PML | Plymouth Marine Laboratory

Marine Matters

Assessing the impact of OA on climate: DMS and DMSP

H4c: OA will lead to a reduced flux of DMS from the oceans to the atmosphere

Frances Hopkins

Stephen Archer, Phil Nightingale, John Stephens

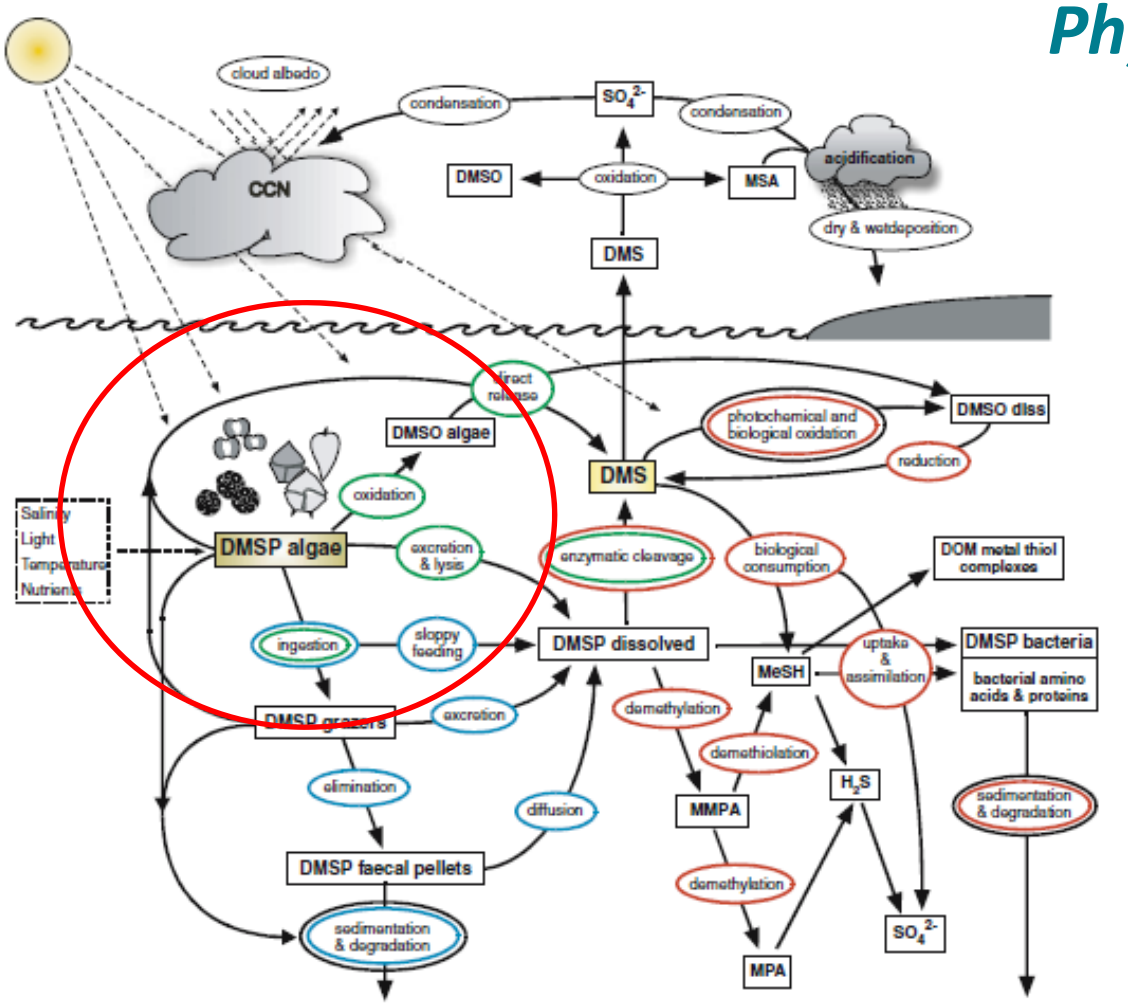
UK Ocean Acidification Research Programme

Assessing the impact of OA on climate: DMS and DMSP

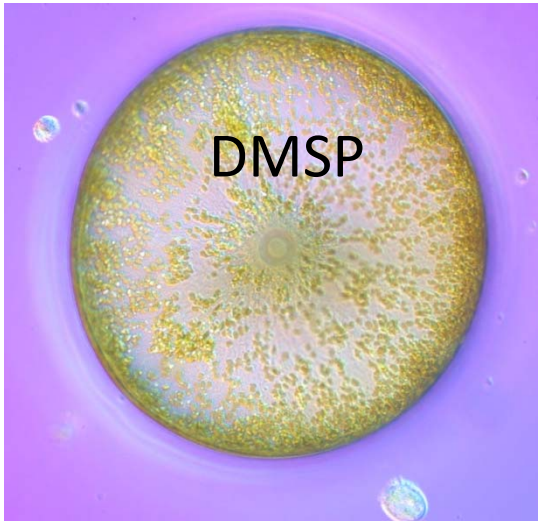
- Why DMS(P)?
- Previous studies
- D366 NW European shelf waters: response to OA

