University of Southampton School of Ocean and Earth Science | National Oceanography Centre, Southampton | UK Ocean Acidification | Sea Surface Consortium UKOA | defra | Natural Environment Research Council

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Shipboard bioassays experiments

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Objectives

Quantitatively investigate the links between changes in the ocean carbonate system (Ocean Acidification; OA) and:

- natural microbial community physiology and morphometry (including $CaCO_3$ shells),
- plankton biodiversity and community structure,
- biogeochemical rates,
- food webs and
- climate-relevant processes.

Containerised lab facility

Controlled conditions in a refrigerated container:

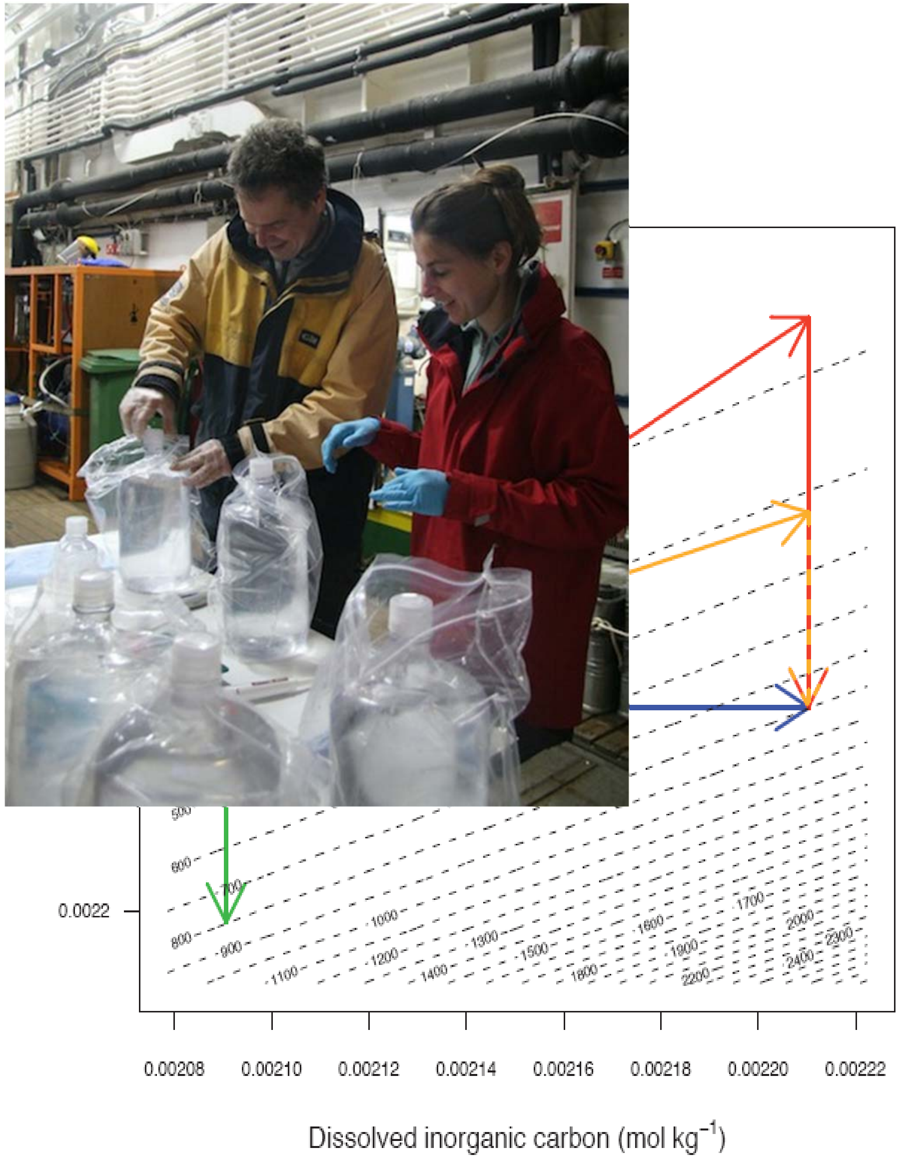
Temperature adjusted to match with the *in situ*

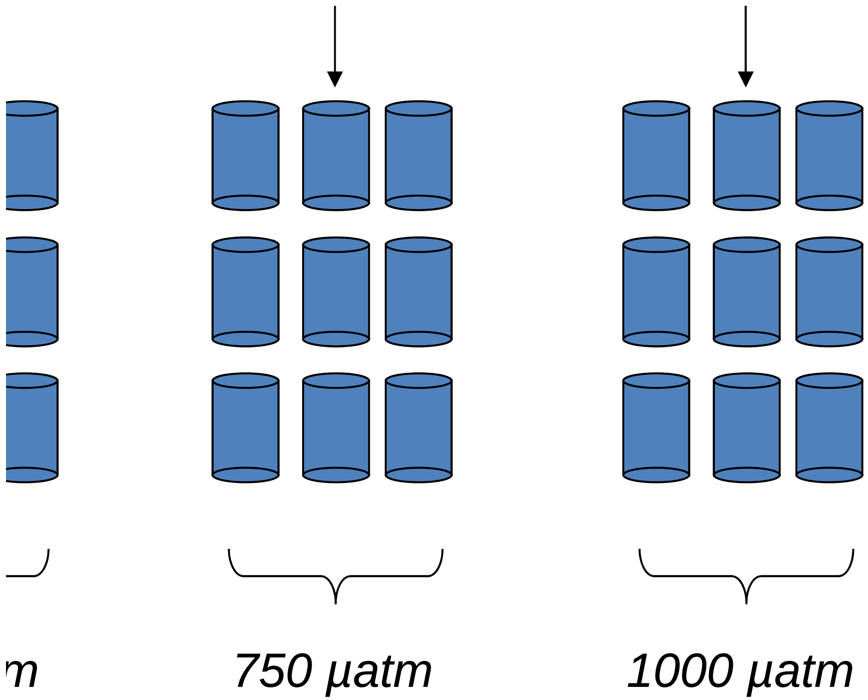
Artificial light sources: 100 μE m^{-2}. s^{-1} (14/8 light/dark cycle)

