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Biogeochemistry of a late marginal coccolithophorid bloom in the Bay of Biscay

J. Harlay[1], C. De Bodt[1], Q. D'Hoop[1], A.V. Borges[2], K. Suykens[2],
N. Van Oostende[3], K. Sabbe[3], N. Roevros[1], S. Groom[4] and L. Chou[1]

[1] Laboratoire d'Océanographie Chimique et Géochimie des Eaux (LOCGE),
Université Libre de Bruxelles, B-1050 Brussels, Belgium
[2] Unité d'Océanographie Chimique, Université de Liège, B-4000, Liège, Belgium
[3] Protistologie & Aquatische Ecologie, Universiteit Gent, B-9000, Gent, Belgium
[4] Remote Sensing Group, Plymouth Marine Laboratory, Plymouth, United Kingdom

Introduction

*role of **primary production**, **calcification** and **export** processes in **coccolithophore blooms***

the **net ecosystem dynamics** (**primary production**, **calcification** and **pelagic respiration**)

the link between the **bacterial community**, **TEP** formation and **carbon export**

Dynamics of coccolithophore blooms:
Contribution in climate regulation ?

Introduction

Coccolithophores:

Diatoms → Coccolithophores

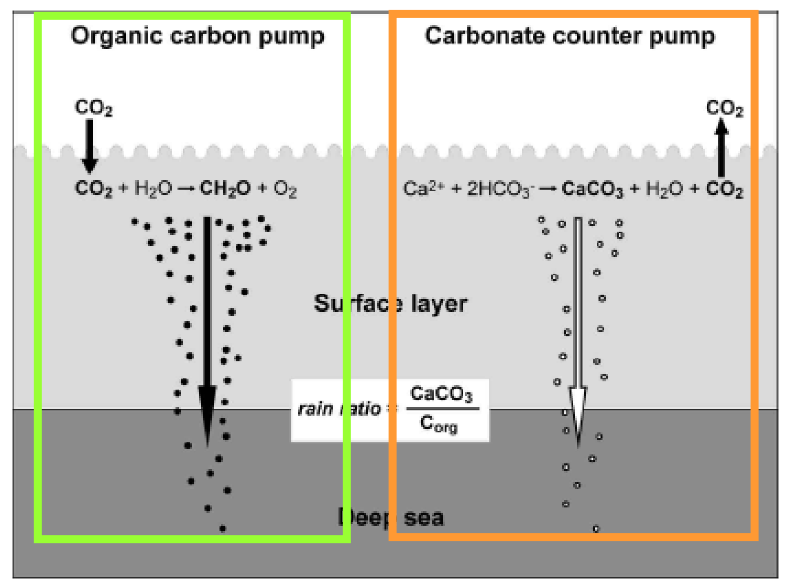
Low requirements for inorganic phosphorus and micronutrients

« Organic phase » followed by the « calcifying phase » → release of coccoliths

With regard to the C-cycle:

Organic or biological pump
(photosynthesis)

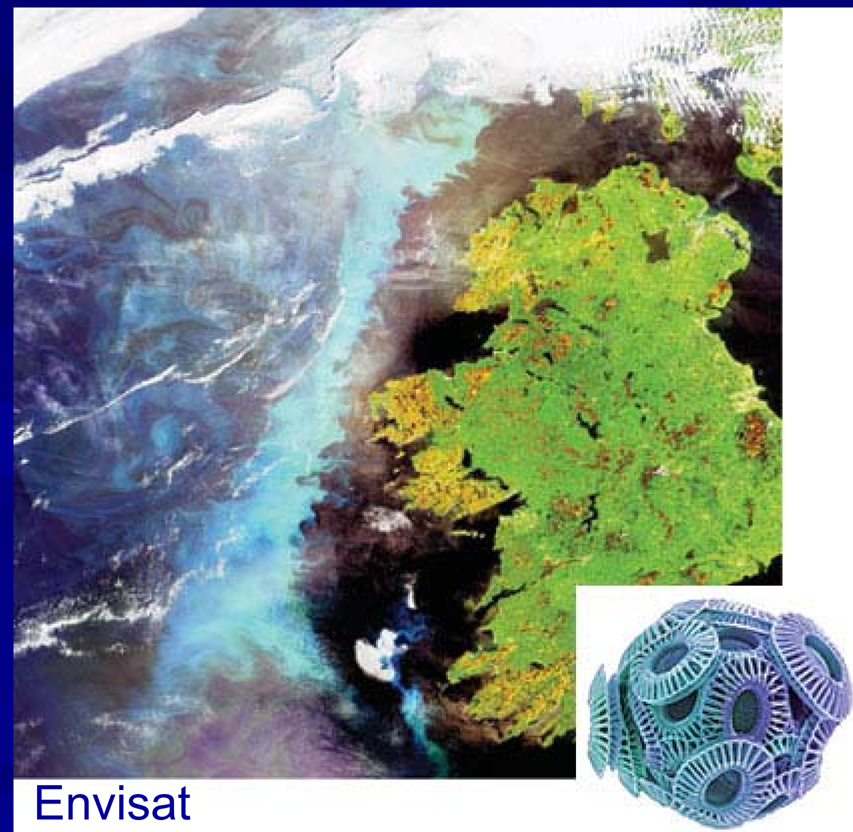
Carbonate counter-pump
(biocalcification)



From Rost & Riebesell, 2004

Introduction

(Nature, 441, 15 June 2006)



