METEOR Cruise 77/1

Talcahuano (Chile) – Callao (Peru)

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FS METEOR

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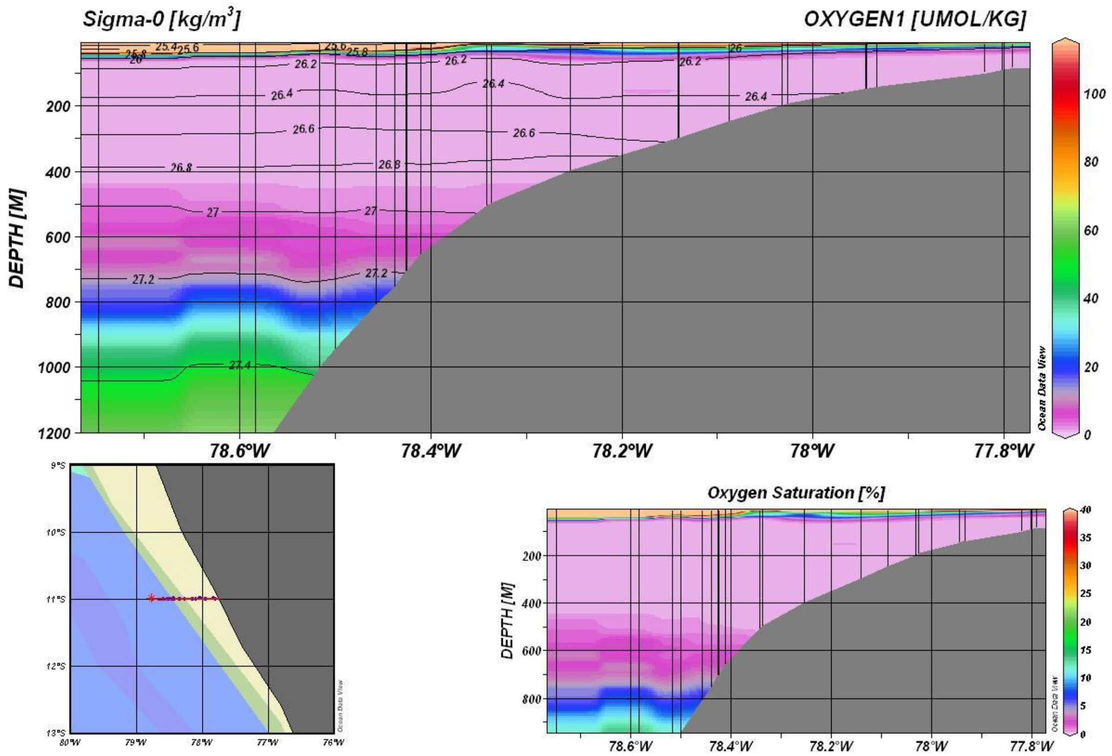
The last week was dedicated to station work at the 11°S-transect which is located in the area of the strongest upwelling intensity. We mapped a transect line with the multi-beam from 80m depth on the shelf to 2000m on the continental slope stretching as far as 56nm. Our station work comprised of CTD/RO casts, OFOS-transects, multi- corer and gravity corer sampling as well as lander deployments across the full depth range of the transect.

Our CTD-survey at the 11˚S-transect line encountered a well developed low oxygen zone (Fig. 1) in the water column across the shelf and into the open ocean. We found that dissolved oxygen was rapidly depleted from the surface waters so that by 80 m depth there was less than 0.1% saturation. The OMZ continued to approximately 400 m depth after which oxygen gradually increased again in the water due to supply via mixing with oxygen containing deep waters.

Fig. 1: Oxygen concentrations across the Peruvian shelf at 11˚S derived from CTD measurements obtained during M77-1.



The low oxygen waters below the surface have strong affects on some chemical cycles. This is most important for redox reactions in which an element can be altered from one oxidation state to another such as in the case of iron where Fe(III) is present when oxygen concentrations are high. This is a highly insoluble form in water and is responsible for the formation of iron oxides. In the absence of oxygen iron can be transformed into Fe(II) which forms green coloured solutions and is highly soluble in water. Another element is iodine normally present in seawater as iodate (IO_3^-) when oxygen is present. In the absence of oxygen it is chemically reduced to iodide (I^-). Presently however we know very little about how this change occurs and what organisms may be responsible. Using water samples obtained from the CTD/rosette we are currently measuring onboard the concentrations of iodide/iodate and Fe(II) to examine the influence of the OMZ on the cycling of iodine, iron and other redox sensitive elements. Our initial results indicate that in the OMZ iodine is only present as iodide and that in the low oxygen waters near the sediments there are high concentrations of iron present as Fe(II) which have been released from the sediments.

