Dissolved Inorganic Carbon dynamics in the northern Bay of Biscay during a Coccolithophore bloom

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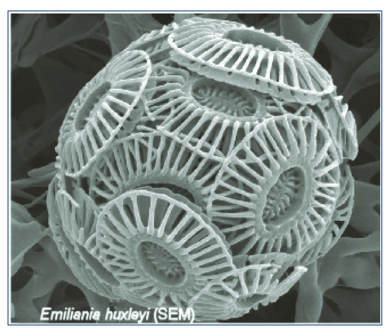
OVERVIEW



Coccolithophores are considered to be the most productive calcifying organisms in the oceans and contribute significantly to global biogeochemical cycles. From the oceanic carbon cycle point of view, the effect of a calcifying bloom deviates from other non-calcifying primary producers.

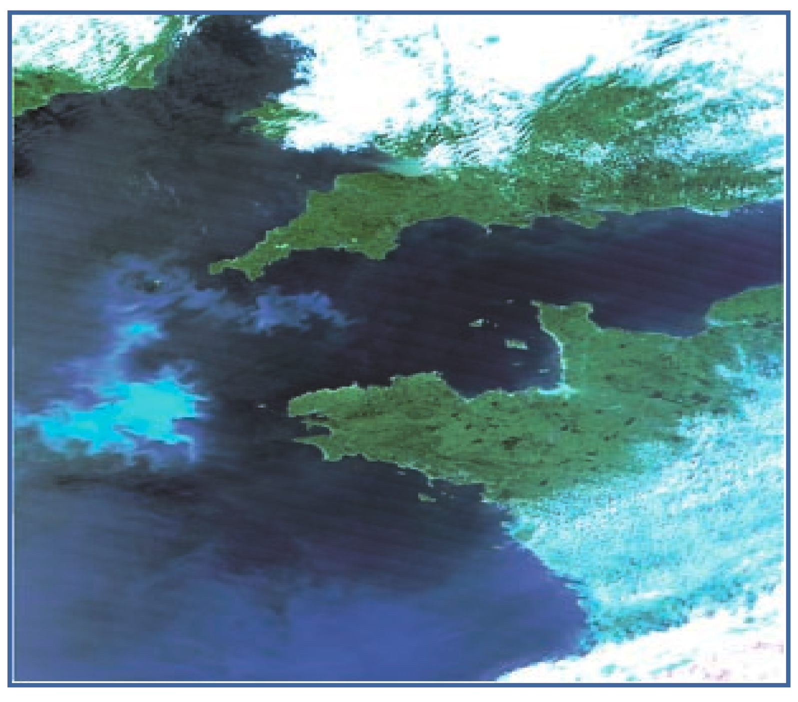


Fig. 1 : composite image (NASA) of a Coccolithophore bloom off Brittany (France, 15 June 2004)

The fixation via photosynthesis of dissolved inorganic carbon (DIC) in the photic zone causes a drawn down of CO_2 near the surface and the organic matter is subsequently exported to the deeper ocean, where it undergoes remineralization. This process, termed *Biological pump*, contributes to drawn down of CO_2 from the atmosphere to the ocean.

The calcification has an opposing effect, the *Carbonate counter-pump*, by the removal of Total Alkalinity (TA) from the sunlit layer and releases CO_2 to the surrounding waters.

The relative strength of both pumps, the so-called *Rain Ratio* (particulate inorganic carbon to particulate organic carbon ratio PIC:POC), determines the overall flux of CO_2 across the atmosphere-ocean interface as well as the yield and intensity of the related carbon sequestration.

Until now, studies have focused on the sunlit production in correlation with environmental parameters. The originality of these preliminary results is to integrate *Transparent Exopolymeric Particles* (TEP) as a possible pathway for both microbial activity and physical removal of surface produc-tion.

AKNOWLEDGMENTS

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http://www.ulb.ac.be/sciences/dste/ocean/carbonate/frame.html

SCOPE OF THE STUDY

In the framework of the Belgian Global Change Programme, we have developed a project devoted to the study of the inorganic carbon cycle in the Bay of Biscay where coccolithophore blooms occur frequently (Fig. 1). Real time remote sensing (Fig. 2-left) allowed us to pinpoint a coccolithophore bloom that was sampled in June 2004 during a multidisciplinary investigation, on board the *R.V. Belgica*.