Set-up

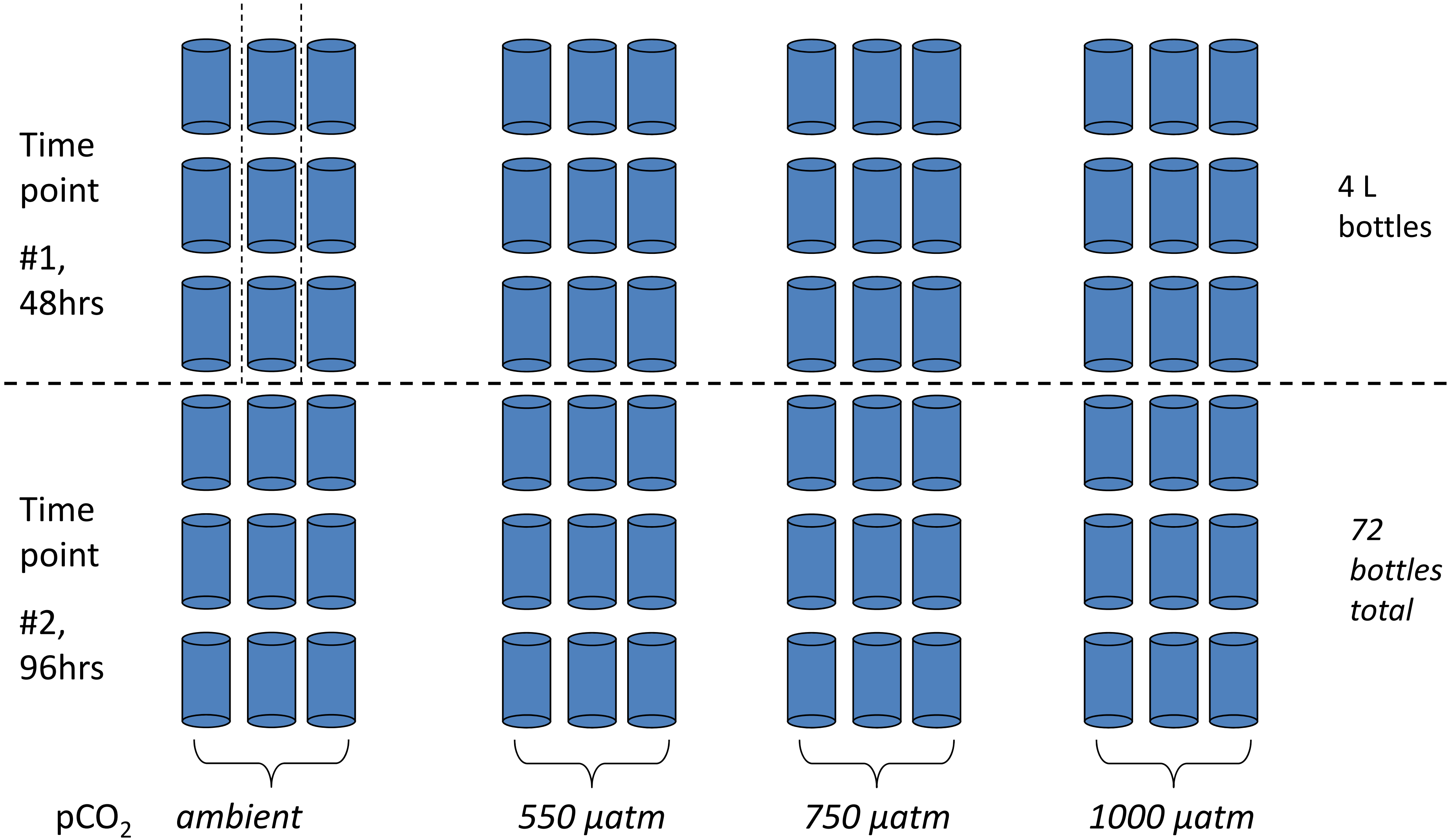
TD of water, 24 x 20L = 480L,
er into bottles on deck

