**March 2019 Salinity Dilution Experiment**

It was discovered that the Water Properties salinometer (Autosal model 8400B s/n 68572) was measuring non-linearly when sample data was compared to recent cruise CTD sensor data. The salinometer was recently returned in this state from Guildline after being repaired. Tests were performed to confirm non-linearity and to provide data to be able to generate a correction factor for the affected data (Cruises 2018-031, 2018-032, 2019-003, Paul Covert’s PRPA, about 50-60 2019-001 samples).

**Drift and Linearity Check**

First, a linearity check was performed simultaneously on both the Arctic salinometer (Autosal model 8400B s/n 69086) and the Water Properties salinometer using linearity pack samples that were well past their due date. Accuracy was not the goal for this initial test and only the relative differences between salinometer conductivity ratios was important.

The salinometers were set up side by side in lab 1400, with each running their own computer and logging hardware and software. The instruments had ample time to equilibrate and stabilize to the set bath temperature of 24 C. With both running, the climate control in the lab was set up to cool a little more frequently (set to 20 C). This maintained the lab temperature at an ideal range of about 22 C ± 1 C according to the platinum resistor thermometer inside the lab.

Once stable, the bath temperatures of the salinometers were checked manually to ensure they were working correctly. Both were in the expected range (69086: 24.023 C; 68572: 24.018 C).

Prior to any analysis, the salinometers were rinsed approximately 10 x with old seawater from samples previously analysed. Both salinometers were standardized following Guildline procedures using a fresh bottle of IAPSO standard seawater per instrument. Both required no adjustment of the standardization dial and fell directly within specification. The standard information is as follows:

* Batch = P161
* K15 = 0.99987 x 2 = 1.99974
* Salinity = 34.995
* Use by Date = 03 May 2020

See worksheet Autosal Linearity Tests in document Salinometer-68572 study\_2xMar2019.xlsx for calibration results.

Prior to running the linearity samples, 10 x deep water reference (DWR) samples were measured simultaneously on each instrument to asses whether any drift was occurring. The water was sampled directly from a carboy that had been set atop the work bench for approximately three days. The carboy was mixed and inverted regularly throughout the run to ensure good mixing and consistent results. 2 samples were collected simultaneously and connected to each salinometer and analyzed at the same time. At least a 2 rinses of the cell were performed between sample sets. The DWR information is as follows:

* Cruise ID = 2019-001
* Station = P25
* Sample ID = 299, 300, 301
* Niskin Bottles = 1, 2, 3
* Depth = 2005 m

See worksheets Deep Water Reference Check and the Summary of Checks in document Salinometer-68572 study\_2xMar2019.xlsx for DWR results.

The following linearity pack samples were used for this test:

*Batch Salinity Use by Date*

10L10 9.926 14 June 2006

30L13 30.004 18 July 2006

P161 34.995 03 May 2020

38H9 37.999 19 Sept 2006

Only one bottle of each linearity sample was available, so each bottle was transferred from salinometer 69086 to salinometer 68572 after it was measured in order of increasing salinity. On most measurements, an additional reading was performed if it was determined that there was sufficient volume to do so. The cells of both salinometers were rinsed 3 times between samples of different salinities. In order to ensure adequate sample volume for both instruments, modifications were made to the logging settings in the software:

*From To*

2 reading per bottle 1 reading per bottle

5 values per reading 3 values per reading

Max standard deviation of 0.0002 Max standard deviation of 0.0002

4 second delay before measurements are recorded 3 second delay before measurements are recorded

**Dilution Preparation**

Dilution samples in the range of 26, 29, 32 and 35 PSU were selected in order to bracket the working ranges of the salinities affected by the malfunctioning Water Properties salinometer.

Dilutions were prepared using IAPSO batch P161 (see above for technical information) as the stock standard. The simple formula C1V1 = C2V2 was used to determine target salinities where;

C1 = Initial salinity (34.995)

V1 = Volume of standard required

C2 = Calculated salinity

V2 = Volumetric flask volume (250 mL nominally)

Three class A volumetric flasks were gravimetrically calibrated on a Denver Instruments XL-410 balance that was professionally calibrated (by chance) on the same day of the experiment. A dry weight of the flask was taken before filling the flask to the 250 mL mark and measuring the weight after filling. The deionized water used for the dilutions was left to equilibrate in the lab for about three days prior to use. The lab temperature varied only slightly from about 20 to 21.5 C. The average difference between 5 dry and wet weights was used for the flask volume (V2) as not to rely on the nominal volume. Flasks were dried with acetone between weight measurements.

To limit the amount of time the standard bottles were left open, the required volume of deionized water was measured first. The water was weighed to the nearest microliter and recorded for final calculation. The flask was then topped up with standard and a new 5 cc syringe and needle was used to carefully bring the volume up to the mark.

Flasks were immediately sealed with a ground glass stopper and parafilm was used to help seal the flask and limit evaporation while the dilutions were being prepared and analyzed. The flasks were inverted a minimum of 20 times to ensure complete mixing.

**Dilution Analysis**

Because Lab 1409a (balance room) and lab 1400 (salinity lab) were close in temperature, it was assumed that the dilutions can be analyzed immediately.

The dilution experiment occurred on the Monday following the linearity test performed on the previous Friday so the salinometers were calibrated once again. The same procedure was followed as above using the same batch of IAPSO standard.

The 250 mL volumetric flasks were connected to the salinometers directly, with the only modification being a longer draw tube such that it reached near the bottom of the flask. Software logging settings were reverted back to the following since there was sufficient volume in 250 mL to account for enough rinsing and a few readings per measurement:

* 2 reading per bottle
* 5 values per reading
* Max standard deviation of 0.0002
* 3 second delay before measurements are recorded

After the first set of measurements were complete, the flasks were emptied, rinsed, dried and the dilution preparation and analysis was performed again. This was done to ensure the repeatability of the experiment.

See worksheets Dilutions, Autosal Comparison and the Summary of Checks in document Salinometer-68572 study\_2xMar2019.xlsx for dilution experiment results.