Short Cruise Report

Expedition R/V METEOR M76/2

Walvis Bay (Namibia) – Walvis Bay

17.05. -04.06.2008

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Introduction and scope

The global coastal ocean comprises around 7% of the Earth surface, has a significant role in the sequestration of carbon by hosting 25% of global biological productivity (prominently in upwelling areas) and storing 90% of organic carbon runoff from land in sediments, and yields 90% of global fisheries. While the physical boundary conditions of shelf seas (and upwelling systems in particular) are adjusting to global warming, human society continues to exploit their natural resources (minerals, fossil fuels, fisheries) without sufficient understanding and prognostic capabilities to foresee how exactly the interplay of changing physical drivers and continued exploitation will affect essential ecosystem goods and services.

A new research effort (GENUS: Geochemistry and Ecology of the Namibian Upwelling System) aims to clarify relationships between climate change, biogeochemical cycles of nutrient elements, radiatively active gases, and ecosystem structure in a large marine ecosystem, the upwelling system of the northern Benguela/SE Africa. Reasons for focussing on the coastal upwelling system offshore Namibia were a) the direct coupling between circulation, oxygen supply to the shelf, and processes in the ecosystem to the atmospheric forcing that varies on seasonal to inter-annual time scales, b) short trophic chains that facilitate a rigorous book-keeping of energy flows, and c) a significant knowledge base and availability of data and model components. The scientific aims of GENUS will be pursued by empirical studies into processes and rates of ocean circulation, biogeochemical cycling of nutrient elements between water column, biota and sediments, trophic interactions and energy flows, and a hierarchy of numerical models from regional climate, ocean circulation, ecosystems, and energy flows. GENUS also aims for a contribution to building capacity in marine sciences in Namibia by staging a joint scholarship programme with NatMIRC, UNAM, and German partner universities, by organising topical workshops in Namibia, and by participation of Namibian scientists on seagoing expeditions.

One of two initial expeditions in 2008 under the auspices of GENUS was cruise METEOR 76-2. This expedition, with two Namibian participants, investigated the reasons for and consequences of variable oxygenation of shelf waters offshore Namibia in the Northern Benguela Coastal Upwelling System. These variable oxygen conditions impact on the fluxes of dissolved constitutents from sediments to the water column and are modulated by microbial communities. The main questions addressed during operations at sea were: 1) How does the physical circulation system affect oxygen conditions on the shelf? 2) How are nutrient element cycles and ratios between nutrients affected by variable oxygen conditions? 3) Which processes in the cycling of nitrogen are responsible for unusual nutrient ratios in the upwelling waters? 4) What is the magnitude of sediment-water exchange processes under variable oxygen condition?

Operations

The ship left Walvis Bay on May 17, 2008 and collected data from a series of stations aligned in 6 transects perpendicular to the coast (at roughly 23°S, 22°S, 21°S, 20°S, 19°S and 17°30´S) (Figure 1). At all stations CTD casts (including water sampling with a rosette sampler) and multicore hauls for surface sediments were done. At 6 stations, we deployed autonomous benthic landers (chamber lander, bottom water profiler, bottom-water sampler) to measure benthic fluxes of dissolved constituents, an autonomous bottom-mounted ADCP to determine near-bottom currents, and we profiled the water column with a pumpcast CTD system and in-situ pumps. In addition, water-column microstructure was recorded by repeated casts with a free-fall microstructure profiler. Between stations, we collected bathymetric and seismic data with the onboard Kongsberg EM 120 multibeam echosounder and Atlas Parasound P70 system, In addition, an automated measurement systems were operated for T/S, nutrient analyses and physical water properties of surface waters (Thermosalinograph, FerryBox by 4-H Jena). The ship returned to Walvis Bay on June 4, 2008.

