HOT-51 Salinity measurement corrections
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Introduction:
HOT-51 primary salinity bottles were analyzed by Reka Domokos in two sessions (A & B). Session A contained 2 IAPSO standards, 3 substandards and 90 bottles. Session A was terminated after the third substandard was analyzed and its salinity was found to be extremely low. Unfortunately, 90 bottles were analyzed before the substandard was measured. It was noticed that the light bulb that heats the water bath did not go off as it normally should. The salinometer's temperature controlling circuitry was then checked and reconnected. Session B resumed several hours later. Session B contained 2 IAPSO standards, 3 substandards and 287 bottles. Duplicates and triplicates were analyzed in Session C 49 days after the bottles were taken by James Potemra (2 IAPSO standards, 5 substandards and 96 bottles). During Session C the salinometer was not as stable as Session B, but not nearly as bad as Session A when the heating element malfunctioned. The second deep cast's bottles were analyzed in the most stable session (B) so they were used to calibrate the CTD.

Review Rational:
Before the corrections applied here, HOT-51's second deep cast (S2C19) was much saltier than almost 200 deep casts in $\theta$-S space (Figure 1). It seemed strange that so much had been done to try and correct the data from Session A, but no corrections were applied to data in Session B even if the substandard measurements fluctuated more than 11 mpsu during that session while the IAPSO measurements changed by only 0.4 mpsu. It has been determined that the 2nd and 3rd substandard measurement's conductivity to salinity conversion was faulty and the recomputed substandard salinities indicates a drift which is consistent to the IAPSO drift.

All salinities after station 2 cast 8 bottle 2 in session B were computed wrong (including the substandards mentioned above). Apparently, these salinities were calculated with a temperature of 0°C instead of the 24°C bath temperature. The recomputed values differ from about -17 mpsu to 4 mpsu. The second deep cast's bottles (Station 2 Cast 19) were among those computed incorrectly. The deepest bottle should be ~5.5 mpsu fresher. This should put the second deep cast (which was too salty) in the historic deep $\theta$-S scatter.

Corrections for Session A came under scrutiny because most of Station 6 Cast 1 bottles measured during this session were flagged as bad. There were no corrections applied to these bottles, but bottles analyzed before and after were corrected. There is no document explaining the rational for the corrections made to Session A's bottles. All data from this session were reviewed and corrected appropriately as explained below.

Subsequently, more problems with the bottle salinity corrections were found and are
discussed below.

**History & new corrections:**

**Session A (Operator: Reka Domokos):**

Session A included bottles from S1C1, S6C1, S2C1, S2C2, and S2C3 (bottles 1-8). It is noted in the salinity report that: "Several hours later the bath temperature of the autosal started to rise due to the failure of the lights to go off". The IAPSO measurement at the end of the session was fresher by 68 mpsu. The salinity report does not specify what was done to correct the data in Session A, however, a file called corrs.dat contains the corrections, but does not say why they were done (corrections are shown as a solid black line in Figure 2). Substandard measurements were only taken before and after the session so apparently the complicated set of corrections were not based solely on the substandard or IAPSO measurements (dotted and dashed lines on Figure 2). Here is a summary of the corrections.

Stn 1 cast 1 all bottles:
linear from +0.01 to +0.0518 and then -0.018 from all

Stn 6 cast 1 all bottles:
no corrections made

Stn 2 cast 1 bottles 1-11:
+0.06 and then -0.018
(duplicates used instead)

Stn 2 cast 1 bottles 12-24:
linear from +0.06 to +0.0384 and then -0.018 from all
(duplicates used instead for bottles 12-23.)