Ocean floor observation and imaging was performed along the 11° S-transect to identify benthic habitats which can be related to different biogeochemical provinces across the continental margin. So far we did eight surveys with the OFOS (Ocean Floor Observation System) covering about 10nm of the sea floor. OFOS carries a video camera, a digital camera which triggers automatically one picture every minute and a storage CTD with oxygen optodes. So far we made about 1000 high definition photos of the seafloor. In the shallower parts underlying the OMZ large aggregations of bacterial mats occur with variable coverage (Fig. 2). At 200m depth the seafloor is nearly completely covered with bacterial mats whereas by 400m only singular patches of bacterial mats are visible. The part of the transect which is outside the core of the OMZ (between 450 and 750 meters water depth) was already completely mapped. The pictures show a great diversity of megafauna (Fig. 4). We observed distinct zones of echinoderm occurrence such as a sea and a brittle star belt. The population of the brittle stars is extraordinary high (Fig. 3). Beyond 1000 meters the number of megafauna organisms clearly decreases.

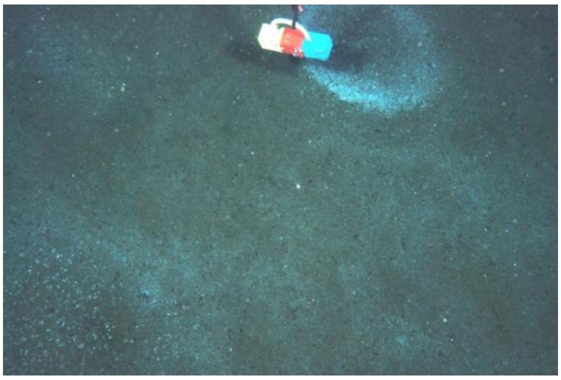
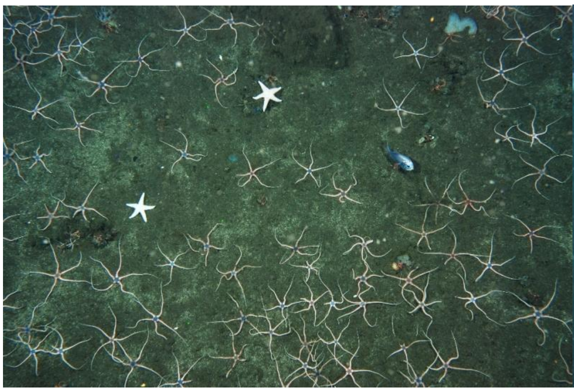


Fig 2-4: Bacterial mats (left above); brittle star belt at 650m (left below); Antozoa at 750m (right below).



We carried out a series of in situ flux measurements in the benthic boundary layer along the 11°S-transect to resolve the effect of changing oxygen conditions on the speciation and flux of nitrogen compounds across the sediment water interface. For our survey we employed the biogeochemical lander observatories BIGO and BIGO-T. Furthermore, extended measurements of N_2, Ar and other gases were conducted in the benthic boundary layer using a CTD/rosette which was equipped with the in situ membrane inlet mass spectrometer "TETHYS" (Fig. 5). These measurements are taken in cooperation with R. Camilli (Woodshole Oceanographic Institution).

TETHYS was deployed successfully during several CTD/RO casts. In a combined approach the TETHYS in situ measurements are cross-calibrated with ex situ measurements of water samples retrieved by the rosette sampler using a ship board laboratory membrane inlet mass spectrometer, MIMS, which is calibrated for di-nitrogen and oxygen. Our measurements identified distinct regions at the continental margin where the bottom water shows higher N_2/Ar ratios compared to the N_2/Ar ratio at saturation for the respective temperature and salinity. These measurements point towards benthic denitrification and/or anammox releasing N_2 into the bottom water.

Fig. 5: CTD/rosette instrumented with the in situ mass-spec. THETYS.

Strong N_2 release started at a water depth of 600 to 700 m where oxygen bottom water concentration declined below about 8% saturation. At this depth range distinct macro-benthic communities such as ophiuroids were observed to occur at extremely high densities (see above). N_2 release continued until a water depth of 200m is reached. Beyond 200m depth no indications for N_2 release were found except at the shallowest station at about 80m. This depth range is characterized by the occurrence of dense microbial mats. The 80m station might be highly dynamic with regard to benthic nitrogen turnover, periodic oxygen intrusion into greater depths might occur periodically which could trigger benthic nitrogen turnover. At depths greater than 700m no indications for nitrogen release were detected.

In the following week we will continue with lander measurements to confirm the observations we made in the bottom water and to resolve the strength of the N_2-release. First lander measurements indicate higher N_2 release at 300 m water depth compared to a site at 700 m which was just below the zone where we detected high N_2/Ar ratios in the bottom water.

On behalf of the science party and Meteor crew, our very best regards.

Olaf Pfannkuche