June 2006

stretched over **500** km

probably due to the common coccolithophore species ***Emiliania huxleyi***

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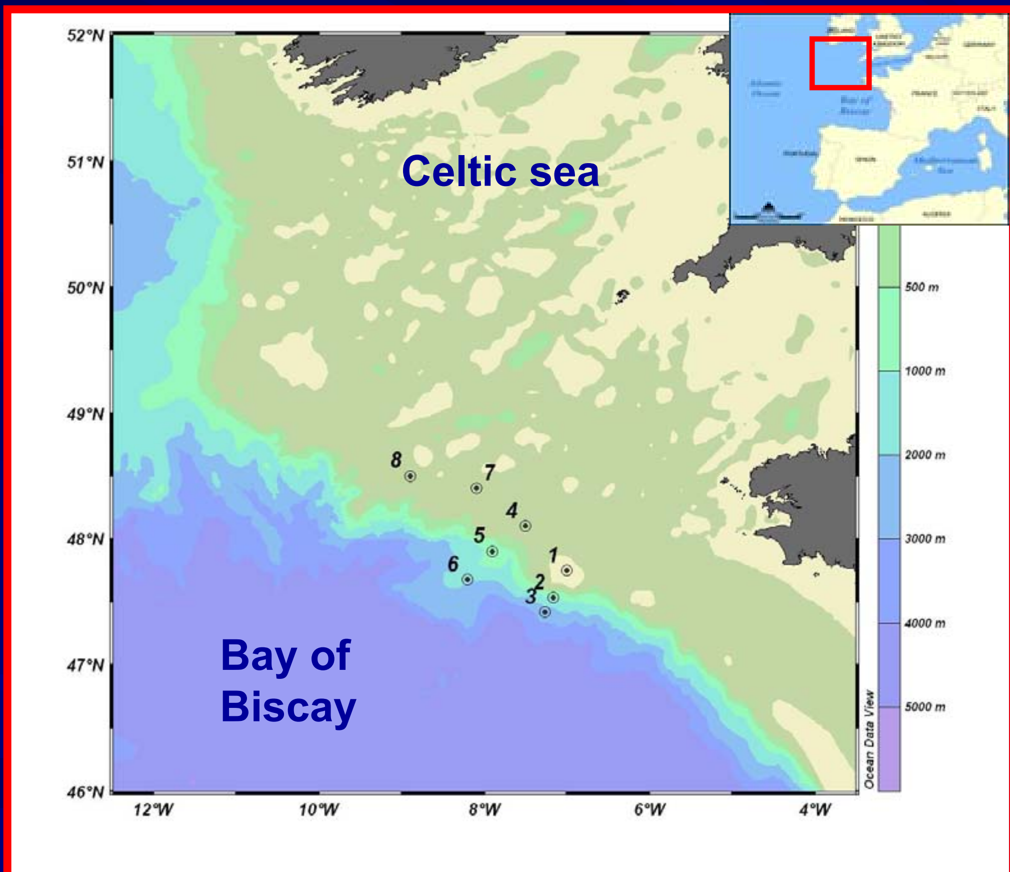
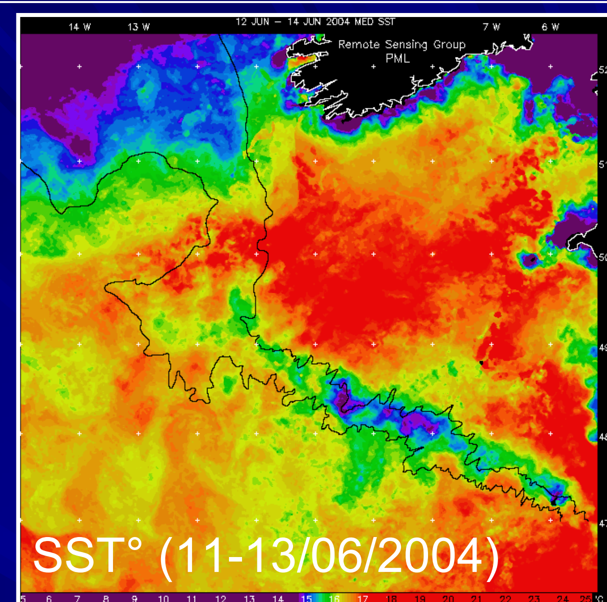
Zone of study

31th May – 10th June 2006





Zone of study

T°: 13-15 °C

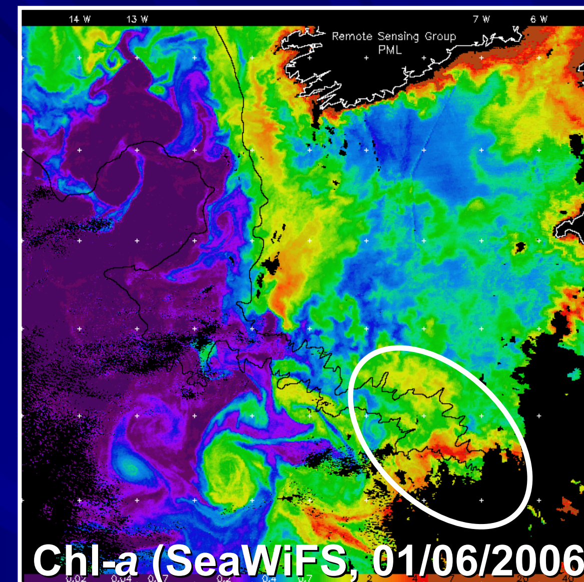
Thermocline 40-50 m

Sal: 35.5 – 35.7

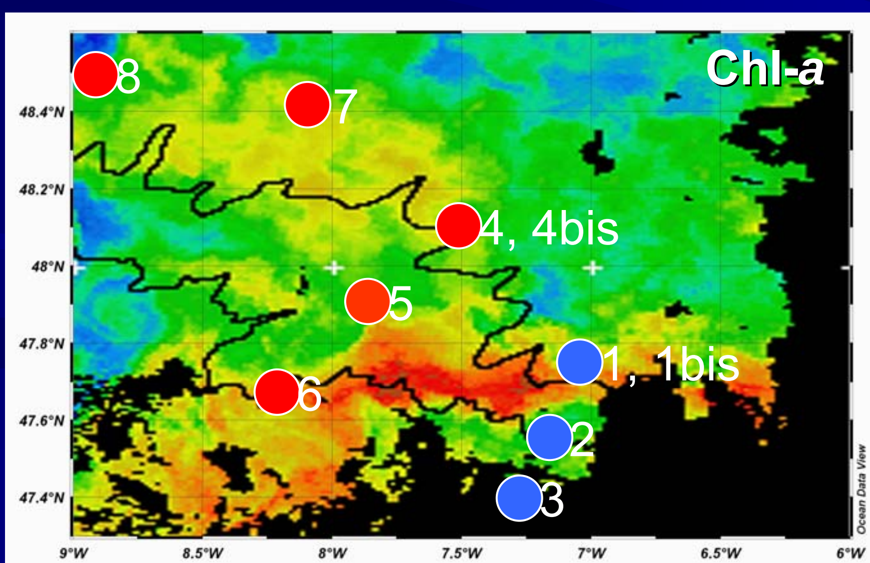
[PO_4] ~ 0 µM

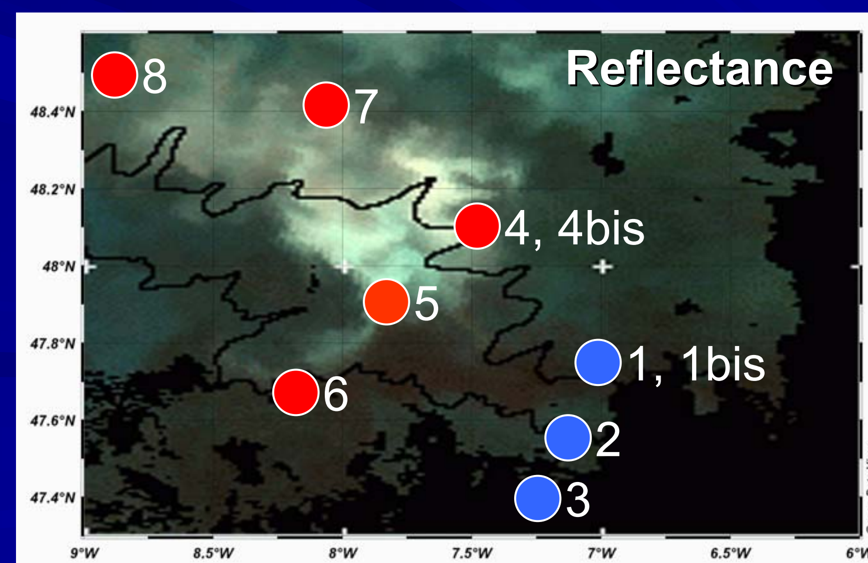
[Si] < 2 µM

[Chl-*a*] = 0.5 - 2 µg/l



Chl-*a* (SeaWiFS, 01/06/2006)

