First trial of the IOW profiling mooring

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The first trial of the profiling mooring for the Gotland Deep GODESS (GOtland Deep Environmental Sampling Station) started on May 6. when we sailed with the IOW ship Professor Albrecht Penck from Rostock. We didn't have much time to do any tests at home with the system as some of the components came together in the final days of preparation. The last bit, the new Rinko oxygen optode from Alec, found it's way to us only one day before loading the ship (it had been held up in Dubai due to the ash cloud from the Islandic volcano eruption). Without the oxygen sensor we were not able to test the balance of the profiling body and also couldn't measure it's buoyancy.

The deployed system is a first trial version with the Sea & Sun multi-parameter CTD (parameters: conductivity, temperature, pressure, Chl a fluorescence, pH, ORP (oxidation/reduction potential), and turbidity) and the oxygen optode connected to the CTD. For later deployments other sensor should be added so the profiler design was held simple and based on the normal Sea & Sun titanium CTD frame. Sea & Sun delivered the frame to our modified design. The only modification is that one corner was pulled out from the usual square as shown in figure 1.

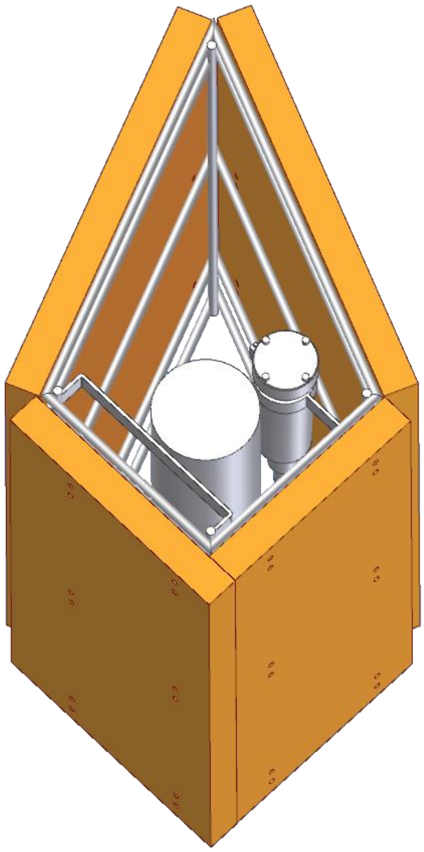

Figure 1: Simplified sketch of the profiling body with the CTD (big cylinder) and the oxygen sensor (small cylinder) installed. The orange plates are syntactic foam sheets that create the buoyancy. Two additional sheets were installed on the inside of the frame. The height of the body is about 50 cm.

The necessary buoyancy (the winch needs a minimum of 8 to 9 kgf to avoid the tension sensor switching the winch motor off) is provided by sheets of syntactic foam, the framework is made from titanium to keep the weight down. The profiling body is connected to the winch line with a bridle that balances the position of the body in the water.