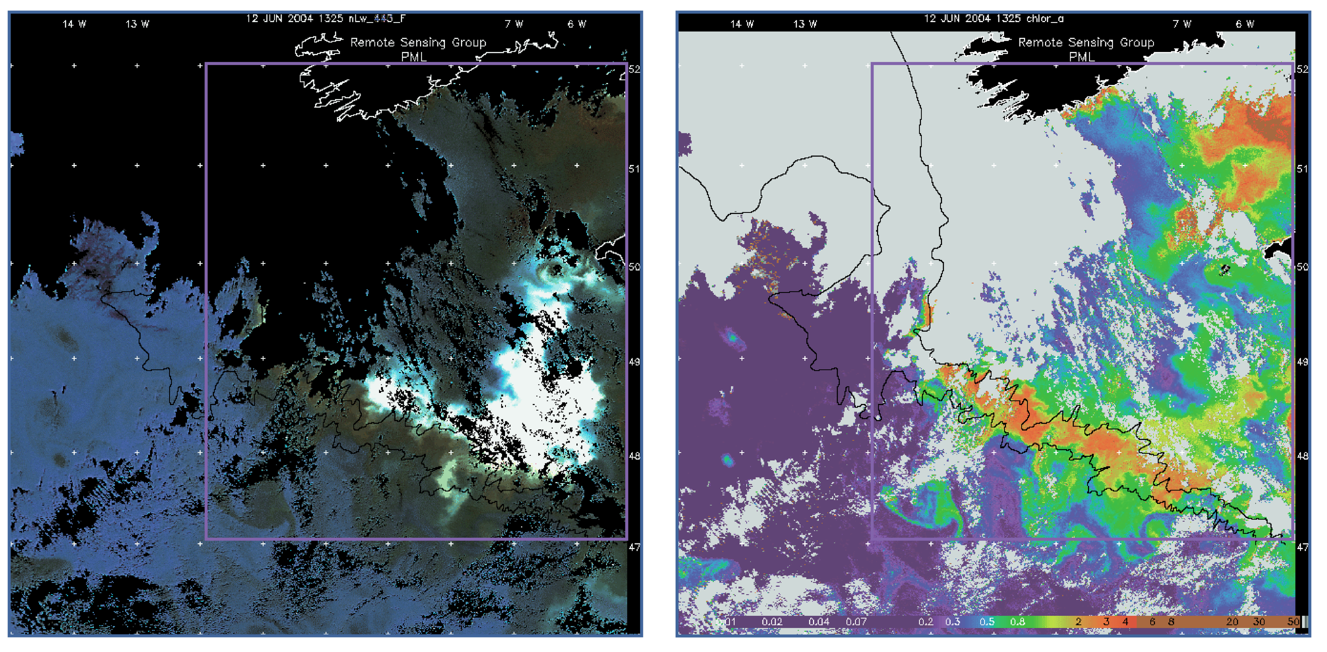

Fig. 2 : Backscattering (left) and SeaWIFs (right) pictures received at the NERC Dundee University Receiving Station, and processed by the Remote Sensing Group at Plymouth Marine Laboratory (12 June 2004)

RESULTS

The western continental shelf and edge of the Bay of Biscay undergo strong hydrodynamic conditions that sustain high rates of productivity (Fig. 2-right). Among the 11 stations sampled for biogeochemical processes, 4 are presented here for various parameters (Fig. 3); their geographic locations are shown on figures 5 and 6 along the 200m isobath.

Station 2 (red) displays typical features of a well-developed coccolithophore bloom : decrease in TA accompanied by high Chl-a concentration.

Conversely, Station 12 (purple) exhibits an early bloom-forming situation. Features observed at Stations 7 (deep-water station) and 10 (shallow-water station) are due to the transition between diatom and coccolithophore-dominated communities, as shown by the decrease of TA in shallow waters coupled to an elevated concentration of PIC in the upper photic zone.

