RV SONNE

Cruise SO308 South Indian Ocean GEOTRACES GI07

31st October – 22nd December 2024

Durban (South Africa) – Fremantle (Australia)

7. Weekly Report

Reporting Period: 9th December - 15th December - 2024

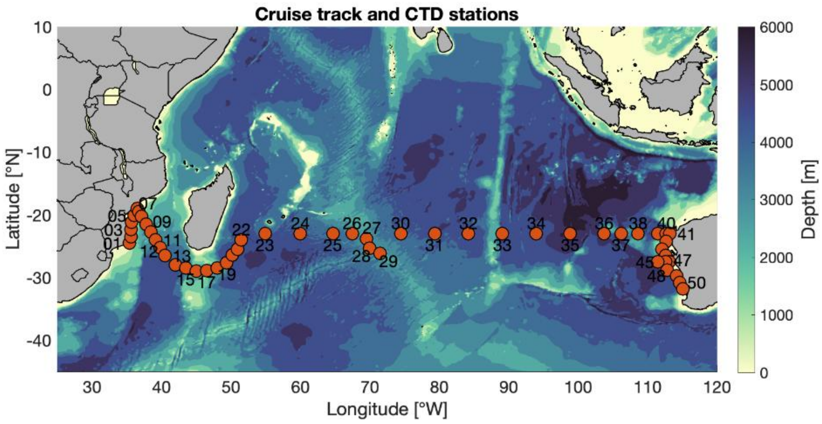

Fig. 1. The cruise track with 51 stations (red dots).

The GEOTRACES research cruise SO308 is 6 weeks underway, and we are sampling in the EEZ of Australia at station 47, our last superstation with deployment of *in situ* pumps (Fig. 1).

Over the last seven days we have sampled 9 stations along 23°S and then in the EEZ of Australia. From stations 41 we started moving southwards with the flow of the Leeuwin Current. This current system brings nitrate depleted waters from the Indonesian regions along the Western Australian coast and towards the southwest of Australia. Other southeastern boundary regions of the world's ocean (SE Pacific and SE Atlantic Ocean have strong upwelling regions with high productivity and important fisheries and oxygen minimum zones. These regions are associated with equatorward currents that are part of their large gyre systems, and cause Eckman driven upwelling along the coasts. The South Indian Ocean gyre system does not reach the Western Australian coast as the poleward Leeuwin Current forms a separation between the Australian mainland and the gyre flow.

Figure 2 shows the meridional sections of conservative temperature, absolute salinity and dissolved oxygen for the cruise SO308 from about 35°E to 111°E. The data are obtained by Paula Damke and Hannah Melzer (GEOMAR). The data indicate the enhanced surface water temperatures of the South Indian Ocean along our transect, and also the signatures of oxygen depleted waters around and below 1000 m. In particular the low oxygen tongue in the eastern region is now becoming evident. The shoaling of the isopycnals towards the east of our transect is evident in the temperature, salinity and oxygen plots.

In the coming days we have 4 stations left, and the wind is expected to increase with waves up to 5 m. The coming days will be fun with the weather conditions during station work and whilst finishing our analyses, packing and loading of containers.

Today, we celebrated the third advent Sunday with again wonderful meals prepared by our fantastic cooks.

