PML | Plymouth Marine Laboratory

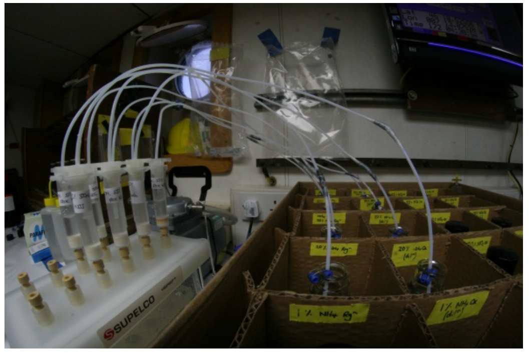
Marine Matters

Pelagic N-cycling during the UK-OA cruise D366

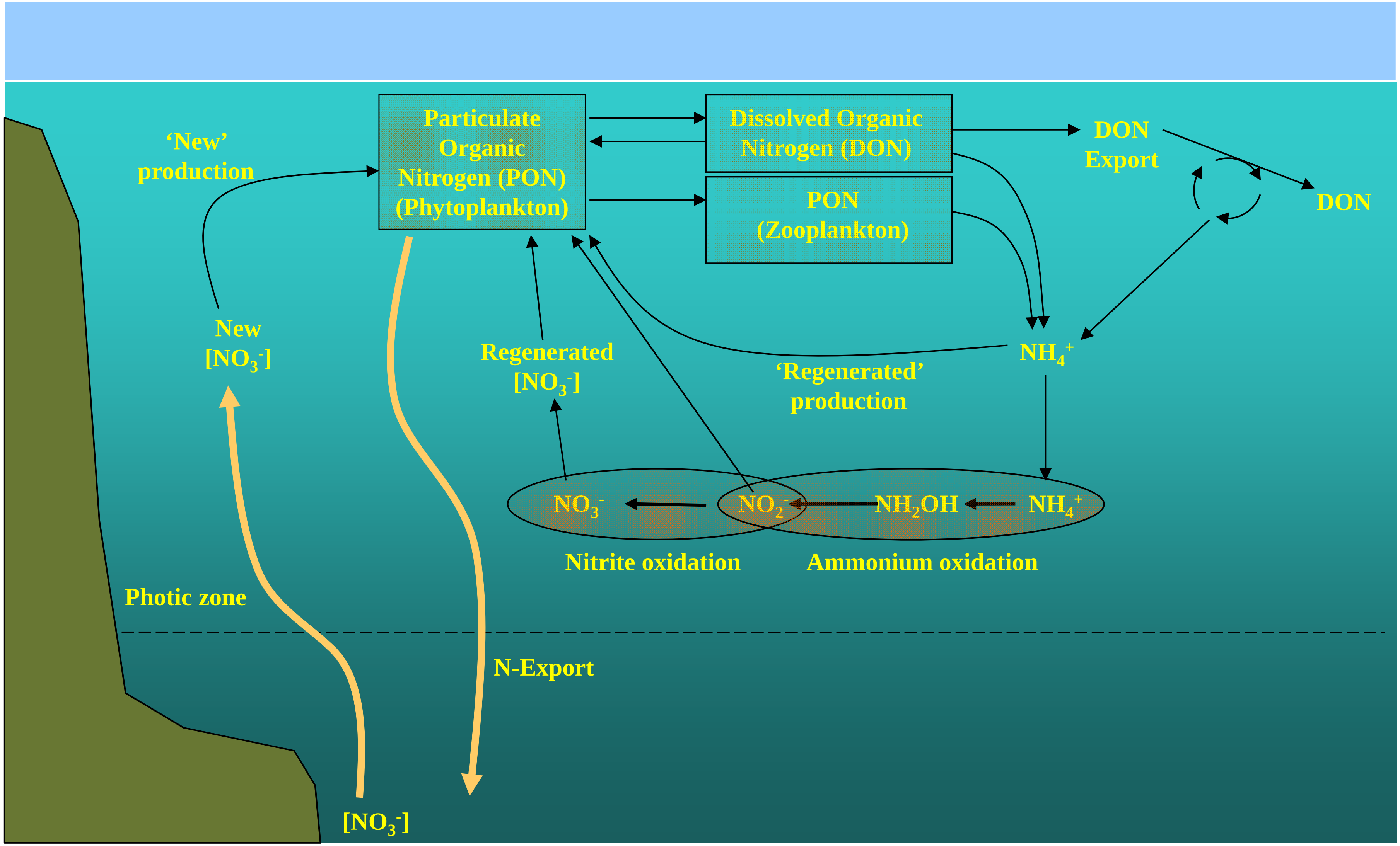
Darren Clark

To make measurements of N-cycle parameters;

1. In the surface ocean at stations around the UK
2. During OA array's



Overview of the pelagic N-cycle

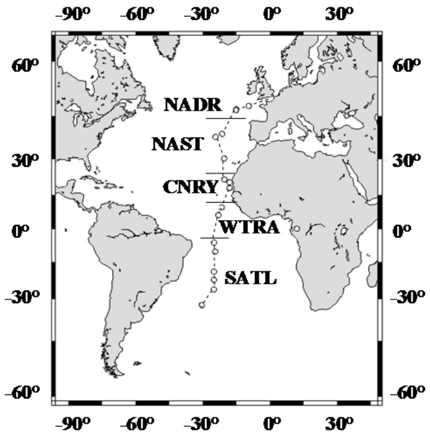


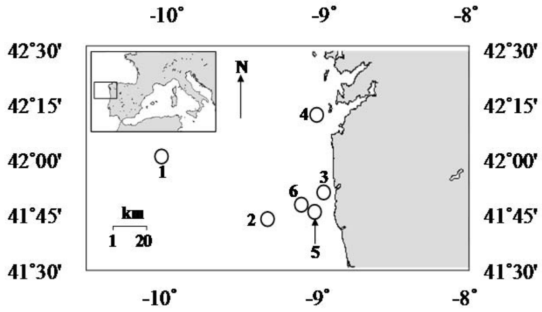
CTD casts at 11 stations in UK shelf seas. Samples taken at 55% sPAR.

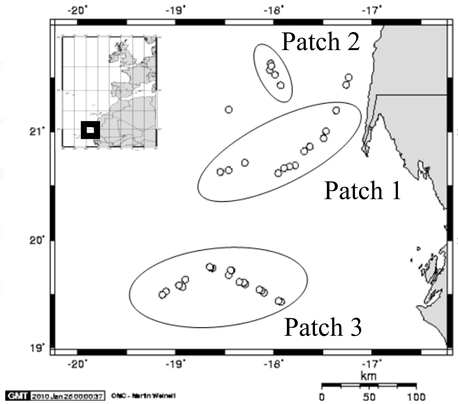
Parameter	Status
NH_4^+ assimilation (3 hour incubations)	Data available
NO_2^- assimilation (3 hour incubations)	Data available
NO_3^- assimilation (3 hour incubations)	Data available
[PON]	Data available
NH_4^+ regeneration	Data available
NH_4^+ oxidation	Data available
NO_2^- oxidation	Data available

OA arrays.

Parameter	Status
NH_4^+ assimilation (24 hour incubations)	Sample analysis underway
NO_2^- assimilation (24 hour incubations)	Sample analysis underway
NO_3^- assimilation (24 hour incubations)	Sample analysis underway
[PON]	PON analysis underway
NH_4^+ regeneration	Data available
NH_4^+ oxidation	Data available