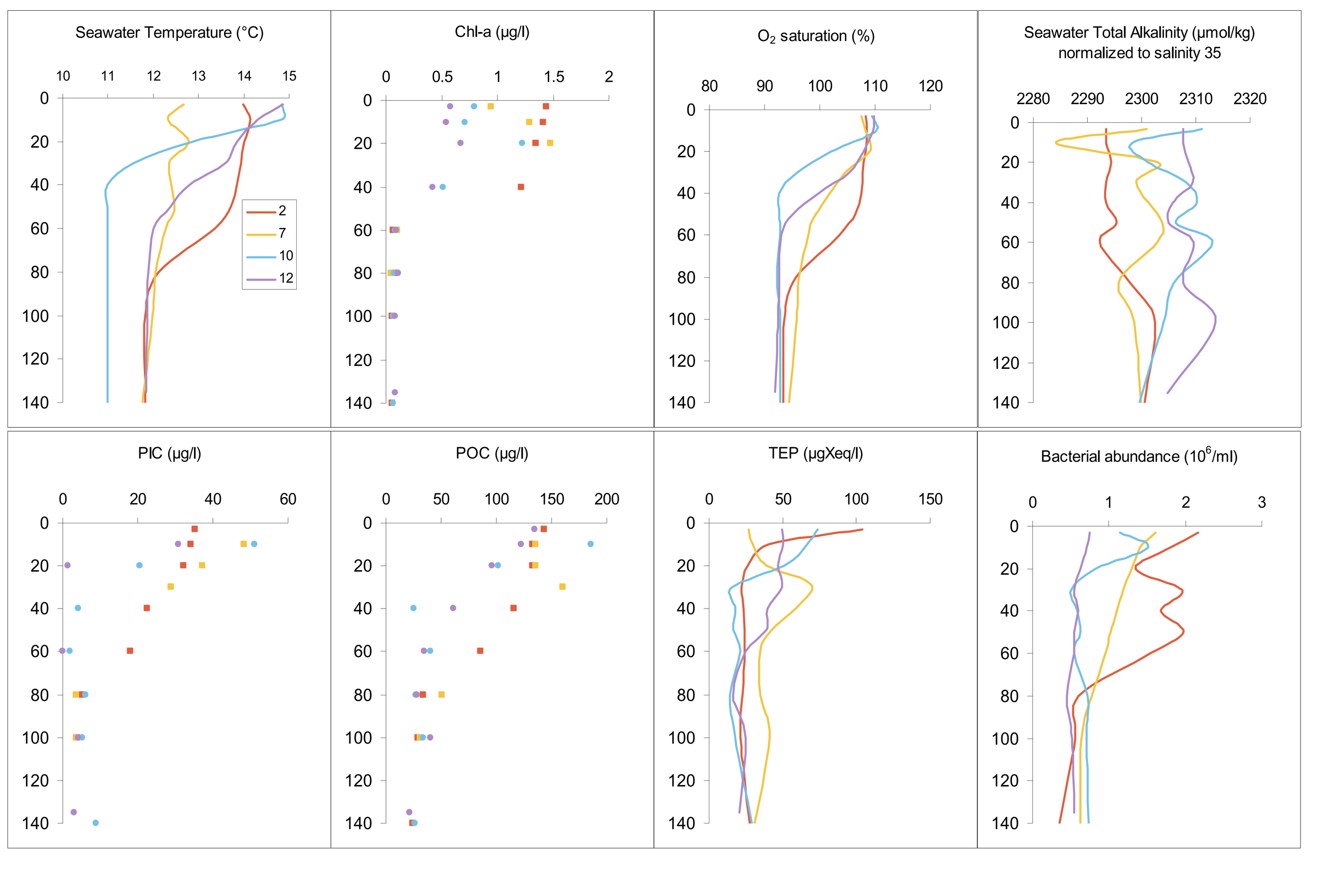

Fig. 3 : vertical profiles of Temperature, Chlorophyll-a, Oxygen saturation, TA (upper panel) and PIC, POC, TEP and Bacterial abundance (lower panel).

At a mature stage, the coccolithophore community (St2) in the upper photic zone is characterized by large amounts of TEP that originate from phytoplanktonic and/or bacterial exudation of C-rich compounds. Whether TEP correlate with high phytoplankton or bacterial biomasses remains an open question, whereas their presence is a common feature in late-bloom situations. The important role of TEP in the composition and fate of the sinking particles becomes increasingly evident.

