Sonderforschungsbereich 754
Climate – Biogeochemistry Interactions in the Tropical Ocean

SFB 754

Publications

Loginova, A.N., C. Borchard, J. Meyer, H. Hauss, R. Kiko and A. Engel (2015) Effects of nitrate and phosphate supply on chromophoric and fluorescent dissolved organic matter in the Eastern Tropical North Atlantic: a mesocosm study. Biogeosciences, 12, 6897- 6914, doi: 10.5194/bg-12-6897-2015

In open-ocean regions, as is the Eastern Tropical North Atlantic (ETNA), pelagic production is the main source of dissolved organic matter (DOM) and is affected by dissolved inorganic nitrogen (DIN) and phosphorus (DIP) concentrations. Changes in pelagic production under nutrient amendments were shown to also modify DOM quantity and quality. However, little information is available about the effects of nutrient variability on chromophoric (CDOM) and fluorescent (FDOM) DOM dynamics. Here results are presented from two mesocosm experiments ("Varied P" and "Varied N") conducted with a natural plankton community from the ETNA, where the effects of DIP and DIN supply on DOM optical properties were studied. CDOM accumulated proportionally to phytoplankton biomass during the experiments. Spectral slope (S) decreased over time indicating accumulation of high molecular weight DOM. In Varied N, an additional CDOM portion, as a result of bacterial DOM reworking, was determined. It increased the CDOM fraction in DOC proportionally to the supplied DIN. The humic-like FDOM component (Comp.1) was produced by bacteria proportionally to DIN supply. The protein-like FDOM component (Comp.2) was released irrespectively to phytoplankton or bacterial biomass, but depended on DIP and DIN concentrations. Under high DIN supply, Comp.2 was removed by bacterial reworking, leading to an accumulation of humic-like Comp.1. No influence of nutrient availability on amino acid-like FDOM component in peptide form (Comp.3) was observed. Comp.3 potentially acted as an intermediate product during formation or degradation of Comp.2. The findings suggest that changes in nutrient concentrations may lead to substantial responses in the quantity and quality of optically active DOM and, therefore, might bias results of the applied in situ optical techniques for an estimation of DOC concentrations in open-ocean regions.

Doering, K., C. Ehlert, P. Grasse, X. Crasta, S. Fleury, M. Frank and R. Schneider (2016) Differences between mono-generic and mixed diatom silicon isotope compositions trace present and past nutrient utilisation off Peru. Geochim. Cosmochim. Acta, 177, 30-47, doi: 10.1016/j.gca.2015.12.029

In this study for the first time silicon (Si) isotope compositions of small mixed diatom species ($d^{30}Si_{bSiO2}$) and of large handpicked mono-generic (i.e. genus=*Coscinodiscus*) diatom samples ($d^{30}Si_{Coscino}$) are combined with diatom assemblages extracted from marine sediments in the Peruvian upwelling region in order to constrain present and past silicate utilisation. The extension of a previous core-top data set from the Peruvian shelf demonstrates that $d^{30}Si_{Coscino}$ values record near-complete Si utilisation, as these are similar to the isotopic composition of the subsurface source waters feeding the upwelling. In contrast, the $d^{30}Si_{bSiO2}$ of small mixed diatom species increase southward along the shelf as well as towards the shore. Highest $d^{30}Si_{bSiO2}$ values are attributed partly to transient iron limitation but primarily to the gradual increase of Si isotope fractionation within the seasonal diatom succession, which are mainly recorded by small diatom species during intense bloom events. In contrast, lower $d^{30}Si_{bSiO2}$ values are related to initial Si isotope utilisation during periods of weak upwelling, when low $Si(OH)_4$ concentrations do not permit intense blooms and small diatom species record substantially lower $d^{30}Si$ signatures. As such, it is proposed that the intensity of the upwelling can be deduced from the offset between $d^{30}Si_{bSiO2}$ and $d^{30}Si_{Coscino}$ ($\Delta^{30}Si_{coscino-bSiO2}$), which is low for strong upwelling conditions and high for prevailing weak upwelling. The information extracted from surface sediments is applied to generate a record of the present-day main upwelling region covering the past 17,700 years and find that this location has also been characterized by a persistent offset ($\Delta^{30}Si_{coscino-bSiO2}$). By comparison with the diatom assemblages it can be shown that the coastal upwelling system changed markedly between weak and strong upwelling conditions. In addition, the model calculations to quantify species-specific Si isotope fractionation effects based on the diatom assemblages indicate an overall minor influence that cannot explain the high amplitude in the measured $d^{30}Si_{bSiO2}$ record.