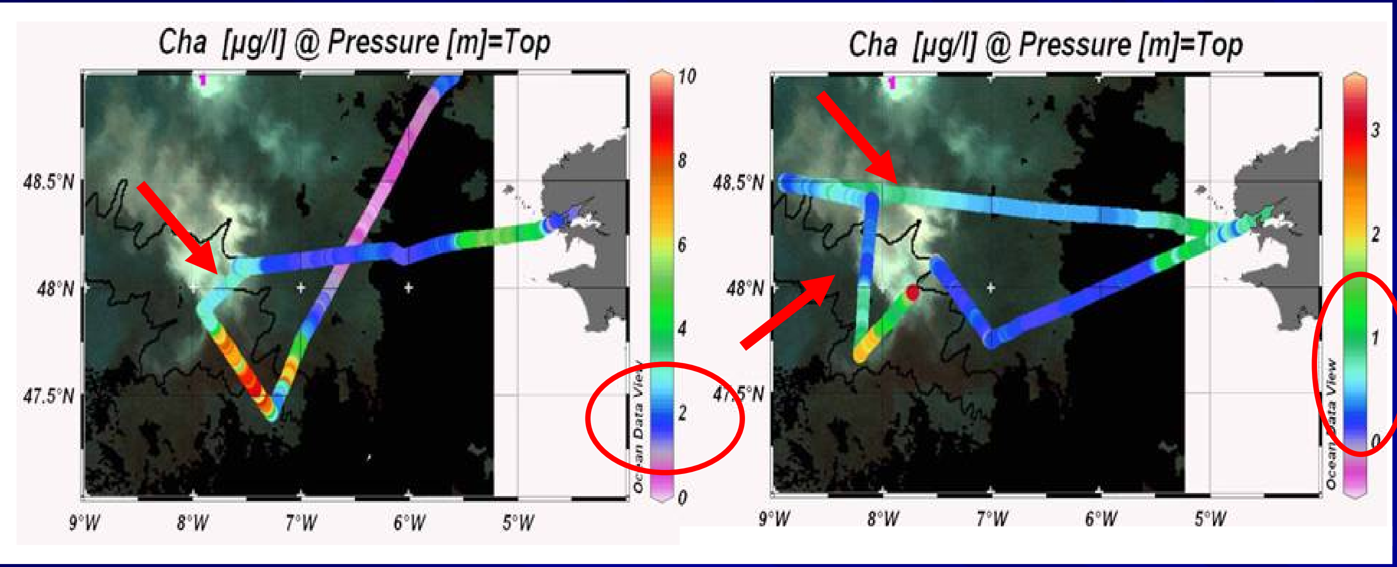


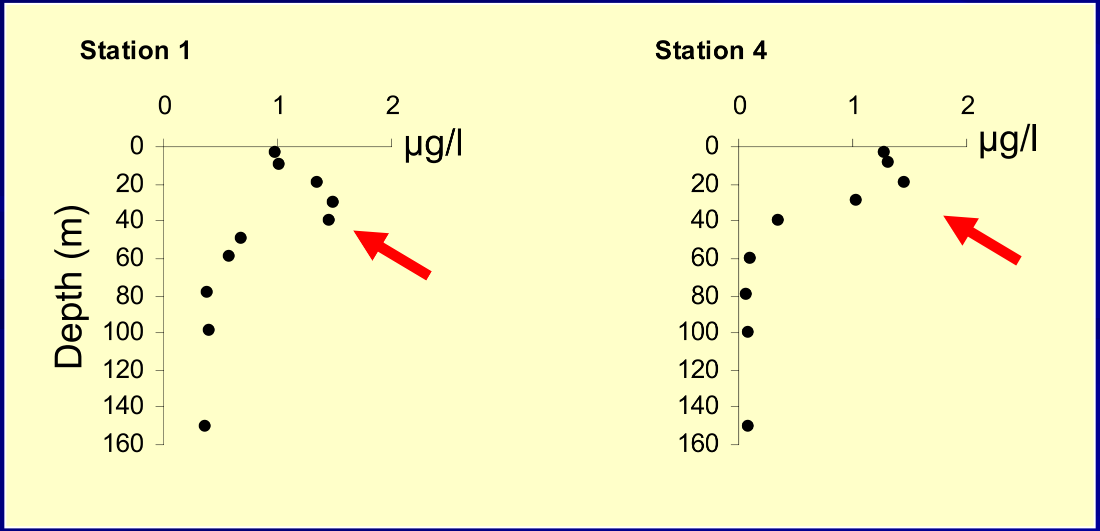


Chlorophyll-*a* concentrations

1st Leg

2nd Leg





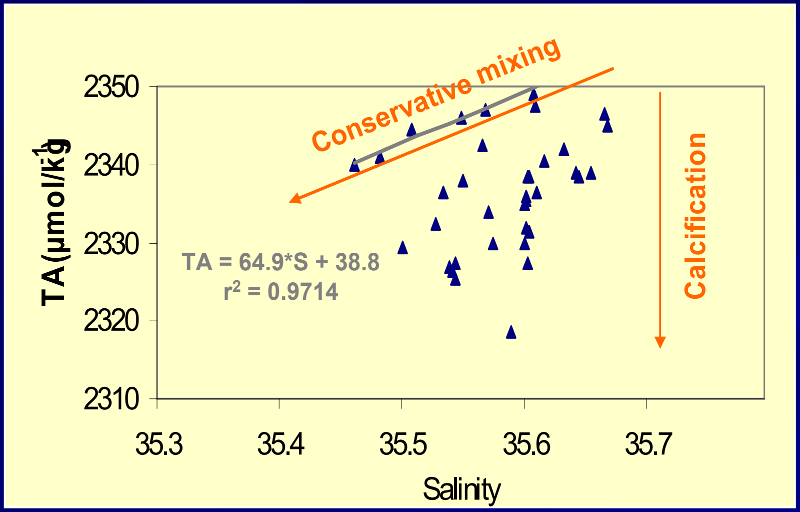
Moderate [Chl-a]