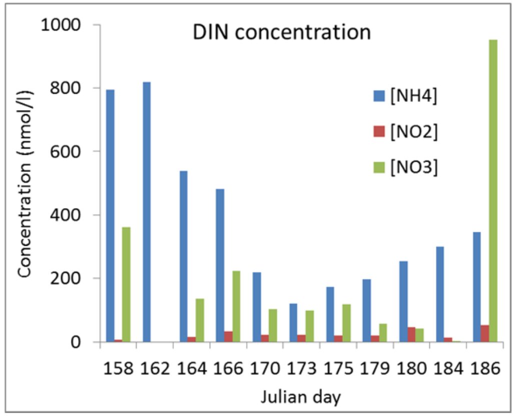


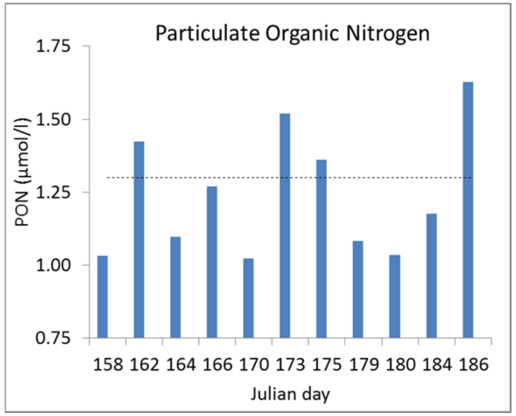


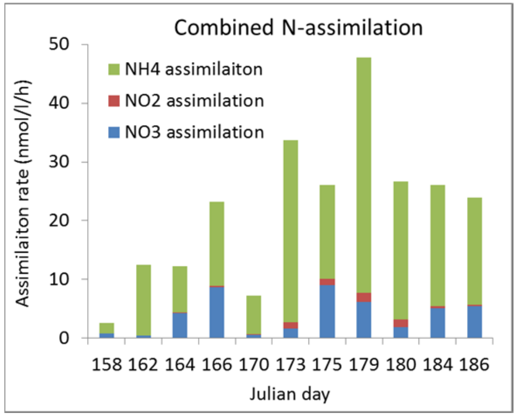


Comparison between N-cycle parameter values measured at 55% sPAR (≈ 5-15m) by GC/MS & IRMS methods (average in brackets).

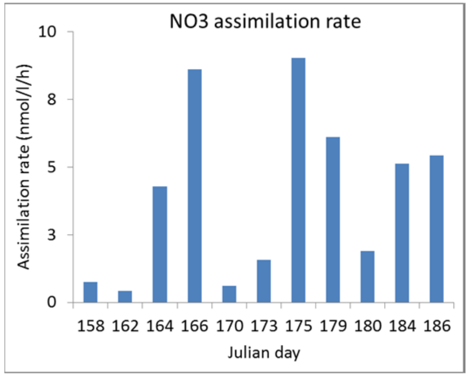
Parameter	N/S. Atlantic gyres	μ-layer	SOLAS-ICON	UKOA stations
NH_4^+ (μmnol l^{-1})	0.004 - 0.102	0.019 - 0.138	0.06 - 1.27	0.120 - 0.818
NO_2^-	0.001 - 0.052	0.001- 0.054	0.27 - 0.71	0.007 - 0.052
NO_3^-	0.001 - 0.187	0.001 - 0.714	4.52 - 12.75	0.042 - 0.953
PON (μmol l^{-1})	n.d	0.55 - 1.30	0.80 - 3.38	1.02 - 1.63
DIN assimilation (nmol l^{-1} h^{-1})				
ρNH_4^+	n.d	0.98 - 12.09 (6.1)	6.1 - 71.7 (24.6)	1.79 - 40.06 (17.46)
ρNO_2^-	n.d.	n.d.	n.d.	0.01 - 1.59 (0.61)
ρNO_3^-	n.d.	0.11 - 3.74 (0.7)	2.0 - 65.7 (18.2)	0.42 – 9.03 (3.99)
DIN regeneration rate (nmol l^{-1} h^{-1})				
NH_4^+ regeneration	0.38 - 3.31 (1.5)	0.09 - 2.52 (0.90)	9.02 - 143.32 (46.3)	3.50 - 14.6 (7.67)
NH_4^+ oxidation	0.03 - 0.40 (0.1)	0.03 - 3.74 (0.58)	0.30 - 9.71 (4.2)	0.01 - 1.85 (0.74)
NO_2^- oxidation	0.04 - 1.28 (0.5)	0.03 - 24.76 (2.24)	2.93 - 81.11 (31.8)	0.05 – 28.9 7 (6.15)

