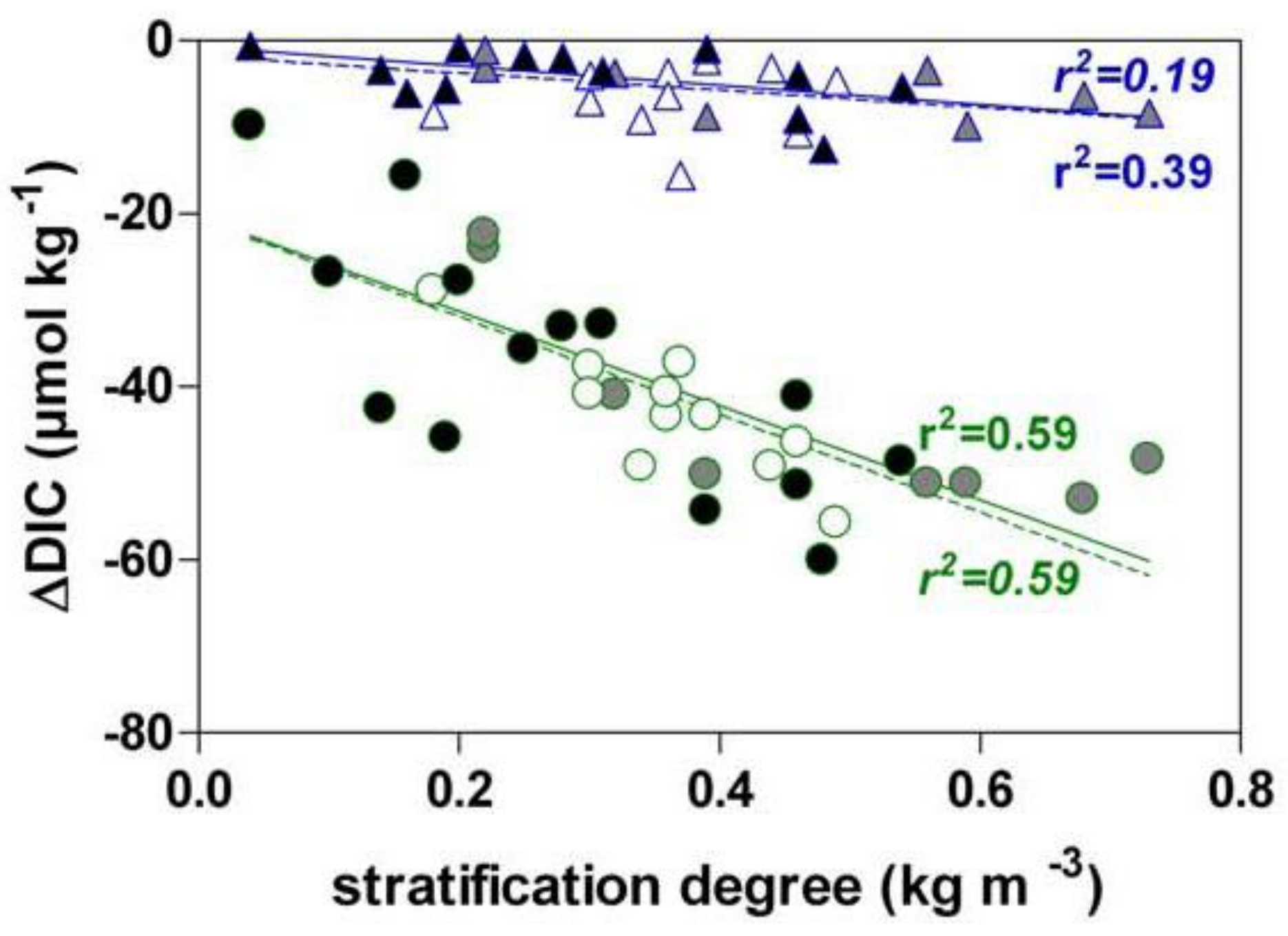

Fig. 7

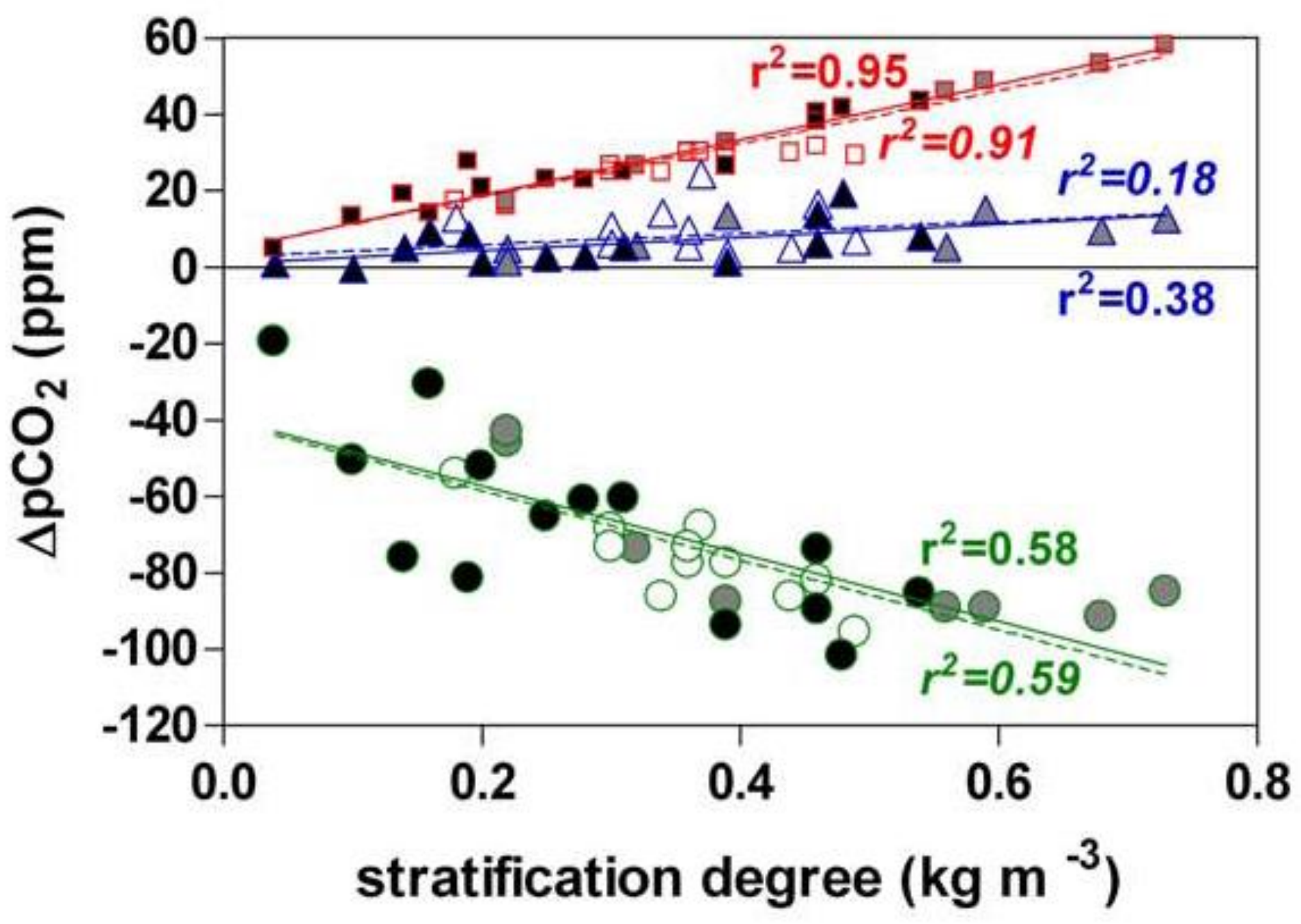

Figure 6: ΔDIC versus the stratification degree. In blue for the ΔDIC influenced by calcification and in green for ΔDIC influenced by primary production. Figure 7: ΔpCO_2 versus the stratification degree. In blue for the ΔpCO_2 influenced by calcification, in green for ΔpCO_2 influenced by primary production and in red for the ΔpCO_2 influenced by SST. During the June 2006 (grey), May 2007 (white) and May 2008 (black) cruises in the northern Bay of Biscay. The solid line corresponds to the linear regression (forced through 0) based on the 2006 and 2008 data-sets (corresponding r^2 is not italicised), the dotted line corresponds to the linear regression (forced through 0) based on the 2006, 2007 and 2008 data-sets (corresponding r^2 is italicised). The 1:1 line is in bold.