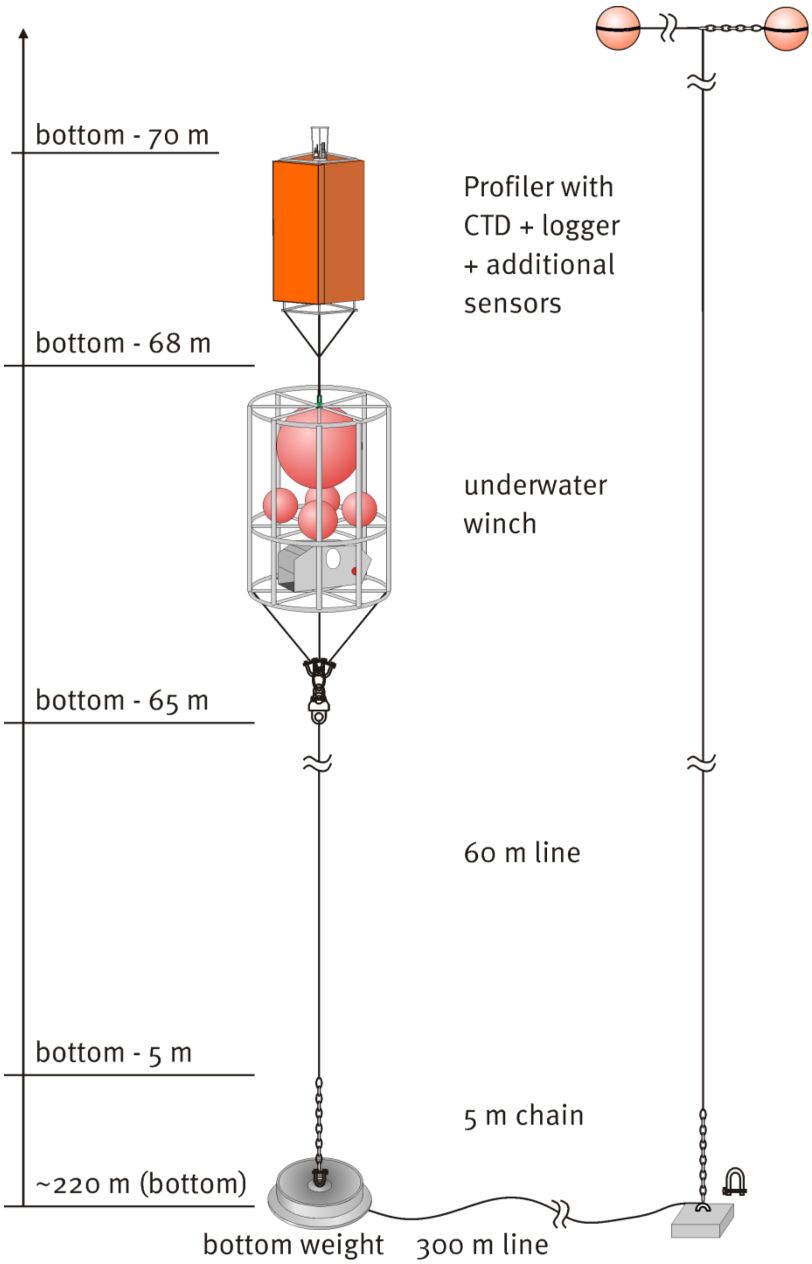

Figure 2: Simplified sketch of the mooring layout for the first trial.

The ship time was limited to five days and the ship needs two days of steaming to reach the position from Rostock. So we only had about 20 hours for the deployment of the mooring. Therefore the underwater winch was programmed to let the profiler ascend to take a profile every hour (as opposed to the intended long term deployment, where a profile will be taken every 12 or 24 hours) and to reel it back in immediately (this will be the case as well when operating routinely as the profiler then sits in anoxic water and in the dark, which reduces the risk of biofouling and also keeps it out of danger from ship traffic). As the recovery was planned for the next morning the winch was programmed for a 17-hour operation. The CTD was programmed to continuously record data at the maximum data rate of ca. 4 Hz as the total deployment time was sufficiently short.

Since the ship remained in the vicinity of the mooring over the deployment period a different layout of the mooring was realized; the releaser and drum with recovery line was not included, instead a line was attached to the other end of the bottom line with floatation balls that where swimming on the water surface, both as a marker and a handle for recovery (see figure 2).

The deployment went without major problems, the only critical moments were when the winch and profiler were drifting close to the ships hull as the CTD sensors, especially the pH and ORP probes are very sensitive to shocks and bending. Figure 3 shows the winch and profiler at deployment. The ground weight was dropped at 10:20 UTC on May 9th at 57°19.22'N, 20°8.22'E and the profiling body reached the parking depth at ca. 150 m about three and a half minutes later. The first profile was programmed to commence at 11:00 UTC.

Figure 3: Deployment of the winch and profiling body for the first trial. The profiling body is upside down as it only rightens itself due to the buoyancy in the water. (Photo D. Meyer)

The next morning (May 10th) the mooring was recovered around 5:30 UTC. The recovery went as smoothly as the deployment (see fig. 4) and a first look at the line drum of the winch revealed that it must have worked at least once. The Sea & Sun CTD also was still logging happily.

After download of the data from the CTD and a first look at the pressure readings it was clear that the deployment had been a success. All 17 profiles went as intended, the first ascend starting a little slower than the following ones that all showed almost the same behaviour. The slow start of the first profile is attributed to the tight winding of the kevlar rope on the winch drum. Figure 5 shows the pressure readings over time.

