QUANTIFICATION OF THE CARBONATE PUMP : A Case Study of an *Emiliania huxleyi* bloom in the Bay of Biscay

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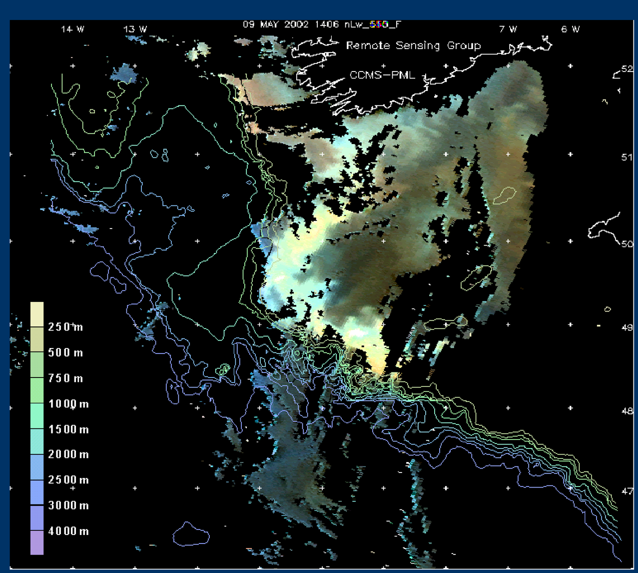
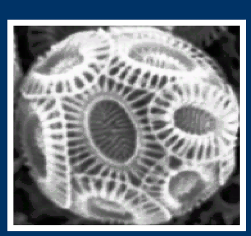
INTRODUCTION

During the *Belgica* BG02/11 cruise (22 April - 11 May 2002) in the northern Bay of Biscay, a slope survey covering transects across the continental margin from the La Chapelle Bank to the Goban Spur area were conducted. The sampling campaign was assisted in addition by remote sensing data from SeaWiFS to locate the coccolithophore blooms, as characterised by white, highly reflective regions as shown by ocean colour imagery. Experiments of ^{14}C incorporation were carried out along the shelf break to determine the production rate of both organic and inorganic particulate carbon.

SeaWiFS data received at the NERC Dundee University Receiving Station and processed by the Remote Sensing Group of the Plymouth Marine Laboratory.



