FS METEOR Cruise M189

April 16 – May 13, 2023

Walvis Bay (Namibia) – Walvis Bay (Namibia)

2nd Weekly Report (April 17 - 23, 2023)

During the second week of our cruise, we successfully completed the work program in Namibian territorial waters. An intensive week of hydrographic and turbulence measurements along high-resolution sections at 23°S and 20°S, mooring and drifter work, and an 18-hour turbulence time series station is behind us.

The boundary current circulation in the northern Benguela upwelling region (17°S - 27°S) is dominated by the northward-setting Benguela Coastal Current at the surface and the Poleward Undercurrent located on the continental slope and shelf. The poleward undercurrent carries oxygen-poor but nutrient-rich South Atlantic Central Water from the more northerly boundary current regions into the upwelling region offshore Namibia. During the summer months in the Southern Hemisphere, the Poleward Undercurrent is more pronounced and transports very low oxygen waters southward along the shelf and upper continental slope (Fig. 1). It is driven by the rotation of the wind field, which is intensified during the austral summer season. In the highly productive northern Benguela upwelling area, oxygen is further depleted by the degradation of organic matter, which can lead to anoxic conditions in bottom waters, especially during the period from February to April.

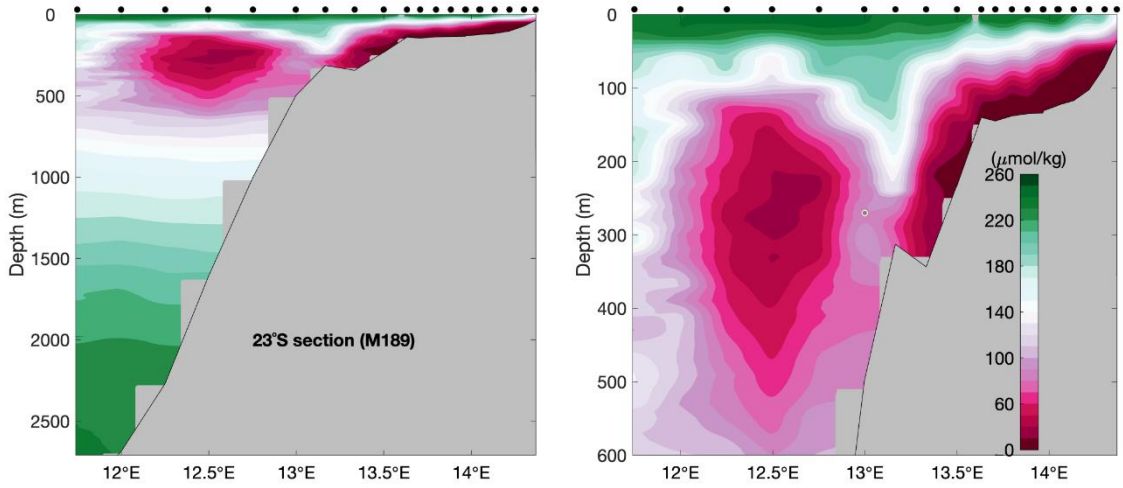

Fig. 1: Distribution of dissolved oxygen concentrations in µmol kg^{-1} along the 23°S section.

On-board oxygen analysis of our water samples using Winkler-titration showed values that, within the limits of measurement accuracy, indicate anoxic bottom water conditions. At the same time, we collected water samples to analyse for their hydrogen sulphide content in the labs back home, which would be evidence of anoxic conditions. One objective of this cruise is to study the cycling of nitrous oxide in the boundary between oxygenated and anoxic water masses. It is generally believed that N_2O degradation is promoted by denitrification at O_2 concentrations below 5 µmol kg^{-1}.

However, our previous observations from this region indicated that N_2O production is also possible under moderately sulfidic conditions in association with denitrifying sulphur bacteria. We found the conditions necessary for these studies, here.

The 23°S section has been sampled on many research cruises over the last decades, and at regular intervals also by our colleagues at the National Marine Information and Research Centre in Swakopmund, Namibia. Thus, our measurements contribute to the observing system in the southeastern Atlantic and, when combined with data sets from previous cruises, allow us to track long-term changes in the physical properties and the ecosystem of the northern Benguela upwelling region.

An important component of the south-eastern Atlantic observation system is a mooring at 23°S, which has been maintained by the Leibniz Institute for Baltic Sea Research, Warnemünde since the end of 2002. It provides valuable data almost continuously throughout the observational period. At the mooring, which is deployed at a water depth of 136 m, acoustic Doppler current profilers measure velocities in the water column, while temperature and salinity time series are recorded at different depths. The mooring and a sediment trap deployed nearby were successfully recovered and redeployed (Fig. 2). We are pleased to report that all moored instruments functioned properly.