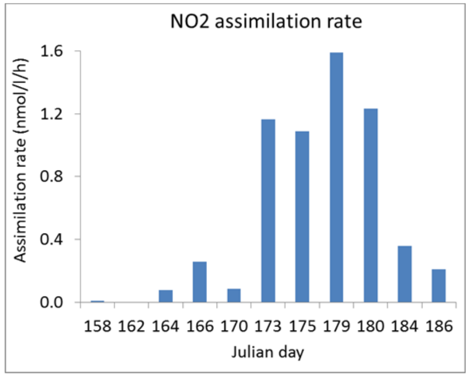


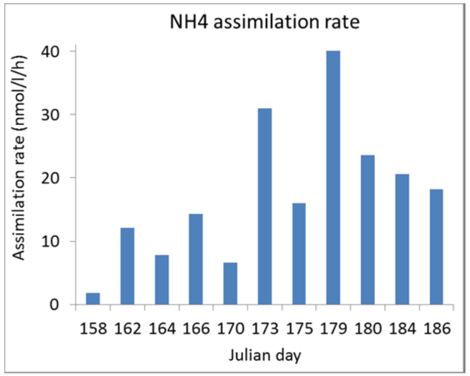


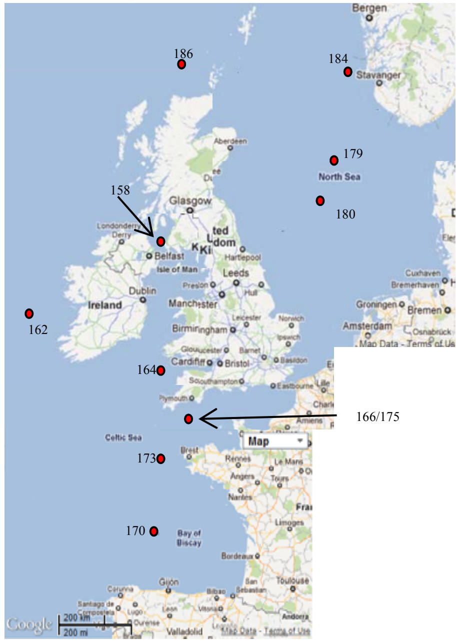


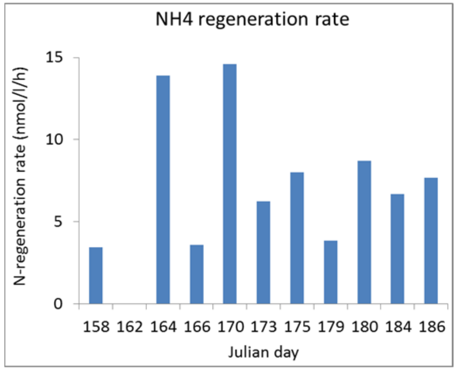
- DIN pool generally dominated by regenerated N (NH_4^+) in surface waters (55% sPAR) around UK.
- [PON] values at individual stations exceeded those measured in the Iberian upwelling.
- Contribution to cell-N dominated by NH_4^+ assimilation at all stations.
- NO_2^- assimilation rarely measured - contributed ≈ 5% to cell-N assimilation at individual stations (generally < 2%).