HCO_3^- + HCl to achieve target pCO_2





Set-up

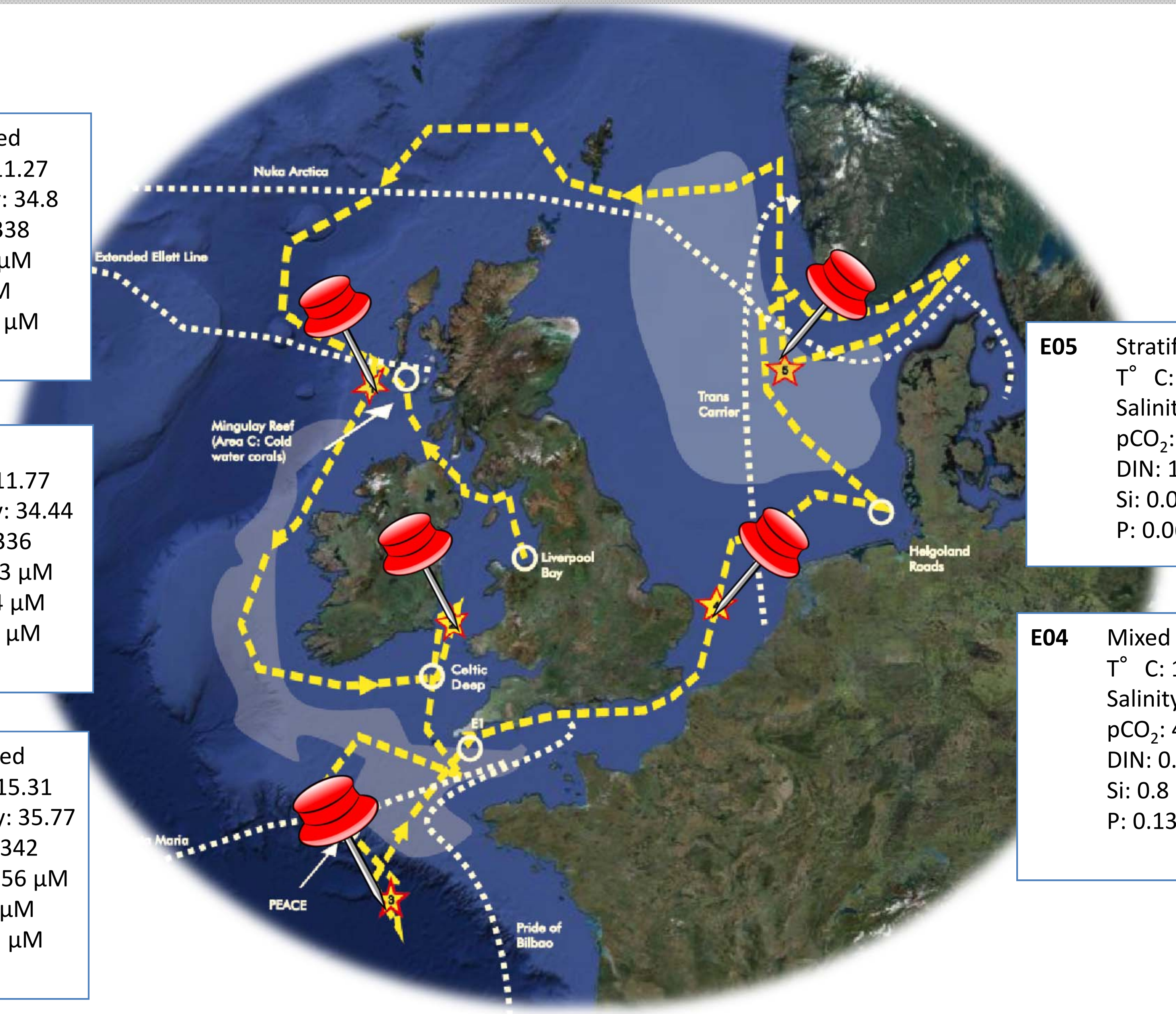

Time point #1, 48hrs
Time point #2, 96hrs
4 L bottles
72 bottles total
pCO2
ambient
550 µatm
750 µatm
1000 µatm

Cruise track (June-July 2011) and bioassay locations

E01 Stratified
T° C: 11.27
Salinity: 34.8
pCO_2: 338
DIN: 1 µM
Si: 2 µM
P: 0.09 µM

E02 Mixed
T° C: 11.77
Salinity: 34.44
pCO_2: 336
DIN: 0.3 µM
Si: 0.44 µM
P: 0.14 µM

E03 Stratified
T° C: 15.31
Salinity: 35.77
pCO2: 342
DIN: 0.56 µM
Si: 0.6 µM
P: 0.05 µM