Stn 2 cast 2 bottles 1-17:
+0.073 and then -0.018
(duplicates used instead)

Stn 2 cast 2 bottles 18-24:
linear from +0.085 to +0.0833 and then -0.018 from all

Stn 2 cast 3 bottles 1-8:
linear from +0.078 to +0.0927 and then -0.018 from all

**New Corrections:**

After correcting the triplicate bottles in Session C (see corrections below), the primary and triplicate bottles from Station 2 Cast 1 and Station 2 Cast 2 were compared. The linear fit of this difference was plotted on Figure 2 as a gray line (dashed-dotted line is the linear fit) confirming the autosal drift. The salinometer
seemed to be reading linearly fresher for the first 27 bottles, possibly as a result of
the light bulb continuing to heat the water beyond 24°C. (The correction for the
first bottle is 0 and the 27th bottle is 44.9 mpsu.) The rest of the bottles seem to need
a correction consistent with the triplicate minus primary slope. (47.1 mpsu for
bottle 28 to 79.1 mpsu for the last bottle (90).)

**Session B (Operator: Reka Domokos):**

IAPSO standard and substandard measurements were analyzed before and after
Session B. The IAPSO standard values differed by only 0.4 mpsu. The reported
substandard measurements, however, varied by 11 mpsu. No corrections were made to
bottles in Session B.

After reviewing the data, it was found that for an unknown reason all salinities after
station 2 cast 8 bottle 2 in Session B were computed with a bath temperature of 0°C.
The only thing that seems plausible is that the keypunching of this session terminated
prematurely and restarted with a 0°C bath temperature.

**New Corrections:**

The salinities (including substandards) were recomputed using a bath temperature
of 24°C. The IAPSO standards and substandards varied by less than 1 mpsu
therefore, no salinometer drift corrections are needed.

**Session C (Duplicates/Triplicates; Operator: Jim Potemra):**

The substandard drift was used to correct the duplicates and triplicates:

+7.4 mpsu
(+6.7 mpsu during the break)
-16.9 mpsu
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-2.8 mpsu (net)

The duplicate data from S2C1 and the triplicate data from S2C2 were reported instead
of the primary data from Session A, except for S2C1 bottle 24 and S2C2 bottles 17-24.
They did not use the duplicate/triplicate values those bottles, because the reading was
blinking (indicating that the reading level needed to be changed) and the operator did
not change the level. They reported the primary data from Session A for those bottles.

**New Corrections:**

The measurements taken at the wrong level are easily correctable by adding 1.0 to
the conductivities.

IAPSO measurements were taken before and after Session C and by the end of the
session was 3.4 mpsu fresher. Substandard measurements were similarly fresher at
the end of the session by 2.8 mpsu. Two substandard measurements were also taken in the middle of the run and were 7.4 and 14.1 mpsu saltier than the initial substandard value. The comparison between the duplicates and triplicates do not validate the saltier substandard measurements, so the IAPSO measurements were used to correct the instrument's drift.

The duplicates were collected in plastic bottles and analyzed 49 days after data collection (Collected on January 19-20 and analyzed on March 10, 1994). Sean Kennan's evaporation experiment compared salt water stored in plastic bottles up to 40 days. Extrapolating to 49 days at a rate of 0.071 mpsu per day gives a 3.48 mpsu correction. When the cast was compared to the other deep cast (S2C19) which was analyzed in the most stable Session B, the 3.48 mpsu correction proved to be too large. Normally deep casts from the same cruise differ by no more than +/- 1 mpsu. The average difference between the two casts after the plastic bottle correction is 1.9 mpsu (Figure 3). This suggests the plastic bottle correction for these bottles should be 1.4 mpsu. The triplicate data from S2C1 and S2C2 are now reported instead of the primary data from Session A.

Other corrections:

Station 1 cast 1 bottle 18 should be 34.9948 (according to conductivity plus correction) instead of the reported 35.9948. This makes the bottle value similar to the CTD value and its flag should change to good.

Station 2 cast 19 bottle 18 was missing from the data file.

Results

Fernando Santiago-Mandujano recalibrated the CTD data with the corrected bottle data and the calibration looks much better. HOT-51's deep casts (S2C1 and S2C19) are now in the deep θ-S scatter (Figure 4).

Prior to these corrections, 29 bottles were flagged as suspect and 35 bottles were flagged bad. Now 4 bottles are flagged as suspect and 17 bottles are flagged as bad.
Figure 1

HOT with plastic bottle evaporation applied for >14 days
Figure 2
HOT–51A corrections)