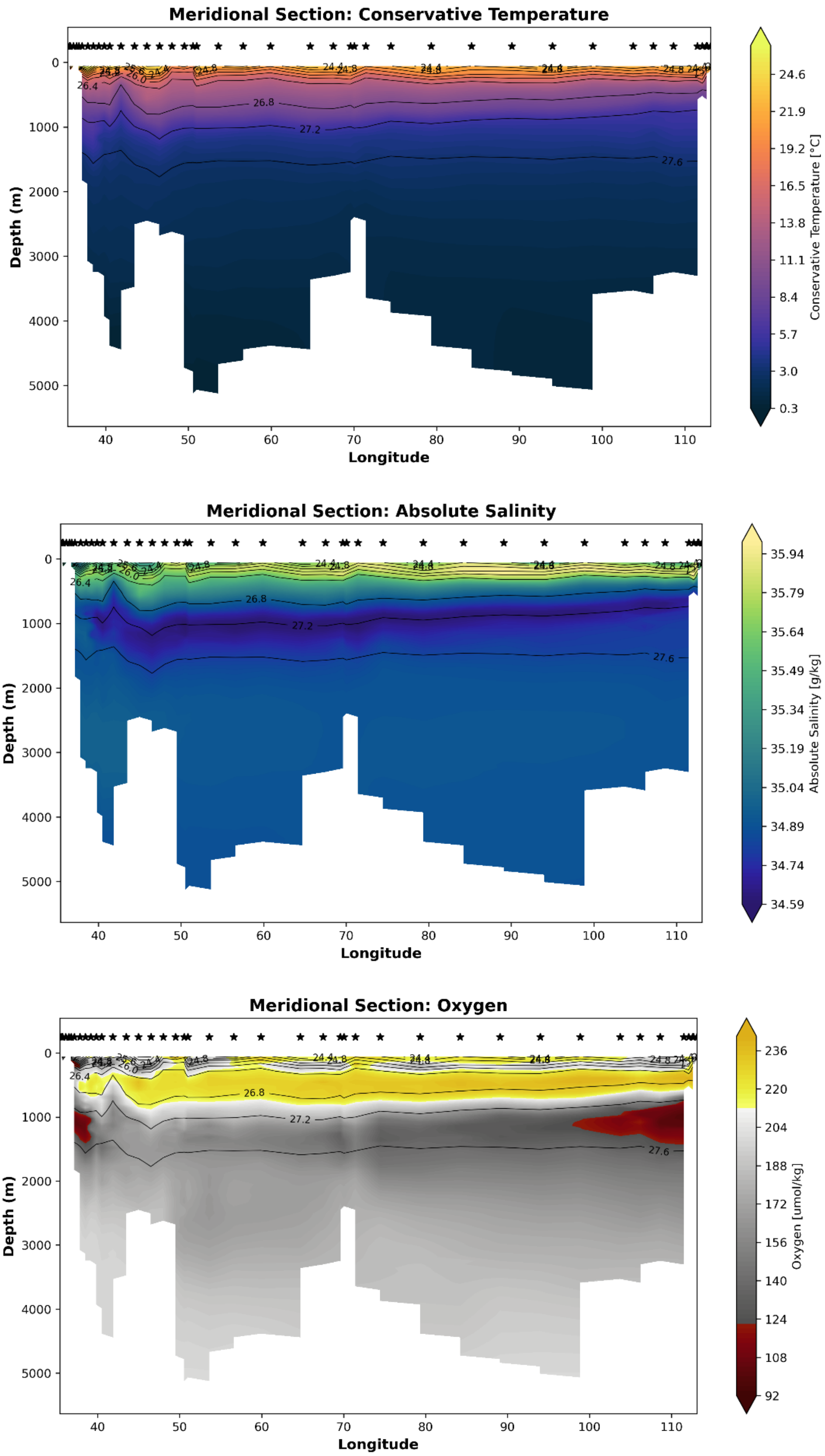

Fig. 2. Meridional section of temperature, salinity and oxygen along the cruise transect. Salinity and oxygen data are preliminary and not yet calibrated. Data Paula Damke and Hannah Melzer. Plots by Hannah Melzer. (GEOMAR).

Fig. 3. Paula Damke with the microstructure profiler. Photo by Can Gürses

Turbulence measurements in the surface ocean

In addition to the multiple CTD casts that we undertake daily, Hannah Melzer and Paula Damke are also measuring at every station the upper ocean turbulence using a microstructure profiler (Fig. 3).

The microstructure profiler is an instrument that is deployed via a small winch at the aft of the ship and allowed to free fall through the water column. It has very sensitive sensors that detect very small changes in velocity and record those as the probe makes its way downward (Fig. 4). The measurements are used to determine the 'microstructure' in the top of the water column (up to about 200-300 m deep), meaning what happens on the microscopic scales over which turbulent mixing occurs (Fig. 5).

Turbulence is important for the mixing of properties (such as salinity, nutrients and temperature) of different fluids—like different layers of water in the ocean. Hannah explains this phenomenon using a coffee analogy: if you add milk to coffee and just let it sit, the two fluids will eventually mix due to diffusion processes, but by then your coffee will be long cold. But if you introduce turbulence into the system by mixing with a spoon, the number of points of contact between the milk and coffee are increased, and a homogenous solution—perfectly milky coffee—will be swiftly achieved while the beverage is still nice and hot.

Fig. 4. Sensors at the tip of the microstructure profiler. Photo by Hannah Melzer.

The turbulent mixing between fluids with different densities is often the result of waves along their interface, called internal waves. Only the very top layer of the ocean is in contact with the atmosphere, and there is usually a clear boundary between this upper layer—called the mixed layer since wind influence keeps it well-mixed— and the rest of the water column. This boundary usually prevents mixing between these layers, but internal waves at the bottom of the mixed layer can move trace elements and nutrients from the mixed layer to the deeper ocean and vice versa (Fig. 6). Measuring both the strength of turbulence and the concentrations of chemical species (determined from seawater collected via the CTD rosette) throughout the mixed layer and deeper water can provide an estimate of the amount of internal-wave-facilitated exchange.

Fig. 5. Hannah Melzer deploys the microstructure profiler. Photo by Can Gürses.

