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Sonderforschungsbereich 754

Climate – Biogeochemistry Interactions in the Tropical Ocean

SFB 754

Publications

Stramma, L., R. Czeschel, T. Tanhua, P. Brandt, M. Visbeck and B.S. Giese (2016) The flow field of the upper hypoxic eastern tropical North Atlantic oxygen minimum zone. Ocean Science, 12, 153-167, doi: 10.5194/os-12-153-2016

A subsurface low oxygen zone is located in the eastern tropical North Atlantic Ocean (ETNA) in the upper ocean with the core of the hypoxic ($O_2 \leq 60$ µmol kg^{-1}) oxygen minimum zone (OMZ) at 400 to 500 m depth. The subsurface circulation in the OMZ region is derived from observations and data assimilation results. Measurements in the ETNA of velocity, oxygen and of a tracer (CF_3SF_5) that was released in April 2008 at ~8° N, 23° W (at ~330 m depth) in November–December 2008, in November–December 2009 and October–November 2010 show the circulation in the upper part of the OMZ with spreading to the east in the North Equatorial Countercurrent (NECC) region and north- westward around the Guinea Dome. Three floats equipped with oxygen sensors deployed at ~ 8° N, 23° W with parking depths at 330, 350 and 400 m depths were used to estimate velocity along the float trajectory at the surface and at the parking depth. At the 350 m park depth north of 9° N a cyclonic northwestward flow across the OMZ was observed. The northward drift of a float into the upper OMZ and a stronger cyclonic flow around the Guinea Dome seem to be connected to a strong Atlantic Meridional Mode (AMM) event in 2009. A near-surface cyclonic circulation cell east of the Cape Verde Islands reaches down into the OMZ layer. The circulation of the upper OMZ mirrors the near-surface circulation. Oxygen measurements from the cruises used here, as well as from other recent cruises up to the year 2014, confirm the continuous deoxygenation trend in the upper OMZ since the 1960s near the Guinea Dome. The three floats deployed with the tracer show spreading paths consistent with the overall observed tracer spreading. Oxygen sensors on the floats remained well calibrated for more than 20 months, and so the oxygen profiles can be used to investigate mesoscale eddy signatures. Mesoscale eddies may modify the oxygen distribution in OMZs. However, in general eddies are less energetic in the ETNA south of the Cape Verde Islands compared to similar latitudes in the eastern tropical South Pacific.

Arévalo-Martínez, D.L., A. Kock, C.R. Löscher, R.A. Schmitz, L. Stramma and H.W. Bange (2016) Influence of mesoscale eddies on the distribution of nitrous oxide in the eastern tropical South Pacific. Biogeosciences, 13, 1105–1118, doi: 10.5194/bg-13-1105-2016

In this study, the first measurements of N_2O across three mesoscale eddies (two mode water or anticyclonic and one cyclonic) in the eastern tropical South Pacific are presented. Eddie's vertical structure, offshore transport, properties during its formation and near-surface primary production determined the N_2O distribution. Substantial depletion of N_2O within the core of anticyclonic eddies suggests that although these are transient features, N-loss processes within their centers can lead to an enhanced N_2O sink which has not being yet accounted for in marine N_2O budgets. These results evidence the relevance of mode water eddies for N_2O distribution, thereby improving the understanding of N-cycling processes, which are of crucial importance in times of climate change and ocean deoxygenation

Rovelli, L., M. Dengler, M. Schmidt, S. Sommer, P. Linke and D.F. McGinnis (2016) Thermocline mixing and vertical oxygen fluxes in the stratified central North Sea. Biogeosciences, 13, 1609–1620, doi: 10.5194/bg-13-1609-2016

In recent decades, the central North Sea has been experiencing a general trend of decreasing dissolved oxygen (O_2) levels during summer. To understand potential causes driving lower O_2, summertime turbulence and O_2 dynamics were investigated in the thermocline and bottom boundary layer (BBL) over a 3-day period. The study focused on coupling biogeochemical with physical transport processes to identify key drivers of the O_2 and organic carbon turnover within the BBL. Combining the flux observations with an analytical process-oriented approach, drivers that ultimately contributed to determining the BBL O_2 levels were resolved. The substantial turbulent O_2 fluxes observed from the thermocline into the otherwise isolated bottom water was attributed to the presence of a baroclinic near-inertial wave. This contribution to the local bottom water O_2 and carbon budgets has been largely overlooked and is shown to play a role in promoting high carbon turnover in the bottom water while simultaneously maintaining high O_2 concentrations. This process may become suppressed with warming climate and stronger stratification, conditions which could promote migrating algal species that potentially shift the O_2 production zone higher up within the thermocline.

Lomnitz, U., S. Sommer, A.W. Dale, C.R. Löscher, A. Noffke, K. Wallmann and C. Hensen (2016) Benthic phosphorus cycling in the Peruvian oxygen minimum zone. Biogeosciences, 13, 1367-1386, doi: 10.5194/bg-13-1367-2016

Oxygen minimum zones (OMZs) that impinge on continental margins favor the release of phosphorus (P) from the sediments to the water column, enhancing primary productivity and the maintenance or expansion of low-oxygen waters. A comprehensive field program in the Peruvian OMZ was undertaken to identify the sources of benthic P at six stations, including the analysis of particles from the water column, surface sediments, and pore fluids, as well as in situ benthic flux measurements. A major fraction of solid-phase P was bound as particulate inorganic P (PIP) both in the water column and in sediments. Sedimentary PIP increased with depth in the sediment at the expense of particulate organic P (POP).

