



CTD Data Processing Report

RV POLARSTERN Cruise PS107

Gerd Rohardt and Jutta Vernaleken

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1. Introduction

This report describes the processing of CTD raw data acquired by Seabird SBE 911plus CTD on board RV POLARSTERN during expedition PS107. The standard processing procedures are described in the document *AWI CTD Data Processing*.

2. Cruise Details

Vessel	RV POLARSTERN
Cruise	PS107
Region	Central and East Fram Strait
Departure	Tromsø, 23 July 2017
Arrival	Tromsø, 19 August 2017
Responsible operator	Wilken-Jon von Appen, Alfred-Wegener-Institute, Germany
Responsible for data processing	Gerd Rohardt, AWI
Number of CTD casts	40
Number of processed casts	39 (see chapter 4)

3. Instrument and Software Configuration

This chapter summarized the configuration of the acquisition software, the rosette assembly, CTD sensors, and salinometer.

Software	CTD data acquisition	SBE ¹ SeasaveV7, Version 7.23.1
	CTD on board processing	ManageCTD ²
	Matlab [®]	Individual tools
Rosette assembly	CTD/Deckunit	SBE911 plus; SN 485 (on board system)
	Carousel Water Sampler	SBE32
Sensors	Pressure	SN 0485; cal: 04.Feb.2014
	Primary Temperatur	SBE3plus; SN 2460; cal ³ : 20.Dec.2016. and 28.Oct.2017
	Primary Conductivity	SBE4C; SN 2055; cal: 22.Nov.2016 and 3.Nov.2017
	Secondary Temperatur	SBE3plus; SN 2417; cal: 20.Dec.2016. and 28.Oct.2017
	Secondary Conductivity	SBE4C; SN 2054; cal: 22.Nov.2016. and 9.Nov.2017
	Oxygen	SBE43; SN 880; cal: 03.Aug.2010 and 4.Nov.2017
	Transmisometer ⁴	Wetlabs CStar;SN 946; cal: 31.Jan.2006
	Fluorometer ⁴	Wetlabs EcoFLR;SN 1670; cal: 11.Dec.2009
	Altimeter	Benthos PSA900;SN 1228; cal: 23.Mar.2009

Rosette assembly

CTD/Deckunit Carousel Water Sampler	SBE911 plus; SN 937 (with LADCP) SBE32
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Sensors

Pressure	SN 0937; cal:20.Nov. 2012
Primary Temperatur	SBE3plus; SN 5101; cal ³ : 13.Dec.2016 and 27.Oct.2017
Primary Conductivity	SBE4C; SN 3290; cal: 13.Dec.2016 and 8.Nov.2017
Secondary Temperatur	SBE3plus; SN 5112; cal: 13.Dec.2016 and 27.Oct.2017
Secondary Conductivity	SBE4C; SN 3570; cal: 13.Dec.2016 and 3.Nov.2017
Oxygen	SBE43; SN 467; cal: 28.Dec.2016 and 14.Nov.2017
Transmisometer ⁴	Wetlabs CStar;SN 1220; cal: 2.Apr.2009
Fluorometer ⁴	Wetlabs EcoFLR;SN 1853; cal: 26.May.2010
Altimeter	Benthos PSA900;SN 47768; cal:23.Mar.2009

Salinometer

Optimare Precision Salinometer OPS Standard Seawater	SN 006 P158; K ₁₅ = 0.99970; valid until: 2018-03-25
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Remarks:

¹ : SBE = Sea Bird Electronics

² : AWI software package which includes SBEDateProcessing, Version 7.22.5

³ : Dates of pre- and post-cruise calibration

⁴ : Not calibrated, use relative values only

4. Specials

This chapter contains the important notes made during the CTD casts or resulting from the salinity samples.

From station 2 until 20 the CTD/water sampler system with SN 485 was used. Because number of spikes increased the complete system was replaced by SN 937 at station 20 cast 8. This CTD worked fine without any serious problems. Table 1 contains further details.