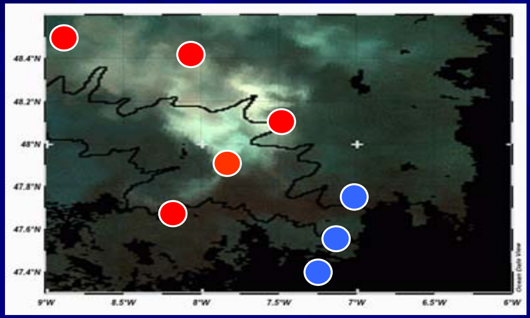
Deep Chl-*a* maximum ~ 20-40m

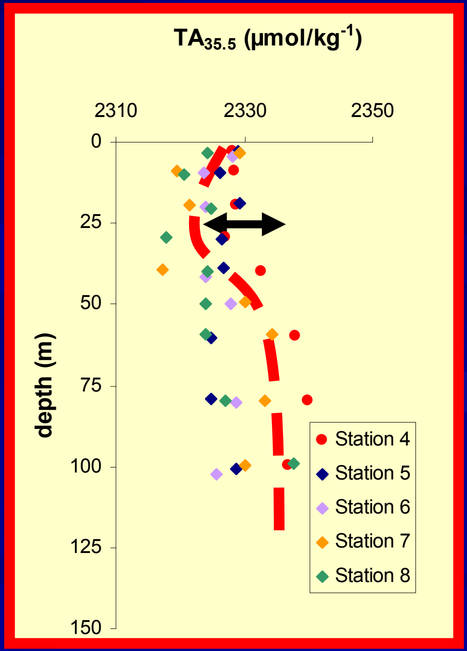
Total alkalinity

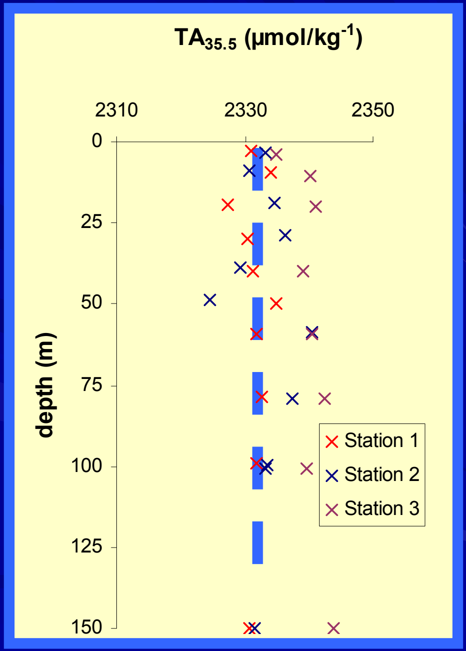
Biogenic calcification:

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





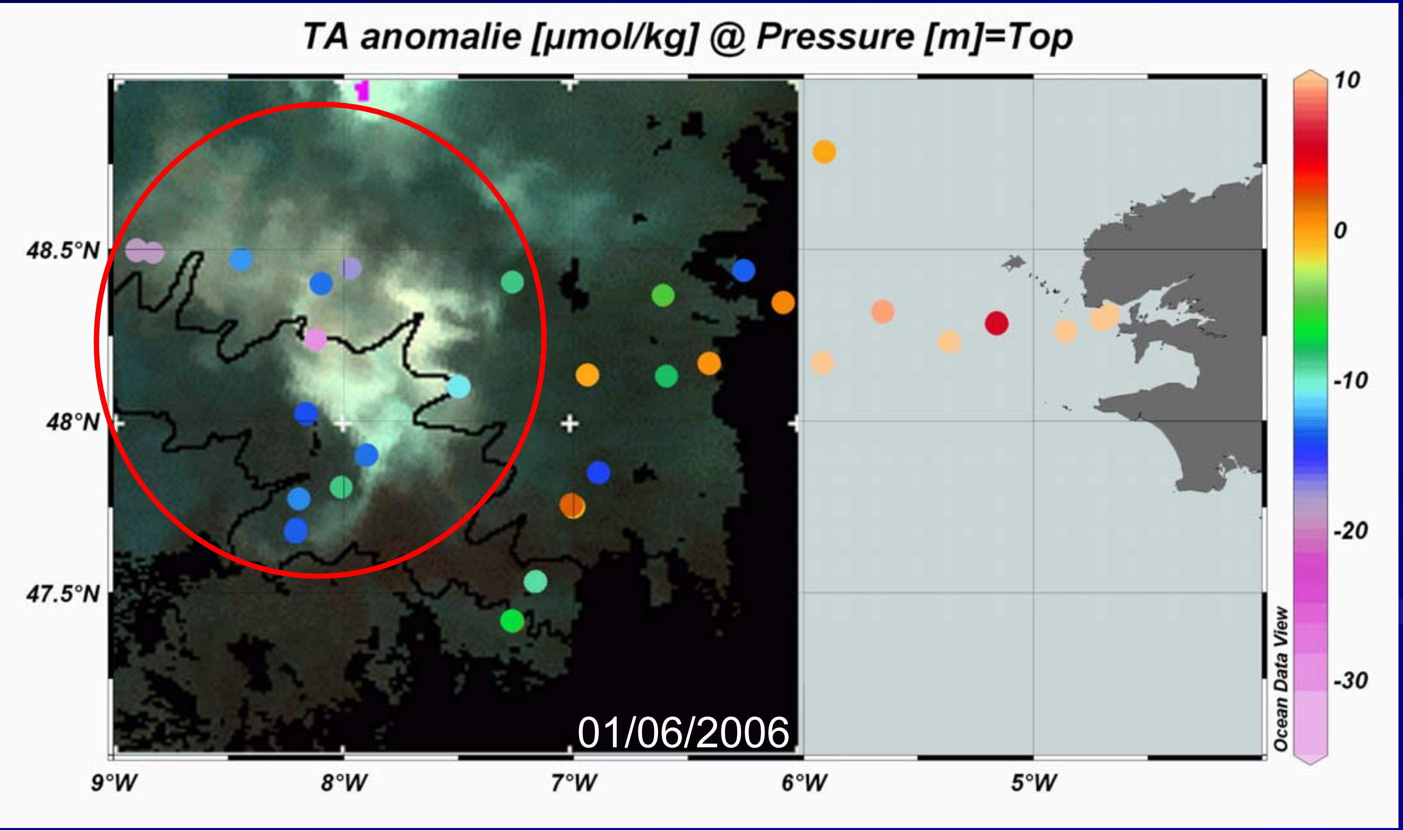




Fingerprint of calcification inside the high reflectance patch

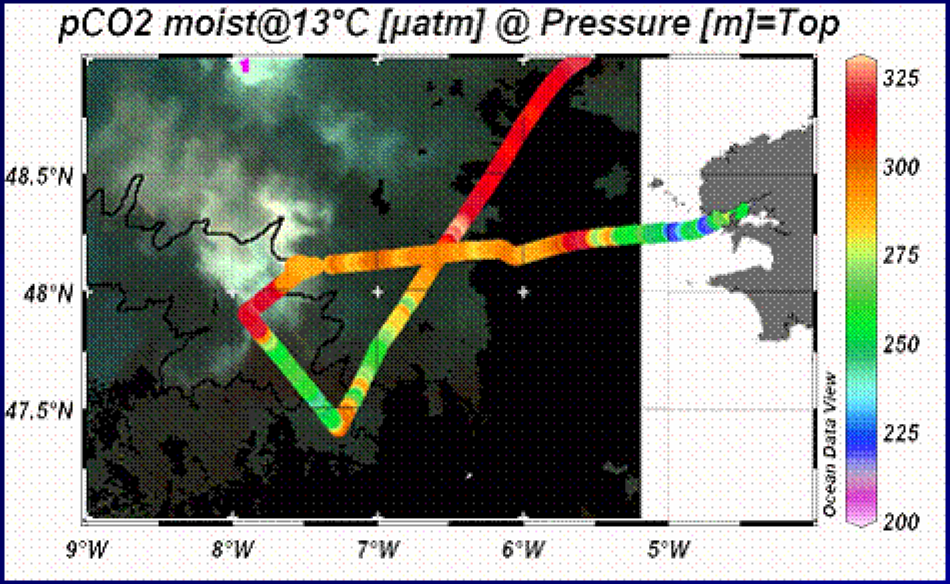
Total alkalinity anomalies

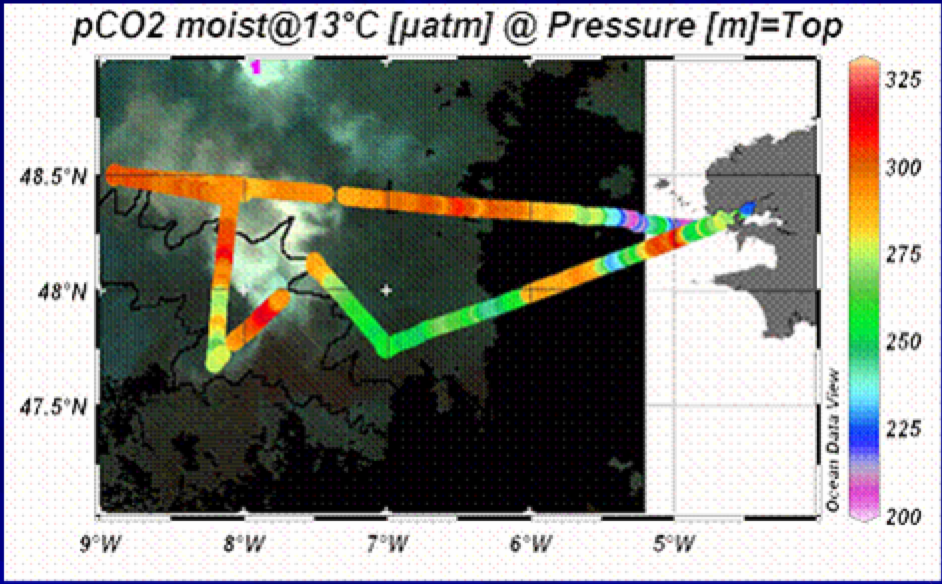
$TA_{anomaly} = TA_{meas} - TA_{sal}$ → maximum range of **26** μmol kg^{-1}



Details in Suykens *et al.* (**Poster** BG0021 Today)
Dissolved inorganic carbon dynamics in the Gulf of Biscay (June 2006)

Sea-surface pCO_2

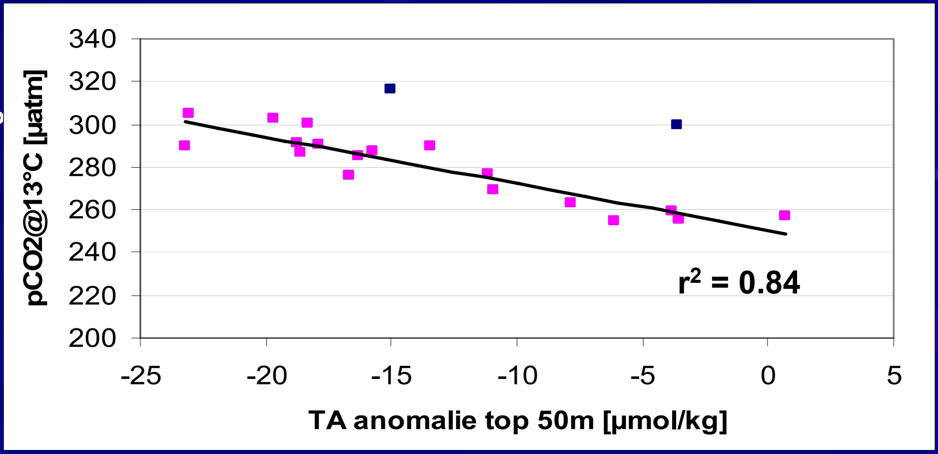




ranged from **250** to **338** µatm ⇒ **sink** for atmospheric CO_2 in early June 2006

