NEWSLETTER 2017 | 3

Sonderforschungsbereich 754

Climate – Biogeochemistry Interactions in the Tropical Ocean

SFB 754

Publications

Browning, T., E. P. Achterberg, J. C. Yong, I. Rapp, C. Utermann, A. Engel and C. M. Moore (2017) Iron limitation of microbial phosphorus acquisition in the tropical North Atlantic. Nat. Commun. 8, 15465, doi:10.1038/ncomms15465

In certain regions of the predominantly nitrogen limited ocean, microbes can become co-limited by phosphorus. Within such regions, a proportion of the dissolved organic phosphorus pool can be accessed by microbes employing a variety of alkaline phosphatase (APase) enzymes. In contrast to the PhoA family of APases that utilize zinc as a cofactor, the recent discovery of iron as a cofactor in the more widespread PhoX and PhoD implies the potential for a biochemically dependant interplay between oceanic zinc, iron and phosphorus cycles. Here enhanced natural community APase activity following iron amendment within the low zinc and moderately low iron Western North Atlantic is demonstrated. In contrast no evidence for trace metal limitation of APase activity beneath the Saharan dust plume in the Eastern Atlantic was found. Such intermittent iron limitation of microbial phosphorus acquisition provides an additional facet in the argument for iron controlling the coupling between oceanic nitrogen and phosphorus cycles.

Singh, A., L. T. Bach, T. Fischer, H. Hauss, R. Kiko, A. J. Paul, P. Stange, P. Vandromme and U. Riebesell (2017) Niche construction by non-diazotrophs for N_2 fixers in the eastern tropical North Atlantic Ocean. Geophys. Res. Lett. 44, doi:10.1002/2017GL074218

Diazotrophic dinitrogen (N_2) fixation contributes ~76% to “new” nitrogen inputs to the sunlit open ocean, but environmental factors determining N_2 fixation rates are not well constrained. Excess phosphate (phosphate–nitrate/16 > 0) and iron availability control N_2 fixation rates in the eastern tropical North Atlantic (ETNA), but it remains an open question how excess phosphate is generated within or supplied to the phosphate-depleted sunlit layer. The observations in the ETNA region (8°N–15°N, 19°W–23°W) suggest that Prochlorococcus and Synechococcus, the two ubiquitous non-diazotrophic cyanobacteria with cellular N:P ratios higher than the Redfield ratio, create an environment of excess phosphate, which cannot be explained by diapycnal mixing, atmospheric, and riverine inputs. Thus, this results unveil a new biogeochemical niche construction mechanism by non-diazotrophic cyanobacteria for their diazotrophic phylum group members (N_2 fixers). Observations may help to understand the prevalence of diazotrophy in low-phosphate, oligotrophic regions.

Shepherd, J. G., P. G. Brewer, A. Oschlies and A. J. Watson (2017) Ocean ventilation and deoxygenation in a warming world: introduction and overview. Philos. Trans. A Math. Phys. Eng. Sci. 375(2102), doi:10.1098/rsta.2017.0240

Changes of ocean ventilation rates and deoxygenation are two of the less obvious but important indirect impacts expected as a result of climate change on the oceans. They are expected to occur because of (i) the effects of increased stratification on ocean circulation and hence its ventilation, due to reduced upwelling, deep-water formation and turbulent mixing, (ii) reduced oxygenation through decreased oxygen solubility at higher surface temperature, and (iii) the effects of warming on biological production, respiration and remineralization. The potential socio-economic consequences of reduced oxygen levels on fisheries and ecosystems may be far-reaching and significant. At a Royal Society Discussion Meeting convened to discuss these matters, 12 oral presentations and 23 posters were presented, covering a wide range of the physical, chemical and biological aspects of the issue. Overall, it appears that there are still considerable discrepancies between the observations and model simulations of the relevant processes. The current understanding of both the causes and consequences of reduced oxygen in the ocean, and the ability to represent them in models are therefore inadequate, and the reasons for this remain unclear. It is too early to say whether or not the socio-economic consequences are likely to be serious. However, the consequences are ecologically, biogeochemically and climatically potentially very significant, and further research on these indirect impacts of climate change via reduced ventilation and oxygenation of the oceans should be accorded a high priority.This article is part of the themed issue 'Ocean ventilation and deoxygenation in a warming world'.