PML | Plymouth Marine Laboratory

DMSP and DMS: production and fate



Phytoplankton physiology



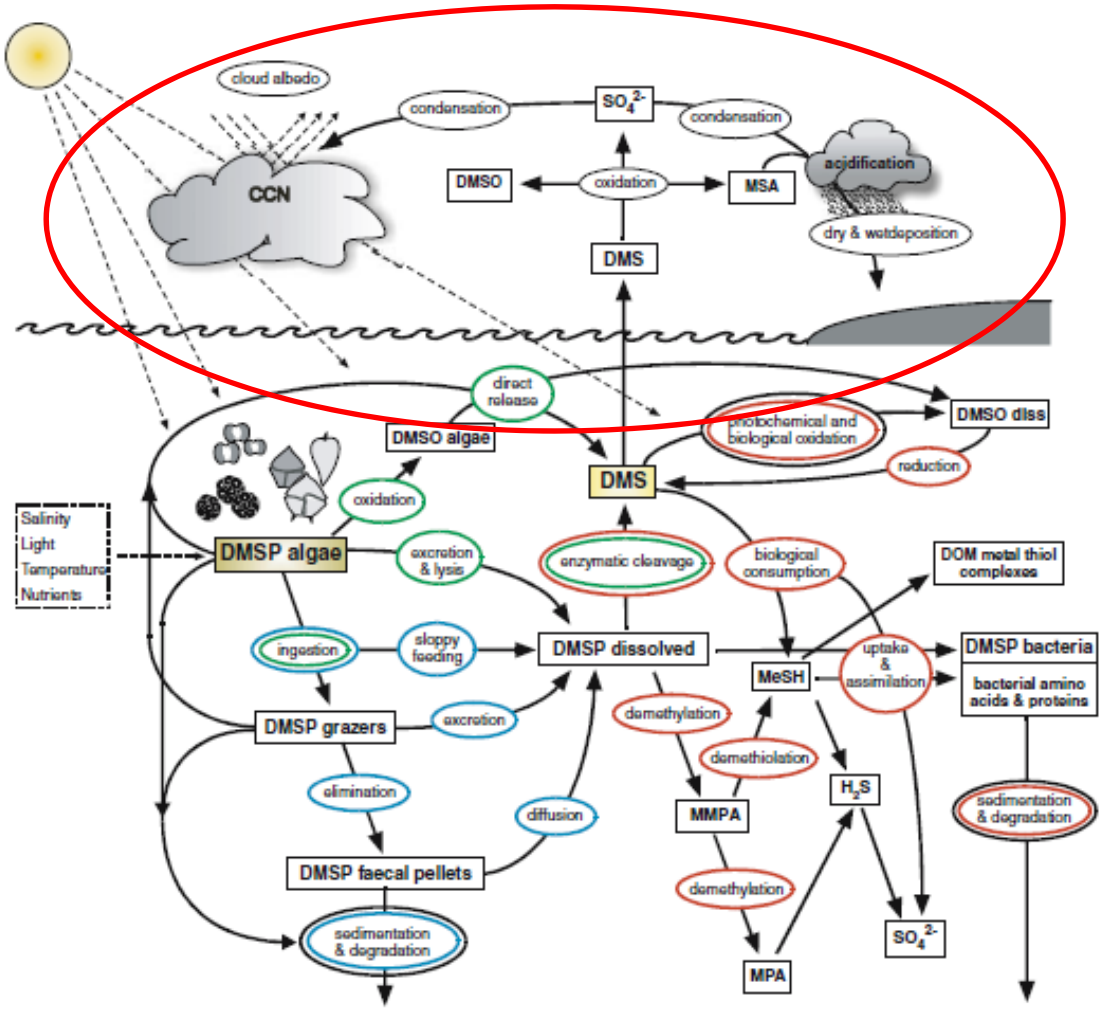
1. Osmolyte/compatible solute
2. Defense: anti-microbial, anti-viral, anti-grazing
3. Metabolic overflow mechanism
4. Anti-oxidant

From Stefels et al. 2007

Photo courtesy of C. Widdicombe

PML | Plymouth Marine Laboratory

DMSP and DMS: production and fate



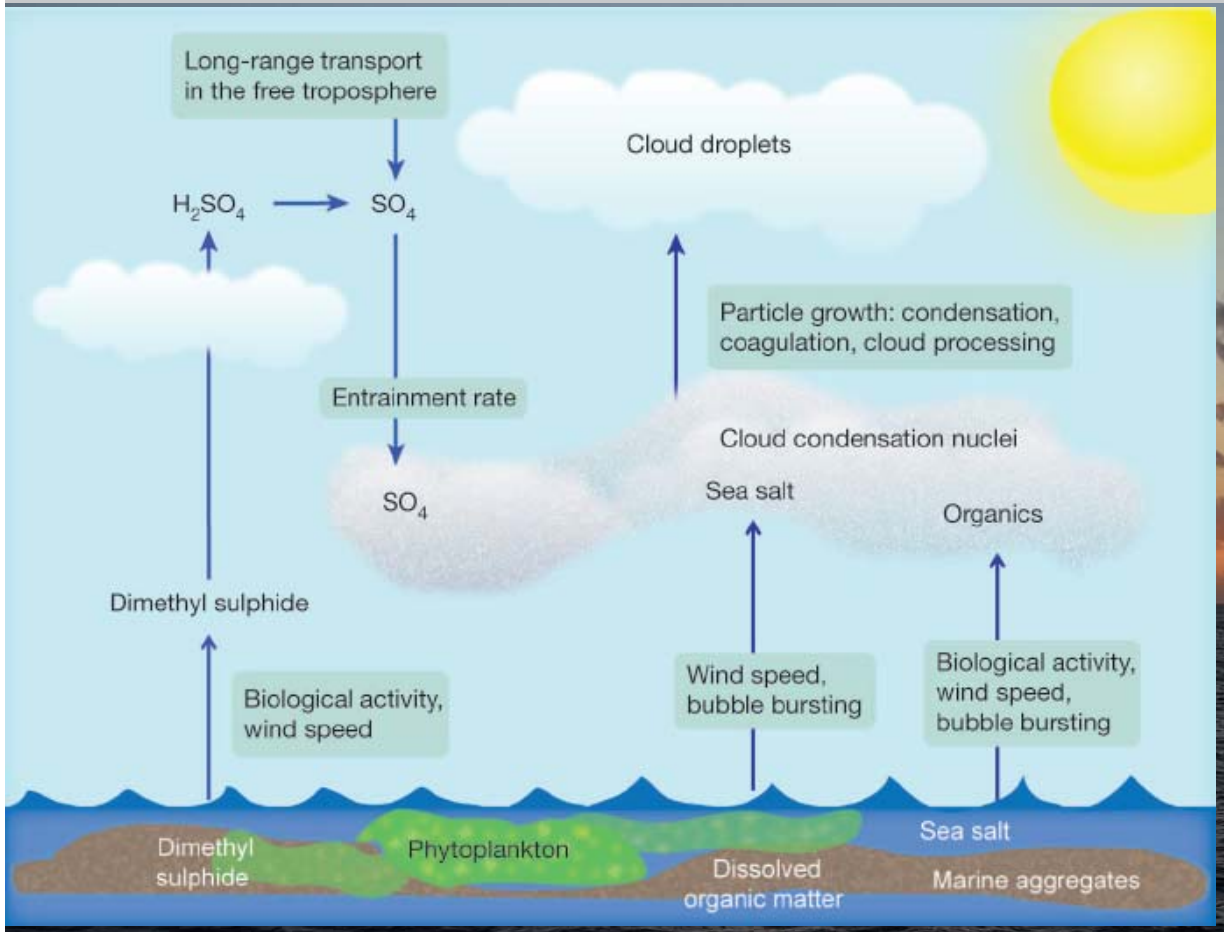
From Stefels et al. 2007

Earth system science

Interactions between ocean and atmosphere: Major regulators of atmospheric composition and climate

PML | Plymouth Marine Laboratory

DMS, CCN, Albedo



DMS: Most significant biological source of gaseous S to remote marine troposphere

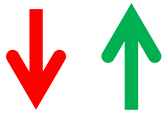
Climate sensitivity to marine DMS emissions

- Strongly debated, possibly small? See Quinn & Bates 2011, Nature, for recent review.
- Unlikely that DMS accounts for bulk of CCN number concentrations in remote MBL – sources of CCN more complex…