First results

The pressure readings allow to look at the stability of the parking depth and the speed of ascend and descend. The time difference between the programmed start of a profile and the first move of the CTD allows to detect the drift between the on board clocks of winch and CTD. And indeed the CTD clock is lagging behind the winch clock by about 2.5 seconds over the 17 hours. While this is not serious for

Figure 4: Recovery of the winch and profiling body after the first deployment.

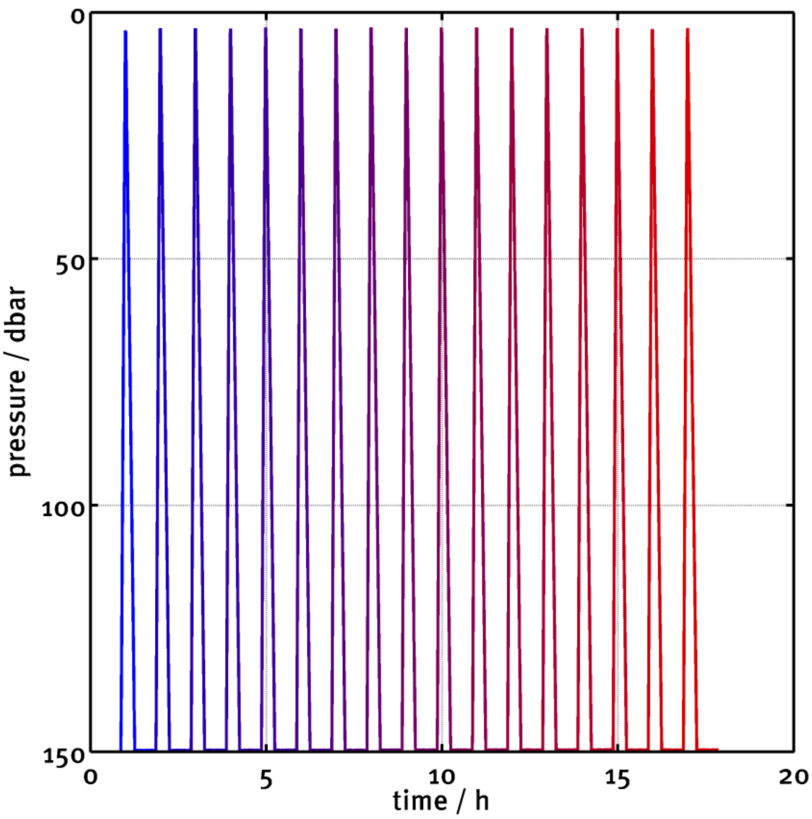

Figure 5: Pressure readings plotted over the deployment time of the mooring. In the following the same colour coding is used for the data plotted, thus providing some temporal reference.

a short deployment it adds up to about 5 minutes over a deployment of 90 days and has to be taken into account for programming of winch and CTD.

The ascent took about seven minutes (from 149 dbar to 3 dbar, 150 m line release programmed) so that the ascend speed was about 0.34 m/s. The descent took about 15.5 minutes which is equivalent to a speed of about 0.16 m/s. Looking at the data provided from NGK, the manufacturer of the underwater winch, this is hinting at a net buoyancy of about 9 kgf of the profiling body with instruments. A later test in local waters with a 10 kg weight hung from the bridle did confirm this estimate. The buoyancy therefore was almost spot on the design goal; less buoyancy carries the risk of the rope tension sensor switching the motor off while more buoyancy means more power demand for a longer time of the motor when reeling the profiling body back down. This in turn reduces the number of profiles that can be taken with one set of batteries.

With the data from the first trial deployment and the data provided by NGK the total number of profiles on one set of winch batteries for a deployment in 160 m and the shallowest sampling depth of 10 m can be estimated to about 380 profiles. This would mean that for a 3 month deployment 4 profiles per day could be taken. This estimate has to be taken with care though and we have to wait for the experience of the first deployments at the station.

The second trial deployment is programmed to take 206 profiles over 34 days with the same set of winch batteries that was used in the first trial.

The data set that was taken during the first trial is shown in the following. The same colour coding as in figure 5 is used, i.e. the first profile is plotted in blue and the colours gradually change up to the last profile that is plotted in red.