Oschlies, A., O. Duteil, J. Getzlaff, W. Koeve, A. Landolfi and S. Schmidtko (2017) Patterns of deoxygenation: sensitivity to natural and anthropogenic drivers. Philos. Trans. A Math. Phys. Eng. Sci. 375(2102), doi:10.1098/rsta.2016.0325

Observational estimates and numerical models both indicate a significant overall decline in marine oxygen levels over the past few decades. Spatial patterns of oxygen change, however, differ considerably between observed and modelled estimates. Particularly in the tropical thermocline that hosts open-ocean oxygen minimum zones, observations indicate a general oxygen decline, whereas most of the state-of-the-art models simulate increasing oxygen levels. Possible reasons for the apparent model-data discrepancies are examined. In order to attribute observed historical variations in oxygen levels, mechanisms of changes in oxygen supply and consumption with sensitivity model simulations are studied here. Specifically, the role of equatorial jets, of lateral and diapycnal mixing processes, of changes in the wind-driven circulation and atmospheric nutrient supply, and of some poorly constrained biogeochemical processes are investigated. Predominantly wind-driven changes in the low-latitude oceanic ventilation are identified as a possible factor contributing to observed oxygen changes in the low-latitude thermocline during the past decades, while the potential role of biogeochemical processes remains difficult to constrain. Implications for the attribution of observed oxygen changes to anthropogenic impacts and research priorities that may help to improve the mechanistic understanding of oxygen changes and the quality of projections into a changing future are discussed. This article is part of the themed issue 'Ocean ventilation and deoxygenation in a warming world'.

Erdem, Z. and J. Schönfeld (2017) Pleistocene to Holocene benthic foraminiferal assemblages from the Peruvian continental margin. Palaeontol. Electron. 20(2), 35A, 1-32

The benthic foraminiferal inventory and their assemblage composition was documented along five sediment cores from the Peruvian margin between 3°S and 18°S at water depths of 500 to 1250 m, covering the lower boundary of today's OMZ. Emphasis was given to certain time intervals during the last 22 thousand years when different climatic and oceanographic conditions prevailed than today. In total three agglutinated and 186 calcareous species were recognised. Bolivina costata, Bolivinita minuta, Cassidulina delicata and Epistominella exigua were most abundant. The foraminiferal distributions revealed a marked change in assemblage composition particularly at the deeper cores during and after the deglaciation. The diversity declined and Bolivina species became dominant. These changes took place gradually over several millennia, and high-frequency fluctuations were not recorded. This pattern provides evidence for rather stable ecological conditions and sluggish changes in bottom water circulation during the last deglaciation.

Scholz, F., C. Siebert, A. W. Dale and M. Frank (2017) Intense molybdenum accumulation in sediments underneath a nitrogenous water column and implications for the reconstruction of paleo-redox conditions based on molybdenum isotopes. Geochim. Cosmochim. Acta 213, 400-417, doi:10.1016/j.gca.2017.06.048

The concentration and isotope composition of molybdenum (Mo) in sediments and sedimentary rocks are widely used proxies for anoxic conditions in the water column of paleo-marine systems. While the mechanisms leading to Mo fixation in modern restricted basins with anoxic and sulfidic (euxinic) conditions are reasonably well constrained, few studies have focused on Mo cycling in the context of open-marine anoxia. Here Mo data for water column particulate matter, modern surface sediments and a paleo-record covering the last 140,000 years from the Peruvian continental margin is presented. Mo concentrations in late Holocene and Eemian (penultimate interglacial) shelf sediments off Peru range from ~70 to 100 µg g^{-1}, an extent of Mo enrichment that is thought to be indicative of (and limited to) euxinic systems. To investigate if this putative anomaly could be related to the occasional occurrence of sulfidic conditions in the water column overlying the Peruvian shelf, trace metal (Mo, vanadium, uranium) enrichments in particulate matter from oxic, nitrate-reducing (nitrogenous) and sulfidic water masses were compared. Coincident enrichments of iron (Fe) (oxyhydr) oxides and Mo in the nitrogenous water column as well as co-variation of dissolved Fe and Mo in the sediment pore water suggest that Mo is delivered to the sediment surface by Fe (oxyhydr)oxides. Most of these precipitate in the anoxic-nitrogenous water column due to oxidation of sediment-derived dissolved Fe with nitrate as a terminal electron acceptor. Upon reductive dissolution in the surface sediment, a fraction of the Fe and Mo is re-precipitated through interaction with pore water sulfide. The Fe- and nitrate-dependent mechanism of Mo accumulation proposed here is supported by the sedimentary Mo isotope composition, which is consistent with Mo adsorption onto Fe (oxyhydr)oxides. Trace metal co-variation patterns as well as Mo and nitrogen isotope systematics suggest that the same mechanism of Mo delivery caused the 'anomalously' high interglacial Mo accumulation rates in the paleo-record. The findings suggest that Fe- and nitrate-dependent Mo shuttling under nitrogenous conditions needs to be considered a possible reason for sedimentary Mo enrichments during past periods of widespread anoxia in the open ocean.