DMS contributes to the multiple sources of CCN in the MBL

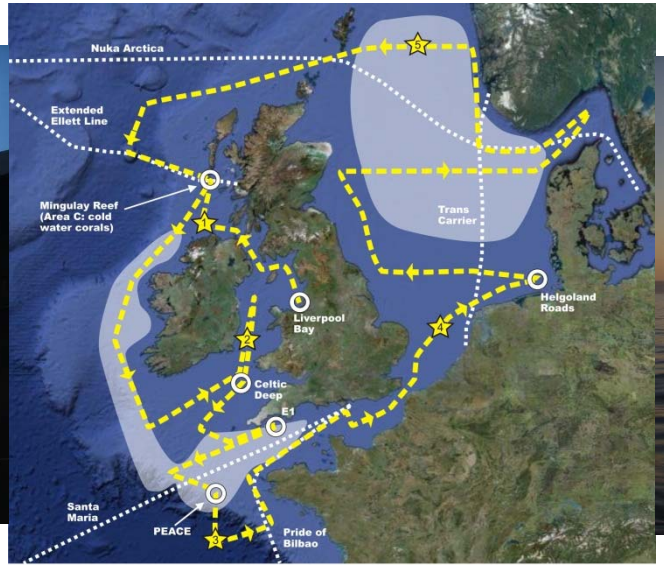
From: Quinn and Bates, 2011

OA studies and DMS/DMSP

	STUDY	RESULTS	comments
DMS	Avgoustidi et al. submitted Bergen **mesocosm** 2003		Decrease under high CO_2
	Hopkins et al. 2010 Bergen **mesocosm** 2006		Decrease under high CO_2
	Vogt et al. 2008 Bergen **mesocosm** 2005		Little difference between ambient and high CO_2 Impact on dynamics?
	Archer et al. in prep Svalbard **mesocosm** 2010		Decrease under high CO_2 during bloom Increase under high CO_2 post-bloom

PML | Plymouth Marine Laboratory

RRS Discovery D366:
June – July 2011 Round Britain Cruise



Bioassays

- E01 - E05: 4 x CO_2, 3 time points, 96 hours
- E06: 3 x CO_2, high resolution sampling, 96 hours

DMS(P) studies

How will OA in NW European shelf waters effect:

- Standing stocks of DMS and DMSP?
  - Provides limited information – net products of various and varying processes
- DMSP synthesis rates? (incorporation of $^{13}CO_2$)
- DMS consumption/production? (^{13}C-DMS loss rates)

Statistics…
One-way ANOVA (*F* = ratio of mean squares, *df* = degrees of freedom, *p* = significance of *F*-test) to identify significant differences between pCO_2 treatments

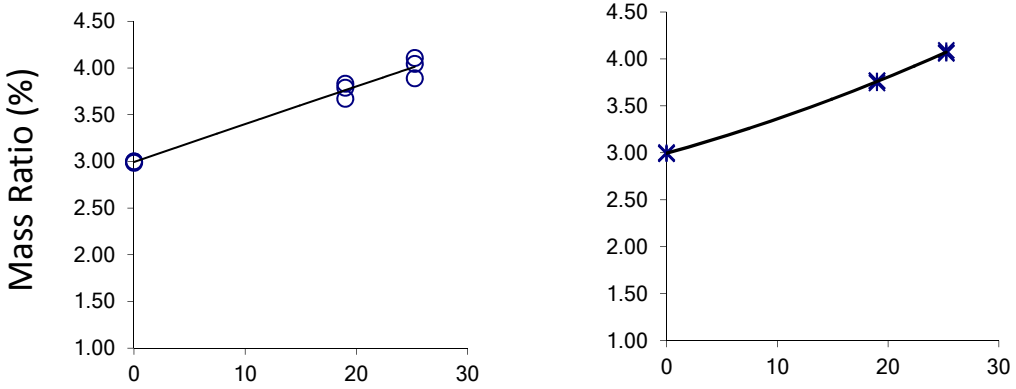
PML | Plymouth Marine Laboratory

Effect of pCO_2 on cycling of DMS(P)?

de novo DMSP synthesis rates (µDMSP) vs pCO_2

- $^{13}CO_2$ – incorporation into DMSPp in Bioassays
- Determined as Mass Ratio of ^{13}C-DMS versus total DMS (Stefels et al. 2009 L&O Methods.)
- Logarithmic growth model applied to calculate µDMSP
- DMSP production (nmol dm^{-3} h^{-1}) from µDMSP x [DMSPp]
- µDMSP determined at T0, T48 and T96 in all bioassays at the 3 levels of pCO_2
- Samples still to be analysed on PTR-MS

Example: Two levels of pCO_2: ^{13}C into DMSP:
Active uptake and good precision (9 incubations / treatment)
Should give us good DMSP production/ synthesis rates

