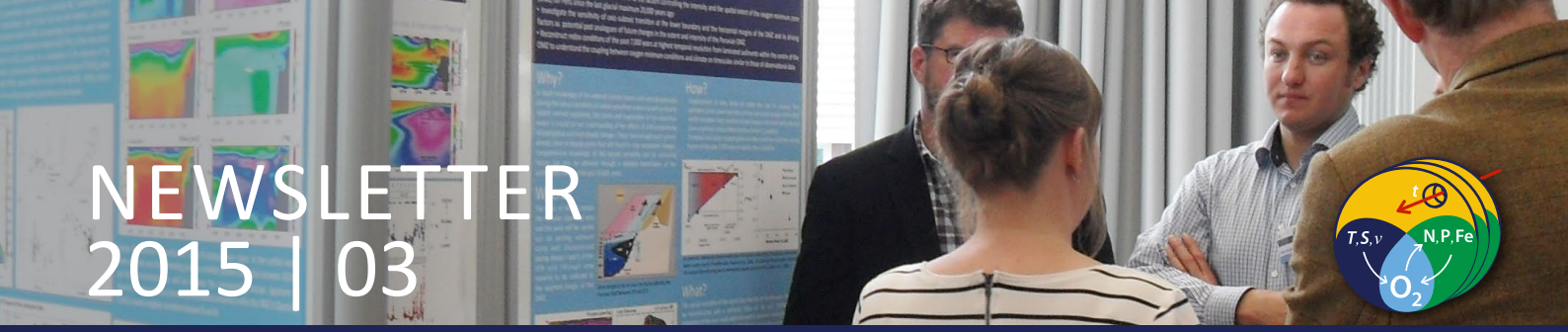

NEWSLETTER 2015 | 03

Sonderforschungsbereich 754

Climate – Biogeochemistry Interactions in the Tropical Ocean

SFB 754

Many thanks to everyone for your great help, input and enthusiasm during (and before!) the SFB 754 evaluation.
Now keep your fingers crossed !!!

Publications

Arteaga, L., M. Pahlow, and A. Oschlies (2014), Global patterns of phytoplankton nutrient and light colimitation inferred from an optimality-based model, Global Biogeochem. Cycles, 28, 648–661, oi:10.1002/2013GB004668.

The widely used concept of constant "Redfield" phytoplankton stoichiometry is often applied for estimating which nutrient limits phytoplankton growth in the surface ocean. Culture experiments, in contrast, show strong relations between growth conditions and cellular stoichiometry with often substantial deviations from Redfield stoichiometry. Here it is investigated to what extent both views agree by analyzing remote sensing and *in situ* data with an optimality-based model of nondiazotrophic phytoplankton growth in order to infer seasonally varying patterns of colimitation by light, nitrogen (N), and phosphorus (P) in the global ocean. The combined model-data analysis suggests strong N and N-P colimitation in the tropical ocean, seasonal light, and N-P colimitation in the Northern Hemisphere, and strong light limitation only during winter in the Southern Ocean. The eastern equatorial Pacific appears as the only ocean area that is essentially not limited by N, P, or light. Even though the optimality-based approach specifically accounts for flexible stoichiometry, inferred patterns of N and P limitation are to some extent consistent with those obtained from an analysis of surface inorganic nutrients with respect to the Redfield N:P ratio. Iron is not part of the analysis, implying that N cell quotas in high-nutrient, low-chlorophyll regions cannot be accurately predicted. Elsewhere, a major effect of iron on the relative distribution of N, P, and light colimitation areas is not expected. The relative importance of N, P, and light in limiting phytoplankton growth diagnosed here by combining observations and an optimal growth model provides a useful constraint for models used to predict future marine biological production under changing environmental conditions.

Bittig, H.C. and A. Körtzinger (2015) Tackling oxygen optode drift: Near-surface and in-air oxygen optode measurements on a float provide an accurate in-situ reference. J. Atmos. Ocean. Tech., doi: 10.1175/JTECH-D-14-00162.1

A yet unexplained drift of (some) oxygen optodes during storage/transport and thus significant deviations from factory/laboratory calibrations have been a major handicap for autonomous oxygen observations. Optode drift appears to be systematic and is predominantly a slope effect due to reduced oxygen sensitivity. A small contribution comes from a reduced luminophore lifetime, which causes a small positive offset. A reliable *in situ* reference is essential to correct such a drift. Traditionally, this called for a ship-based reference cast, which poses some challenges for opportunistic float deployments. This study presents an easily implemented alternative using near-surface/in-air measurements of an Aanderaa optode on a 10-cm stalk and compares it to the more traditional approaches (factory, laboratory, and *in situ* deployment calibration). In-air samples show a systematic bias depending on the water saturation, which is likely caused by occasional submersions of the standard-height stalk optode. Linear regression of measured in-air supersaturation against in-water supersaturation (using ancillary meteorological data to define the saturation level) robustly removes this bias and thus provides a precise (0.2%) and accurate (1%) *in situ* correction that is available throughout the entire instrument's lifetime.