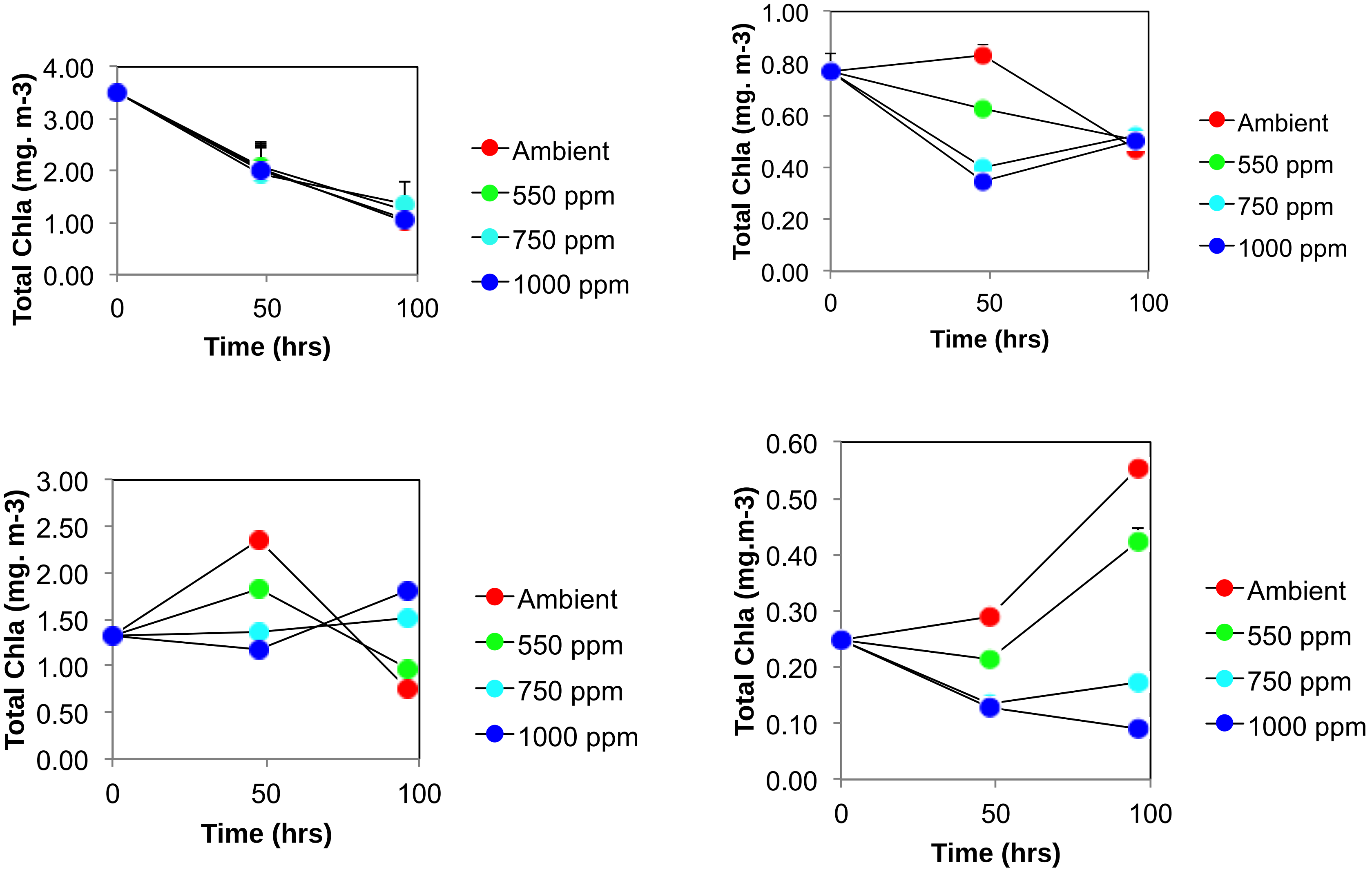
E05 Stratified
T° C: 13.96
Salinity: 35
pCO_2: 370
DIN: 1.7 µM
Si: 0.04 µM
P: 0.06 µM

E04 Mixed
T° C: 14.57
Salinity: 34.05
pCO_2: 407
DIN: 0.8 µM
Si: 0.8 µM
P: 0.13 µM

Measured parameters

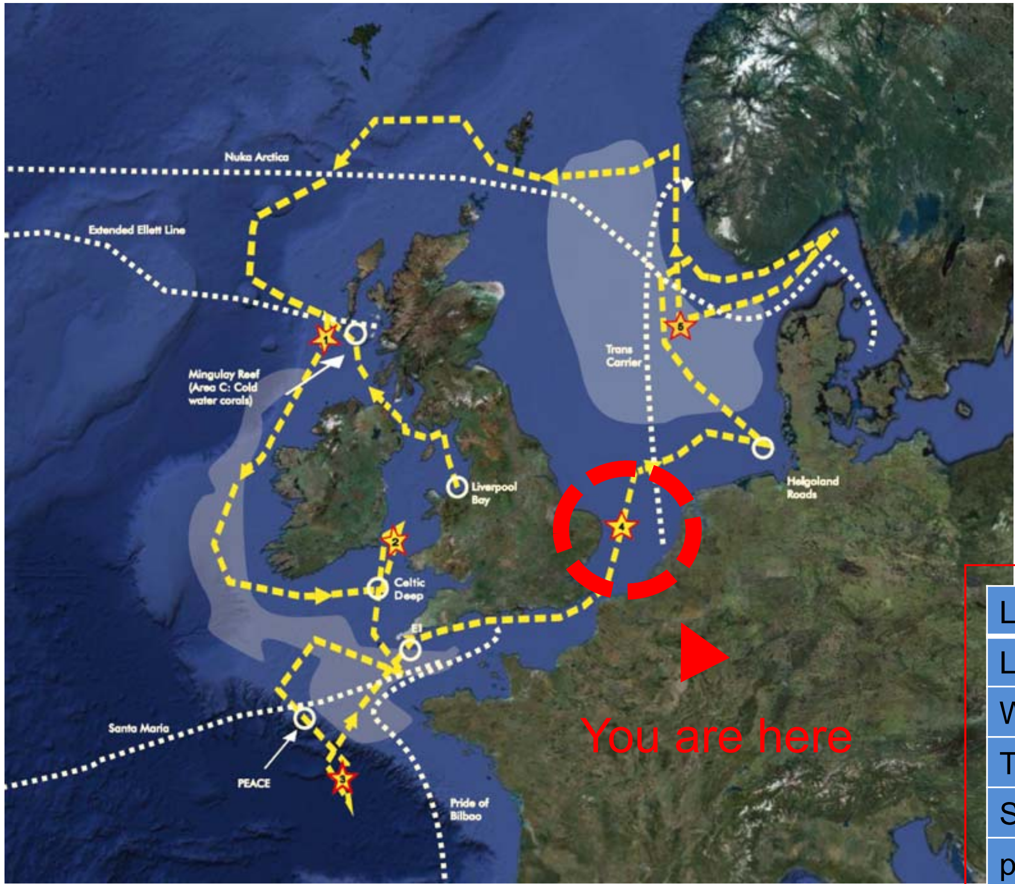
Carbonate chemistry (*UoSoton*)
Macro-nutrients (*NOCS)*
POC/PON/POP *(UoSoton)*
Total Chl_a/size fractionated $chlorophyll_a$*(UoSoton,UoEssex)*
Photophysiology (Fv/Fm, σ, тau) *(UoEssex)*
P/E *(UoEssex)*
Primary production (*NOCS)*
Calcite production (*NOCS)*
Coccolithophores assemblage *(NHM)*
PIC *(NHM)*
Microbial community composition (*NOCS, PML)*
Respiration *(UoSoton)*
Ammonium *(UoSoton)*
DOC/TEP *(UoSoton)*
DMSP production, DMSP-DMSP conversion rates *(PML)*
CH_4, N_2O *(PML)*
Oxidation rates of NH_4^+ and NO_2^- *(PML)*
Genetic diversity *(MBA)*
Proteins/RNA (*UoSoton*)