Fig. 8

Fig. 9

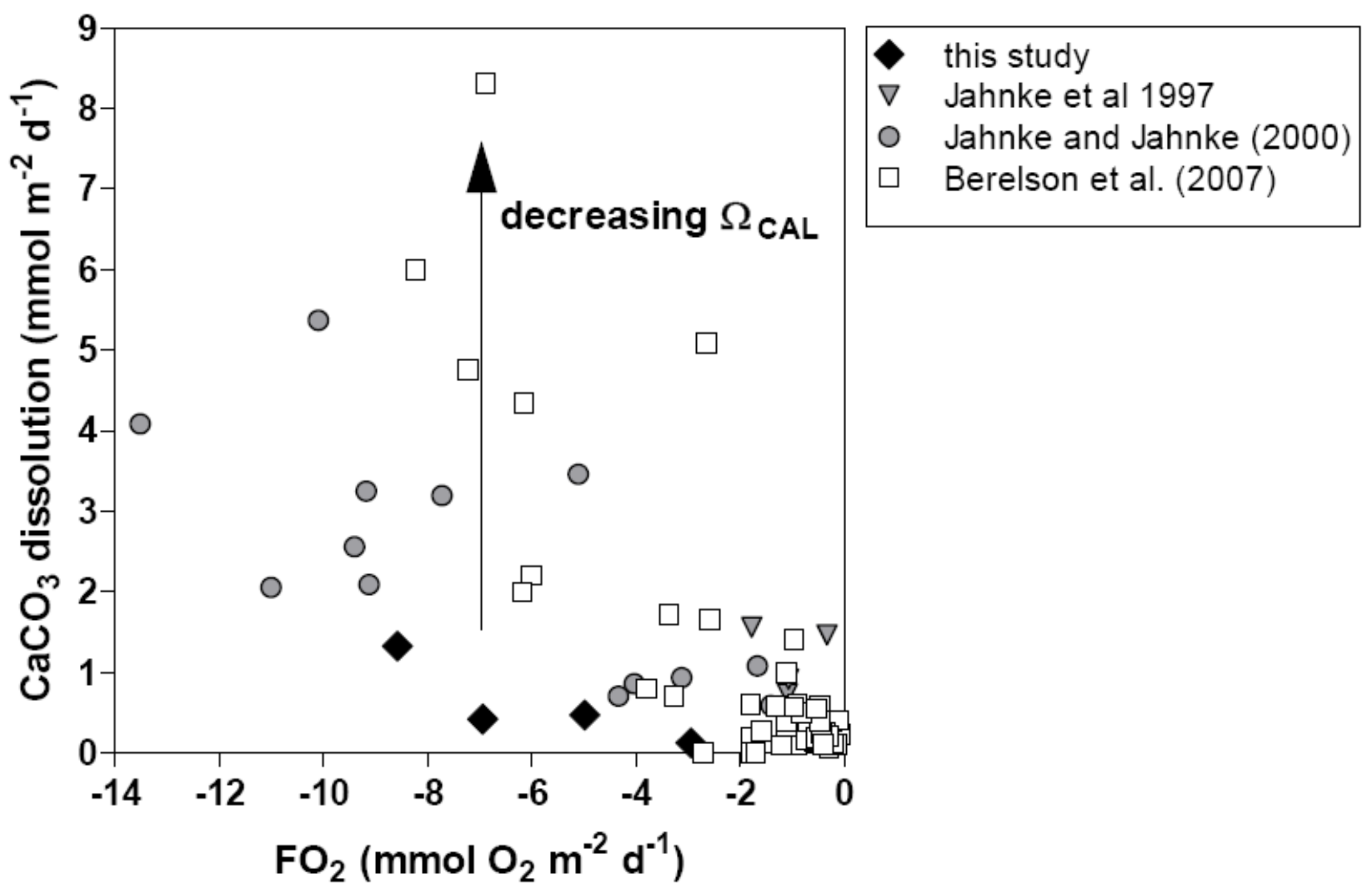

Figure 9: Subcore sampling. Figure 10: Benthic $CaCO_3$ dissolution (mmol m^{-2} d^{-1}) versus the flux of O_2 (FO_2) (mmol O_2 m^{-2} d^{-1}) in the northern Bay of Biscay (this study), in the California continental slope (Jahnke *et al.*, 1997), in the US Mid-Atlantic continental slope (Jahnke and Jahnke, 2000), and from a compilation in deep ocean sediments (Berelson et al., 2007). Ω_{Ca} represents the $CaCO_3$ saturation state.

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