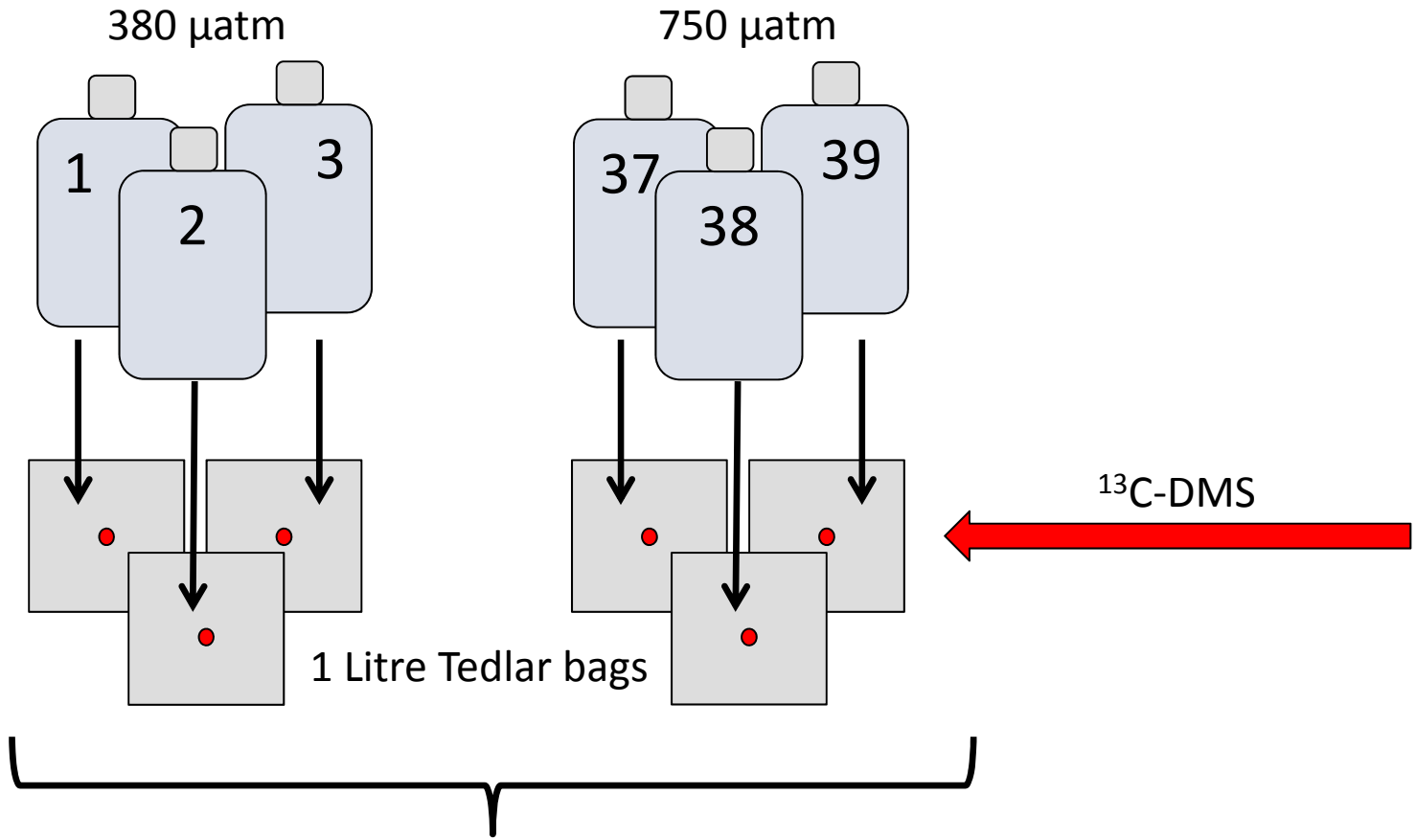


See Archer et al.to be submitted

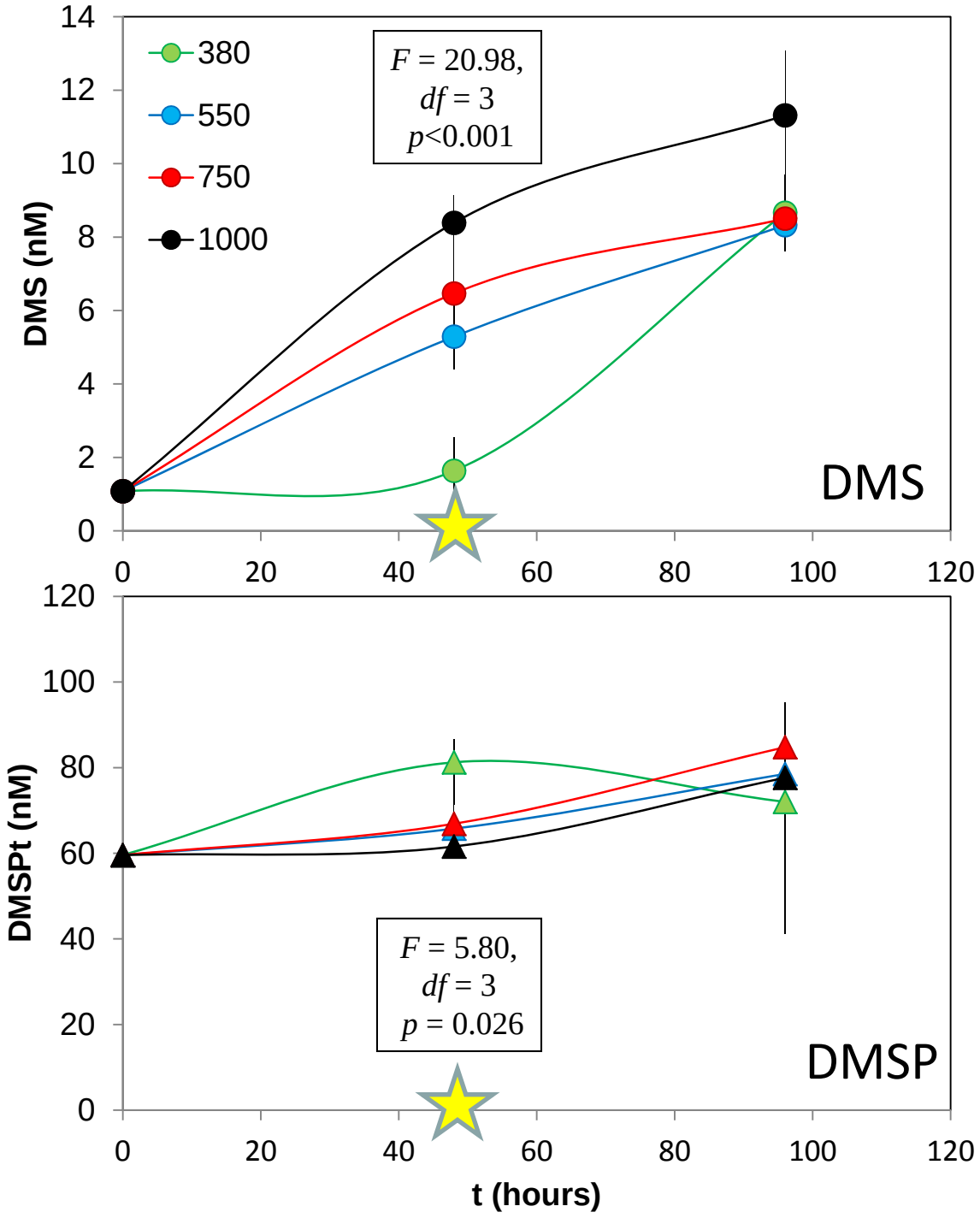
PML | Plymouth Marine Laboratory

Effect of pCO_2 on cycling of DMS(P)?