Dale, A.W., S. Sommer, U. Lomnitz, I. Montes, T. Treude, J. Gier, C. Hensen, M. Dengler, K. Stolpovsky, L.D. Bryant and K. Wallmann (2015) Organic carbon production, mineralization and preservation on the Peruvian margin. Biogeosciences, 12, 1537-1559, doi: 10.5194/bg-12-1537-2015

Carbon cycling in Peruvian margin sediments (11 and 12° S) was examined at 16 stations, from 74 m water depth on the middle shelf down to 1024 m, using a combination of *in situ* flux measurements, sedimentary geochemistry and modelling. Bottom water oxygen was below detection limit down to ca. 400 m and increased to 53 µM at the deepest station. Sediment accumulation rates decreased sharply seaward of the middle shelf and subsequently increased at the deep stations. The organic carbon burial efficiency (CBE) was unusually low on the middle shelf (< 20 %) when compared to an existing global database, for reasons which may be linked to episodic ventilation of the bottom waters by oceanographic anomalies. Deposition of reworked, degraded material originating from sites higher up on the slope is proposed to explain unusually high sedimentation rates and CBE (> 60 %) at the deep oxygenated sites. In line with other studies, CBE was elevated under oxygen-deficient waters in the mid-water oxygen minimum zone. Organic carbon rain rates calculated from the benthic fluxes alluded to efficient mineralisation of organic matter in the water column compared to other oxygen-deficient environments. The observations at the Peruvian margin suggest that a lack of oxygen does not greatly affect the degradation of organic matter in the water column but promotes the preservation of organic matter in sediments.

Kalvelage, T., G. Lavik, M.M. Jensen, N.P. Revsbech, C. Löscher, H. Schunck, D. Desai, H. Hauss, R. Kiko, M. Holtappels, J. LaRoche, R., Schmitz, M.I. Graco and M.M.M. Kuypers (2015) Aerobic Microbial Respiration In Oceanic Oxygen Minimum Zones. PLoS ONE, 10 (7), e0133526, doi: 10.1371/journal.pone.0133526

Oxygen minimum zones are major sites of fixed nitrogen loss in the ocean. Recent studies have highlighted the importance of anaerobic ammonium oxidation, anammox, in pelagic nitrogen removal. Sources of ammonium for the anammox reaction, however, remain controversial, as heterotrophic denitrification and alternative anaerobic pathways of organic matter remineralization cannot account for the ammonium requirements of reported anammox rates. Here, the significance of microaerobic respiration as a source of ammonium during organic matter degradation

is explored in the oxygen-deficient waters off Namibia and Peru. Experiments with additions of double-labelled oxygen revealed high aerobic activity in the upper OMZs, likely controlled by surface organic matter export. Consistently observed oxygen consumption in samples retrieved throughout the lower OMZs hints at efficient exploitation of vertically and laterally advected, oxygenated waters in this zone by aerobic microorganisms. In accordance, metagenomic and metatranscriptomic analyses identified genes encoding for aerobic terminal oxidases and demonstrated their expression by diverse microbial communities, even in virtually anoxic waters. The results suggest that microaerobic respiration is a major mode of organic matter remineralization and source of ammonium (~45-100%) in the upper oxygen minimum zones, and reconcile hitherto observed mismatches between ammonium producing and consuming processes therein.

Kiko, R., H. Hauss, M. Dengler, S. Sommer and F. Melzner (2015) The squat lobster Pleuroncodes monodon tolerates anoxic "dead zone" conditions off Peru. Mar. Biol., 162, 9, 1913-1921, doi: 10.1007/s00227-015-2709-6

The squat lobster *Pleuroncodes monodon* is a key species of the highly productive, but oxygen-poor upwelling system of the Eastern Tropical South Pacific. Observations of *P. monodon* in the water column off Peru have led to the hypothesis that anoxic conditions force this otherwise primarily benthic species to adopt a pelagic lifestyle. Here it is shown that off Peru, *P. monodon* can be found in the oxygenated surface water, but also on the anoxic seafloor. Physiological experiments demonstrate that juvenile and adult specimens have a very low critical respiratory pO_2 of 0.5 kPa and that adults survive anoxia for 30.5–70.5 h. Anoxic conditions at the seafloor should therefore force *P. monodon* to regularly migrate to the oxic surface layer in order to restore energy reserves and recycle metabolic end products of anaerobic metabolism. It was recently estimated that the ammonium supply mediated by diel vertical migrations (DVMs) of zooplankton and nekton considerably fuels bacterial anaerobic ammonium oxidation—a major loss process for fixed nitrogen in the ocean. These estimates were based on the implicit assumption that anoxia does not result in a down-regulation of ammonium excretion. Here, it is shown that exposure to anoxia elicits a fourfold reduction in ammonium excretion from 2.1 ± 0.6 µmol h^{-1} g dry $weight^{-1}$ under normoxic to 0.5 ± 0.6 µmol h^{-1} g DW^{-1} under anoxic conditions in *P. monodon*. Estimates of ammonium supply to the anoxic core of oxygen minimum zones via DVM therefore are likely too high.