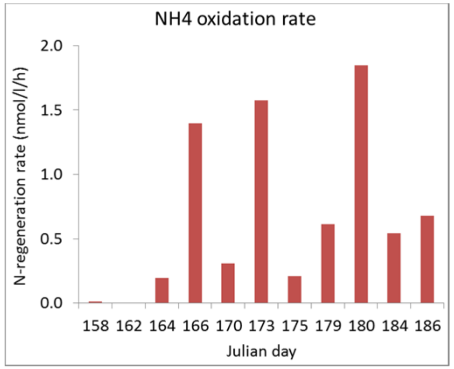


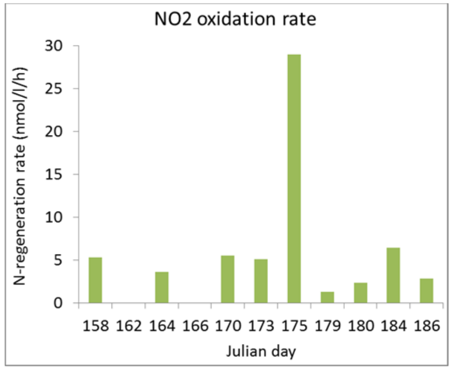


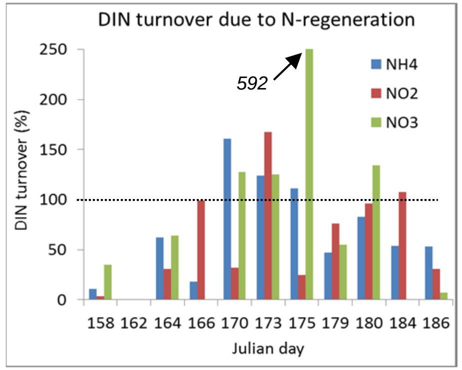




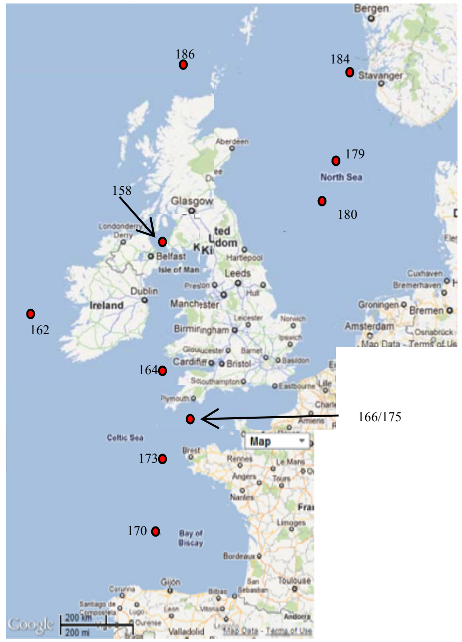


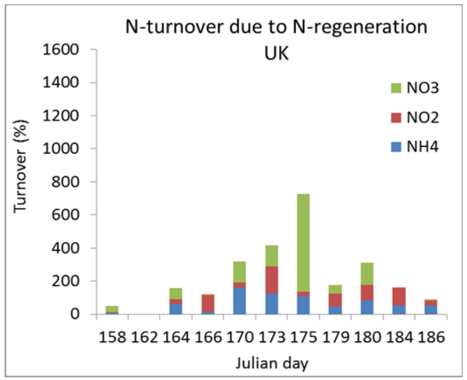


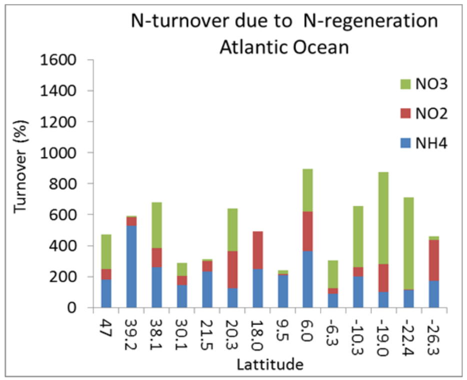


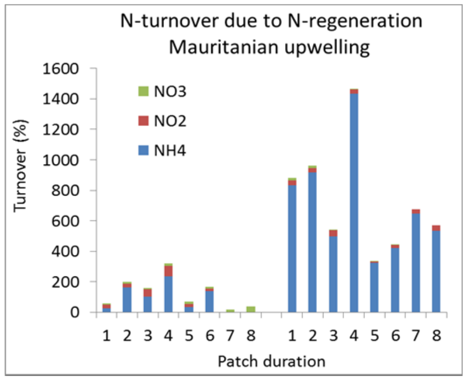


- N-regeneration measured in the surface ocean at stations around the UK.
- At many stations a substantial fraction of the DIN pool turned over within a day, exceeding 1 d^{-1} in the SW.
- The 'whole pool' turnover resembles that of the open ocean and contrasts with that of upwelling regions.