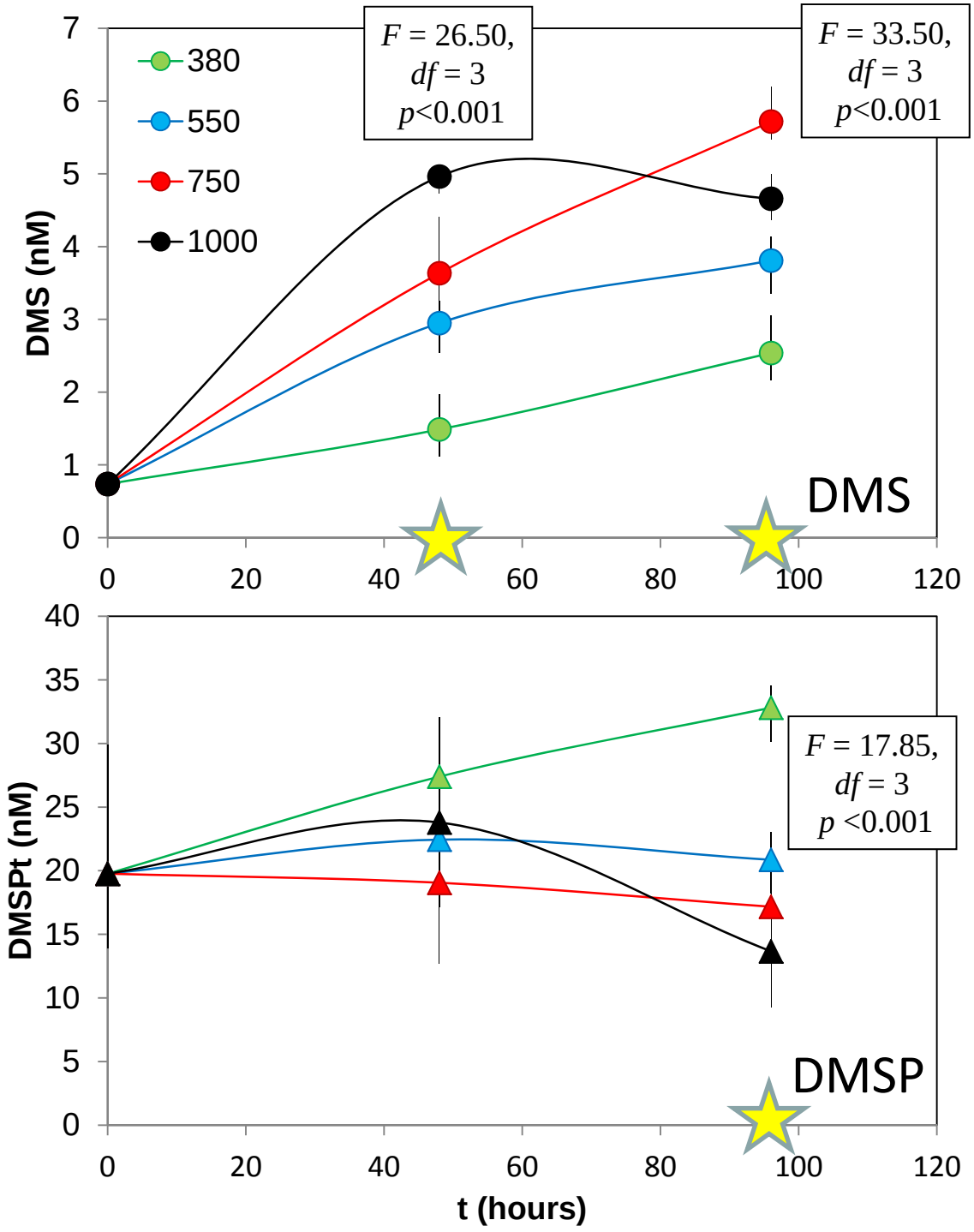
^{13}C-DMS Loss Rates (DMS consumption and gross production)



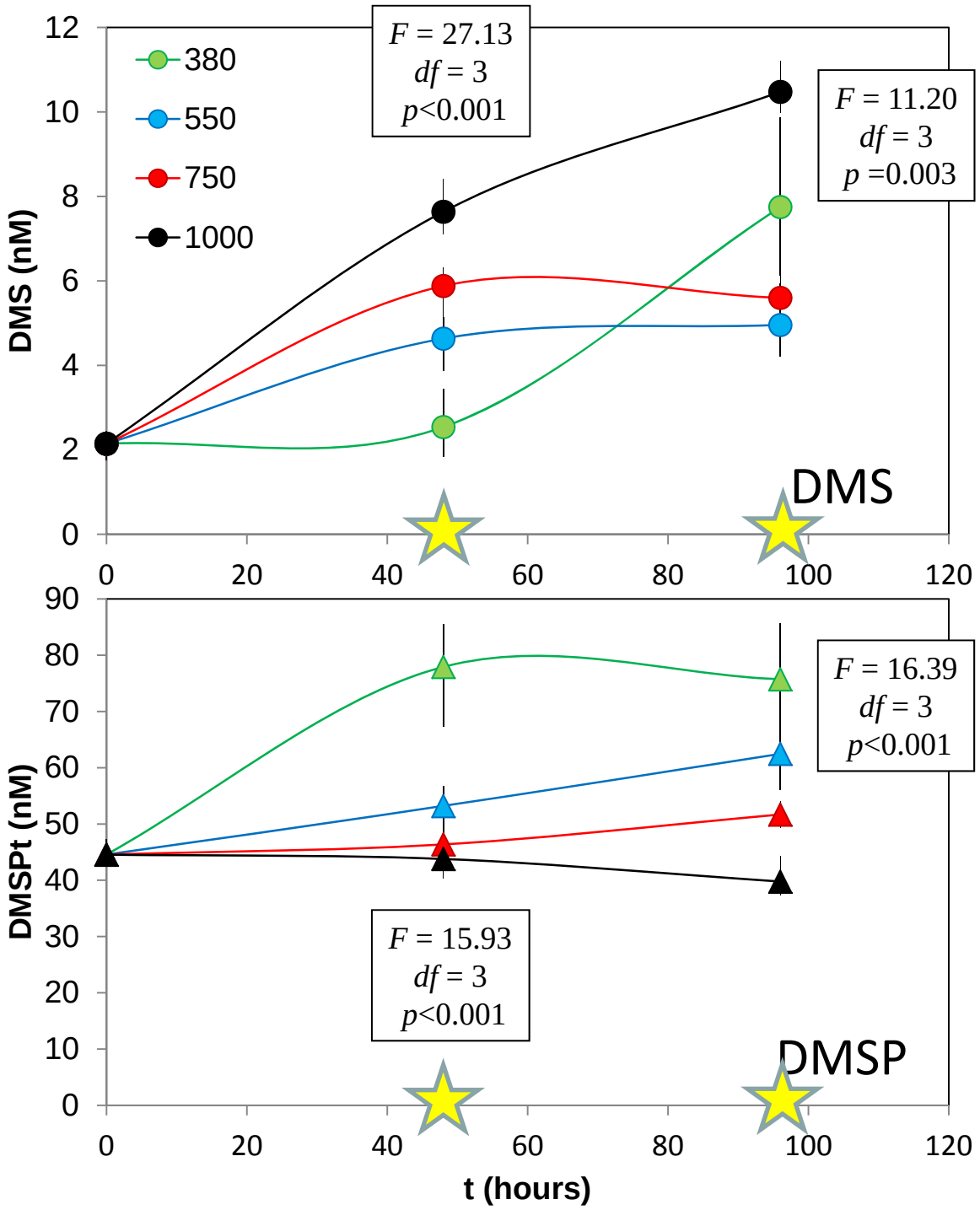
Dark incubation (12 hours)
Samples withdrawn every 4 hours
Analysed using GC-MS
Repeated at T0, T48, T96