strong correlation: TA anomaly *vs.* pCO_2@13°C

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



Primary production and calcification

Primary production

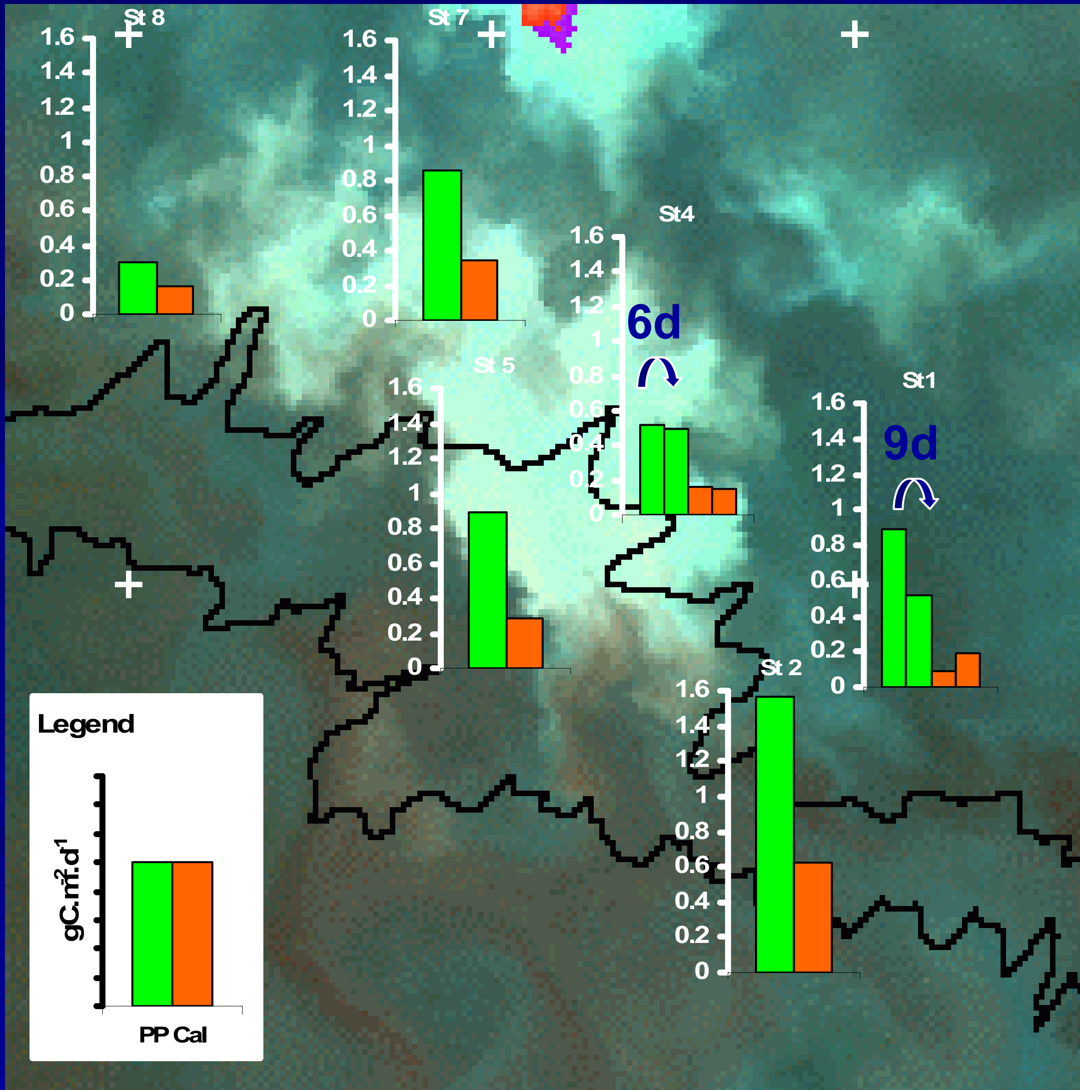
< 1 gC m^{-2} d^{-1} inside the patch
> 1.5 gC m^{-2} d^{-1} at station 2

Calcification rates

0.2 - 0.5 gC m^{-2} d^{-1}

PIC:POC ~ 0.4
(molar uptake ratio)

Primary production decreased at stations 1 and 4

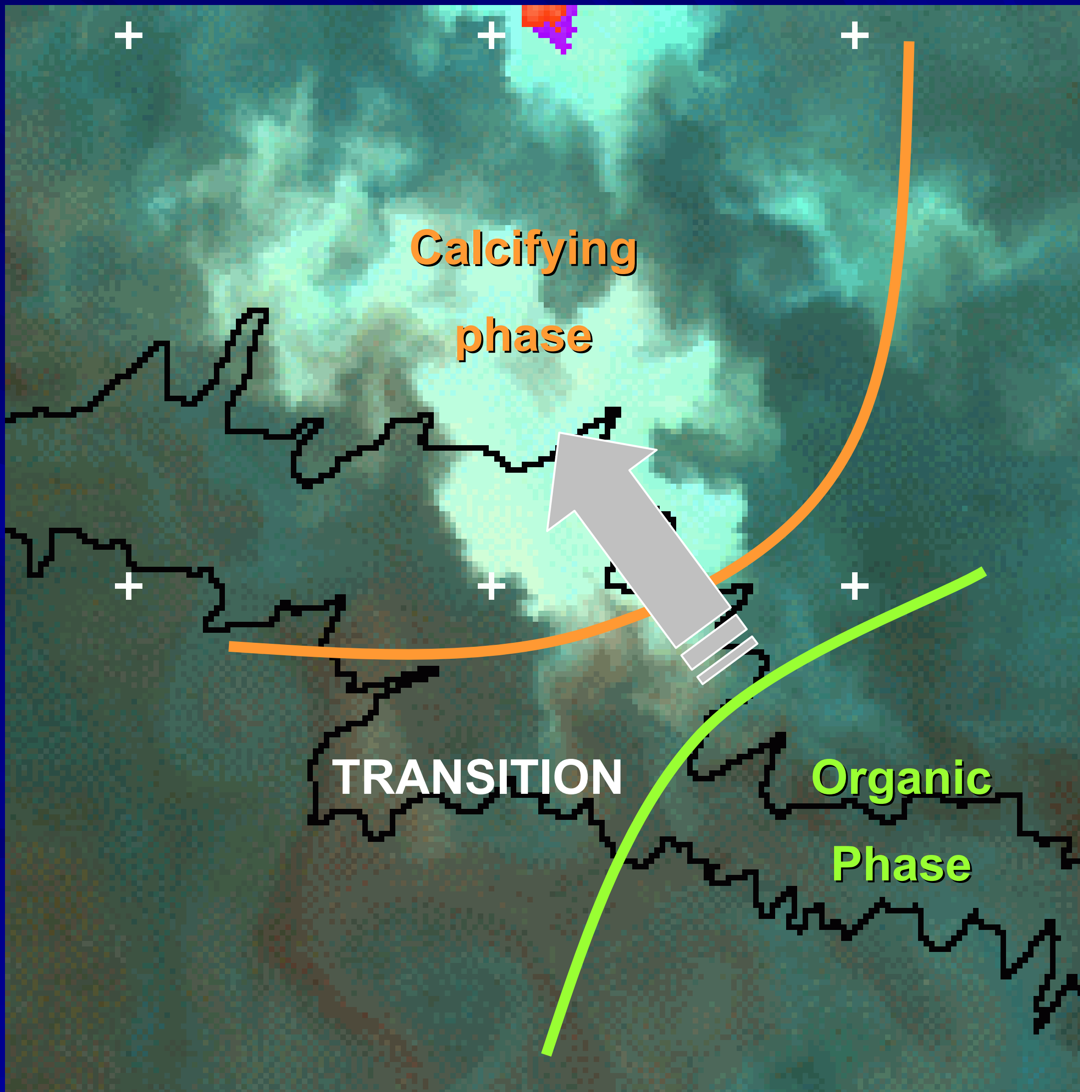


Primary production and calcification

Zone dominated by the **organic phase** (1, 2)