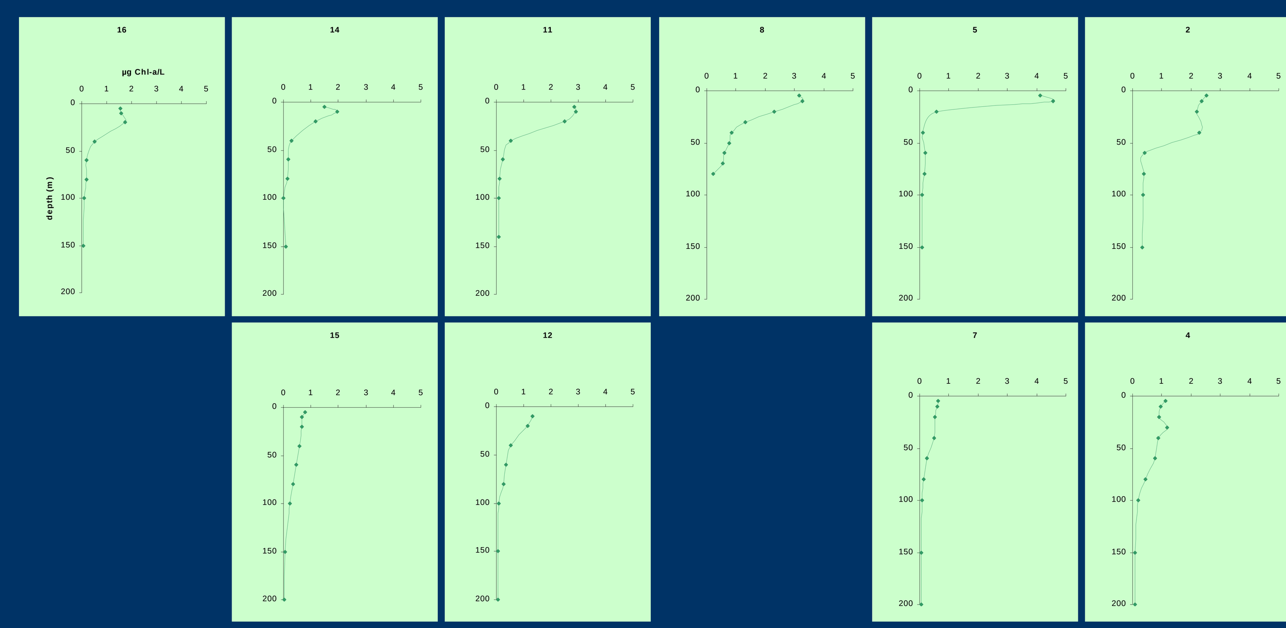


Coccolithophores, among which *Emiliania huxleyi* is the most widespread species in the world's oceans, are the dominant calcifying phytoplankton in the area of investigation. Their importance in biogeochemical cycling is supported not only by their capacity for organic matter production *via* **photosynthesis**, the **biological pump**, but also by their ability to produce calcified **coccoliths**, the **carbonate pump,** which represents a major contribution to the particulate carbon flux to the deep ocean.
In the photic zone, the **biological pump** removes inorganic carbon from the surface ocean, while the **carbonate pump**, according to the equation $Ca^{2+} + 2HCO_3^- \Leftrightarrow CaCO_3 + H_2O + CO_2\uparrow$ releases CO_2 and consumes Total Alkalinity to produce biogenic calcium carbonate. It is generally accepted that the overall effect of photosynthesis and calcification constitutes a net sink of carbon from the atmosphere. There remains still large uncertainties in the production and fate of biogenic calcium carbonate in the oceanic carbon cycle.

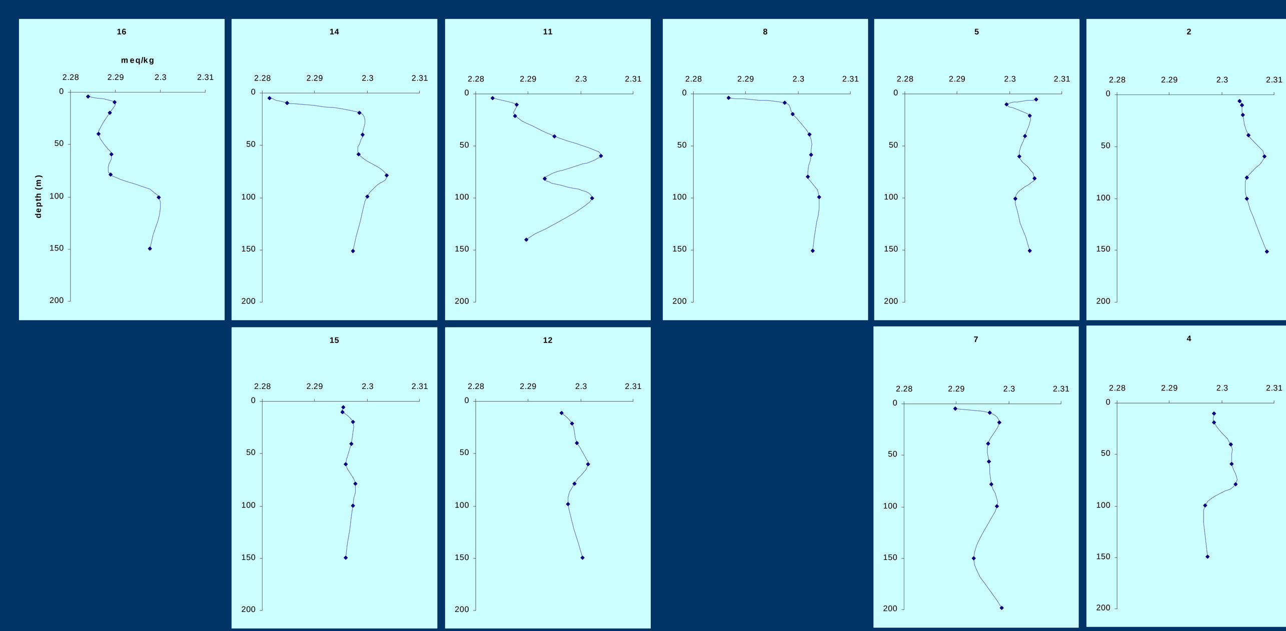
HYDROGRAPHY

Chlorophyll-a concentrations increase in surface waters from less than 1 to more than 4 $\mu g.l^{-1}$ as one moves from offshore (i.e. Station 7) towards the continental shelf (i.e. Station 5). Furthermore, there is a constant increase of Chl-a concentration from north (Station 16) to south (Station 2).

These concentrations are typical of those commonly observed during the spring phytoplankton bloom in this area.



