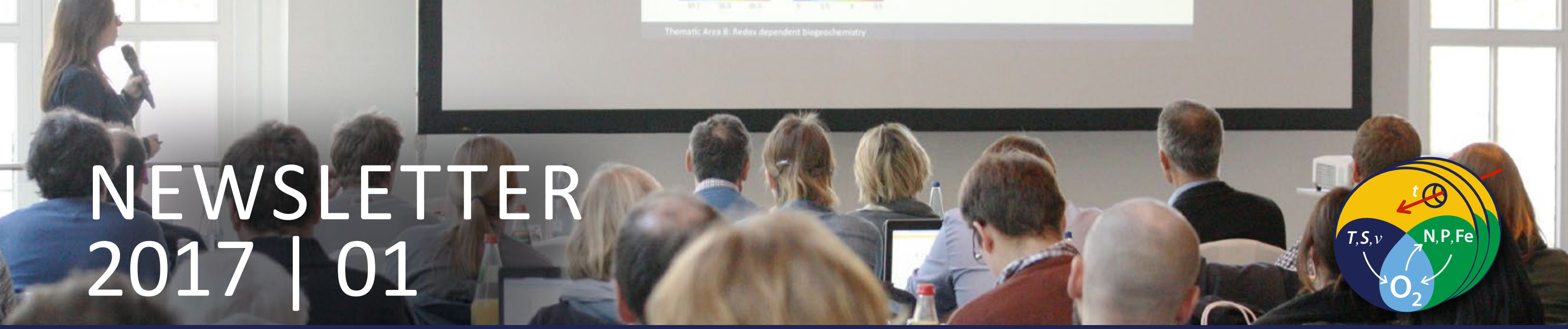

NEWSLETTER 2017 | 01

Sonderforschungsbereich 754

Climate – Biogeochemistry Interactions in the Tropical Ocean

SFB 754

Publications

Callbeck, C. M., G. Lavik, L. Stramma, M. M. M. Kuypers and L. A. Bristow (2017) Enhanced nitrogen loss by eddy-induced vertical transport in the offshore peruvian oxygen minimum zone. PLoS ONE 12(1), e0170059, doi: 10.1371/journal.pone.0170059

The eastern tropical South Pacific (ETSP) upwelling region is one of the ocean's largest sinks of fixed nitrogen. How nitrogen loss and primary production are regulated in the offshore ETSP region where coastal upwelling is less influential remains unclear. Here the impact of mesoscale eddies on anammox and denitrification activity using ^{15}N-labelled in situ incubation experiments is investigated. Anammox was shown to be the dominant nitrogen loss process, but varied across the eddy, whereas denitrification was below detection at all stations. Anammox rates at the eddy periphery were greater than at the center. Similarly, depth-integrated chlorophyll paralleled anammox activity, increasing at the periphery relative to the eddy center; suggestive of enhanced organic matter export along the periphery supporting nitrogen loss. This can be attributed to enhanced vertical nutrient transport caused by an eddy-driven submesoscale mechanism operating at the eddy periphery. In the ETSP region, the widespread distribution of eddies and the large heterogeneity observed in anammox rates from a compilation of stations suggests that eddy-driven vertical nutrient transport may regulate offshore primary production and thereby nitrogen loss.

Claus, M., R. J. Greatbatch, P. Brandt and J. M. Toole (2016) Forcing of the atlantic equatorial deep jets derived from observations. J. Phys. Oceanogr. 46(12), 3549-3562, doi: 10.1175/JPO-D-16-0140.1

The equatorial deep jets (EDJs) are a ubiquitous feature of the equatorial oceans; in the Atlantic Ocean, they are the dominant mode of interannual variability of the zonal flow at intermediate depth. On the basis of more than 10 years of moored observations of zonal velocity at 23°W, the vertically propagating EDJs are best described as superimposed oscillations of the 13th to the 23rd baroclinic modes with a dominant oscillation period for all modes of 1650 days. This period is close to the resonance period of the respective gravest equatorial basin mode for the dominant vertical modes 16 and 17. It is argued that since the equatorial basin mode is composed of linear equatorial waves, a linear reduced-gravity model can be employed for each baroclinic mode, driven by spatially homogeneous zonal forcing oscillating with the EDJ period. The fit of the model solutions to observations at 23°W yields a basinwide reconstruction of the EDJs and the associated vertical structure of their forcing. From the resulting vertical profile of mean power input and vertical energy flux on the equator, it follows that the EDJs are locally maintained over a considerable depth range, from 500 to 2500 m, with the maximum power input and vertical energy flux at 1300 m. The strong dissipation closely ties the apparent vertical propagation of energy to the vertical distribution of power input and, together with the EDJs' prevailing downward phase propagation, requires the phase of the forcing of the EDJs to propagate downward.