Diversity in responses to ocean acidification



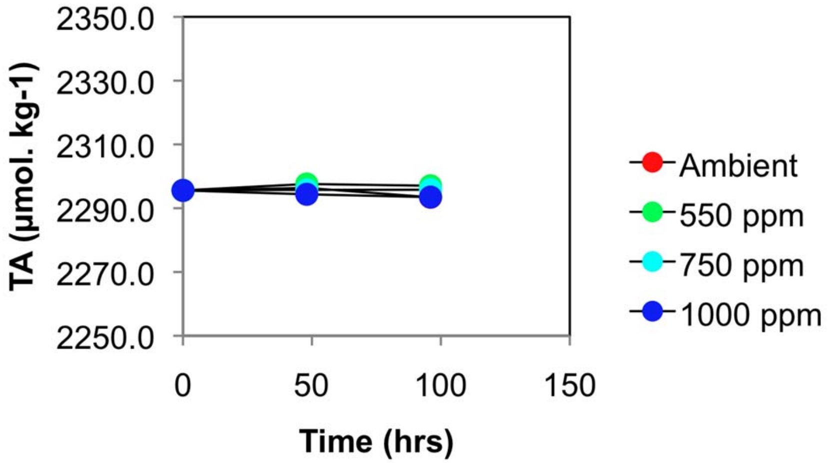
Discrepancies in Chl_a trends between bioassays illustrate the importance of initial conditions in response to OA.

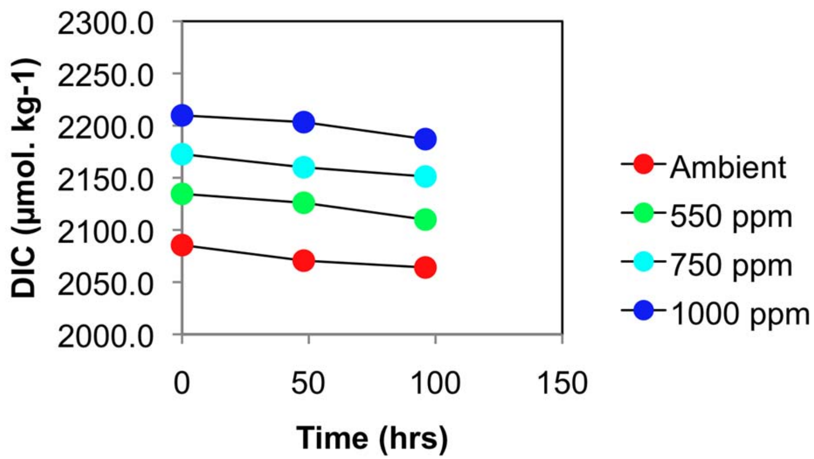
Zoom on the South North sea bioassay (E04)



Latitude [deg+veN]	52.59
Longitude [deg+veW]	2.29
Water column	Mixed
Temperature (°C)	14.57
Salinity	34.05
pCO_2 (ppm)	407
Nitrates/nitrites (µM)	0.8
Phosphates (µM)	0.13
Silicates (µM)	0.8