The profiles of **total alkalinity** normalized to a salinity of 35 indicate a consumption by calcifying phytoplankton in surface waters. In the case of the offshore stations, the pattern of the vertical distribution is almost linear, denoting a minor effect of primary production on this parameter.
The large decrease observed in surface waters of station 16 indicate a late stage of the bloom, when all the coccoliths a spread, giving milky waters), whereas southern stations are in an early stage.
This is rather a temporal effect of the sampling than a physiological delay due to low latitudes.



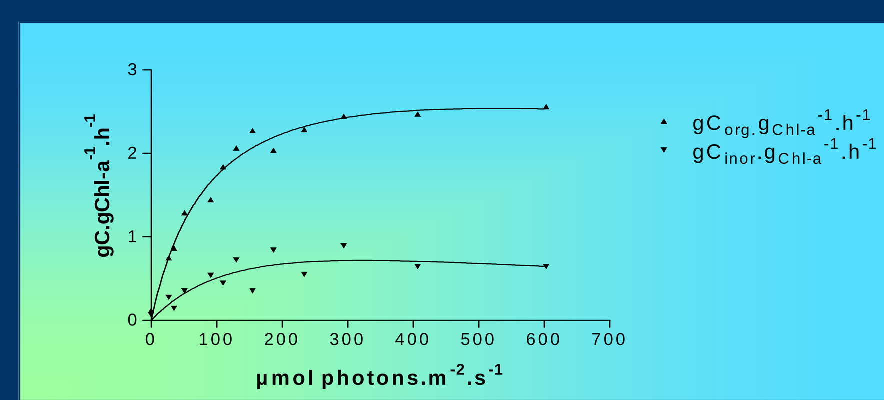
CARBON FLUXES IN THE PHOTIC ZONE

^{14}C uptake *vs.* light intensity experiments have allowed the characterisation of the photosynthetic properties of the phytoplankton based on the classical Platt equation:

$$P^B = P^B_{max} \left[1-\exp(-\alpha E / P^B_{max})\right] \exp(-\beta E / P^B_{max})$$

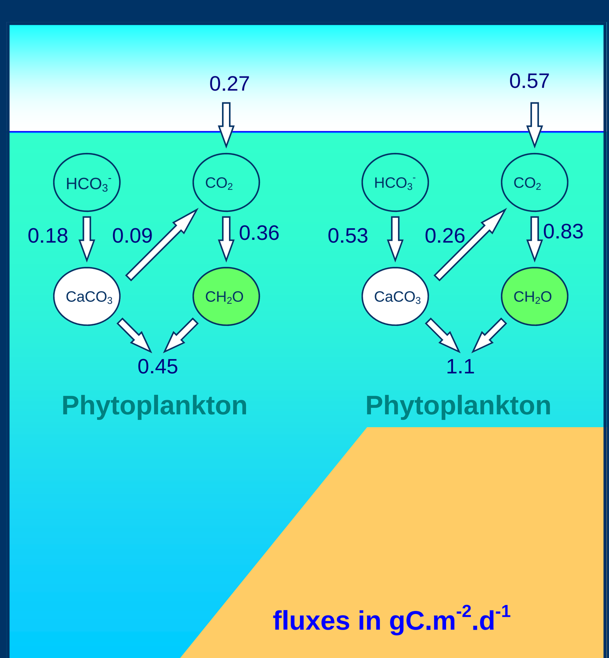
where P^B is the photosythetic rate, P^B_{max} the maximum photosynthesis rate, α the maximum light utilization coefficient, β the photoinhibition parameter and E the photosynthetically avalaible radiation (PAR). The light adaptation parameter E_k can also be defined by P^B_{max}/α.