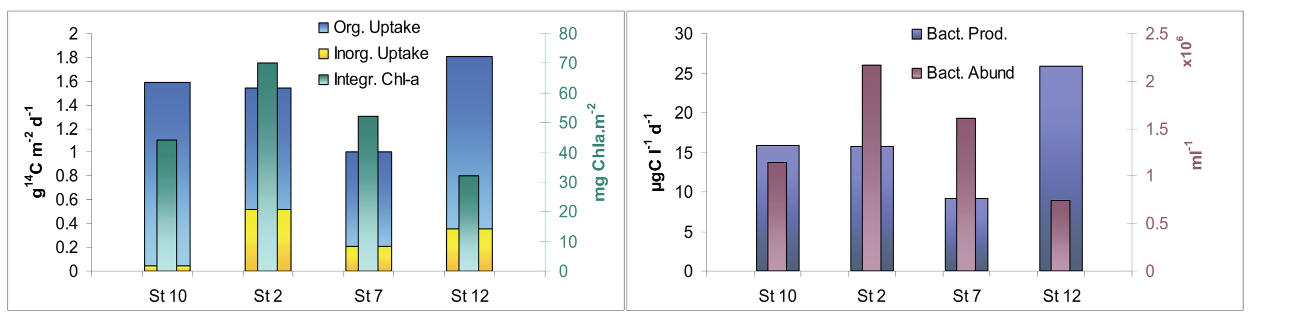

Fig. 4 : (left) daily uptake of ^{14}C for organic and inorganic C synthesis and Chlorophyll stock. (right) Bacterial production (based on ^{3}H-Leu incorporation) and abundance in surface waters.

Radioactive Leu-based bacterial production in surface waters is shown in figure 4 (right). A high production level is observed at Station 12 in spite of a low bacterial biomass that is characteristic of the early bloom-forming situation. The utilization of DIC for organic and inorganic phytoplanktonic carbon production (Fig. 4-left) can be compared to the partial pressure of CO_2 (pCO_2) in surface waters (Fig. 5). pCO_2 values ranging from 280 to 370 μatm could be attributed to a « carbonate counter-pump » effect resulting from the development of coccolithophorid blooms. In contrast, pCO_2 values decrease considerably around 4°W where a non-calcifying coastal phytoplankton bloom occurred (data not shown).

