High-precision calibration of salinity measurements

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Background

High-precision calibration of salinity measurements is of utmost importance for detecting changes in the oceans salinity such as trends within climate change. Here we present our calibration strategy using the Optimare Precision Salinometer (OPS). The OPS is capable of measuring the salinity with a resolution and repeatability of 0.0001. This does not relate in accuracy, as the accuracy of the standard sea water is given with 0.001.

Optimare Precision Salinometer, instrument and measurement technic

The OPS was developed at the Alfred Wegener Institute, in cooperation with Optimare. This new salinometer improves the achievable accuracy enormously in comparison to previous instruments, which allows researchers to investigate reliably numerous issues that were difficult to access before, like the potential stratification in a sample bottle or a CTD-Rosette-bottle, used to extract water from the deep oceans. The most important technical features and improvements are:

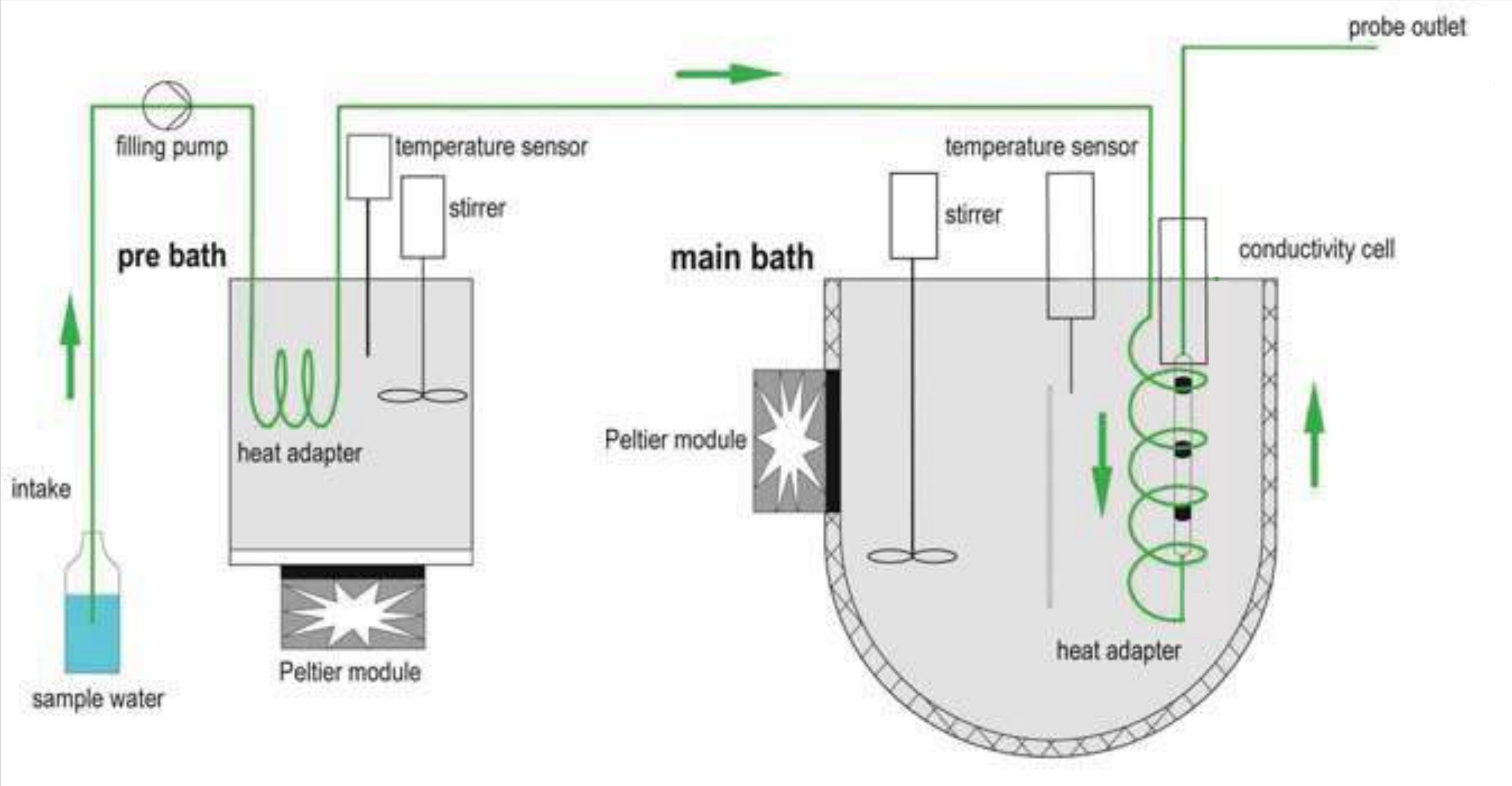
Thermal management: no electrical heaters, heat input via dissipation of mechanical energy by a continuously running, controlled stirrer, cooling by a controlled Peltier element.