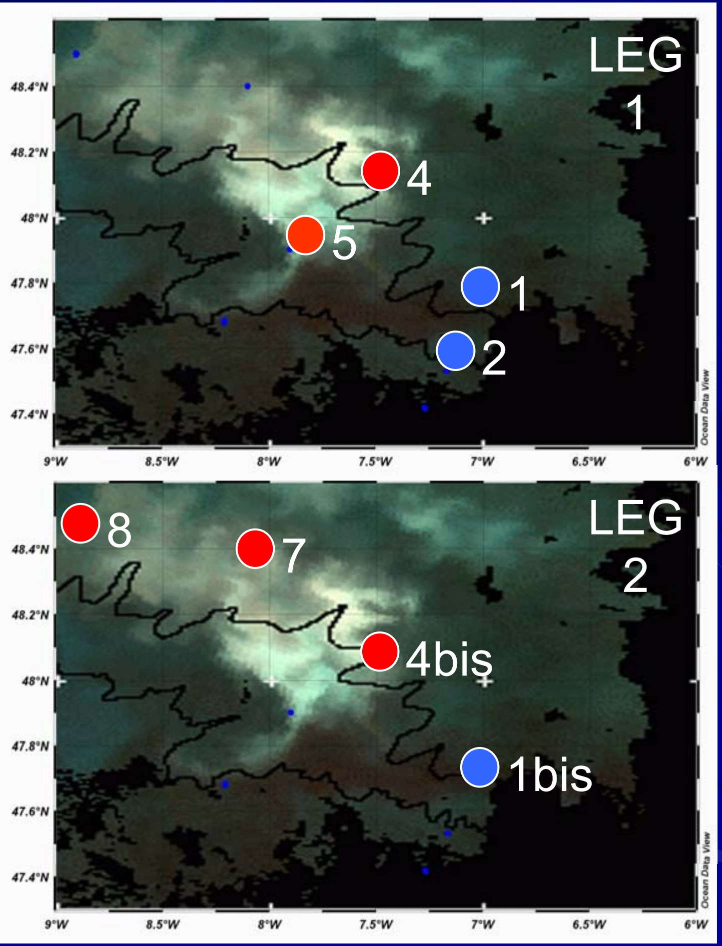
Zone of **transition** (4, 5)

Zone dominated by the **calcifying phase** (7, 8)



Pelagic respiration rates

Station	PP	CAL	RESP
	(mmolC.m^{-2}.d^{-1})		
1	**74.2**	7.5	**82.3**
1bis	**43.3**	15.8	**116.9**
2	**130.8**	51.7	**90.7**
5	**74.2**	24.2	
4	**43.3**	13.3	**86.3**
4bis	**41.7**	12.5	**114.9**
7	**71.7**	28.3	**88.3**
8	**25.0**	13.3	**106.8**



Ranging from 82 to 117 mmolC m^{-2} d^{-1}

Total respiration as a major source of CO_2 (76 → 90 %)

Respiration rates exceed primary production rates, except at st 2

Increase at revisited stations

Lysis rate

Dissolved Esterase Activity method (Riegman *et al*., 2002)

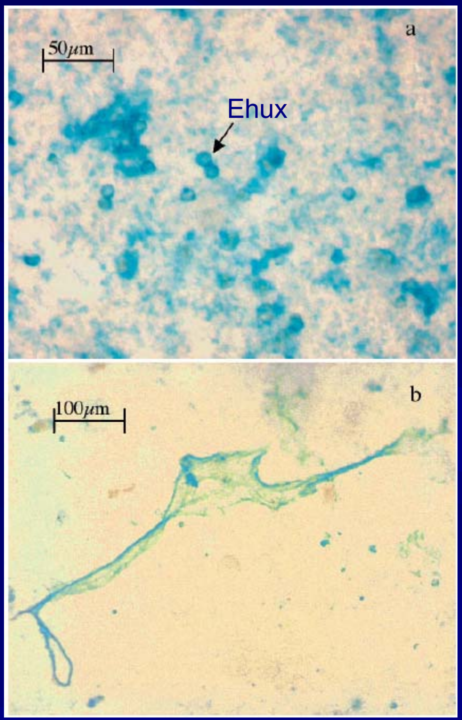
Cell Lysis → Zooplankton grazing

Van Boeckel *et al*., 1992 → Viral activity

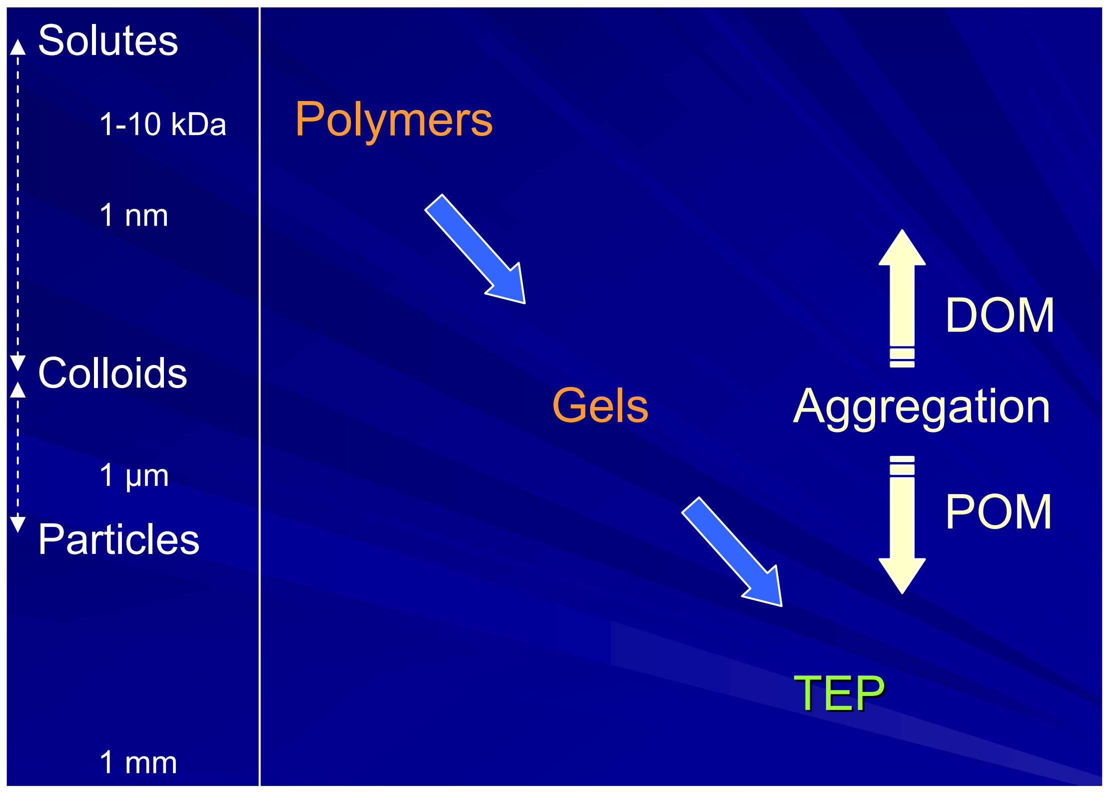
Station	date	Lysis (d^{-1})
2	1/06/2006	**0.320**
4	2/06/2006	**0.253**
8	6/06/2006	**0.318**
7	7/06/2006	**0.178**
1bis	9/06/2006	**1.339**