Fig. 2: Recovery of the sediment trap at 23°S.

During our measurements along 23°S we observed a rather rare phenomenon of an ocean-atmosphere interaction, the excitation of an inertial wave by winds rotating anticyclonically, counter clockwise in the southern hemisphere. Between April 16 and April 18, the formation of an atmospheric trough along the Namibian coast resulted in variable winds that rotated anticyclonically with a period of about 30 hours, which corresponds to the local inertial period. These winds excite particularly strong currents in the ocean rotating in circles with the inertial period. Thus, the track of the drifter that we deployed last Sunday showed circular motions in addition to a mean southwestward-setting current (Fig. 3, left). The inertial wave currents are predominantly confined to the surface layer, which is less than 10m in our study area. However, here we could observe the rotating currents somewhat attenuated down to depths of 40m (Fig. 3 centre).

Inertial waves cause particularly strong vertical changes in the horizontal currents at the base of the surface mixed layer, leading to increased mixing in the stratified ocean below the mixed layer. Velocities measured on the drifter from an acoustic Doppler current profiler show the increased vertical current shear at depths between 5m and 10m (Fig. 3 right). The increased mixing caused by inertial waves plays an important role for the cooling of the surface layer but also for the transport of nutrients from deeper layers to the near-surface. In our study area, they thus represent an additional process that increases productivity in the upwelling area and contributes to the cooling of surface temperatures.

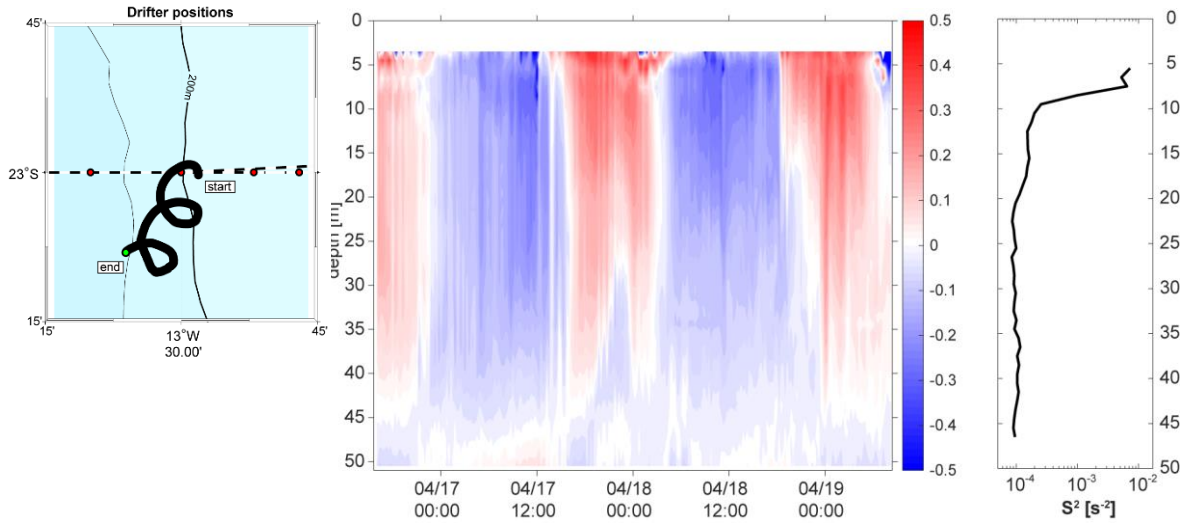

Fig. 3: Trajectory of our drifter over a period of nearly 3 days (left). Upper-ocean meridional velocity from the acoustic Doppler current profiler attached to the drift (centre). Vertical change of the horizontal velocities measured with the drifter (right).

This Sunday evening, we set course for Walvis Bay, where we expect to arrive on Monday afternoon to complete customs formalities for leaving Namibia. The mood on board continues to be very good and despite the intensive station work, the cruise is taking place in a very cooperative, friendly and pleasant atmosphere. Captain Rainer Hammacher and his entire METEOR team make a great contribution to this - thank you very much!

Best regards from the southeastern tropical Atlantic Ocean on behalf of all cruise participants of M189,

Marcus Dengler

(GEOMAR Helmholtz Centre for Ocean Research Kiel)