Sonderforschungsbereich 754
Climate – Biogeochemistry Interactions in the Tropical Ocean

SFB 754

Publications

Martínez-Pérez, C., W. Mohr, A. Schwedt, J. Dürschlag, C.M. Callbeck, H. Schunck, J. Dekaezemacker, C.R.T. Buckner, G. Lavik, B.M. Fuchs and M.M.M. Kuypers (2017) Metabolic versatility of a novel N_2-fixing Alphaproteobacterium isolated from a marine oxygen minimum zone. Environ. Microbiol., accepted article, doi: 10.1111/1462-2920.14008

Dinitrogen (N_2) fixation is the largest source of new nitrogen (N) to the ocean. The diversity of N_2-fixing microorganisms in the ocean is dominated by heterotrophic organisms, yet, very little is known about this particular group. A novel N_2-fixing Alphaproteobacterium was isolated from the oxygen-minimum zone off Peru, a region that has been hypothesized to harbor significant N_2 fixation rates. The study gives insights into the metabolic potential and versatility of this newly-isolated N_2-fixing microorganism that, based on molecular studies, is potentially widespread in the ocean.

Le Moigne, F.A.C., C. Cisternas-Novoa, J. Piontek, M. Maßmig and A. Engel (2017) On the effect of low oxygen concentrations on bacterial degradation of sinking particles. Sci. Rep. 7(16722), doi: 10.1038/s41598-017-16903-3

In marine OMZs, the transfer of particulate organic carbon (POC) to depth via the biological carbon pump might be enhanced as a result of slower remineralisation under lower dissolved O_2 concentrations (DO). In parallel, nitrogen (N) loss to the atmosphere through microbial processes, such as denitrification and anammox, is directly linked to particulate nitrogen (PN) export. However it is unclear (1) whether DO is the only factor that potentially enhances POC transfer in OMZs, and (2) if particle fluxes are sufficient to support observed N loss rates. A degradation experiment was performed on sinking particles collected from the Baltic Sea, where anoxic zones are observed. Sinking material was harvested using surface-tethered sediment traps and subsequently incubated in darkness at different DO levels, including severe suboxia (<0.5 mg l^{-1} DO). The results show that DO plays a role in regulating POC and PN degradation rates. POC(PN) degradation was reduced by approximately 100% from the high to low DO to the lowest DO. The amount of NH_4^+ produced from the pool of remineralising organic N matched estimations of NH_4^+ anammox requirements during our experiment. This anammox was likely fueled by DON degradation rather than PON degradation.

Kiko, R., A. Biastoch, P. Brandt, S. Cravatte, H. Hauss, R. Hummels, I. Kriest, F. Marin, A.M.P. McDonnell, A. Oschlies, M. Picheral, F.U. Schwarzkopf, A.M. Thurnherr and L. Stemmann (2017) Biological and physical influences on marine snowfall at the equator. Nat. Geosci. 10, 852–858, doi: 10.1038/ngeo3042

High primary productivity in the equatorial Atlantic and Pacific Oceans is one of the key features of tropical ocean biogeochemistry and fuels a substantial flux of particulate matter toward the abyssal ocean. How biological processes and equatorial current dynamics shape the particle size distribution and flux however is poorly understood. Here high-resolution size-resolved particle imaging and Acoustic Doppler Current Profiler data is used to assess these influences in equatorial oceans. An increase in particle abundance and flux at depths of 300 to 600 m at the Atlantic and Pacific equator was found, a depth range to which zooplankton and nekton migrate vertically in a daily cycle. This particle maximum to fecal pellet production is attributed by these organisms. At depths of 1,000 to 4,000 m the particulate organic carbon flux is three times greater in the equatorial belt (1°S-1°N) than in off-equatorial regions. At 3,000 m, the flux is dominated by small particles less than 0.53 mm in diameter. The dominance of small particles seems to be caused by enhanced active and passive particle export in this region, as well as by the focusing of particles by deep eastward jets found at 2°N and 2°S. Thus it is suggest that zooplankton movements and ocean currents modulate the transfer of particulate carbon from the surface to the deep ocean.

Matthießen, J., R.J. Greatbatch, M. Claus, F. Ascani and P. Brandt (2017) The emergence of equatorial deep jets in an idealised primitive equation model: an interpretation in terms of basin modes. Ocean Dyn. 67(12), 1511-1522, doi: 10.1007/s10236-017-1111-y

Ocean circulation models do not generally exhibit equatorial deep jets (EDJs), even though EDJs are a recognised feature of the observed ocean circulation along the equator and they are thought to be important for tracer transport along the equator and even equatorial climate. EDJs are nevertheless found in nonlinear primitive equation models with idealised box geometry. Here several such model runs are analysed. It is noted that the variability of the zonal velocity in the model is dominated by the gravest linear equatorial basin mode for a wide range of baroclinic vertical normal modes and that the EDJs in the model are dominated by energy contained in vertical modes between 10 and 20. The emergence of the EDJs is shown to involve the linear superposition of several such neighbouring basin modes. Furthermore, the phase of these basin modes is set at the start of the model run and, in the case of the reference experiment, the same basin modes can be found in a companion experiment in which the amplitude of the forcing has been reduced by a factor of 1000. It is also argued that following the spin-up, energy must be transferred between different vertical modes. This is because the model simulations are dominated by downward phase propagation following

the spin-up whereas our reconstructions imply episodes of upward and downward propagation. The transfer of energy between the vertical modes is associated with a decadal modulation of the EDJs.