The ratio of particulate organic carbon (POC) to POP exceeded the Redfield ratio both in the water column (202 ± 29) and in surface sediments (303 ± 77). However, the POC to total particulate P (TPP = POP + PIP) ratio was close to Redfield in the water column (103 ± 9) and in sediment samples (102 ± 15). This suggests that the relative burial efficiencies of POC and TPP are similar under low-oxygen conditions and that the sediments underlying the anoxic waters on the Peru margin are not depleted in P compared to Redfield. Benthic fluxes of dissolved P were extremely high (up to 1.04 ± 0.31 mmol m^{-2} d^{-1}), however, showing that a lack of oxygen promotes the intensified release of dissolved P from sediments, whilst preserving the POC / TPP burial ratio. Benthic dissolved P fluxes were always higher than the TPP rain rate to the seabed, which is proposed to be caused by transient P release by bacterial mats that had stored P during previous periods when bottom waters were less reducing. At one station located at the lower rim of the OMZ, dissolved P was taken up by the sediments, indicating ongoing phosphorite formation. This is further supported by decreasing porewater phosphate concentrations with sediment depth, whereas solid-phase P concentrations were comparatively high.

Erdem, Z., J. Schönfeld, N. Glock, M. Dengler, T. Mosch, S. Sommer, J. Elger and A. Eisenhauer (2016) Peruvian sediments as recorders of an evolving hiatus for the last 22 thousand years. Quatenary Science Reviews, 137, 1-14, doi: 10.1016/j.quascirev.2016.01.029

In the present study, the stratigraphical information of 31 sediment cores from the Peruvian margin was combined in order to determine the extent of the hiatus and assess the responsible mechanisms. The cores were located between 3 and 18°S and water depths of 90 to 1300 m within and below today's OMZ. A widespread unconformity and related erosional features, omission surfaces and phosphorites, were observed in sediment cores from the area south of 7°S, depicting a prograding feature on the continental slope from south to north during the deglaciation. Combining recent oceanographic and sedimentological observations, it is inferred that, tide-topography interaction and resulting non-linear internal waves (NLIWs) shape the slope by erosion, carry sediments upslope or downslope and leave widespread phosphoritic lag sediments, while the Peru Chile Undercurrent (PCUC) transports the resuspended sediments southward causing non-deposition. This exceptional sedimentary regime makes the Peruvian margin a modern analogue for such environments. Overall, the compilation of downcore records showed that enhanced bottom currents due to tide-topography interaction were progressively evolving and affected a wider area with the onset of the last deglaciation. Elevated tidal amplitudes and variability of mid-depth water masses (i.e.; density changes) and hydrodynamics in relation with changing climate were potential reasons of this evolving feature of erosion and reworking. Additionally, erosion and non-deposition was observed widest and even was encountered on the continental shelf during the early Holocene, potentially indicating a strong phase of the PCUC mirroring today's El Niño- like conditions.

Czerny, J.M.S., H. Hauss, C.R. Löscher and U. Riebesell (2016) Dissolved N:P ratio changes in the eastern tropical North Atlantic: effect on phytoplankton growth and community structure. Mar. Ecol. Prog. Ser., 545, 49-62, doi: 10.3354/meps11600

Previous bioassays conducted in the oligotrophic Atlantic Ocean identified availability of inorganic nitrogen (N) as the proximate limiting nutrient control of primary production, but additionally displayed a synergistic growth effect of combined N and phosphorus (P) addition. To classify conditions of nutrient limitation of coastal phytoplankton in the tropical ocean, an 11 d nutrient-enrichment experiment was performed with a natural phytoplankton community from shelf waters off northwest Africa in shipboard mesocosms. Pigment and gene fingerprinting were used in combination with flow cytometry for classification and quantification of the taxon-specific photoautotrophic response to differences in nutrient supply. The developing primary bloom was dominated by diatoms and was significantly higher in the treatments receiving initial N addition. The combined supply of N and P did not induce a further increase in phytoplankton abundance compared to high N addition alone. A secondary bloom during the course of the experiment again displayed higher primary producer standing stock in the N-fertilized treatments. Bacterial abundance correlated positively with phytoplankton biomass. Dominance of the photoautotrophic assemblage by N-limited diatoms in conjunction with a probable absence of any P-limited phytoplankton species prevented an additive effect of combined N and P addition on total phytoplankton biomass. Furthermore, after nutrient exhaustion, dinitrogen (N_2)-fixing cyanobacteria succeeded the bloom-forming diatoms. Shelf waters in the tropical eastern Atlantic may thus support growth of diazotrophic cyanobacteria such as *Trichodesmium* sp. subsequent to upwelling pulses.

News

KRISTIN BURMEISTER, PhD candidate subproject A9, received the **European Geosciences Union** (EGU) **Outstanding Student Poster and PICO** (OSPP) **Award** for her poster presentation "*What caused the 2009 cold event in the Atlantic cold tongue region?*" at the last EGU conference in Vienna (17 - 22 April 2016)

Conferences

GOLDSCHMIDT 2016
26 June - 01 July 2016,
Yokohama (Japan)

3RD GLOBAL GEOLOGISTS ANNUAL MEETING
11-12 July 2016,
Brisbane (Australia)

4TH INT. CONFERENCE ON OCEANOGRAPHY & MARINE BIOLOGY
18-19 July 2016,
Brisbane (Australia)

THE ROYAL SOCIETY
12-13 September 2016,
London (UK)

SFB 754 Intern

SFB 754 ANNUAL RETREAT
13-14 February 2017, Kiel

SFB 754 INTERNATIONAL CONFERENCE 2018
03-07 September 2018, Kiel

SFB 754 Cruise

METEOR M130
Tropical Atlantic, 28 Aug. - 03 Oct. 2016,
Chief Scientist: Dengler

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