Meyer, J., C.R. Löscher, S.C. Neulinger, A.F. Reichel, A. Loginova, C. Borchard, R.A. Schmitz, H. Hauss, R. Kiko and U. Riebesell (2016) Changing nutrient stoichiometry affects phytoplankton production, DOP accumulation and dinitrogen fixation – a mesocosm experiment in the eastern tropical North Atlantic. Biogeosciences, 13, 781-794, doi: 10.5194/bg-13-781-2016

Ocean deoxygenation due to climate change may alter redox-sensitive nutrient cycles in the marine environment. The productive eastern tropical North Atlantic (ETNA) upwelling region may be particularly affected when the relatively moderate oxygen minimum zone (OMZ) deoxygenates further and microbially driven nitrogen (N) loss processes are promoted. Consequently, water masses with a low nitrogen to phosphorus (N : P) ratio could reach the euphotic layer, possibly influencing primary production in those waters. Previous mesocosm studies in the oligotrophic Atlantic Ocean identified nitrate availability as a control of primary production, while a possible co-limitation of nitrate and phosphate could not be ruled out. To better understand the impact of changing N : P ratios on primary production and N_2 fixation in the ETNA surface ocean, a land-based mesocosm experiments with natural plankton communities was conducted and a broad range of N : P ratios

(2.67– 48) was applied. In all mesocosms silicic acid was supplied at 15 µmol L^{-1}. Nutrient drawdown, biomass accumulation and nitrogen fixation in response to variable nutrient stoichiometry was monitored. The results confirmed nitrate to be the key factor determining primary production, while excess phosphate was channeled through particulate organic matter (POP) into the dissolved organic matter (DOP) pool. In mesocosms with low inorganic phosphate availability, DOP was utilized while N_2 fixation increased, suggesting a link between those two processes. Interestingly this observation was most pronounced in mesocosms where nitrate was still available, indicating that bioavailable N does not necessarily suppress N_2 fixation. A shift from a mixed cyanobacteria–proteobacteria dominated active diazotrophic community towards a diatom-diazotrophic association of the Richelia-Rhizosolenia symbiosis was observed. It is hypothesized that a potential change in nutrient stoichiometry in the ETNA might lead to a general shift within the diazotrophic community, potentially influencing primary productivity and carbon export.

Thomsen, S., T. Kanzow, G. Krahmann, R.J. Greatbatch, M. Dengler and G. Lavik (2015) The formation of a subsurface anticyclonic eddy in the Peru-Chile Undercurrent and its impact on the near-coastal salinity, oxygen, and nutrient distributions. J. Geophys. Res. Oceans, 120, doi: 10.1002/2015JC010878

The formation of a subsurface anticyclonic eddy in the Peru-Chile Undercurrent (PCUC) in January and February 2013 is investigated using a multiplatform four-dimensional observational approach. Research vessel, multiple glider, and mooring-based measurements were conducted in the Peruvian upwelling regime near 12°30′ S. The data set consists of >10,000 glider profiles and repeated vessel-based hydrography and velocity transects. It allows a detailed description of the eddy formation and its impact on the near-coastal salinity, oxygen, and nutrient distributions. In early January, a strong PCUC with maximum pole-ward velocities of ~0.25 m/s at 100–200 m depth was observed. Starting on 20 January, a subsurface anticyclonic eddy developed in the PCUC downstream of a topographic bend, suggesting flow separation as the eddy formation mechanism. The eddy core waters exhibited oxygen concentration of <1 µmol/kg, an elevated nitrogen deficit of ~17 µmol/L, and potential vorticity close to zero, which seemed to originate from the bottom boundary layer of the continental slope. The eddy-induced across-shelf velocities resulted in an elevated exchange of water masses between the upper continental slope and the open ocean. Small-scale salinity and oxygen structures were formed by along-isopycnal stirring, and indications of eddy-driven oxygen ventilation of the upper oxygen minimum zone were observed. It is concluded that mesoscale stirring of solutes and the offshore transport of eddy core properties could provide an important coastal open ocean exchange mechanism with potentially large implications for nutrient budgets and biogeochemical cycling in the oxygen minimum zone off Peru.