- This study aimed to investigate how OA conditions influenced NH_4^+ regeneration and nitrification.

- Previous OA related studies of NH_4^+ oxidation have all found that rates drop under OA conditions ($NH_4^+ \leftrightarrow NH_3$). However, studies have been conducted in a range of matrices including soil/sludge/sediment/seawater.

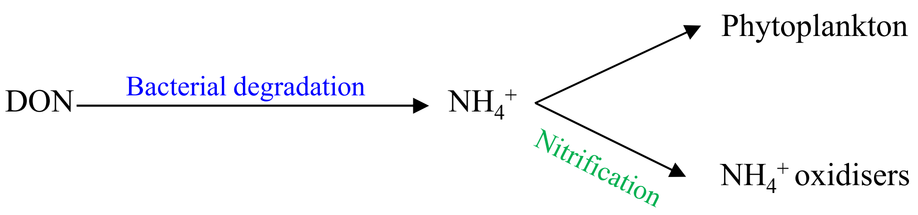
Study	Location & depths	Method	Comment
Huesemann et al 2002	Washington (Coastal Pacific). Samples from 0.5m and 160 m (photic and aphotic depths)	Metabolic inhibitors	i) NH_4^+ addition possibly 1000 times greater than ambient – substantial perturbation to the system. ii) Stimulation of NH_4^+ oxidation activity/potential rates measured?
Berman et al 2010	HOT/BATS/ALOHA. Samples from 45, 175, 240m (aphotic depths only)	^{15}N methods with trace additions	i) Strong evidence for drop in NH_4^+ oxidation rates from aphotic samples.

- This study may represent the first investigation of N-regeneration within the photic zone using trace additions of ^{15}N.

- Competition for NH_4^+ between phytoplankton and NH_4^+ oxidising organisms will be an important factor in the photic zone.

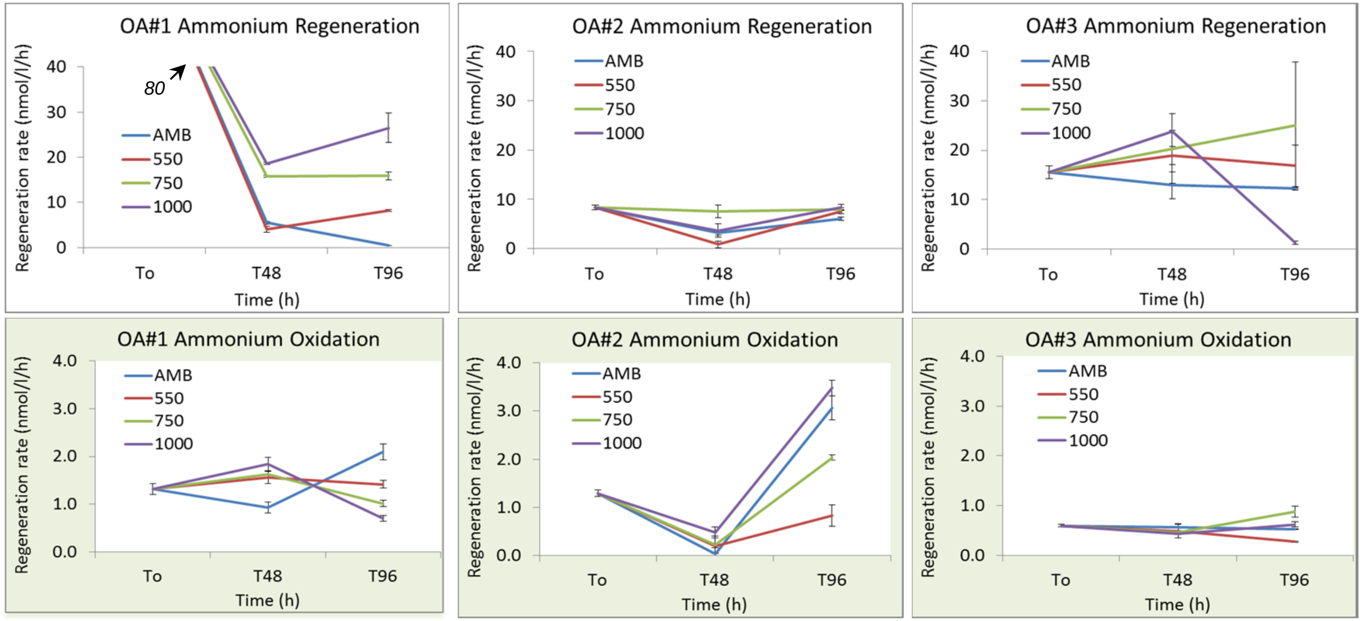
- How is the bacterial degradation of organic matter influenced by OA?