Conductivity measurement: continuous measurement of the conductivity in the cell, thus continuous control over the stability of the cell state, low interference with electromagnetic fields.

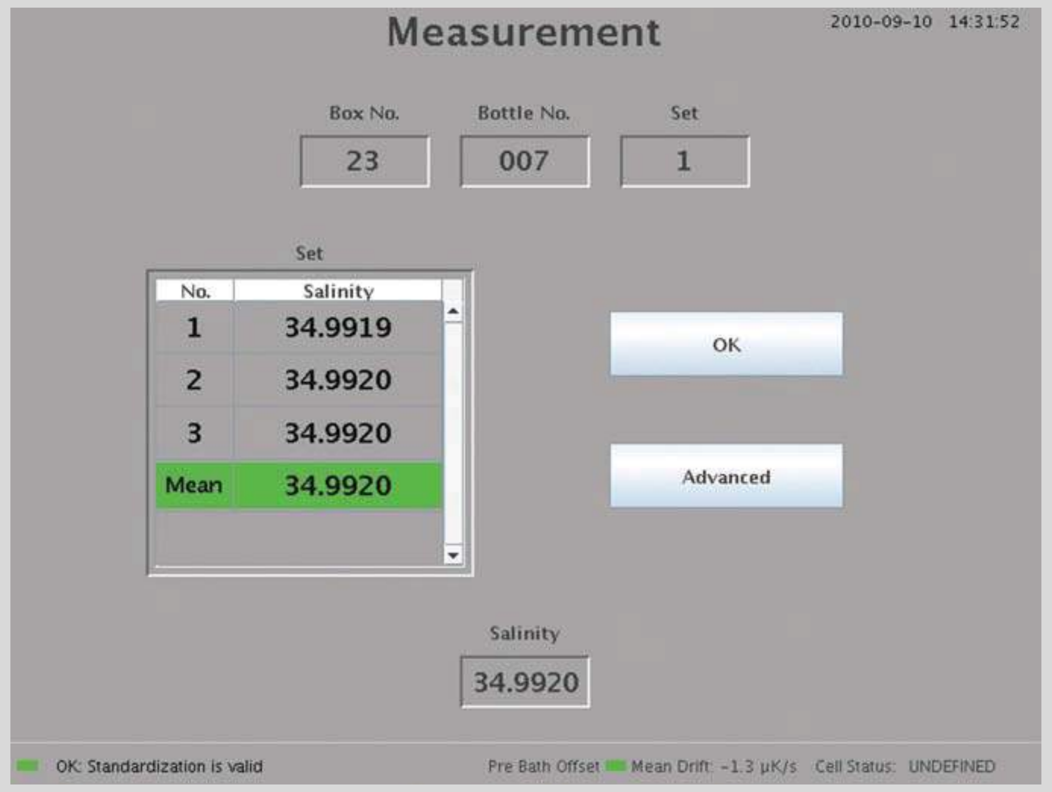
Range: No need to change the measurement range.

Results: Results are automatically logged in a text file.

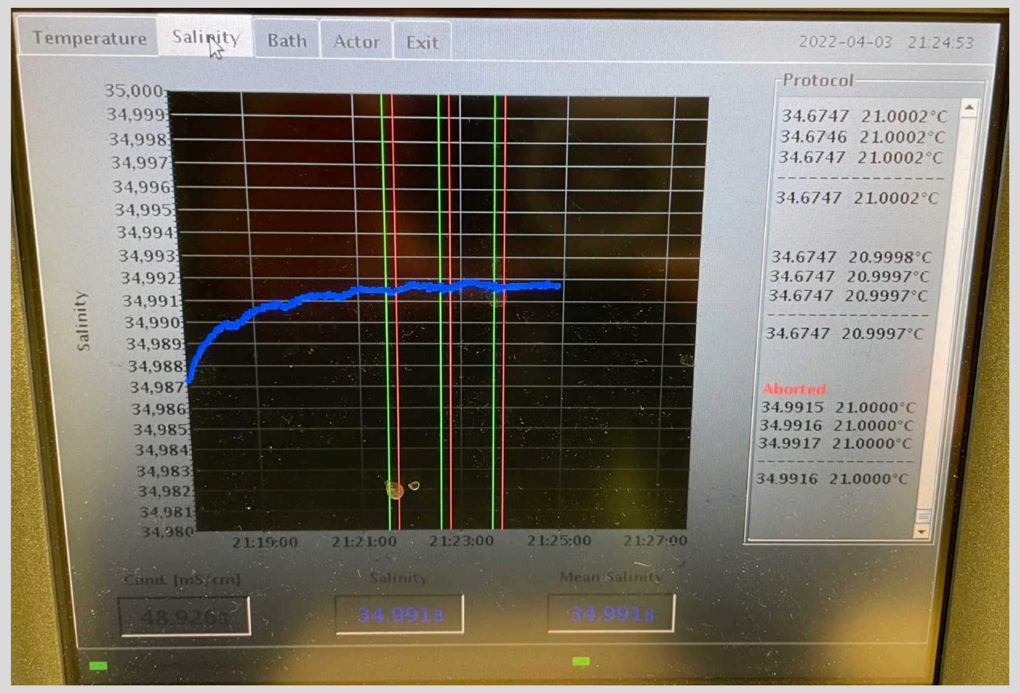
Most steps in the measurement process, including the standardization with standard seawater, are automatized, such as the full cycle of flushing and filing the cell, taking the measurement, computing the salinity and writing the result into a text file. This reduces the risk of mistakes and operating errors.