Tab. 1: List of CTD/Water Sampler stations from leg PS107

Station	Cast	Date/Time	Latitude	Longitude	Depth (m)	Altimeter (m)	Pmax (dbar)	Serial no.	Remarks
2	1	25-Jul-2017 22:18:01	78 36.150 N	5 1.518 E	2353	10	2330	485	
2	4	26-Jul-2017 02:24:06	78 36.258 N	5 0.248 E	2357			485	no data recorded
2	13	26-Jul-2017 11:47:24	78 36.498 N	5 3.324 E	2342	99	254	485	
6	3	27-Jul-2017 17:39:53	79 3.864 N	4 10.866 E	2463	10	2445	485	T and S profiles showed lots of spikes from ~100m to 700m depth
6	8	28-Jul-2017 02:29:57	79 3.906 N	4 10.086 E	2470	99	101	485	beam transmission error
7	1	28-Jul-2017 20:42:46	79 3.198 N	3 44.982 E	2831	99	1522	485	
8	1	29-Jul-2017 05:03:03	79 2.790 N	3 36.348 E	3365	99	253	485	beam transmission error
10	4	29-Jul-2017 17:58:18	78 58.608 N	2 29.658 E	2428	99	506	485	
12	3	30-Jul-2017 02:04:03	78 56.688 N	2 42.102 E	2399	99	513	485	
14	3	30-Jul-2017 02:04:03	78 56.945 N	2 42.102 E	2399		513	485	bottle file PS107_014_01_bottle24.hex
16	3	30-Jul-2017 22:32:19	79 0.270 N	2 17.016 E	2466	99	506	485	beam transmission back to reasonable values after CTD went below 320m
16	3	30-Jul-2017 22:32:19	79 0.270 N	2 17.016 E	2466	99	1522	485	beam transmission back to reasonable values after CTD went below 320m
19	1	31-Jul-2017 13:24:00	79 3.558 N	3 28.920 E	3969	99	1523	485	transmission beam worked after 300m
20	1	01-Aug-2017 00:51:15	79 7.404 N	2 49.134 E	5534	10	5646	485	change of CTD
20	8	01-Aug-2017 16:37:41	79 8.016 N	2 50.688 E	5569	99	405	937	
21	1	02-Aug-2017 03:50:23	78 57.858 N	0 0.228 E	2548	99	1521	937	
21	5	02-Aug-2017 10:44:15	78 57.708 N	0 2.376 E	2558	99	304	937	
22	1	02-Aug-2017 21:15:43	78 49.002 N	2 48.042 W	2590	10	2572	937	
22	6	03-Aug-2017 08:09:05	78 49.128 N	2 43.014 W	2607	99	254	937	
24	1	03-Aug-2017 22:33:25	78 51.348 N	3 56.496 W	1992	10	1974	937	T/C have large difference
25	1	04-Aug-2017 11:11:05	78 49.866 N	2 47.508 W	2589	99	253	937	
28	1	05-Aug-2017 04:19:31	78 56.016 N	4 38.088 W	1557	11	1529	937	
29	1	05-Aug-2017 22:52:18	78 59.694 N	5 28.410 W	980	8	958	937	O2 sensor doesn't work properly
30	1	06-Aug-2017 18:06:07	79 18.090 N	1 59.778 W	2573	99	1522	937	O2 sensor is broken
31	1	07-Aug-2017 01:00:12	79 26.034 N	0 0.162 E	2880	99	1522	937	O2 looks reasonable again
32	1	07-Aug-2017 11:28:00	79 34.926 N	2 0.708 E	2324	99	1523	937	
33	1	07-Aug-2017 19:56:00	79 44.256 N	4 26.100 E	2622	10	2604	937	
33	6	08-Aug-2017 03:18:33	79 43.632 N	4 30.174 E	2775	99	254	937	
34	1	08-Aug-2017 18:18:43	79 58.188 N	2 54.402 E	2612	8	2607	937	
34	5	09-Aug-2017 03:06:09	80 0.018 N	2 56.412 E	2551	99	254	937	
36	1	10-Aug-2017 04:27:25	79 35.286 N	5 10.440 E	2778	9	2768	937	
37	1	11-Aug-2017 00:29:45	79 6.492 N	4 35.964 E	1892	9	1905	937	
42	1	11-Aug-2017 21:58:35	79 7.842 N	4 54.174 E	1540	9	1525	937	
42	5	12-Aug-2017 03:11:26	79 7.872 N	4 54.354 E	1537	99	203	937	
43	1	12-Aug-2017 12:02:06	79 8.412 N	6 5.448 E	1284	9	1265	937	
43	6	12-Aug-2017 18:12:02	79 9.162 N	6 6.912 E	1317	86	253	937	
44	3	13-Aug-2017 11:53:09	79 2.046 N	7 0.114 E	1308	8	1288	937	
45	1	14-Aug-2017 00:16:36	79 0.270 N	8 21.816 E	759	10	750	937	
47	1	14-Aug-2017 16:55:28	78 58.974 N	9 30.486 E	235	9	223	937	
48	1	14-Aug-2017 23:11:27	79 1.758 N	11 6.102 E	287	11	275	937	