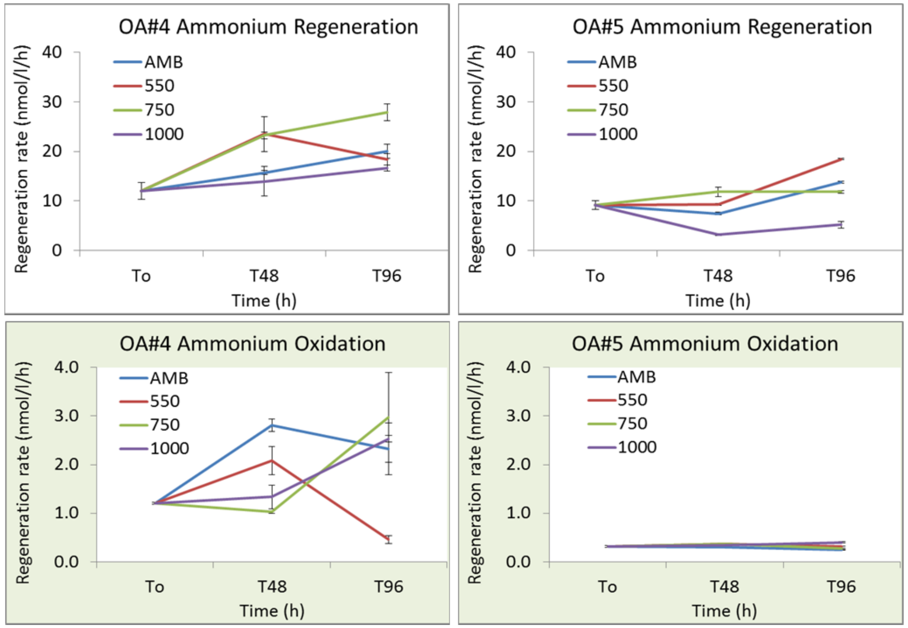
- A significant fraction of regenerated N enters the nitrification pathway - is this modified under OA conditions?



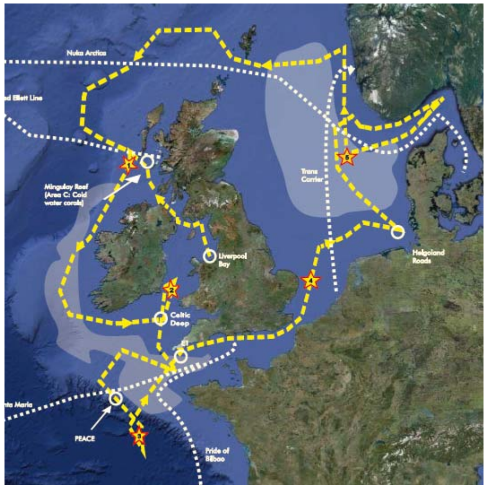
Fraction of NH_4^+ entering NH_4^+ oxidation pathway