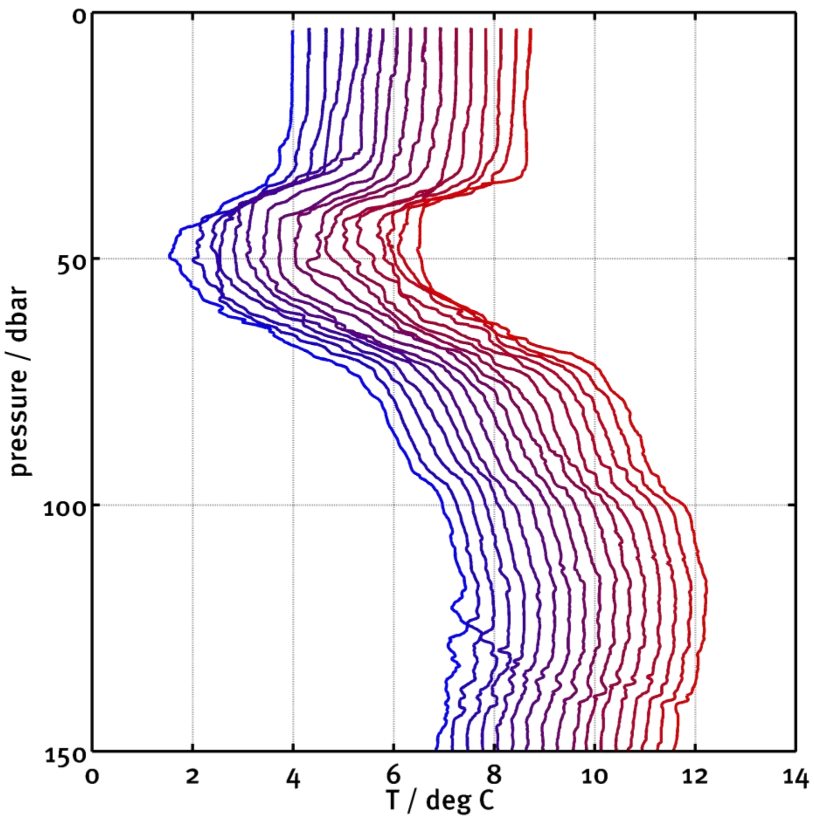

Figure 6: Temperature profiles plotted with an offset of 0.3°C per profile. Blue: first profile, red: last profile.

Figure 6 shows the 17 temperature profiles taken during the first deployment. Apart from the variability in the high gradient regions it shows some small structures at about 140 m that slowly progresses through the water column.

Figure 7 shows the salinity profiles, figure 8 the density profiles.

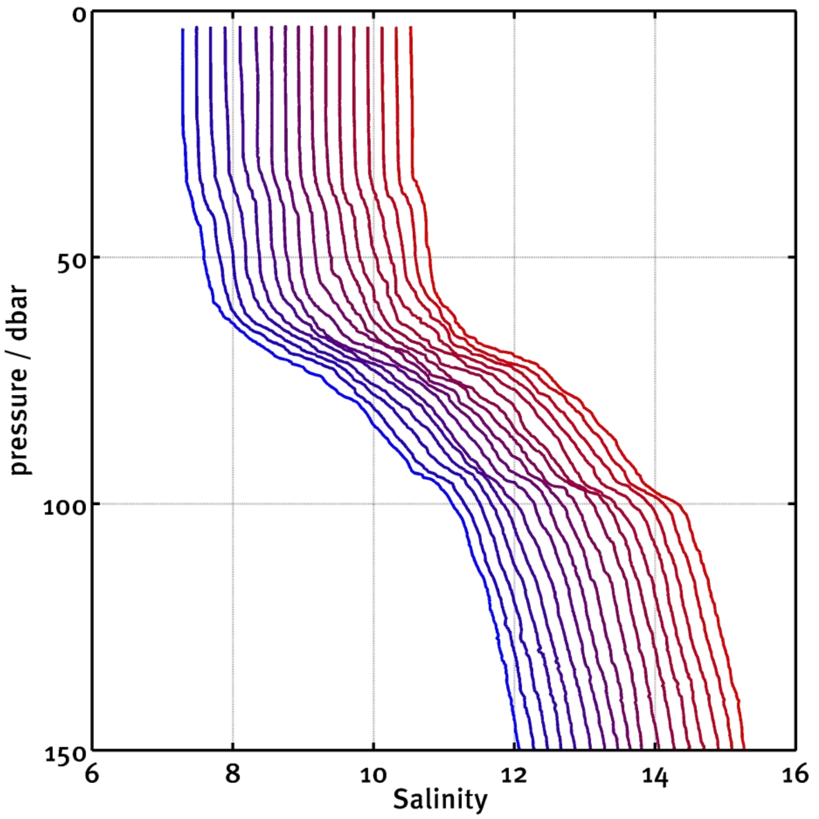

Figure 7: Salinity profiles plotted with an offset of 0.2 per profile. Blue: first profile, red: last profile.