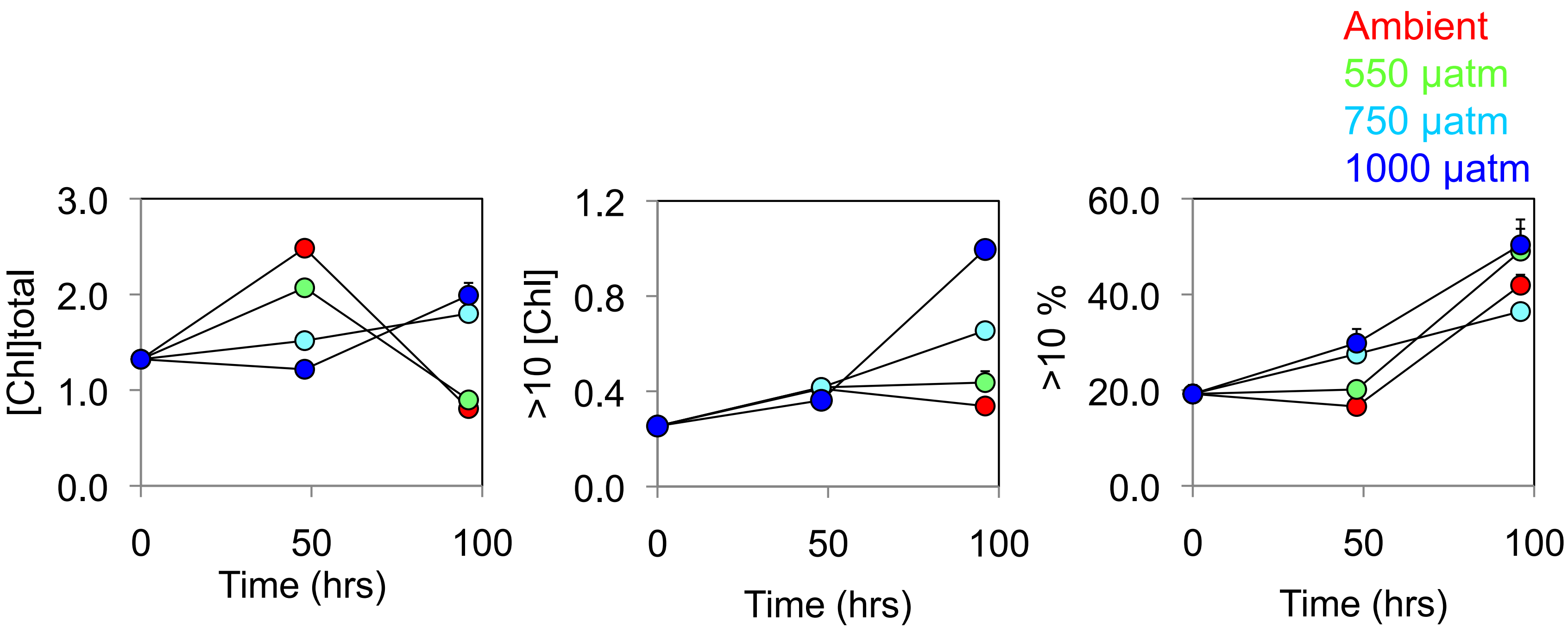
Carbonate chemistry in E04 bioassay





As expected, the TA remained unchanged with time and pCO_2 through the experiment while the DIC concentration is increasing with pCO_2 and decreasing with time.

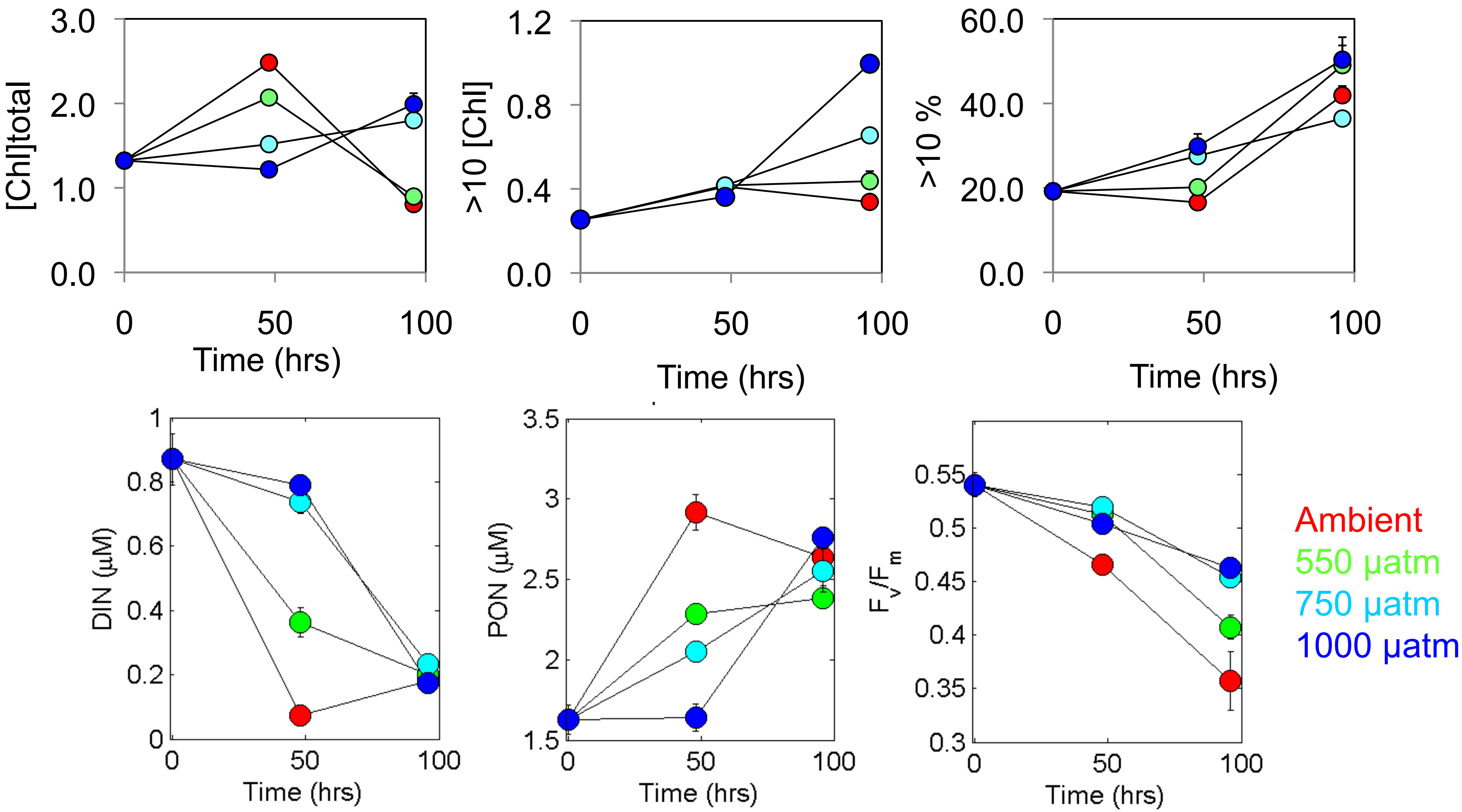
Interpretation of Time series experiments