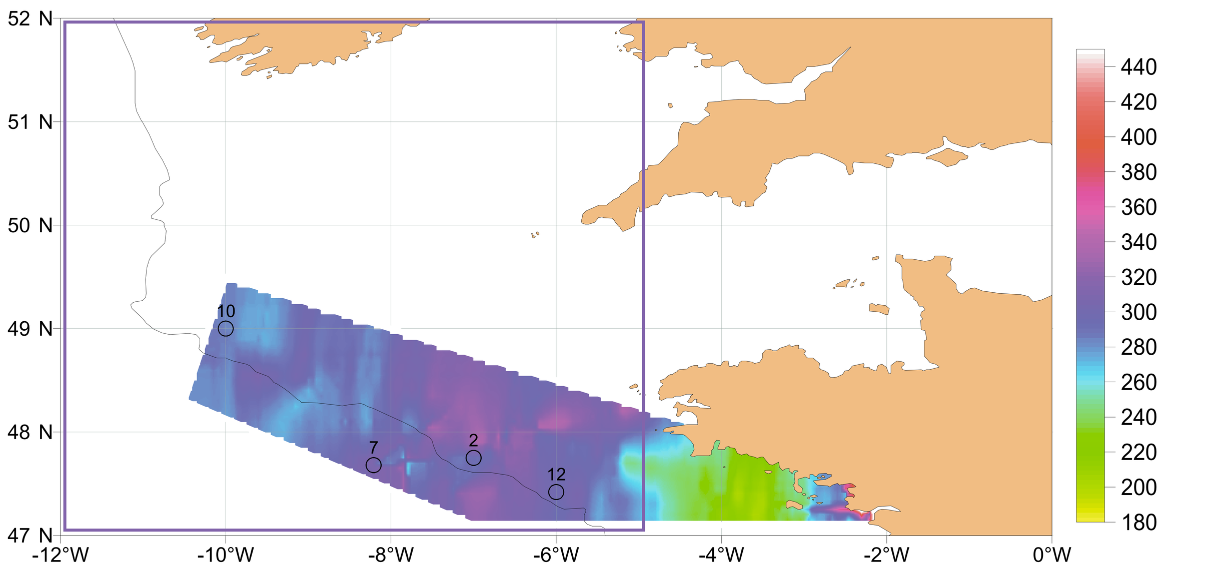

Fig. 5 : distribution of seawater pCO_2 (μatm) in June 2004 (direct measurement)

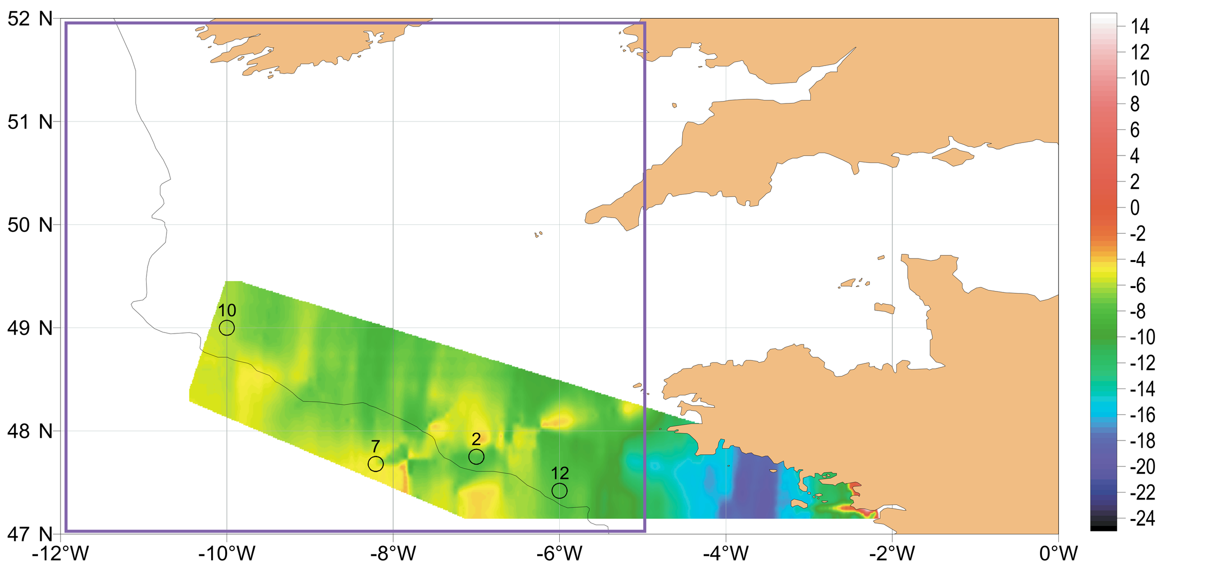

Fig. 6 : Air-sea CO_2 fluxes (mmolCO_2.m^{-2}.d^{-1}) from the composite pCO_2, temperature and salinity in June 2004 and wind speed data from NOAA, calculated according to Wanninkhof (J. Geophys. Res. 97(C5), 1992).

CONCLUSIONS

The results on air-sea CO_2 flux (Fig. 6) indicate that the phytoplanktonic communities investigated during this study behave as a sink for atmospheric CO_2. However, the CO_2 sequestration is lowered by calcification, resulting in a smaller air-sea CO_2 flux.

Further investigations should consider the "ballast effect" of $CaCO_3$ lithes and TEP, as well as the substrate effect that could provide TEP for microbial activity and biogeochemical transformation during settling.

Representing a continuum between dissolved and particulate matter due to their gel and stickiness properties, (1) to what extent could TEP act in the transformation and export of biogenic material and (2) how would they affect the vertical distribution of carbonate alkalinity?

Addressing these two questions could be of major importance in the understanding of future interactions between $CaCO_3$ cycle and climatic changes.