Hopwood, M. J., A. J. Birchill, M. Gledhill, E. P. Achterberg, J. K. Klar and A. Milne (2017) A Comparison between Four Analytical Methods for the Measurement of Fe(II) at Nanomolar Concentrations in Coastal Seawater. Front. Mar. Sci. 4(192), doi:10.3389/fmars.2017.00192

Dissolved Fe(II) in seawater is an important micronutrient for microbial organisms, but its analysis is challenging due to its transient nature. In a series of experiments, where Fe(II) spikes were added to manipulated seawaters, the observed Fe(II) concentrations from four analytical methods were compared: spectrophotometry with ferrozine, stripping voltammetry, and flow injection analysis using luminol (with, and without, a pre-concentration column). Comparisons between the different methods were undertaken from the derived oxidation rate constant (k1). Whilst the two luminol based methods produced the most similar concentrations throughout, k1 was still subject to a 20–30% discrepancy between them. Contributing factors may have included uncertainty in the calibration curves, and different responses to interferences from Co(II) and DOC. k1 derived from ferrozine observed Fe(II) concentrations was 3–80%, and 4–16%, of that derived from luminol observed Fe(II) with, and without, preconcentration respectively. The poorest comparability of k1 was found after humic/fulvic material was added to raise DOC to 120 µM. A luminol method without pre-concentration then observed Fe(II) to fall below the detection limit (<0.49 nM) within 10 min of a 17 nM Fe(II) spike addition, yet other methods still observed Fe(II) concentrations of 2.7 to 3.7 nM 30 min later. k1 also diverged accordingly with the ferrozine derived value 4% of that derived from luminol without pre-concentration. These apparent inconsistencies suggest that some inter-dataset differences in measured Fe(II) oxidation rates may be attributable to differences in the analytical methods used rather than arising from shifts in Fe(II) speciation.

News

FLORIAN SCHÜTTE

SFB 754 postdoc (A5) was honored with the KOMPASS price for innovative research for his investigations on mesoscale eddies in the Eastern Tropical North Atlantic at the 8th Maritime Summer Meeting in Kiel

Conferences

5TH INT. CONFERENCE ON OCEANOGRAPHY & MARINE BIOLOGY
18 – 20 October 2017, Seoul (South Korea)

PIRATA-PREFACE-TAV MEETING
5 – 10 November 2017, Fortaleza (Brazil)

INTERNATIONAL WORKSHOP ON MARINE & ATMOSPHERIC SCIENCES IN WEST AFRICA
13 – 17 November 2017, Mindelo (Cabo Verde)

AGU FALL MEETING 2017
11 – 15 December 2017, New Orleans (USA)

2018 OCEAN SCIENCES MEETING
11 – 16 February 2018, Portland, Oregon (USA)

PICES 4TH INTERNATIONAL SYMPOSIUM
4 – 8 June 2018, Washington DC (USA)

SFB 754 INTERNATIONAL CONFERENCE
3 – 7 September 2018, Kiel (Germany)

SFB 754 Intern

SFB 754 WORKSHOP ON CRUISE DATA 2016 - 2019
20th November 2017

SFB 754 EARLY CAREER SCIENTISTS RETREAT
21 – 23 November 2017, *Gutshaus Parin*