Meteor 55: 4th Weekly Report (4.11.2002-10.11.2002)

The fourth week of the cruise has been full of incident. Remaining uppermost in our minds is our unexpected meeting with Polarstern on the high seas. More about that later. The week also saw us collect our 2000th water sample, complete our section across the tropical Atlantic including sampling over the continental shelf of Guinea Bissau, and we also conducted our final 'routine' CTD station. We initiated a series of 'mega-experiments', or on-deck incubations, involving most of the groups on board. These experiments will continue during the transit to Douala. The experiments are already stimulating a lot of discussion concerning follow-up research on future expeditions. More about those ideas in my final report perhaps. Underway and air sampling will continue until we leave the waters of the Ivory Coast.

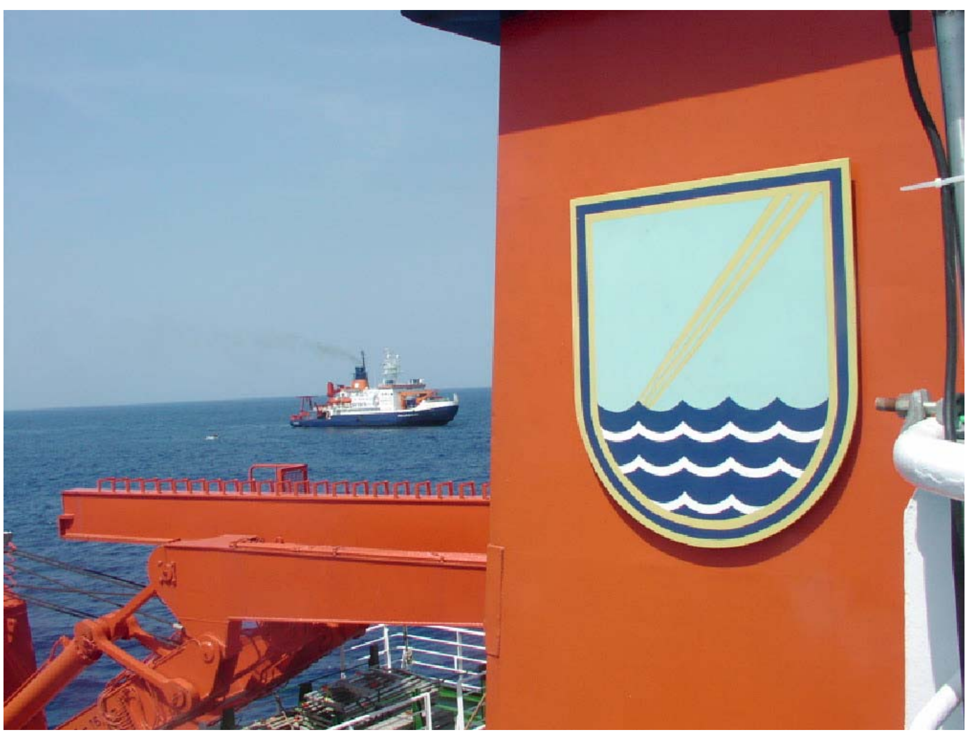
Our memories of the past week are dominated by the high-seas meeting of Polarstern and Meteor which took place on Friday 8th November at 1300 UTC. Thanks to networking between the DWD weather technicians on board Polarstern and Meteor, we had learned, mid-way through our cruise, that Polarstern was steaming southwards from Vigo to Cape Town. Clearly our cruise tracks were going to cross, but the chance of an intersection seemed exceedingly remote. Polarstern was on a rapid transit to Cape Town and had a very tight schedule. Our temporal constraint was based on our permission to do station work in the EEZ of Guinea Bissau for a maximum of 72 hours. We had to make sure that we used every minute of this allowed time in order to complete our transect to the African coast. If Polarstern entered our area before or during those 3 days, then no meeting would be possible. As it was, Polarstern gave us an ETA at 11°N 20°W of Friday 8th November, 1300 UTC. We were scheduled to finish our last station in Guinea Bissau waters at 11°N, 19°W late on Thursday night. Our plan had been to do more stations in the region along 11°N. It was clear that our paths were going to intersect.

Meeting Polarstern offered up a solution to a problem that had been worrying us. The last-minute change of port call from Abidjan to Douala had messed up our plans for return shipment of frozen samples. Our agent in Douala gave us a price of thousands of dollars for the very limited quantities of dry ice we needed. Clearly shipping frozen samples from Douala was not going to work. We were facing having to leave the samples on board Meteor until she reached Cape Town after Christmas. The Polarstern's rapid transit to Cape Town opened up an alternative means to get our samples back safely and quickly.