E01
Mingaley Reef
Stratified



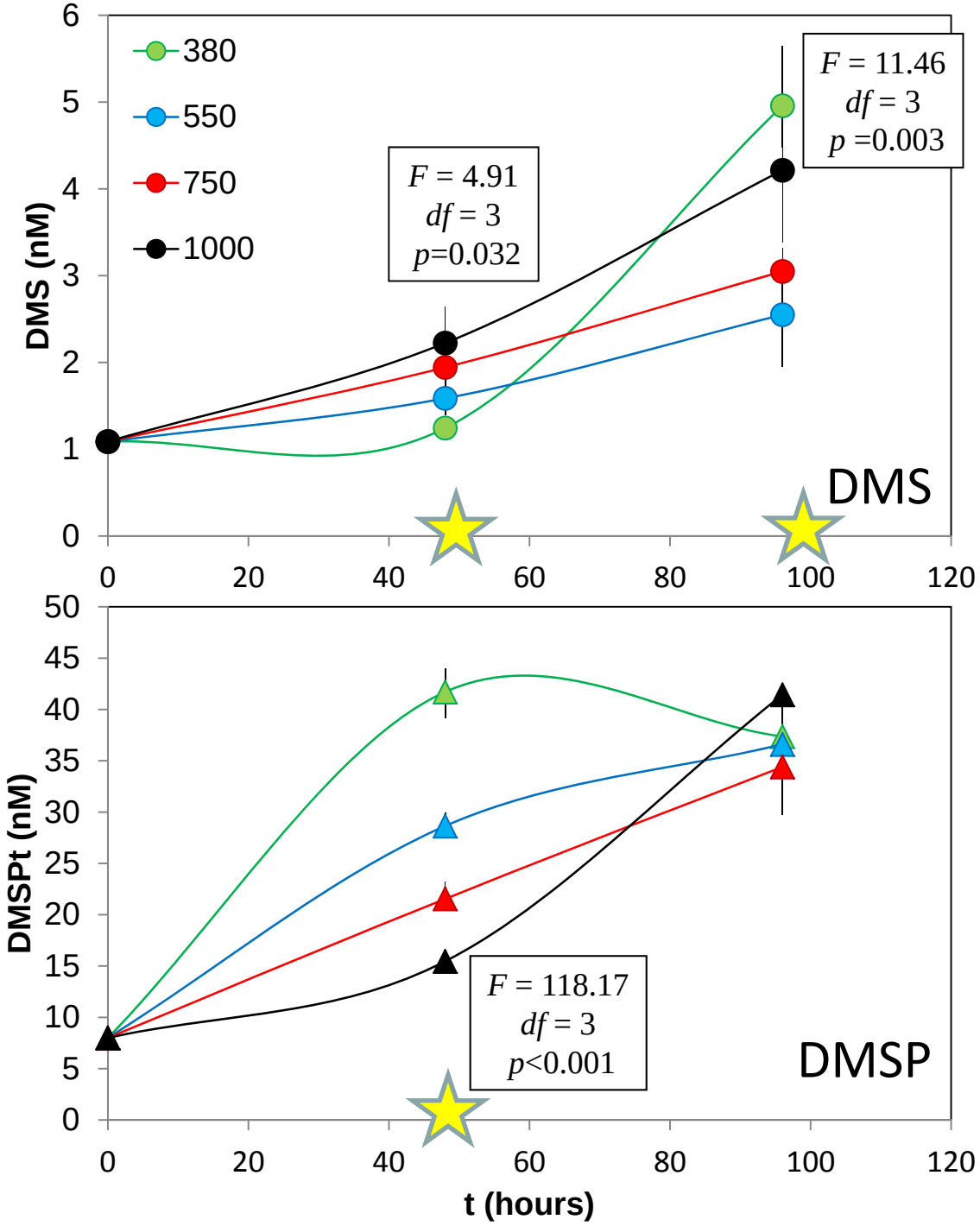
E02
Irish Sea
Mixed



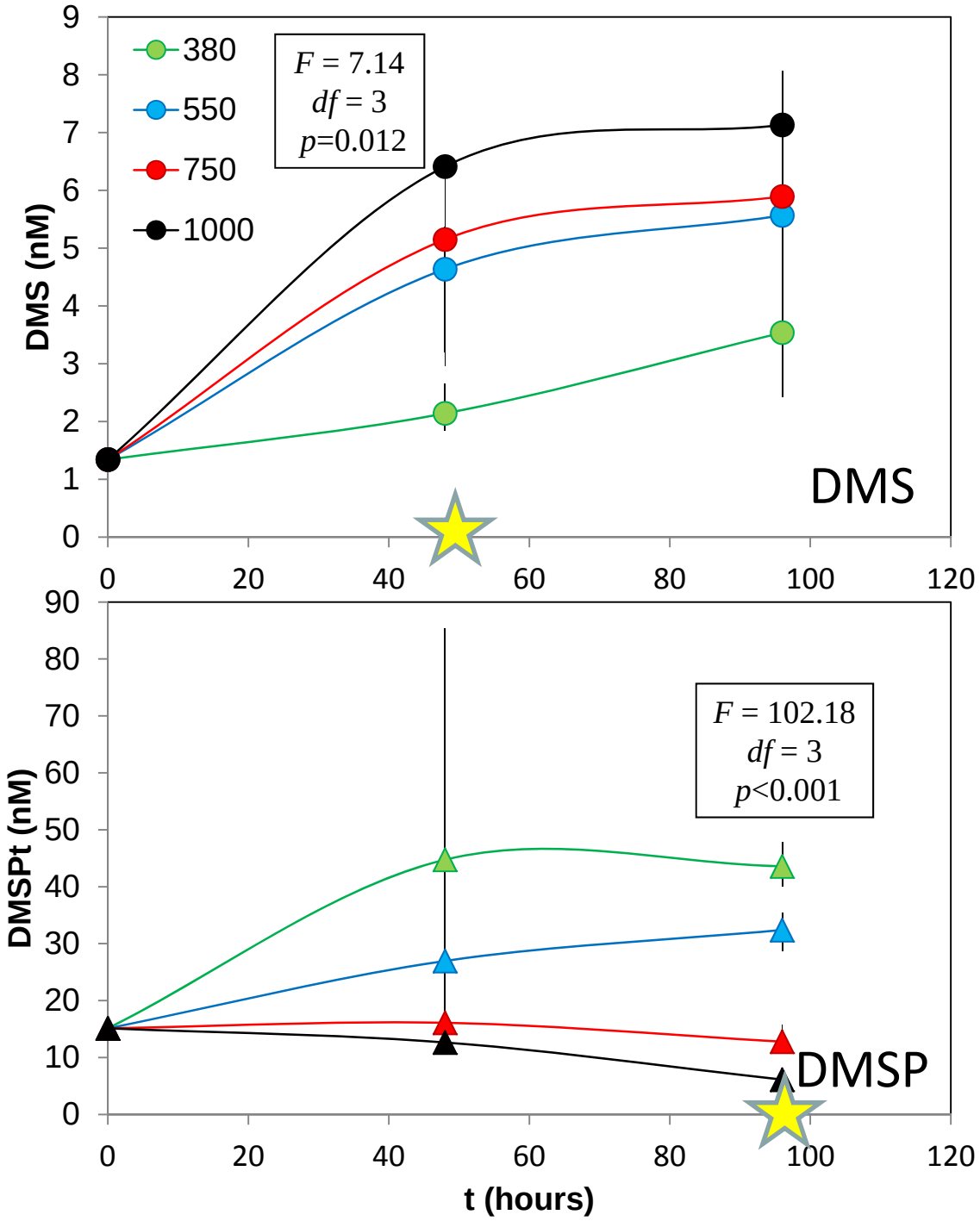
E03

Bay of Biscay

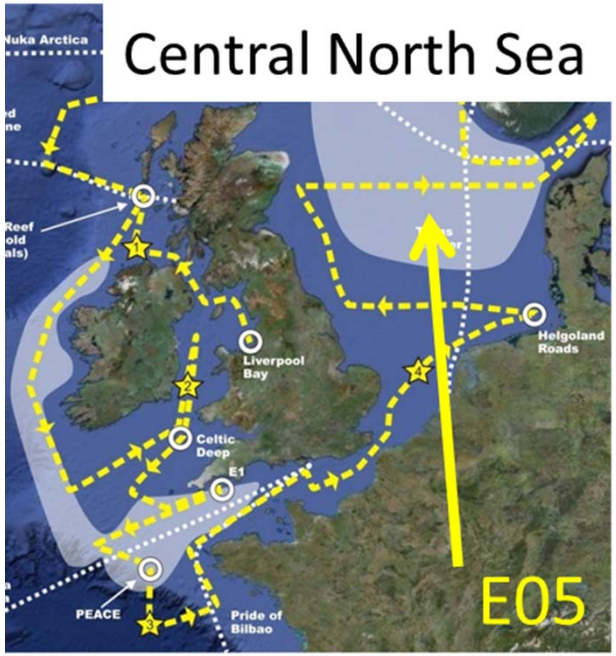
Stratified



E04
S North Sea