Nürnberg, D., T. Böschen, K. Doering, E. Mollier-Vogel, J. Raddatz and R.R. Schneider (2015) Sea surface and subsurface circulation dynamics off equatorial Peru during the last ≈17 kyrs. Paleoceanography, doi: 10.1002/2014PA002706

The complex deglacial to Holocene oceanographic development in the Gulf of Guayaquil (Eastern Equatorial Pacific) is reconstructed for sea surface and subsurface ocean levels from (isotope) geochemical proxies based on marine sediment cores. At sea surface, southern sourced Cold Coastal Water and tropical Equatorial Surface Water/ Tropical Surface Water are intimately related. In particular since ~10 ka, independent sea surface temperature proxies capturing different seasons emphasize the growing seasonal contrast in the Gulf of Guayaquil, which is in contrast to ocean areas further offshore. Cold Coastal Water became rapidly present in the Gulf of Guayaquil during the austral winter season in line with the strengthening of the Southeast Trades, while coastal upwelling off Peru gradually intensified and expanded northward in response to a seasonally changing atmospheric circulation pattern affecting the core locations intensively since 4 ka BP. Equatorial Surface Water, instead, was displaced and Tropical Surface Water moved northward together with the Equatorial Front. At subsurface, the presence of Equatorial Under Current-sourced Equatorial Subsurface Water was continuously growing, prominently since ~10–8 ka B.P. During Heinrich Stadial 1 and large parts of the Bølling/Allerød, and similarly during short Holocene time intervals at ~5.1–4 ka B.P. and ~1.5–0.5 ka B.P., the admixture of Equatorial Subsurface Water was reduced in response to both short-term weakening of Equatorial Under Current strength from the northwest and emplacement by tropical Equatorial Surface Water, considerably warming the uppermost ocean layers.

Schönfeld, J., W. Kuhnt, Z. Erdem, S. Flögel, N. Glock, M. Aquit, M. Frank and A. Holbourn (2015) Records of past mid-depth ventilation: Cretaceous ocean anoxic event 2 vs. Recent oxygen minimum zones. Biogeosciences, 12 (4), 1169-1189, doi: 10.5194/bg-12-1169-2015

In the Mesozoic entire oceanic basins transiently became dysoxic or anoxic. The Cretaceous ocean anoxic events (OAEs) were characterised by laminated organic-carbon rich shales and low-oxygen indicating trace fossils preserved in the sedimentary record. Yet assessments of the intensity and extent of Cretaceous near-bottom water oxygenation have been hampered by deep or long-term diagenesis and the evolution of marine biota serving as oxygen indicators in today's ocean. Sedimentary features similar to those found in Cretaceous strata were observed in deposits underlying Recent OMZs. Their implications for constraining past bottom-water oxygenation are addressed in this review. OMZ sediments from the Peruvian upwelling are compared with deposits of the late Cenomanian OAE 2 from the north-west African shelf. Holocene laminated sediments are encountered at bottom-water oxygen levels of <7µmolkg^{-1} under the Peruvian upwelling and < 5 µmol kg^{-1} in California Borderland basins and the Pakistan Margin. Seasonal to decadal changes of sediment input are necessary to create laminae of different composition. The millimetre-sized trace fossil *Chondrites* was commonly found in Cretaceous strata and Recent oxygen-depleted environments where its diameter increased with oxygen levels from 5 to 45 µmol kg^{-1}. *Chondrites* has not been re- ported in Peruvian sediments but centimetre-sized crab burrows appeared around 10 µmol kg^{-1}, which may indicate a minimum oxygen value for bioturbated Cretaceous strata. Organic carbon accumulation rates ranged from 0.7 and 2.8 g C cm^{-2} kyr^{-1} in laminated OAE 2 sections in Tarfaya Basin, Morocco, matching late Holocene accumulation rates of laminated Peruvian sediments under Recent oxygen levels below 5 µmol kg^{-1}. Sediments deposited at > 10 µmol kg^{-1} showed an inverse exponential relationship of bottom-water oxygen levels and organic carbon accumulation depicting enhanced bioirrigation and decomposition of organic matter with increased oxygen supply. In the absence of seasonal laminations and under conditions of low burial diagenesis, this relationship may facilitate quantitative estimates of palaeo-oxygenation.

Conferences

AGU FALL MEETING 2015 - SESSION 8570
14–18 December 2015, San Francisco (USA)
Eastern boundary upwelling systems: Natural laboratories for studying the impacts of multiple stressors on marine ecosystems?
I. Montes, F. Chavez, B. Dewitte and V.C. Garçon

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

EGU GENERAL ASSEMBLY 2016,
17.-22.April 2016, Vienna (Austria)

EDITORIAL
Dr. Chris Schelten

Phone 0431/600-4242
cschelten@geomar.de