I was pleased to learn that my fellow marine chemist, Gerhard Kattner of the Alfred-Wegener Institut in Bremerhaven, was chief scientist on board Polarstern. I learnt from Gerhard that Polarstern had a mixture of disciplines on board that was very similar to ours. Their science programs ranged from measurements of a range of trace atmospheric species including ozone, through to marine chemistry and marine biological investigations. One key goal of their cruise was to collect data (e.g. with an upward-looking FTIR system) in order to calibrate the new European satellite ENVISAT. Another program is looking at persistent organic pollutants to obtain information about transport and exchange in and between the atmosphere and the ocean. The biological program deals with the distribution of the tropical zooplankton and its biochemical composition with special regards on lipids. These programs were being conducted at the start of Polarstern's 20th Antarctic research campaign. She is due to dock in Cape Town on November 22. We agreed over the radio that this was an excellent opportunity to compare programs and exchange ideas. Also, Polarstern generously agreed to accept our frozen samples for more rapid shipment back to Germany from Cape Town.

Following our morning station on Friday the 8th we sailed back to the agreed upon meeting location, with Polarstern clearly visible on the horizon. Curiously, a drifting orange float, that Neptune had apparently left for us, marked the rendezvous location. Conditions were ideal for the meeting: hot and sunny with calm seas. Polarstern manoevered into position a few hundred meters away from us and then Gerhard Kattner and the senior scientific staff from the Polarstern travelled to Meteor on rubber boats.

Meteor and Polarstern



Polarstern and Meteor funnel logo


POLARSTERN

Kattner and Wallace

After this initial meeting, there was an extensive exchange of scientific staff and crew members between the ships for a period of 3 hours. The rubber boats shuttled back and forth between the two ships while hundreds of photographs were being taken, tours of the ships conducted and souvenirs swapped and purchased. In addition to making final arrangements for the sample shipments, the occasion was used by the atmospheric chemists from Polarstern and Meteor to compare their respective programs. Notably, Polarstern and Meteor are both equipped with Multiaxial Differential Optical Absorption Spectroscopy systems from the University of Heidelberg. The meeting allowed an unusual opportunity for direct inter-comparison of these systems at sea.

After about 3 hours, the last rubber boats returned staff to their respective vessels, the ships horns were sounded, and Meteor and Polarstern sailed apart to resume their respective programs.

Polarstern silhoutte

The meeting was a welcome interlude to our science program. During the past week, we crossed the waters of the Guinea Dome and performed several stations over the continental slope and shelf of Guinea Bissau. We completed two east-west transects over the continental margin, including several deep stations. At Station 43 on November 7th we celebrated the collection of sample number 2000. During this eastern portion of the transect we have been sampling a more intense oxygen minimum at about 400m as well as a shallow oxygen minimum at less than 100m. Both minima are clearly reflected as maxima in N_2O concentrations. Nutrient isolines have shoaled and gradients steepened.

Along the section, the halocarbons such as methyl iodide and bromoform are showing highly consistent profiles: generally they show a sub-surface maximum either above or in the vicinity of the chlorophyll maximum. The processes responsible for producing this trace gas maximum are still unclear and presently the subject of considerable experimental work on board. At this stage it looks as though a definitive experimental definition of the environmental factors controlling the formation of these compounds may elude us. However the profiles and experiments we have conducted so far are the basis for hypotheses that can be tested subsequently in the laboratory.

We have been fortunate that the CTD and rosette, in the capable hands of Jens Schafstall and Hans-Peter Hansen, have worked almost flawlessly since early in the cruise. Not more than a handful of Niskin bottles have failed to close or closed at the wrong depth. We are, therefore, already well along with our data assembly. The CTD oxygen sensor calibration is nearly completed and all the CTD data together with nutrient, oxygen, chlorophyll and primary productivity data have been assembled and plotted as profiles and sections. The quality of the overall data set appears to be very high.

The final week of the cruise will see completion of two additional experiments, processing of samples, assembly and distribution of shipboard data and, of course, packing.