5. In-situ Salinity Calibration

To monitor the accuracy and precision of the CTD's conductivity sensors, water samples were taken on 17 CTD casts for salinity/conductivity measurements. Salinities of the water samples were determined on board using an Optimare Precision Salinometer (OPS). The resulting corrections (ops-s0, ops-s1, see Table 2 and 3) could not be used. No duplicates were taken. Also the salinity gradient was too high in the sampled layers less than 1500 m.

Tab. 2: Salinity samples taken and measured when the CTD SN 485 was used

station_cast	datetime	btl	press	s0	s1	ops	ops-s0	ops-s1
2_01	25.07.2017 20:52	6	2031	34,9124	34,9130	34,9005	-0,0119	-0,0125
6_03	27.07.2017 16:32	7	2031	34,9100	34,9113	34,9020	-0,0080	-0,0093
7_01	28.07.2017 20:08	1	1521	34,9092	34,9100	35,2535	0,3443	0,3435
18_03	31.07.2017 05:11	1	1522	34,9117	34,9122	34,9194	0,0077	0,0072
19_01	31.07.2017 12:44	1	1523	34,9105	34,9111	34,9056	-0,0049	-0,0055
20_01	31.07.2017 22:46	5	5632	34,9220	34,9323	34,9260	0,0040	-0,0063

CTD SN 485 was deployed during the previous cruise PS106. For that cruise a salinity correction results in ops-s0 = 0.004, which is the same as for station/cast 20_01.

Tab. 2: Salinity samples taken and measured when the CTD SN 937 was used

station_cast	datetime	btl	press	s0	s1	ops	ops-s0	ops-s1
24_01	03.08.2017 21:43	1	1974	34,9238	34,9230	34,9273	0,0035	0,0043
28_01	05.08.2017 03:40	1	1529	34,9156	34,9136	34,9185	0,0029	0,0049
29_01	05.08.2017 22:08	1	957	34,8901	34,8888	34,9264	0,0363	0,0376
30_01	06.08.2017 17:30	1	1014	34,9029	34,9009	34,9056	0,0027	0,0047
32_01	07.08.2017 10:51	1	1522	34,9158	34,9140	34,9310	0,0152	0,0170
33_01	07.08.2017 19:02	9	1015	34,9110	34,9092	34,9157	0,0047	0,0065
34_01	08.08.2017 17:04	6	1015	34,9220	34,9200	34,9273	0,0053	0,0073
37_01	10.08.2017 23:44	1	1521	34,9124	34,9109	34,9217	0,0093	0,0108
42_01	11.08.2017 21:13	2	1014	34,9139	34,9120	34,9349	0,0210	0,0229
43_01	12.08.2017 11:10	9	1013	34,9158	34,9136	34,9165	0,0007	0,0029
45_01	13.08.2017 23:53	1	750	34,9739	34,9742	34,9788	0,0049	0,0046

CTD SN 937 was deployed during PS109 too. Here salinity were taken from deep layers resulting in salinity correction steadily changing from -0.0007 (first cast) to + 0.0017 (last cast). All salinity samples taken during PS107 are outside of this range. Assuming a steadily drifting sensor would result in a value of ops-s0 in the order of -0.001 or even less.