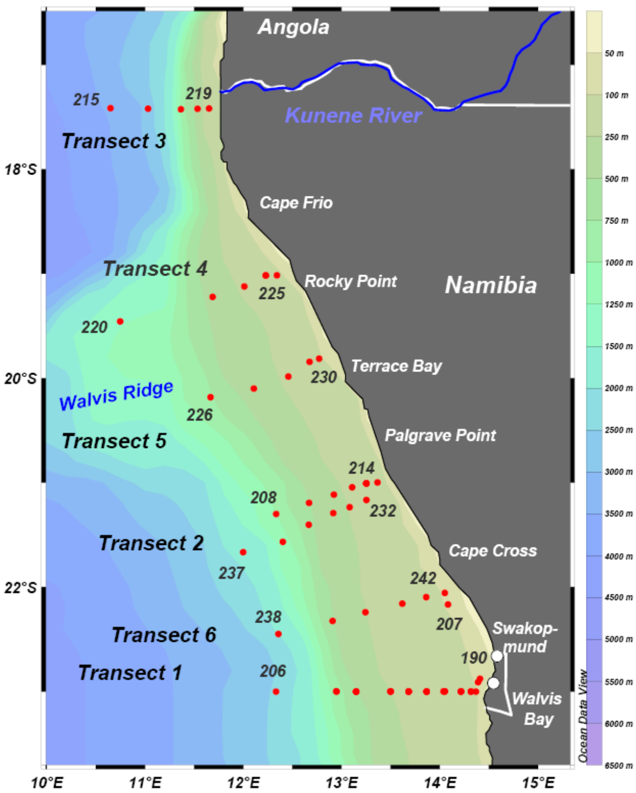

Figure 1: Stations (red dots) occupied during expedition Meteor 76-2 were aligned in different water masses and water depths on 6 transects perpendicular to the Namibian coast.

Preliminary results of operations and investigations at sea

The **hydrographic investigations** during the Meteor cruise M76/2 were focussed on two main topics. With respect to the large scale dynamics of the system, a CTD station grid was occupied that consisted of transects perpendicular to the coast. Transects covered were the shelf between the shelf break and the coast between 17.5 and 23°S. These measurements will complement the existing data sets from the RV M.S.MERIAN cruises MSM7/2 and MSM7/3 in March/April 2008. Our observations in the northern Benguela suggest that the summer season 2008 was characterised by exceptionally high surface temperatures and an increased frequency of coastal hydrogen sulphide outbreaks. In view of global change it will be important to clarify whether the uncommon conditions were caused by a usual Benguela Nino or can be attributed to a long term change.

Biogeochemical investigations concentrated on conditions in (a) the upper water column, (b) processes in the N-cycle in the water column, and (c) benthic flux rates. For the latter two areas, samples of sediments, pore waters, suspended matter and water were collected that will be analysed in shore-based laboratories. The conditions in surface waters were established by on-board measurements.

To document the oceanographic and biogeochemical situation during the expedition Meteor 76-2, we used an on-line measuring system (FerryBox; 4H-JENA). This type of instrument is increasingly used for environmental monitoring on ships of opportunity and yields high-quality data (particulate and dissolved consituents) in high temporal and spatial (on a moving vessel) resolution. In addition, an instrument to determine the pCO_2 of seawater was linked with the data system of the FerryBox. **Figure 2** shows the track of the ship through the waters offshore Namibia in the time period from May 20 to June 3 and the values of parameters recorded. Figure 2a and 2b depict temperature and salinity as measured by the ship´s thermosalinograph that was synchronized to the FerryBox data system via GPS. Figures 2d and 2e show oxygen concentrations (µmol/L) and chlorophyll *a* fluorescence (arbitrary units). Note the high values of both parameters south of 22°S, where apparently a plankton bloom was recorded. In contrast, oxygen levels were low (below 200 (µmol/L) in freshly upwelled and cold surface water N´ of 18°S. The spatial patterns of pCO_2 in surface waters are strictly antagonistic to concentrations of oxygen and were highest near the coast, and in particular in the freshly upwelled plume N´ of 18°S (where the concentrations exceeded the calibration range of the instrument). Phosphate and nitrate concentrations showed distinctly different patterns: Whereas both were high in the plume N´ of 18°S, phosphate concentrations were high in the area around 2°S, while nitrate concentrations were depleted. This phenomenon has previously been noted and was attributed to denitrification; it is most obvious in the frequently anoxic area around 22° S. Silicate levels were always high near the coast and coincided with colder water, and decreased rapidly as the water warmed and moved offshore.

On-board investigations in the water column showed micromolar ammonium concentrations within or just below the chlorophyll maximum at all stations and in the bottom waters (1-4 µM). In the intermediate waters, the ammonium was generally submicromolar. High nitrite concentrations (1-5 µM) were found in the same zones as ammonium with the highest concentrations in bottom waters with low oxygen concentrations (>5 µM).

A suite of autonomous instruments, including benthic landers, investigated conditions in the benthic boundary layer (BBL), the transition between sediment and bottom water. In general, the BBL was well mixed and steep gradients of the on board measured nutrients were found only at station 206. Release of H_2S from the sediment was detected at station 206 and 231). Further nutrient and gas samples need to be analyzed. The velocity measurements show that surface waves induce high current velocities in the BBL even at water depths of about 100m. Oxygen measurements seem to correlate with wave frequency and indicate a possible vertical transport mechanism for solutes and resuspended matter. Rate measurements in the BBL were performed and the results will be compared with the rates in the upper water column.