Köhn, E.E., S. Thomsen, D.L. Arévalo-Martínez and T. Kanzow (2017) Submesoscale CO_2 variability across an upwelling front off Peru. Ocean Sci. 13, 1017–1033, doi: 10.5194/os-13-1017-2017

As a major source for atmospheric CO_2, the Peruvian upwelling region exhibits strong variability in surface fCO_2 on short spatial and temporal scales. Understanding the physical processes driving the strong variability is of fundamental importance for constraining the effect of marine emissions from upwelling regions on the global CO_2 budget. In this study, a frontal decay on length scales of $O(10$ km) was observed off the Peruvian coast following a pronounced decrease in down-frontal (equatorward) wind speed with a time lag of 9 h. Simultaneously, the sea-to-air flux of CO_2 on the inshore (cold) side of the front dropped from up to 80 to 10 mmol m^{-2} day^{-1}, while the offshore (warm) side of the front was constantly outgassing at a rate of 10–20 mmol m^{-2} day^{-1}. Based on repeated ship transects the decay of the front was observed to occur in two phases. The first phase was characterized by a development of coherent surface temperature anomalies which gained in amplitude over 6–9 h. The second phase was characterized by a disappearance of the surface temperature front within 6 h. Submesoscale mixed-layer instabilities were present but seem too slow to completely remove the temperature gradient in this short time period. Dynamics such as a pressure-driven gravity current appear to be a likely mechanism behind the evolution of the front.

Grasse, P., L. Bosse, E.C. Hathorne, P. Böning, K. Pahnke and M. Frank (2017) Short-term variability of dissolved rare earth elements and neodymium isotopes in the entire water column of the Panama Basin. Earth Planet. Sci. Lett. 475, 242-253, doi: 10.1016/j.epsl.2017.07.022

The distribution of dissolved rare earth elements (REEs) and neodymium isotopes (εNd) in the open ocean traces water mass mixing and provides information on lithogenic inputs to the source regions of the water masses. In this study the first dissolved REE concentrations and Nd isotope compositions of seawater from the Panama Basin (M90) in the Eastern Equatorial Pacific (EEP) are presented. The REE data demonstrate significant surface input via continental particles, which are partially dissolved in the water column and thereby release REEs and particularly radiogenic Nd isotope signatures to the subsurface ocean. As result, the εNd signatures of these water masses are more radiogenic than source water masses in the EEP entering the Panama Basin, which can only be explained by the release of radiogenic Nd through partial dissolution of volcanic particles from the Central American Volcanic Arc. The reoccupation of one station within 3.5 yr demonstrates that the high amounts of radiogenic Nd released from particles can partially reset water mass Nd isotope and REE signatures of the entire Panama Basin water column on time scales of a few years. The large amounts of REEs readily released from volcanic particles may require a different parameterization of the Nd isotope signal acquisition processes of water masses in models of the oceanic Nd isotope distribution and are important for the global Nd budget.

Salvatteci, R., D. Field, D. Gutierrez, T. Baumgartner, V. Ferreira, L. Ortlieb, A. Sifeddine, D. Grados and A. Bertrand (2017) Multifarious anchovy and sardine regimes in the Humboldt Current System during the last 150 years. Glob. Change Biol., accepted author manuscript, doi: 10.1111/gcb.13991

The Humboldt Current System (HCS) has the highest production of forage fish in the world, though it is highly variable and the future of the primary component, anchovy, is uncertain in the context of global warming. Paradigms based on late 20th century observations suggest that large-scale forcing controls decadal-scale fluctuations of anchovy and sardine across different boundary currents of the Pacific. Records of anchovy and sardine fluctuations since 1860 AD using fish scales from multiple sites containing laminated sediments are developed and are compared with Pacific basin-scale and regional indices of ocean-climate variability. Our records reveal two main anchovy and sardine phases with a timescale that is not consistent with previously proposed periodicities. Rather, the regime shifts in the HCS are related to 3D habitat changes driven by changes in upwelling intensity from both regional and large-scale forcing. Moreover, it os shown that a long-term increase in coastal upwelling translates via a bottom-up mechanism to top predators suggesting that the warming climate, at least up to the start of the 21st century, was favourable for fishery productivity in the HCS.

News

PHILOSPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A
"Ocean ventilation and deoxygenation in a warming world" compiled and edited by J. Shepherd, P. Brewer, A. Oschlies and A. Watson
PDF downloads of articles available here.

REPORT: VARIABILITY IN THE OXYCLINE AND ITS IMPACTS ON THE ECOSYSTEM (VOICE) SCIENCE PLAN WORKSHOP
The workshop took place on 13-15 September 2017 in Monterey, CA, USA, and was hosted by the Monterey Bay Aquarium Research Institute (MBARI).
PDF available here.

Conferences

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

EGU GENERAL ASSEMBLY
8 – 13 April 2018, Vienna (Austria)

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

GOLDSCHMIDT 2018
12 – 17 August 2018, Boston (USA)

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

SFB 754 Intern

SFB 754 ANNUAL RETREAT
26 – 27 February 2018, Kieler Yacht Club, Kiel (Germany)

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