While the profiles look very similar some small variations are visible (e.g. in salinity and density between profiles 11, 12 and 13 at around 70 metres depth).

The dissolved oxygen profiles show similar features as the temperature in the depth. The small variations, however, could be more important in this suboxic/anoxic region. The profiles are shown in figure 9. Figure 10 shows the same data in a different way, with colour coded oxygen saturation values. All saturations greater 20% are plotted in red to highlight the structure in the low saturations.

The first trial also yielded the same number of pH, ORP, Chl a fluorescence and turbidity profiles that are not shown in this report. The pH and ORP electrodes did show a drift over time that slowed down as the deployment progressed. The longer term performance of these electrode sensors has to be looked at after the second and following trials.

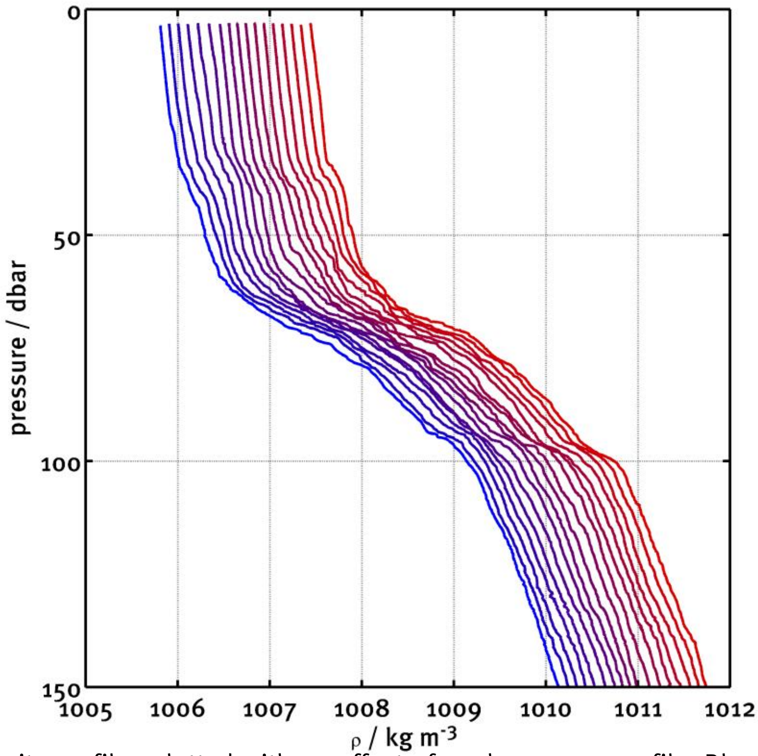

Figure 8: Density profiles plotted with an offset of 0.1 kg m^{-3} per profile. Blue: first profile, red: last profile.