Dale, A. W., M. Graco and K. Wallmann (2017) Strong and dynamic benthic-pelagic coupling and feedbacks in a coastal upwelling system (Peruvian shelf). Front. Mar. Sci. 4, doi: 10.3389/fmars.2017.00029

Monthly time-series data (1998–2009) of bottom water oxygen, nitrate and nitrite concentrations from the outer shelf (150 m water depth) in the OMZ offshore Peru were coupled to a layered biogeochemical sediment model to investigate benthic-pelagic coupling over multi-annual time scales. The model includes the mineralization of four reactive pools of particulate organic carbon (POC) with lifetimes of 0.13, 1.3, 20, and 1700 year that were constrained using empirical data. Total POC rain rates to the seafloor were derived from satellite based estimates of primary production. Solute fluxes and concentrations in sediment porewater showed highly dynamic behavior over the course of a typical year. Fixed N loss across the whole time-series agreed very well with a previously-published vertically-integrated sediment model for coupling the benthic and pelagic N cycle in regional and global models. Dissimilatory nitrate reduction to ammonium (DNRA) emerges as a major process in the benthic N cycle, more than twice the rate of ammonification of organic nitrogen. The model predicts sulfide emissions from the sediment, in agreement with past observations of benthic sulfide fluxes and sulfide plume distributions in the water column. This study demonstrates that sediments on the Peruvian shelf are not static repositories that are independent of changes taking place in the water column. The results strongly suggest the shelf sediments must exert an important feedback on biogeochemical processes in the overlying waters, and should be considered in regional model studies.

Doering, K., Z. Erdem, C. Ehlert, S. Fleury, M. Frank and R. Schneider (2016) Changes in diatom productivity and upwelling intensity off Peru since the Last Glacial Maximum: Response to basin-scale atmospheric and oceanic forcing. Paleoceanography 31(10), 1453–1473, doi: 10.1002/2016PA002936

New records of stable silicon isotope signatures (δ^{30}Si) together with concentrations of biogenic opal and organic carbon from the central (9°S) and northern (5°S) Peruvian margin reveal changes in diatom productivity and nutrient utilization during the past 20,000 years. The findings are based on a new approach using the difference between the δ^{30}Si signatures of small (11-32 µm) and large (>150 µm) diatom fractions ($\Delta^{30}Si_{coscino\text{-}bSi}$) in combination with the variance in diatom assemblages for reconstruction of past upwelling intensity. The southern upwelling area off Peru shows a general decoupling of the environmental conditions mainly caused by a northward shift of the main upwelling cell from its modern position at 12-15°S towards 9°S during Termination 1. At this time only moderate upwelling intensity and productivity levels prevailed between 9°S and 12°S due to a more northerly position of Southern Westerly Winds and the South Pacific Subtropical High. Furthermore, a marked decrease in productivity during Heinrich Stadial 1 coincided with enhanced biogenic opal production in the Eastern Equatorial Pacific, which was induced by a southward shift of the Intertropical Convergence zone and enhanced northeasterly trade winds. Modern conditions were only established at the onset of the Holocene.

Hopwood, M. J., I. Rapp, C. Schlosser and E. P. Achterberg (2017) Hydrogen peroxide in deep waters from the Mediterranean Sea, South Atlantic and South Pacific Oceans. Sci. Rep. 7(43436), doi: 10.1038/srep43436

Hydrogen peroxide (H_2O_2) is present ubiquitously in marine surface waters where it is a reactive intermediate in the cycling of many trace elements. Photochemical processes are considered the dominant natural H_2O_2 source, yet cannot explain nanomolar H_2O_2 concentrations below the photic zone. Here the concentration of H_2O_2 in full depth profiles across three ocean basins is determined (Mediterranean Sea, South Atlantic and South Pacific Oceans) and the contribution of interfering species to 'apparent H_2O_2', as analysed by the luminol based chemiluminescence technique assessed. Within the vicinity of coastal OMZs, accurate measurement of H_2O_2 was not possible due to interference from Fe(II). Offshore, in deep (>1000 m) waters H_2O_2 concentrations ranged from 0.25 ± 0.27 nM (Mediterranean, Balearics-Algeria) to 2.9 ± 2.2 nM (Mediterranean, Corsica-France). This indicates that a dark, pelagic H_2O_2 production mechanism must occur throughout the ocean. A bacterial source of H_2O_2 is the most likely origin and likely sufficient to account for all of the observed H_2O_2 in the deep ocean.