Typical for a late-spring bloom situation
0.02-0.3 d^{-1} in Riegman & Winter (2003)

Transparent Exopolymer Particles



From Engel *et al.*, (2004)



Adapted from Verdugo *et al.*, (2004)

See also De Bodt *et al.* (Poster XY0734 **Wednesday**)

Calcification and transparent exopolymer particles (TEP) production in batch cultures of Emiliania huxleyi exposed to different pCO_2

Transparent Exopolymer Particles

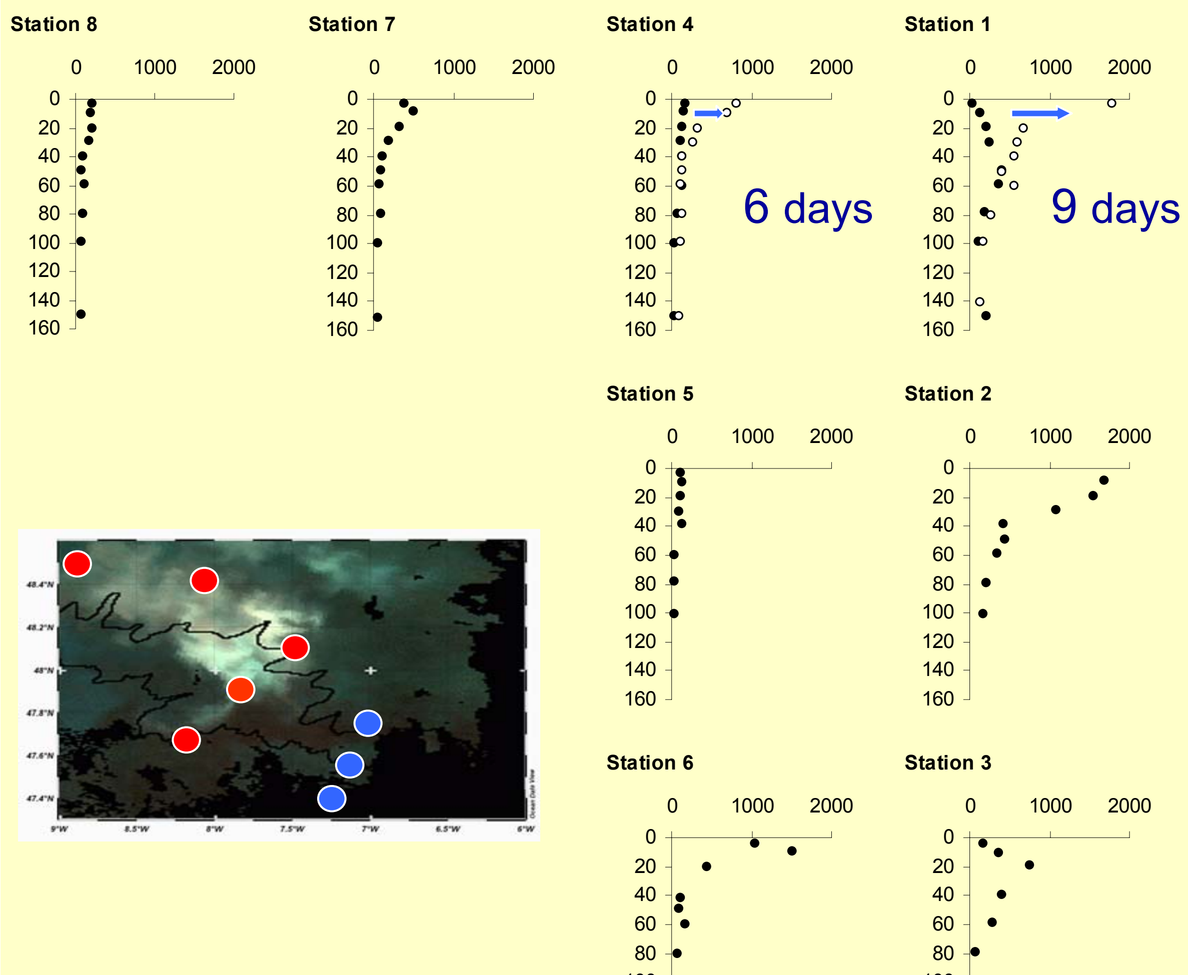
Our study:
500-800 and up to **2000** µg Xeq/l

Engel (2004):
28 to **120** µg Xeq/l
NAO (June-July 1996)

Passow *et al.* (2001):
500 µg Xeq/l (Santa Barbara Channel)

Passow & Alldredge (1995):
920 µg Xeq/l (batch culture, *Ehux*)

Size spectrum and specific **polysaccharide composition** ?



(TEP conc. in µg Xeq/l)

Bacterial community structure

DGGE / PCR 16s rDNA

« **particle-associated fraction** »

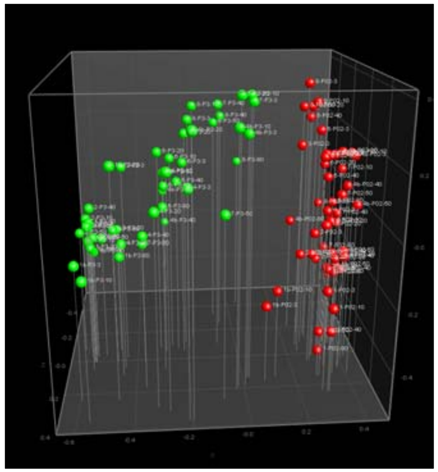
(> 3 µm)

- α-proteobacteria (*Roseobacter*)
- *SAR86* lineage

DMS-cleavage pathway
Organic-S metabolism

« **free-living fraction** »

(0.2 – 3 µm)



Particle-associated fraction
Free-living fraction

CONCLUSIONS

The continental margin has hydrodynamic features that enhance biological activity and especially promote **coccolithophore blooms**.

This ecosystem was still a **sink for atmospheric CO_2** due to the history of the bloom development.
But the intensity of the CO_2-producing processes is important and may switch the system from a sink to a source of CO_2.

The **elevated concentrations of TEP**, accompanied by **high cell lysis rates,** may lead to the **production and subsequent export of macro-aggregates**, which could be enhanced by the ballasting of calcite particles.

"What is the role of bacteria in aggregates ? Dissolution of $CaCO_3$? DMS-cleavage pathway ?"

Contribution to C export and preservation via shelf-ocean exchanges

Future of shelf carbonate sediments in a high-CO_2 world…

Thank you for your attention

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