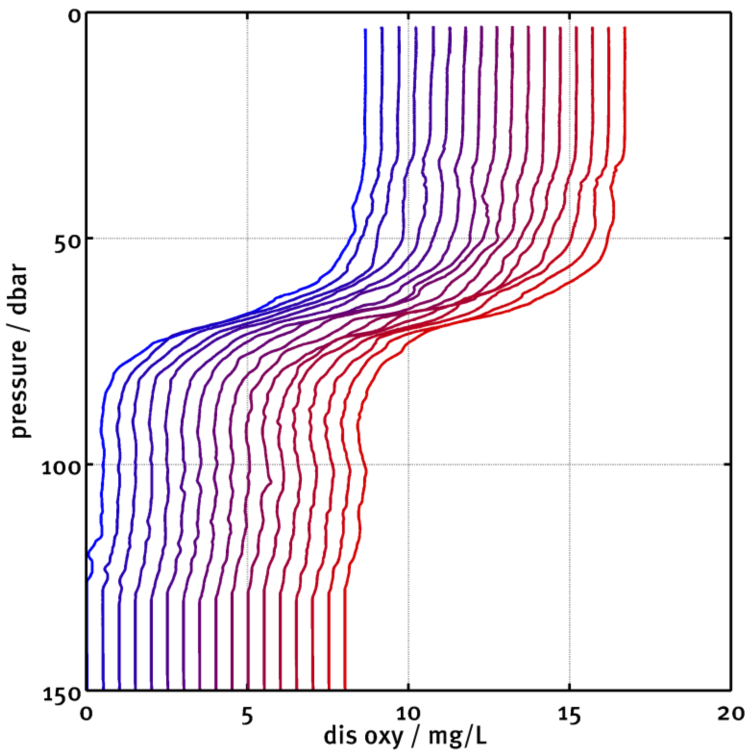

Figure 9: Dissolved oxygen profiles plotted with an offset of 0.5 mg l^{-1} per profile. Blue: first profile, red: last profile.

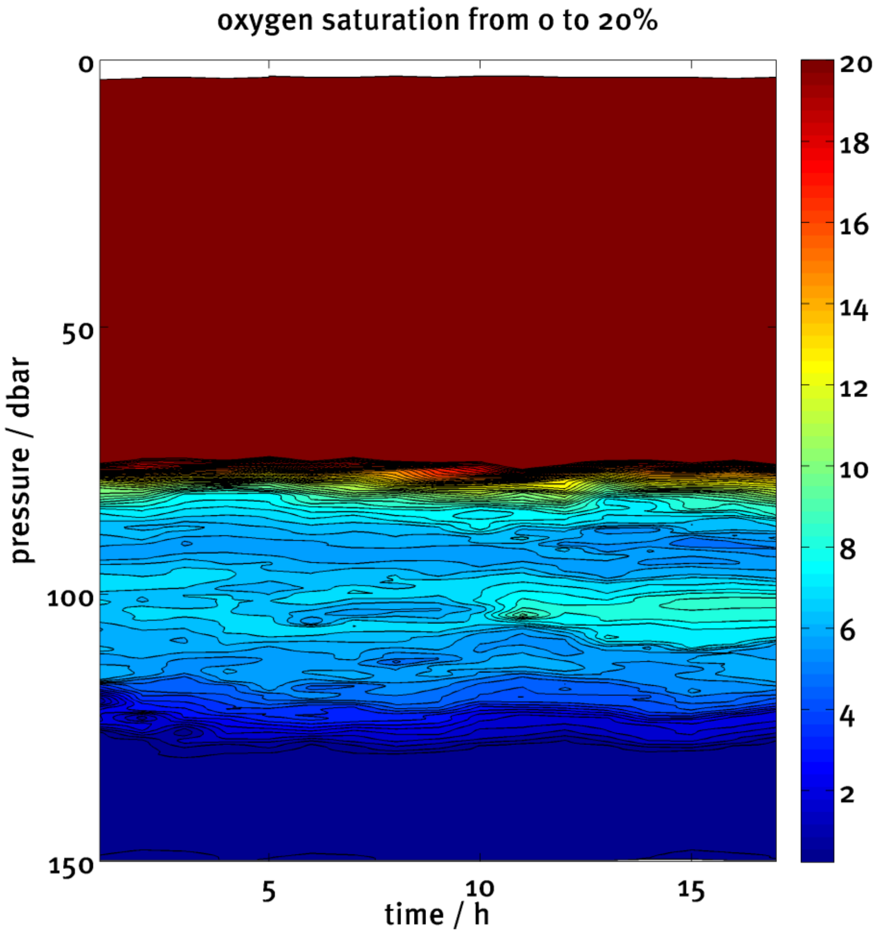

Figure 9: Dissolved oxygen profiles plotted with an offset of 0.5 mg l^{-1} per profile. Blue: first profile, red: last profile.

This first short trial already shows that it is worthwhile to look at the dynamics on the short time scale. To find the ideal frequency of profiles longer tests have to be run. The current set up of the mooring allows to take four profiles a day over a period of three months. If this offers substantially more information than two profiles or a single profile per day remains to be seen.