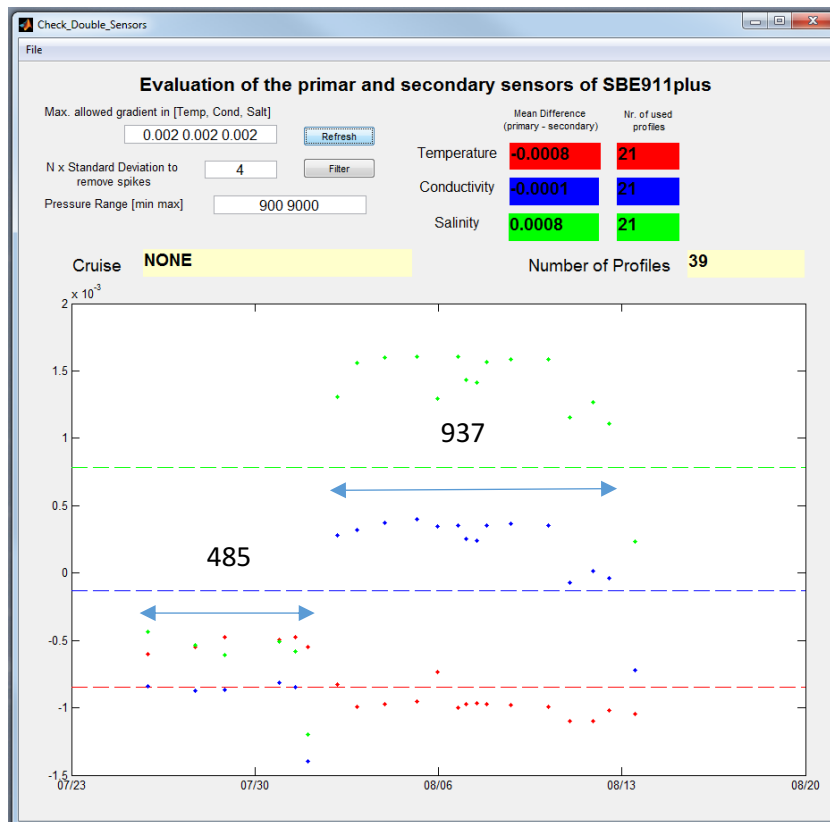


Fig. 1: The statistics of the differences between the primary and secondary sensor pair from layers below 900 m and gradients less than 0.002 ($^{\circ}\text{C}/\text{m}$ or mS/m^2). The differences are stable during the cruise.

6. Data Processing

The standard processing procedures are described in the document *AWI CTD Data Processing*

Tab. 3: The number of interpolated/removed spikes from the 1dbar-interval values with the software CTDdespike.