Mixed

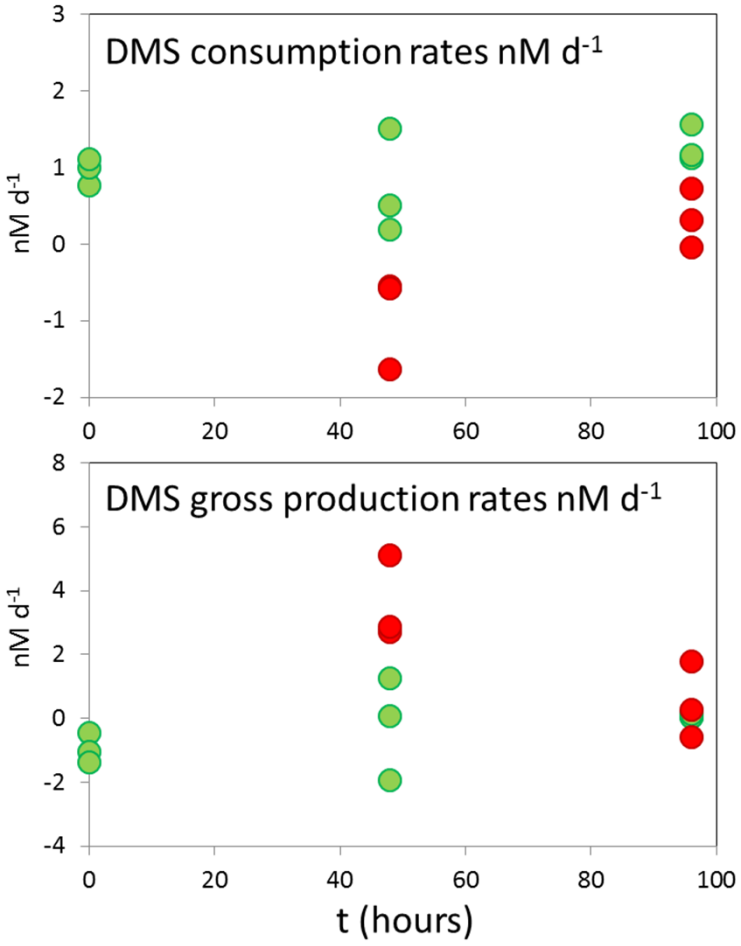


E05
C North Sea
Stratified



E05
C North Sea
Stratified

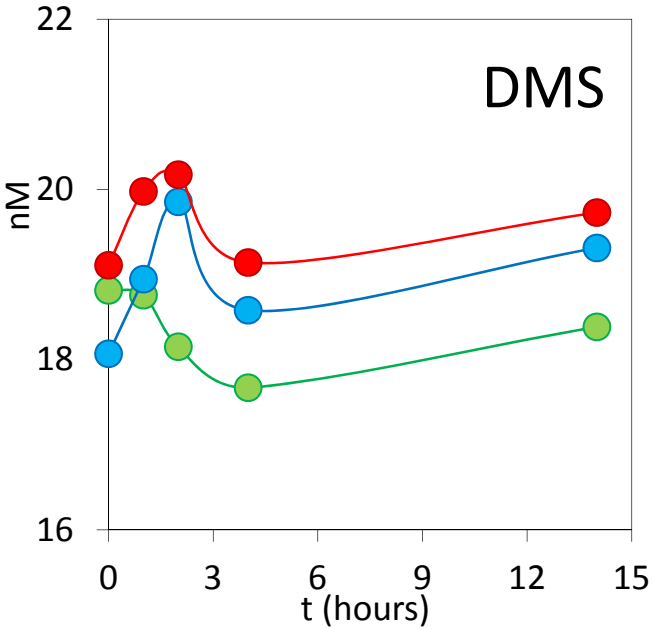
Standing stocks
DMS: 1000 > 750 > 550 > 380
DMSP: 380 > 550 > 750 > 1000