Highest Chl_a values for the ambient condition after 2 days while the bloom is delayed with increasing pCO_2.

The small size phytoplankton dominates the microbial community (80% at T_0) and appears more sensitive to ocean acidification than > 10 µm fraction.

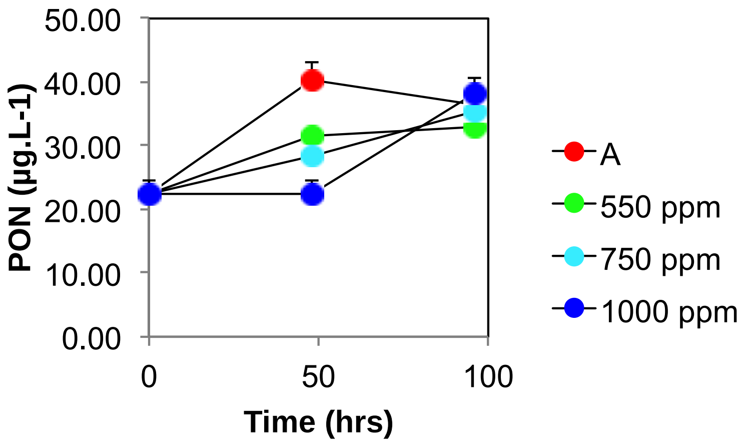
Interpretation of Time series experiments

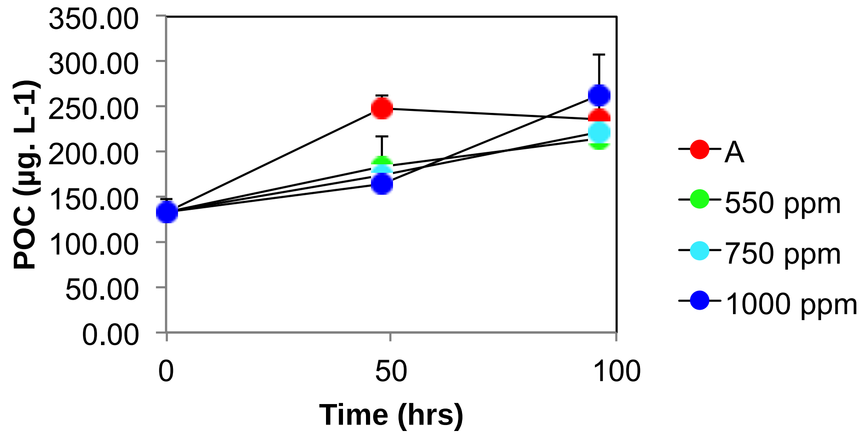


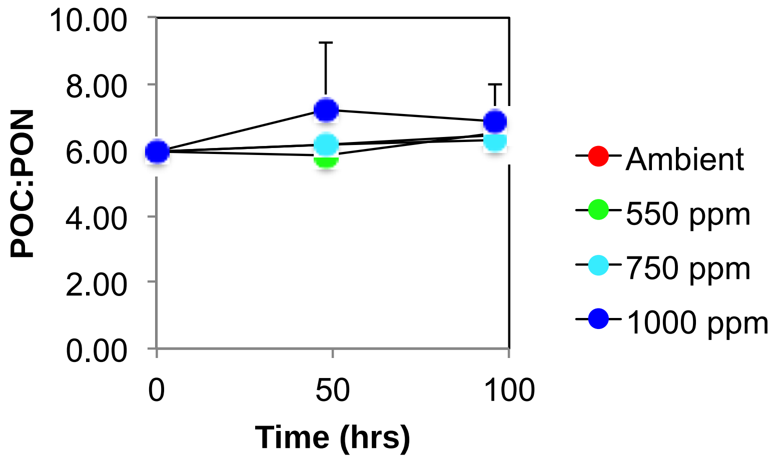
Slow down in nutrients uptake and organic matter production with increasing pCO_2.