Station	Cast	Records	TEMP	SAL	O2	FCHL	TRANS
2	1	2329	0	0	0	0	0
2	13	253	0	0	0	0	0
6	3	2444	0	0	0	0	0
6	8	100	0	0	0	0	0
7	1	1521	0	0	0	0	0
8	1	252	0	0	0	0	0
10	4	506	0	0	0	0	0
10	4	505	0	0	0	0	0
12	3	512	0	0	0	0	0
16	3	505	0	0	0	0	0
16	3	1521	0	0	0	0	0
19	1	1517	0	0	0	0	0
20	1	5645	0	0	0	0	0
20	8	401	0	0	0	0	0
21	1	1517	0	0	0	0	0
21	5	300	0	0	0	0	0
22	1	2568	0	0	0	0	0
22	6	250	0	0	0	0	0
24	1	1970	0	0	0	0	0
25	1	249	0	0	0	0	0
28	1	1525	0	0	0	0	0
29	1	954	0	0	0	0	0
30	1	1518	0	0	0	0	0
31	1	1518	0	0	0	0	0
32	1	1519	0	0	0	0	0
33	1	2600	0	0	0	0	0
33	6	250	0	0	0	0	0
34	1	2452	0	0	0	0	0
34	5	250	0	0	0	0	0
36	2	2752	0	0	0	0	0
37	1	1901	0	0	0	0	0
42	1	1521	0	0	0	0	0
42	5	199	0	0	0	0	0
43	1	1249	0	0	0	0	0
43	6	96	0	0	0	0	0
44	3	1284	0	0	0	0	0
45	1	746	0	0	0	0	0
47	1	219	0	0	0	0	0
48	1	271	0	0	0	0	0

Tab. 4: The number of interpolated (column INT) and removed (column NaN) records from the 1dbar-interval during the final processing.

Station	Temperature		Salinity		Oxygen		Transmissometer		Fluorometer	
	NaN	INT	NaN	INT	NaN	INT	NaN	INT	NaN	INT
002_01	0	0	0	0	0	0	0	1	0	0
002_13	0	0	0	0	0	0	0	0	0	0
006_03	0	0	0	0	0	0	4	3	0	0
006_08	0	0	0	0	0	0	50	0	0	0
007_01	0	0	0	0	0	0	97	3	0	0
008_01	0	0	0	0	0	0	252	0	0	0
010_04	0	0	0	0	0	0	332	0	0	0
012_03	0	0	0	0	0	0	391	0	0	0
014_01	0	0	0	0	0	0	376	22	0	0
016_03	0	0	0	0	0	0	373	0	0	0
018_03	0	0	0	0	0	0	335	2	0	0
019_01	27	0	27	0	26	0	299	2	0	0
020_01	0	0	0	0	0	3109	228	143	0	0
020_08	0	0	0	0	0	0	0	0	0	0
021_01	0	0	0	0	0	0	0	0	0	0
021_05	0	0	0	0	0	0	0	0	0	0
022_01	0	0	0	1	0	0	0	3	0	0
022_06	0	0	0	0	0	0	0	0	0	0
024_01	0	0	0	0	0	0	0	0	0	0
025_01	0	0	0	0	0	0	0	0	0	0
028_01	0	0	0	0	0	0	0	0	0	0
029_01	0	0	0	0	0	0	0	0	0	0
030_01	0	0	0	0	0	0	0	0	0	0
031_01	0	0	0	0	0	0	0	1	0	0
032_01	0	0	0	0	0	0	0	0	0	0
033_01	0	0	0	2	0	0	0	2	0	0
033_06	0	0	0	0	0	0	0	0	0	0
034_01	0	0	0	0	0	0	0	0	0	0
034_05	0	0	0	0	0	0	0	0	0	0
036_01	0	0	0	0	0	0	0	0	0	0
037_01	0	0	0	0	0	0	0	0	0	0
042_01	0	0	0	0	0	0	0	0	0	0
042_05	0	0	0	0	0	0	0	0	0	0
043_01	0	0	0	0	0	0	0	0	0	0
044_03	0	0	0	0	0	0	0	0	0	0
045_01	0	0	0	0	0	0	0	0	0	0
047_01	0	0	0	0	0	0	0	0	0	0
048_01	0	0	0	0	0	0	0	0	0	0

Applying the temperature and salinity correction from post-calibration

Tab. 5: Temperature correction based on the post-calibration valid SN 485 for station 2-1 to 20-1

Temperature	Serial Number	Offset	Conductivity	Serial Number	Slope
Primary (T0)	2460	-0.00002 °C	Primary (C0)	2055	0.9999848
Secondary (T1)	2417	0.00000 °C	Secondary (C1)	2054	1.0001289