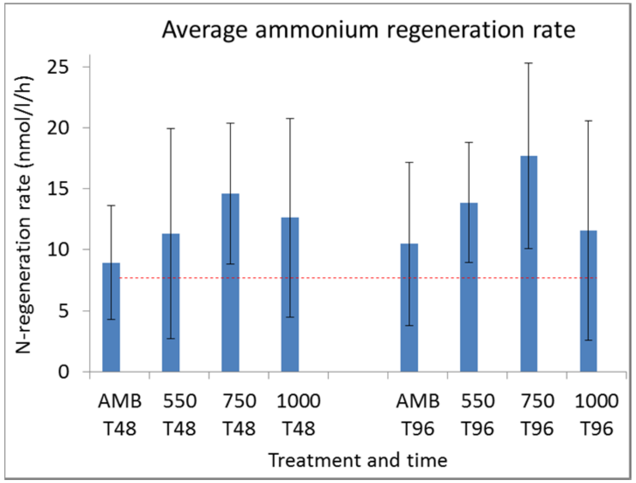
- 0.04-0.45 NW African upwelling
- 0.01-0.43 Iberian Peninsula
- 0.21-0.33 Monterey Bay (Ward 2005)
- 0.05-0.33 Monterey bay (Wankel et al 2007)
- 0.00-0.09 UK shelf seas
- ??? UK shelf sea under OA conditions

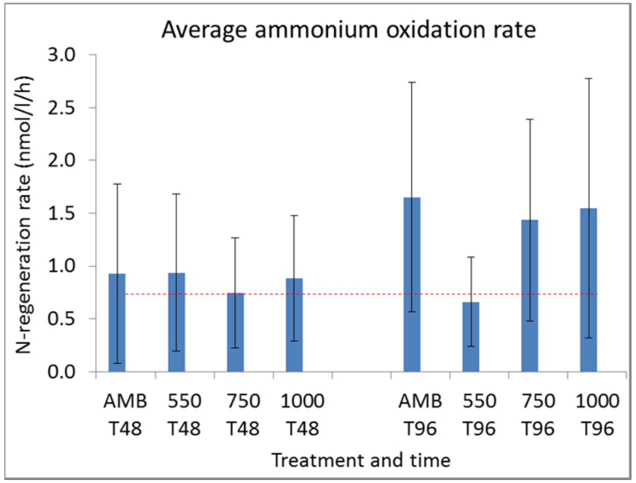


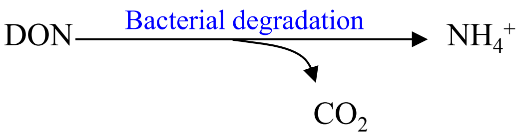


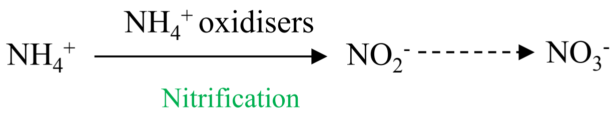
- Evident variability in rates and trends for both NH_4^+ regeneration and NH_4^+ oxidation











- Average rates for treatments highlight potential structure; sources of variability will include geographical location – further analysis may draw out significant trends.

- For NH_4^+ regeneration:

  - Results imply an increase in regeneration rates above the average measured for UK waters.

  - If this is found to be robust, results imply increased bacterial degradation of DOM pool and associated CO_2 release.

  - DIN pool concentration may increase, shifted further towards NH_4^+. Changes in phytoplankton community structure and productivity may be anticipated.

- For NH_4^+ oxidation:

  - No convincing trend. Nitrifying bacteria/archaea represent a small, slow growing fraction of the total population.

  - The fraction of NH_4^+ entering the nitrification pathway is yet to be determined – requires OA NH_4^+ assimilation data.

Conclusions

- Relatively active N –cycling takes place within the photic zone of the ‘present day’ UK shelf seas.
- Bacterial degradation of DOM and regeneration of NH_4^+ increased above UK average under OA conditions.
- The influence of OA upon nitrification is less clear.

Next steps

- Complete sample analysis to allow comprehensive data analysis to be undertaken.

Acknowledgments

- Officers, crew and scientists of D366
- Lisa Al-moosawi (PML) for IRMS analysis.