Kock, A., D.L. Arévalo-Martínez, C.R. Löscher and H.W. Bange (2016) Extreme N_2O accumulation in the coastal oxygen minimum zone off Peru. Biogeosciences, 13, 827-840, doi: 10.5194/bg-13-827-2016

Depth profiles of nitrous oxide (N_2O) were measured during six cruises to the upwelling area and oxygen minimum zone (OMZ) off Peru in 2009 and 2012/2013, covering both the coastal shelf region and the adjacent open ocean. N_2O profiles displayed a strong sensitivity towards oxygen concentrations. Open ocean profiles with distances to the shelf break larger than the first baroclinic Rossby radius of deformation showed a transition from a broad maximum close to the Equator to a double-peak structure south of 5° S where the oxygen minimum was more pronounced. Maximum N_2O concentrations in the open ocean were about 80 nM. A linear relationship between ΔN_2O and apparent oxygen utilization (AOU) could be found for measurements within the upper oxycline, with a slope similar to studies in other oceanic regions. In contrast, N_2O profiles close to the shelf revealed a much higher variability, and N_2O concentrations higher than 100 nM were often observed. The highest N_2O concentration measured at the shelf was ~850 nM. Due to the extremely sharp oxygen gradients at the shelf, N_2O maxima occurred in very shallow water depths of less than 50 m. In the coastal area, a linear relationship between ΔN_2O and AOU could not be observed as extremely high ΔN_2O values were scattered over the full range of oxygen concentrations. The data points that showed the strongest deviation from a linear ΔN_2O / AOU relationship also showed signals of intense nitrogen loss. These results indicate that the coastal upwelling at the Peruvian coast and the subsequent strong remineralization in the water column causes conditions that lead to extreme N_2O accumulation, most likely due to the interplay of intense mixing and high rates of remineralization which lead to a rapid switching of the OMZ waters between anoxic and oxic conditions. This, in turn, could trigger incomplete denitrification or pulses of increased nitrification with extreme N_2O production.

News

Congratulations to **DR. CAROLIN LÖSCHER** who was granted a Marie Skłodowska-Curie Research Fellowship. With additional Danish funds she was granted, Carolin will start setting up her own research group at the University of Southern Denmark in June 2016 as part of Prof. Don Canfields department. Her research project ‚NITROX' (*Nitrogen Regeneration under changing Oxygen conditions*) will explore the redox sensitivity of N_2-fixation as a major factor of marine biological productivity in the modern ocean and over geological timescales. Carolin will still be involved in the SFB 754 cooperating closely with Prof. Hermann Bange (B4) and supporting the SFB 754 young scientists cohort. She conducted her PhD thesis in the SFB 754 subproject B4 (Prof. J. LaRoche/ Prof. R. Schmitz-Streit) in 2011 and was since then postdoc within B4.

AGU 2015
14 - 18 Dec. 2015, San Francisco, USA
The SFB 754 was represented at the DFG booth by a selected team.

Conferences

OCEAN SCIENCES MEETING
21-26 February 2016,
New Orleans (USA)

GLOBAL CLIMATE OBSERVING SYSTEM (GCOS)
2-4 March 2016, Amsterdam (NL)

EGU 2016
17-22 April 2016, Vienna (Austria)

SFB 754 Intern

SFB 754 ANNUAL RETREAT
14-15 March 2016, Kiel