Tab. 6: Temperature correction based on the post-calibration valid SN 937 for station 20-8 to 48-1

Temperature	Serial Number	Offset	Conductivity	Serial Number	Slope
Primary (T0)	5101	0.00034 °C	Primary (C0)	3290	0.9999720
Secondary (T1)	5112	0.00063 °C	Secondary (C1)	3570	0.9999212

Because the primary sensors from CTD SN485 were used during PS106 these were taken for this cruise too. As well the primary sensors from CTD SN937 were used during PS109 too.

For temperature the correction from the post-calibration was applied; see Table 5 and 6:

$$\text{SN 485: } T_{\text{corr}} = T_0$$

$$\text{SN 937: } T_{\text{corr}} = T_0 + 0.00034/2$$

For salinity the corrected based on the in-situ calibration (Chapter 5) and the comparison with the in-situ calibration applied for SN 485 during cruise PS106 and for SN 937 during PS109:

$$\text{SN 485: } S_{\text{corr}} = S + 0.004$$

$$\text{SN 937: } S_{\text{corr}} = S$$

Transmissometer and fluorometer

The transmissometer (CSTAR) and fluorometer (ecoFLR) were not calibrated during the cruise. For this reason data from these sensors are given as “relative units”. That means e.g. the chlorophyll can be used for determining the depth of the chlorophyll maximum but do not compare the quantity of the chlorophyll with previous cruises. Same applies for the transmissometer.

Oxygen

No in-situ calibration (Winkler titration) was performed for the oxygen sensor SBE43. The oxygen profiles were compared with profiles from cruise ARK-XXVII/1 which were corrected based on Winkler titration.

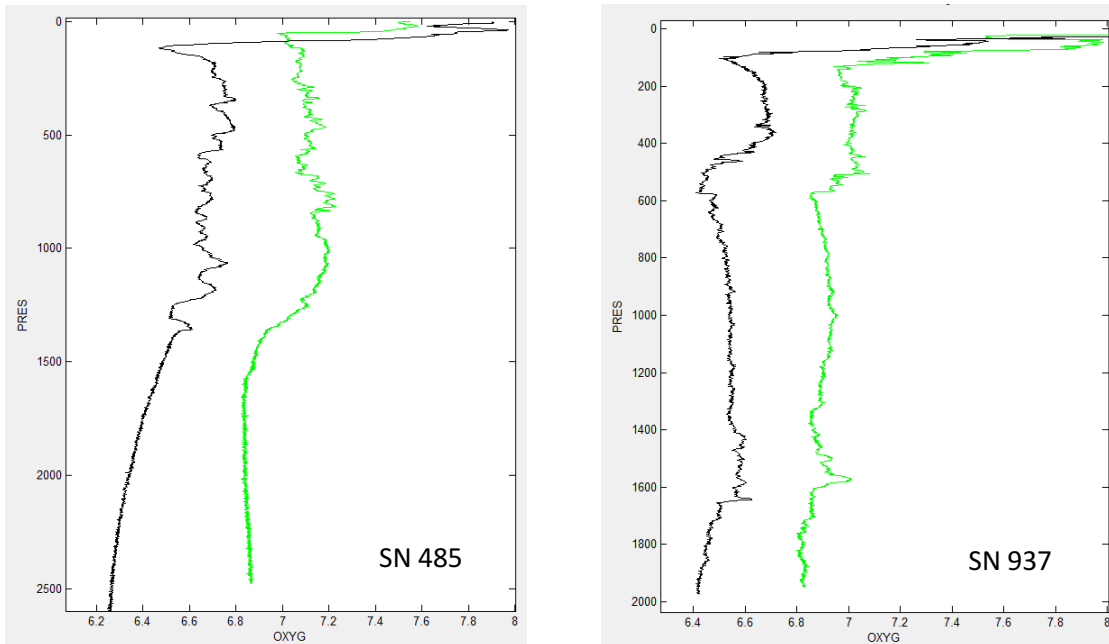


Fig. 2: The comparison with calibrated oxygen profiles from cruise ARK-XXVII/1 in green with uncalibrated oxygen profiles from cruise PS107 in black.