Meyer, J., C. R. Löscher, G. Lavik and U. Riebesell (2017) Mechanisms of P* Reduction in the Eastern Tropical South Pacific. Front. Mar. Sci. 19, doi: 10.3389/fmars.2017.00001

Water masses influenced by OMZs feature low inorganic nitrogen (N) to phosphorus (P) ratios. The surplus of P over N is thought to favor non-Redfield primary production by bloom-forming phytoplankton species. Additionally, excess phosphate (P*) is thought to provide a niche for nitrogen fixing organisms. In order to assess the effect of low inorganic nutrient ratios on the stoichiometry and composition of primary producers, biogeochemical measurements were carried out in 2012 during a research cruise in the eastern tropical South Pacific (ETSP). Based on pigment analyses, a succession of different phytoplankton functional groups was observed along onshore—offshore transects with diatoms dominating the productive upwelling region, and prymnesiophytes, cryptophytes, and Synechococcus prevailing in the oligotrophic open ocean. Although inorganic nutrient supply ratios were below Redfield proportions throughout the sampling area, the stoichiometry of particulate organic nitrogen to phosphorus (PON:POP) generally exceeded ratios of 16:1. Despite PON:POP ≥ 16, high P*-values in the surface layer (0–50 m) above the shelf rapidly decreased as water masses were advected offshore. There are three mechanisms which can explain these observations: (1) non-Redfield primary production, where the excess phosphorus in the biomass is directly released as dissolved organic phosphorus (DOP), (2) non-Redfield primary production, which is masked by a particulate organic matter pool mainly consisting of P-depleted detrital biomass, and/or (3) Redfield primary production combined with N_2 fixation. The observations suggest that the three processes occur simultaneously in the study area; quantifying the relative importance of each of these mechanisms needs further investigation. Therefore, it remains uncertain whether the ETSP is a net sink for bioavailable N or whether the N-deficit in this area is replenished locally.

Schütte, F., J. Karstensen, G. Krahmann, H. Hauss, B. Fiedler, P. Brandt, M. Visbeck and A. Körtzinger (2016) Characterization of "dead-zone" eddies in the eastern tropical North Atlantic. Biogeosciences 13, 5865-5881, doi: 10.5194/bg-13-5865-2016

Localized open-ocean low-oxygen "dead zones" in the eastern tropical North Atlantic (ETNA) are recently discovered ocean features that can develop in dynamically isolated water masses within cyclonic eddies (CE) and anticyclonic modewater eddies (ACME). Analysis of a comprehensive oxygen dataset reveals that "dead-zone" eddies are found in surprisingly high numbers and in a large area from about 4 to 22°N, from the shelf at the eastern boundary to 38°W. In total, 173 profiles with oxygen concentrations below the minimum background concentration (40 µmol kg^{-1}) could be associated with 27 independent eddies. Lowest oxygen concentrations in CEs are less than 10µmol kg^{-1} while in ACMEs even suboxic (<1 µmol kg^{-1}) levels are observed. North of 12°N, the oxygen-depleted eddies carry anomalously low-salinity water into the open ocean, pointing to an eddy generation near the eastern boundary. In contrast, the oxygen-depleted eddies south of 12°N carry weak hydrographic anomalies in their cores and seem to be generated in the open ocean. In both regions a decrease in oxygen from east to west is identified supporting the enroute creation of the low-oxygen core through a combination of high productivity in the eddy surface waters and an isolation of the eddy cores with respect to lateral oxygen supply. The low-oxygen core depth in the eddies aligns with the depth of the shallow oxygen minimum zone (sOMZ) of the ETNA. Averaged over the whole area an oxygen reduction of 7 µmol kg^{-1} in the depth range of 50-150m (peak reduction 16 µmol kg^{-1} at 100 m) can be associated with the dispersion of the eddies. Thus the locally increased oxygen consumption within the eddy cores enhances the total oxygen consumption in the open ETNA Ocean and seems to be a contributor to the formation of the sOMZ.

Conferences

EGU GENERAL ASSEMBLY 2017
23 – 28 April 2017, Vienna (Austria)

GOLDSCHMIDT 2017
13 – 18 August, Paris (France)

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

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

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

Sessions: Biogeochemical feedbacks • Coastal systems • Impacts on ecosystems • Impacts on fisheries / socioeconomics • Major upwelling systems • Oxygen consumption / microbiology • Paleo perspective • Physiological effects & multiple stressors • Prediction & monitoring • Ventilation / oxygen supply

If you are interested to convene one of the sessions, please contact cschelten@geomar.de

EDITORIAL
Dr. Chris Schelten
Phone 0431/600-4242
cschelten@geomar.de