Increase in photo-efficiency with increasing pCO_2 (specific to this bioassay).

Interpretation of Time series experiments

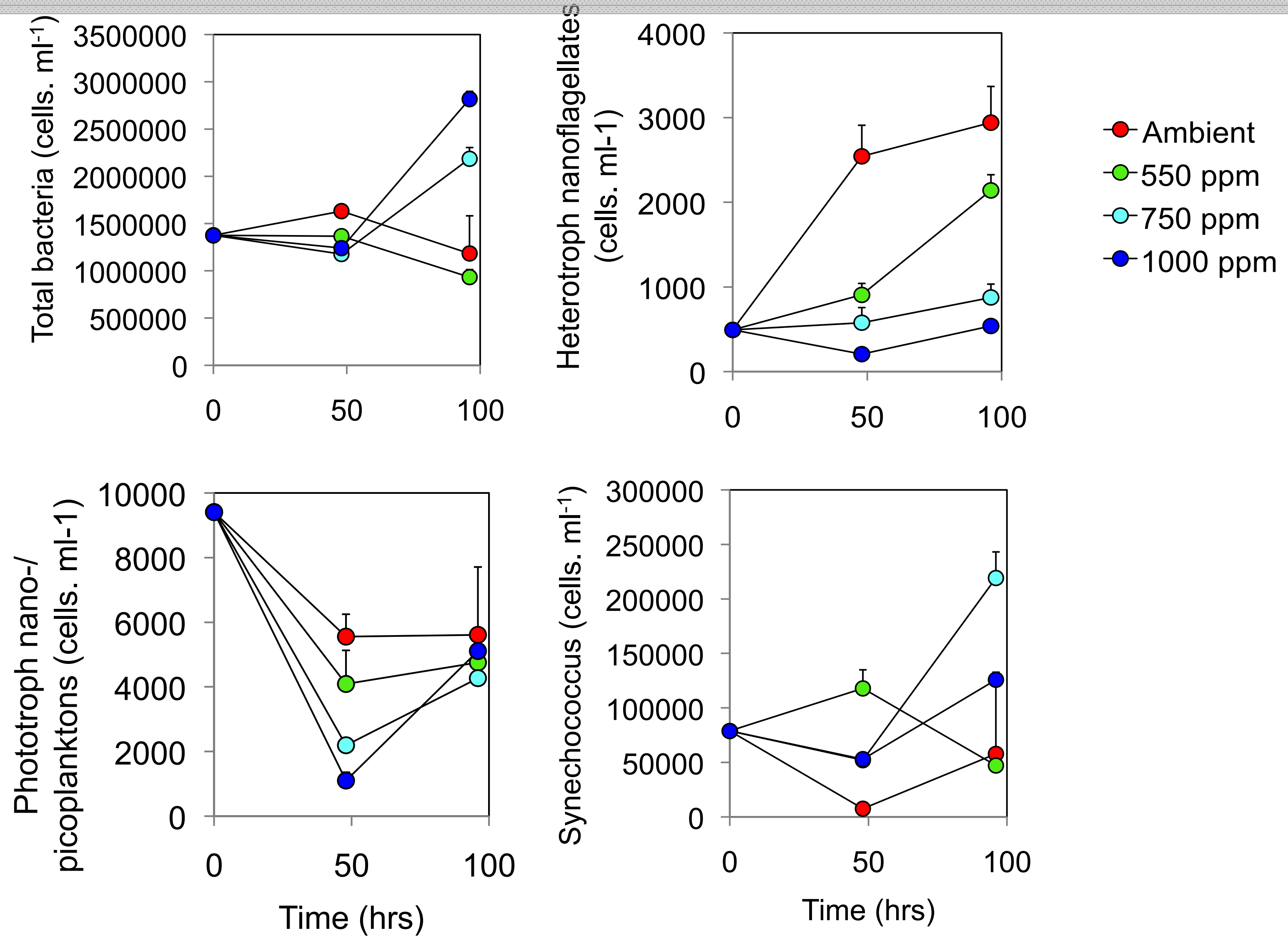






The production of organic matter is affected by high pCO_2 while C:N ratio remains unchanged.

Interpretation of Time series experiments



Shift in community composition with increasing pCO_2.

Conclusions

The natural communities observed were impacted by ocean acidification.

After 2 days, the chlorophyll content is higher under low pCO_2. The peak of chlorophyll corresponds to the highest particulate organic matter concentration and the exhaustion of nutrient sources.

After 4 days, the trend is inverted. As the nutrients uptake is lower at high pCO_2, the bloom is delayed and occurs later.

C:N stoichiometry was not affected by higher pCO_2 and similar to the Redfield ratio of 6.6 in today's ocean.

Shift in microbial community structure (increase in bacteria and decrease in small size fraction and nanoflagellates) with changing pCO_2.

Take home messages

All the measurements performed during the cruise are required to interpret correctly the data from each bioassay,

A strong group-specific response to high pCO_2 was observed in the majority of bioassay experiments.

Such responses have important implications for trophic dynamics and biogeochemical cycling in both present day and future oceanic ecosystems

The diversity of initial environmental conditions as well as the multidisciplinary approach adopted as part of the project will potentially highlight new acclimation mechanisms of the planktonic community to future ocean acidification.

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defra
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