And now, as promised last week, here are reports concerning the biology and trace metal programs:

Phytoplankton biomass and productivity:

Many of the chemical species (or their precursors) emitted from the ocean and measured by the marine and atmospheric chemists are hypothesised to have been produced initially by phytoplankton. Therefore, parallel to the chemical measurements the distribution and activity of the phytoplankton is routinely determined in the upper 150m of the water column. The photosynthetic pigment chlorophyll, common to all phytoplankton groups, is used to map the distribution pattern of the algae. In general surface chlorophyll values were pretty low (< 0,1 µg/l) with small maxima in the Amazon plume and close to the African coast. We clearly see a deep chlorophyll maximum between 60m to 35m which becomes shallower and more pronounced towards the east along the transect. Such a deep chlorophyll maximum is typical for these tropical regions and is caused by lack of nutrients in the surface waters forcing the phytoplankton to resort to the deeper part of the euphotic zone where they can acquire nutrients from within the thermocline. Despite the high chlorophyll concentrations, primary production is very low at this depth and light is the limiting factor for phytoplankton growth. Experiments with water from the deep chlorophyll maximum show that phytoplankton from this low-light environment respond fast when brought up to higher light intensities. In contrast to the surface water, they are not nutrient limited and develop high growth rates at higher light levels. Post-cruise analysis of a range of different pigments, flow cytometry and microscopy will give additional information concerning which phytoplankton groups are present in the chlorophyll maximum and in the other parts of the water column. In first microscopic inspections we observe a wide variety of species that are either autotrphic or heterotrophic, including very colourful copepods, many of them carrying eggs, many dinoflagellates, tintinnids, and radiolarians.

Most pronounced among the autotrophic phytoplankton are occasionally relatively high densities of the nitrogen-fixing cyanobacterium Trichodesmium. They occur in long trichoms consisting of hundreds of cells and the trichoms are again packed in colonies of two different forms. On calm days the colonies float on the surface visible by the naked eye as little yellow- brownish dots. Production by Trichodesmium is a crucial variable because these organisms are amongst the only ones that are independent of nitrogenous nutrients. They are able to take up dinitrogen from the water and convert it into biomass. The biomass is then later degraded in the water column delivering additional nutrients to an otherwise limited environment. This is one of the main reason to study Trichodesmium production during the cruise in more detail.

On average, primary production has been 1 g C m^{-2} d^{-1} and in the Amazon plume and close to the African coast it was 3-4 times higher. Satellite images that we received on board showed higher chlorophyll concentrations along the equator originating from the upwelling region off the African coast. However, our data showed only a modest increase above the average level at the equator. This suggests that the elevated chlorophyll levels observed by the satellite were probably produced "downstream" and haD been advected to our position.

The small phytoplankton (less than 2µm in diameter) are the most active and they dominate primary production. This is also typical for tropical plankton. In order to understand the balance between production of organic matter and its breakdown, we also measure bacterial production and the activity of hydrolytic enzymes (phosphatase). These measurements will give an indication how fast the organic matter produced by the phytoplankton is being recycled.

Trace Metals:

During the M55 cruise the trace metal group from IfM – Kiel has been examining the influence of Saharan dust on the concentration of iron in the near surface waters across the central Atlantic. Iron is a major constituient of Saharan dust, but is poorly soluble in seawater, and so most rapidly sinks from the surface ocean to the sediments below. Iron is a key element for phytoplankton growth as it is required for both photosynthesis and respiration., in many open ocean regions, away from sources of iron supplied directly by rivers or from coastal shelves, iron has been shown to be the key limiting element for phytoplankton growth.

Our results gained so far during M55 point to the strong influence of Saharan dust on the distribution of iron in the central Atlantic with by far the highest concentrations found in the eastern basin closest to the source regions in the Sahara itself. Our work has also focussed on the different forms of iron found in seawater and how they change upon addition of the Fe-rich Saharan dust falling from above. Interpretation of the data will be assisted by comparison with dust deposition estimates derived from an atmospheric transport model. This combination of real-time model predictions of atmospheric dust input, with in-situ observations has, to the best of our knowledge, not been attempted before. During the later stages of the cruise we plan to conduct some dissolution experiments using dust collected along the transect. The results to date suggest that the work in this region should greatly increase our understanding of the processes that affect the distribution and cycling of iron in the ocean.

Next week: wrap-up of the cruise and, hopefully, insight into results from the on-board bioassay experiments and the 'mega-experiments'. Also: the ideas for our next Meteor cruise!

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Fahrtleiter, Meteor 55