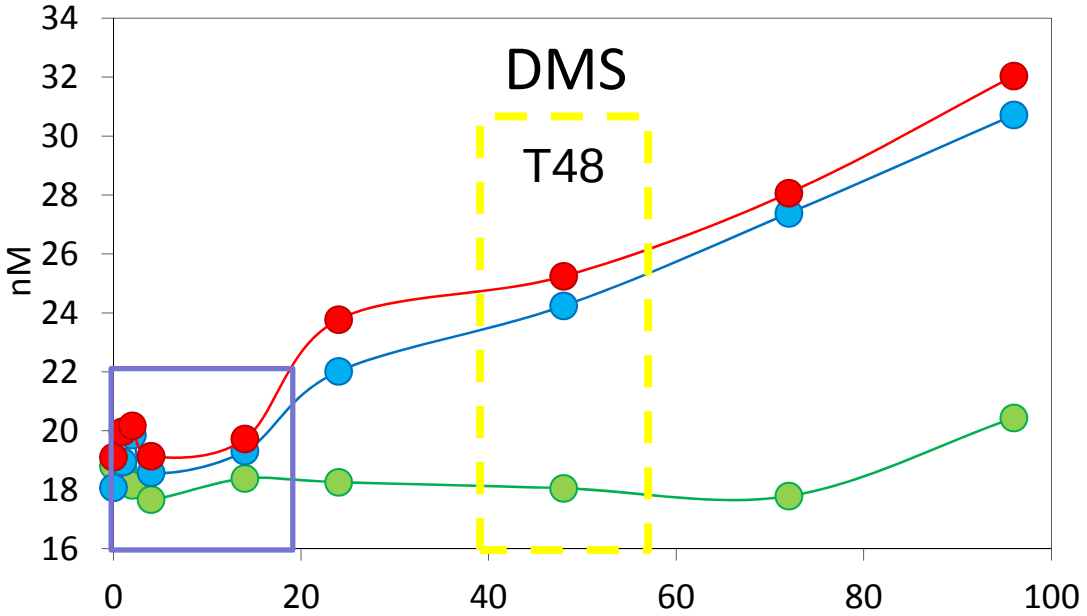


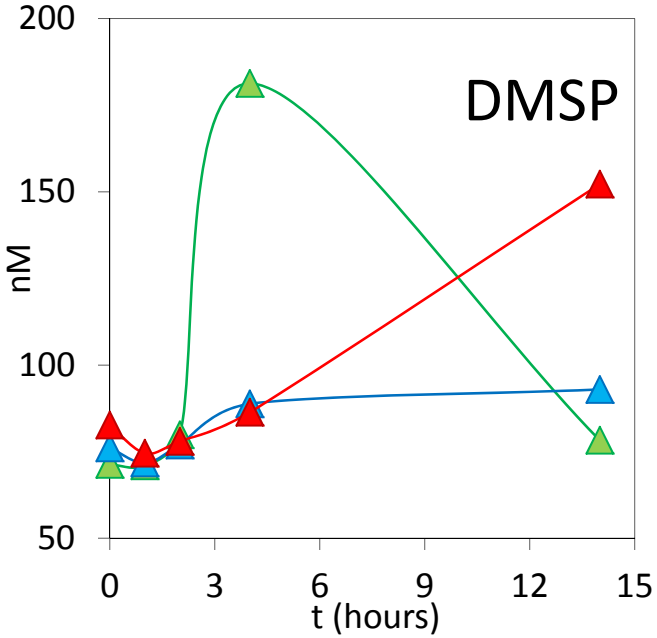
DMS consumption
380 > 750 = less DMS at 380?

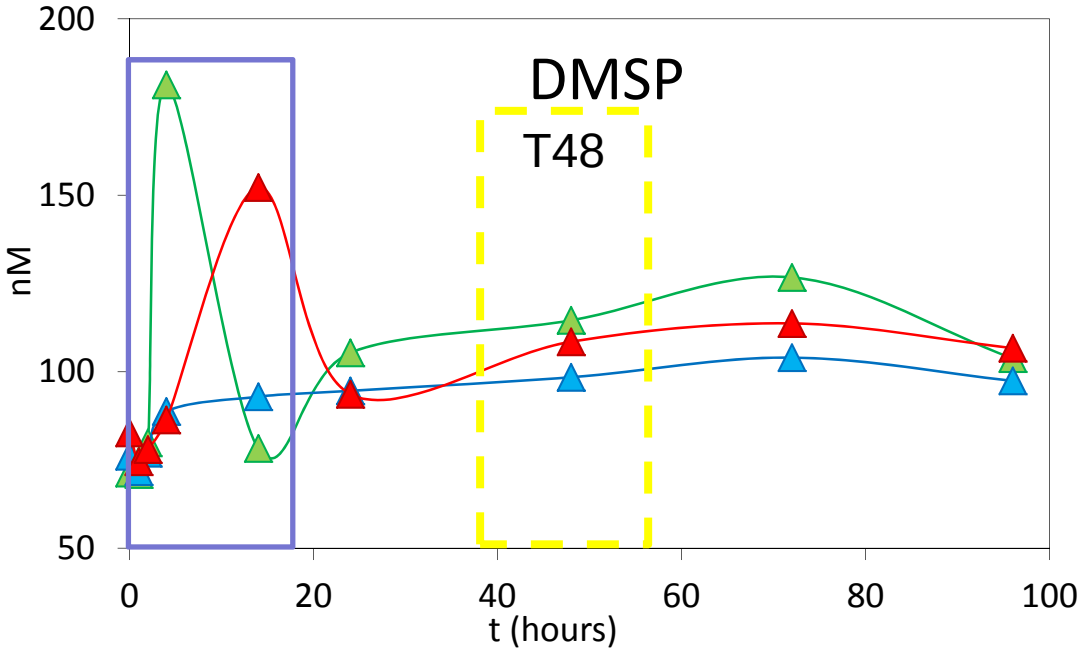
DMS gross production
750 > 380 = more DMS at 750?

E06: High Resolution Sampling: Rapid response to acidification







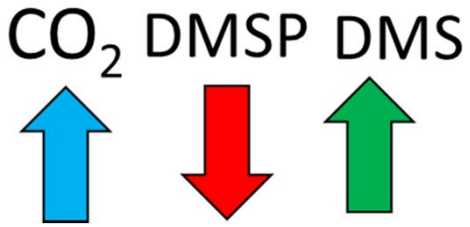


Effect of pCO_2 on DMS(P)?

Summary

Response of DMS(P) to OA on the NW European shelf: consistent

- DMS increases with increasing pCO_2
- DMSP (total and particulate) decreases with increasing pCO_2
- Opposite response to a number of previous mesocosm studies



- Response to acidification is rapid with sharp changes in concentration seen after 1 hour. But differences between treatment persist, and even increase, over the following 96h.
- Differences in rates of consumption/production of DMS between 380 and 750 may help to explain some of these differences in standing stocks (requires further investigation and method development)
- pCO_2 effects on DMSP synthesis rates? Results pending….
- Next step? Detailed examination of response of plankton community: links to DMS(P)

Thanks for listening