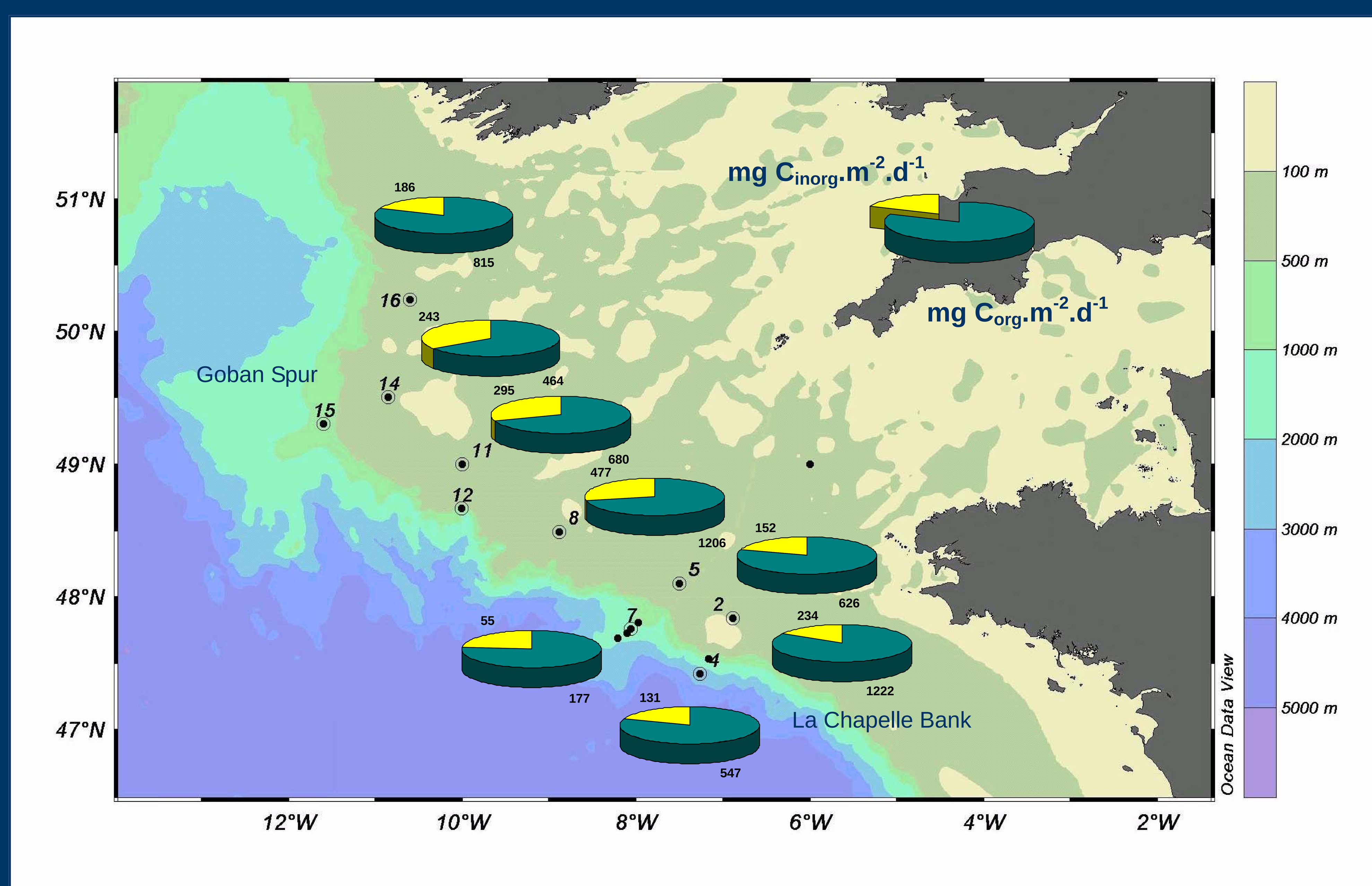
The results compared to the theoretical curves show that, in general, the plankton at depth exhibits a higher photosynthetic efficiency but is not affected by photoinhibition, which can be neglected in the present study. Interestingly enough, the rate of calcification follows a similar trend to the P *vs.* E curve and rate parameters of the Platt equation can be calculated accordingly.



The parallelism of the two curves indicates that photosynthesis and calcification are intimately coupled. Carbon fluxes in gC m^{-2} d^{-1} have been calculated by integrating the optimal primary production (wiith the simulated light intensity of a sunny day and its related photoperiod) and the associated calcification rate.

Conclusions





The primary production observed during our field survey was mainly associated with the coccolithophores. The total transfer of dissolved inorganic carbon to the particulate phase in the northern Bay of Biscay area is estimated to be 2.03 gC m^{-2} d^{-1} for the shelf break and 1.14 gC m^{-2} d^{-1} for the slope region. Of this carbon, approximately 20 to 25% is associated with the inorganic carbonate phase. The organic carbon produced is rapidly remineralised in the water column during settling, while the calcium carbonate resists much better to dissolution. Consequently, the carbon deposited and preserved in the sediments is mainly present as calcium carbonate and inorganic carbon flux becomes therefore significant at a global marine scale.

Recent investigations have shown that calcium carbonate could dissolve even in shallow and intermediate waters where this mineral phase is over-saturated. It is therefore important to understand the mechanisms associated with this process. This aspect constitutes the follow-up of the present research.

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(http://www.awi-bremerhaven.de/GEO/ODV/))
Project Internet Site: http://www.ulb.ac.be/sciences/dste/ocean/carbonate/frame.html

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