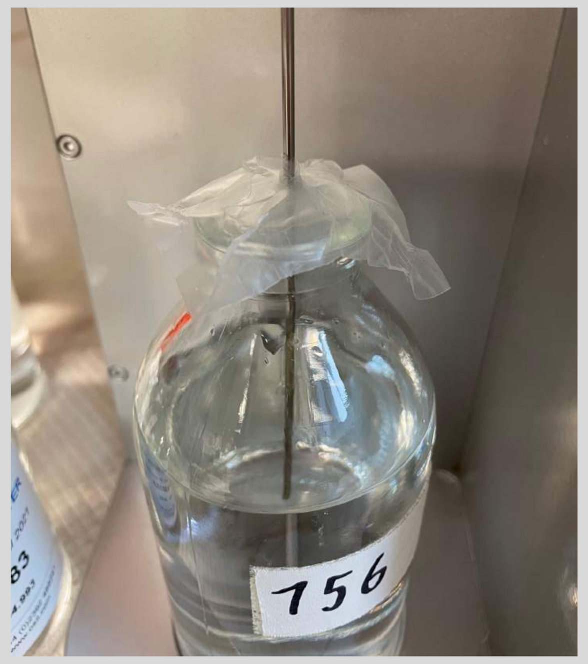
Schematic showing the main elements of the Optimare Precision Salinometer



Left picture: Display of a typical result shown on the touch-screen display after finishing the measurement of a water sample bottle. The top row gives the sample number as given by the operator at the beginning of the measurement cycle. Below the three measured salinity values as well as the mean are listed. Those results are automatically logged in a text file. The advanced mode can be used by the operator to get more information on the status of the conductively cell.



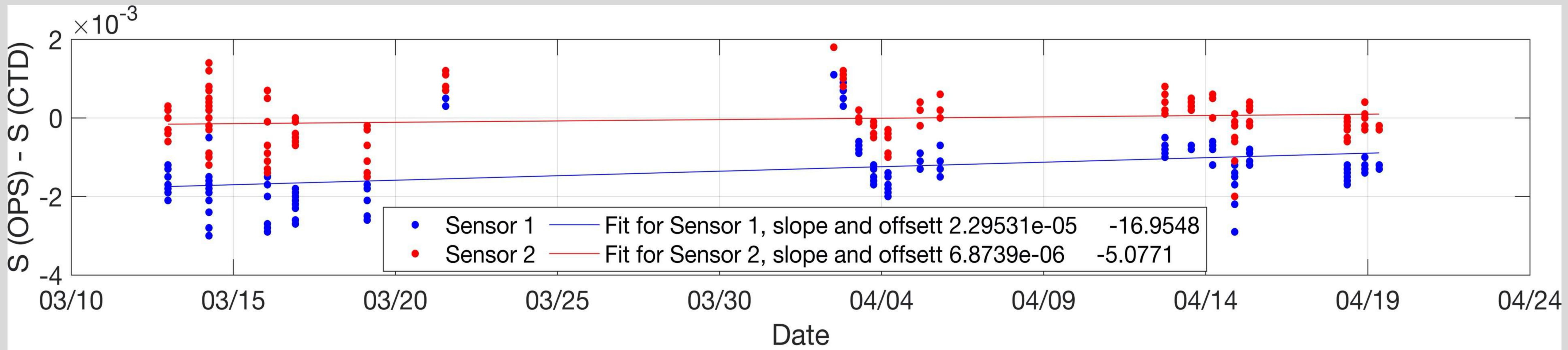
Right picture: The advanced mode shows the ad-hoc reading of the conductivity as well as the timing (green and red lines) of a measurement. The result is displayed on the right. From the top panel the fields "temperature", "bath", and "actor" can be selected to monitor the temperature of the pre and main bath, to adjust the control of both baths and to e.g. move the intake or switch on/off the light in the conductivity cell.