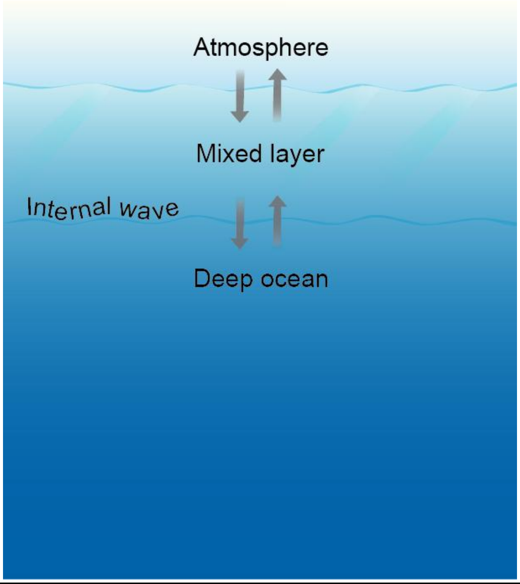

Fig. 6. Simplified schematic of turbulent mixing in the ocean. Image by Charlotte Eckmann.

Observations of dissolved Hg in the South Indian Ocean

Mercury (Hg) is a notoriously toxic trace metal which can be found in nearly every reservoir on earth. Natural sources of Hg include volcanoes and hydrothermal vents, while elevated Hg is supplied by anthropogenic inputs, primarily driven by coal burning, gold mining, and cement production. In the ocean, Hg is found in different forms, including methylmercury (MeHg), which is toxic and can both bioaccumulate and biomagnify (meaning that concentrations in living organisms increase moving up the foodchain). Because of its toxicity to humans and wildlife, it is important to measure concentrations and understand distribution of Hg and MeHg in all ocean basins. To date, there has been no reported measurement of Hg speciation in the Southern Indian Ocean, making this research and these results very exciting.

Across the SO308 transect samples have been collected for seawater speciation, sediments, (including some porewater profiles) and filtered particles. Seawater samples are analysed on-board for both total Hg and DGM, with quantification via cold vapor atomic fluorescence. The MeHg samples are collected and acidified and will be measured in the lab back on land. Kati Gosnell and Marco Ajmar (GEOMAR) are handling both the sampling and on-board analysis of total Hg, in addition to select profiles of dissolved gaseous Hg (DGM). Preliminary results (Fig. 7) show that total Hg is very low across the SIO, with most deep water concentrations reaching approximately 1 pM. The DGM is also very low, with deep waters showing <0.4 pM.

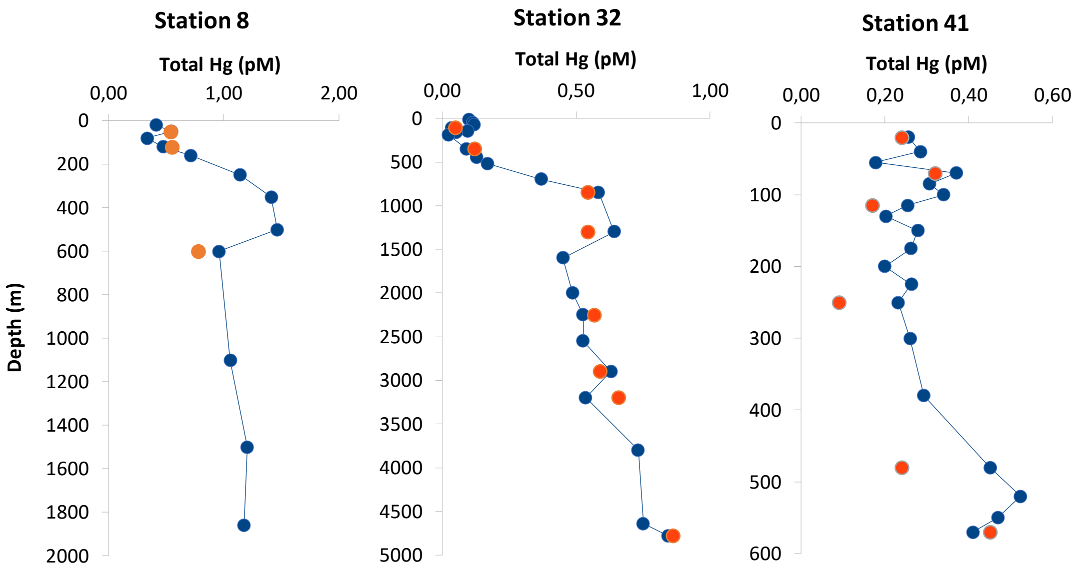

Fig. 7. Total mercury (Hg) profiles for the SIO transect. Station 8 was sampled off the Mozambique coast, and shows influx from the Zambezi river. Station 32 exemplifies a typical open ocean profile. While station 41, was sampled off the Australian coast, is very low as consistent with shallower surface waters. Note the different depths on each profile.

RV SONNE at sea 27°30 S/111°30 E

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