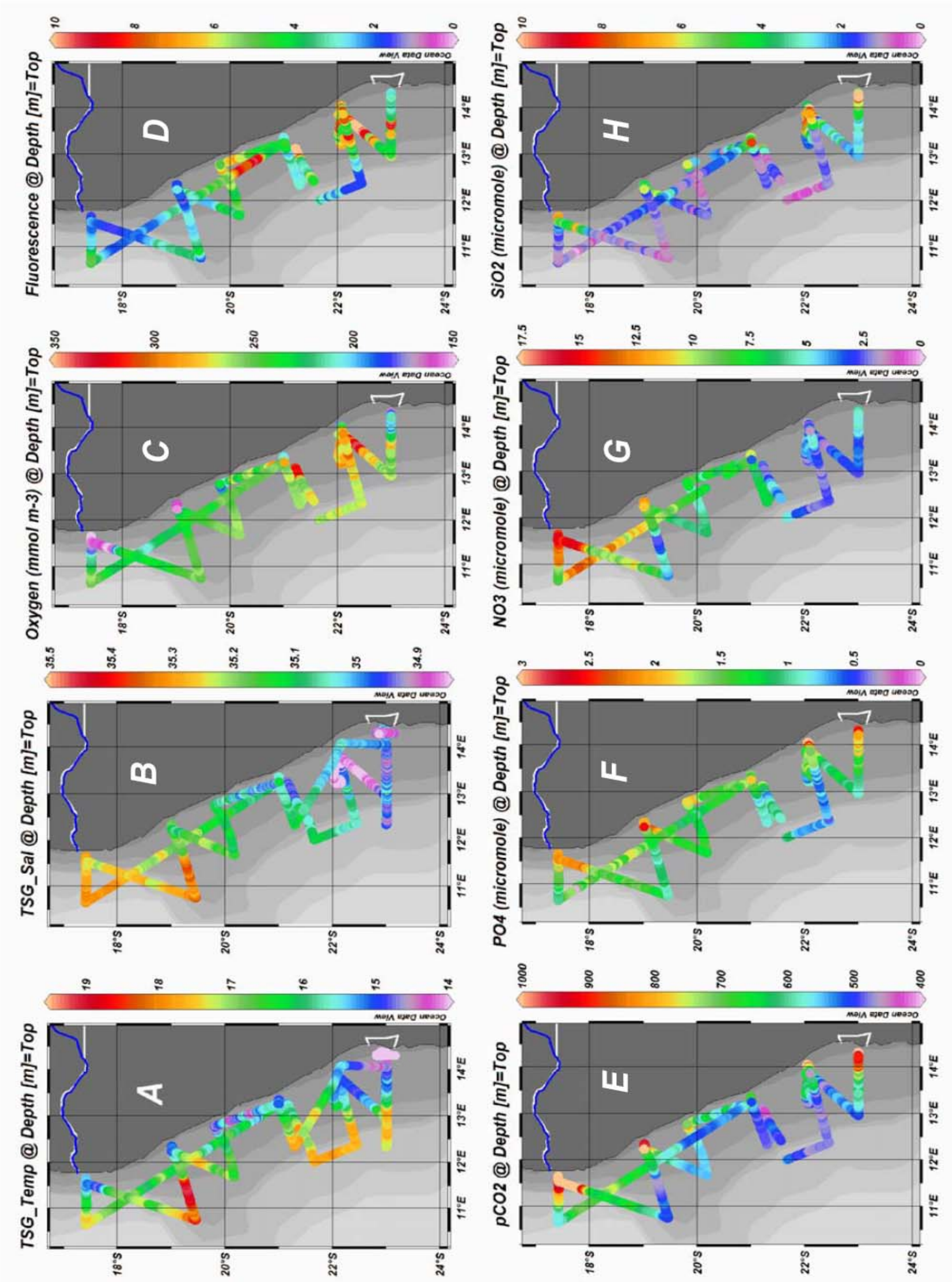

Figure 2: Results of FerryBox on-line measurements during expedition Meteor 76-2 offshore Namibia. Panels A to G depict results for temperature (A) and salinity (B) at 5 m water depth measured by the ship´s thermosalinograph. Panels C to H are color-coded concentrations or measurement values for oxygen (C), fluorescence (D), partial pressure of CO_2 (E), phosphate (F), nitrate (G) and silicate (H) in surface waters collected from 3 m depth at the ship´s bow by a circular pump system.