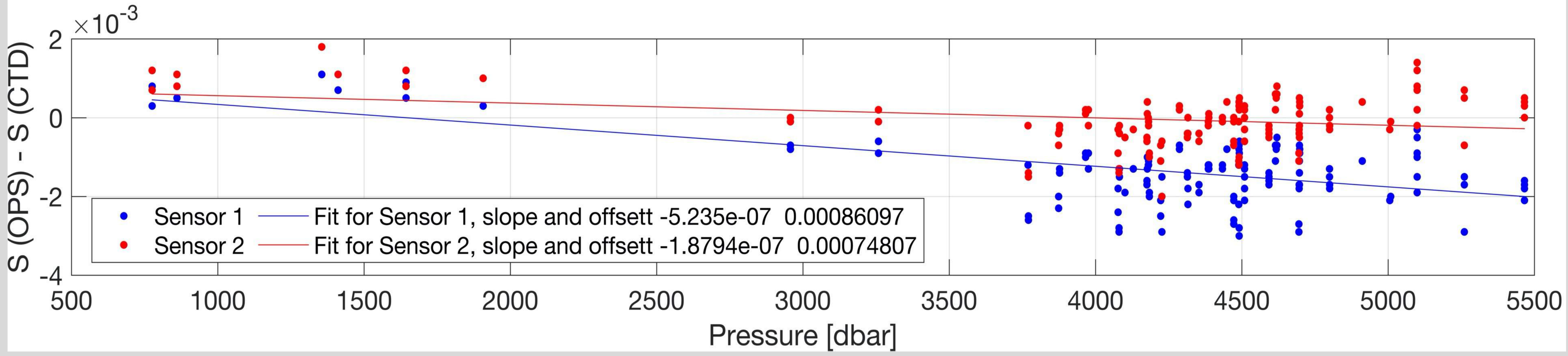


Left picture: Sample bottle and water intake. To reduce evaporation during the measurement a piece of Parafilm is attached at the intake of the salinometer such that it covers the bottle.

Calibration of CTD data using salinity samples measured with the OPS

For precise calibration of CTD data the selection of a suitable environment is of high importance. Only regions with a low gradient and little fluctuations can be used to find a meaningful result, when comparing the in-situ measurement with the salinometer based value. During a CTD-cast we visually identify a region of low temperature stratification and close a CTD-sampling bottle in that layer. From each sampled layer we take a double sample from the CTD-sampling bottle. The OPS measurements of those double samples routinely agree within 0.0005 to even 0.0000. Offsets determined with samples from those homogeneous regions are used to determine temporal drift and pressure dependence of the conductivity sensors which can later be used to correct the salinity sensor readings for the whole water column. The plot below shows salinity data from one of our cruises. Only a very low temporal drift was determined for this cruise with sensor 2 showing even less drift. The pressure dependence can be determined by taking samples from different depths. The pressure dependence of sensor 2 is lower compared to sensor 1. In this case sensor pair 2 would be chosen as the better performing one and the data of channel 2 would be used, after correction, for the final data set. It is essential to correct a possible pressure dependency of the temperature sensor first, before introducing a pressure correction to the salinity or conductivity data.





Sample treatment and sampling bottles

Sampling: When sampling for salinity we make sure to sample the CTD quickly, as stratification will build up in the CTD-Rosette-bottle.

Solubility of gases in seawater: If water from deeper layers is brought to the surface, outgassing takes place (the solubility of gases generally decreases with increasing temperature and decreases with decreasing pressure). This outgassing creates micro-bubbles, which contaminate the measurement. To reduce micro-bubbles we degas the samples. For degassing, the samples are slightly heated and overpressure is released from the bottles.

Bottles: The bottles we use are borosilicate glass bottles of hydrolytic class 1 with a neck diameter of 32mm.

After the over-pressure is released from the bottles, the samples are left to adjust to room temperature for a few hours.

Bottles in temperature bath with injection needles stabbed through the lid for degassing. Needles should be applied only for a few seconds, to minimize evaporation.

To ensure a consistent mixing procedure, a shaker is used to shake the sampling bottles right before they are measured with the OPS.

Literature:

Budéus, G., 2011. Bringing Laboratory Salinometry To Modern Standards. Sea-Technology.

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