The correction for the oxygen was applied as follows:

$$\text{SN 485: } \text{OXY}_{\text{corr}} = \text{OXY} + 0.6 \text{ ml/l}$$

$$\text{SN 937: } \text{OXY}_{\text{corr}} = \text{OXY} + 0.45 \text{ ml/l}$$

In Figure 3, lower right panel, is the scatter plot of the uncorrected oxygen from all profiles measured with CTD SN485 and SN937. Notice the separation of the oxygen in the deeper layers; see arrow.

Figure 4 displays the corrected profiles to verify the applied corrections in temperature, salinity and oxygen.

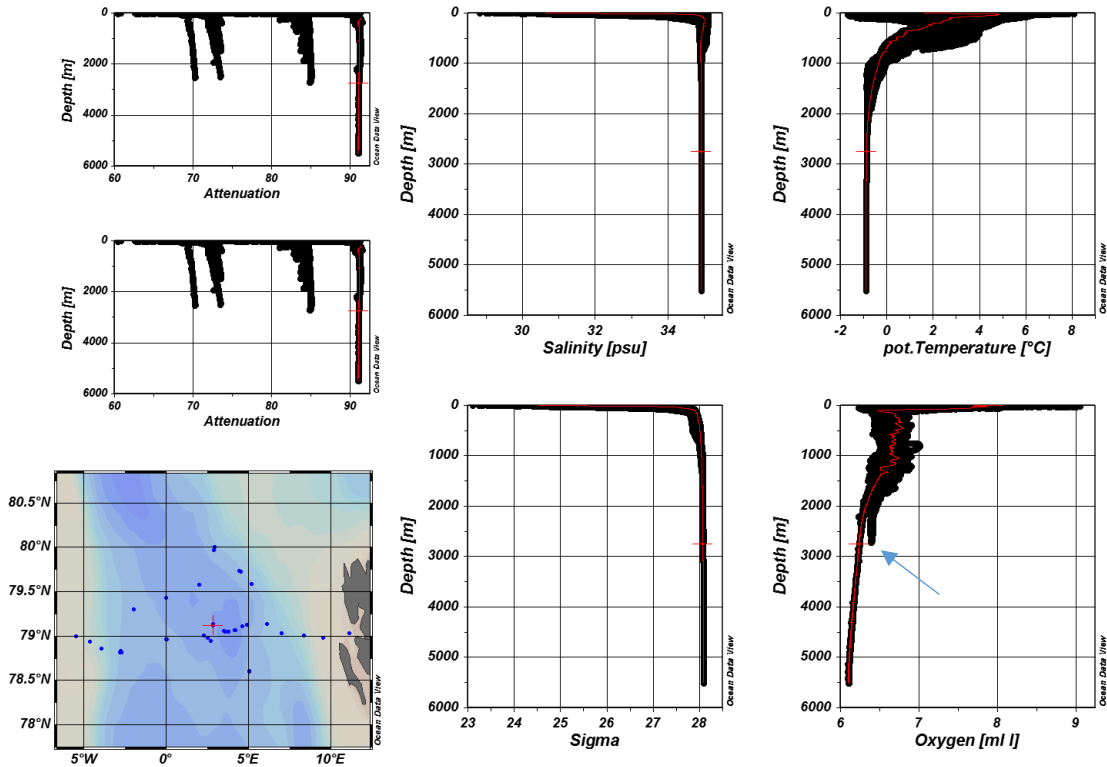


Fig. 3: The scatter plot from all uncorrected profiles measured with CTD SN485 and SN937. The lower right panel shows the separation of the oxygen in the deeper layers; see arrow

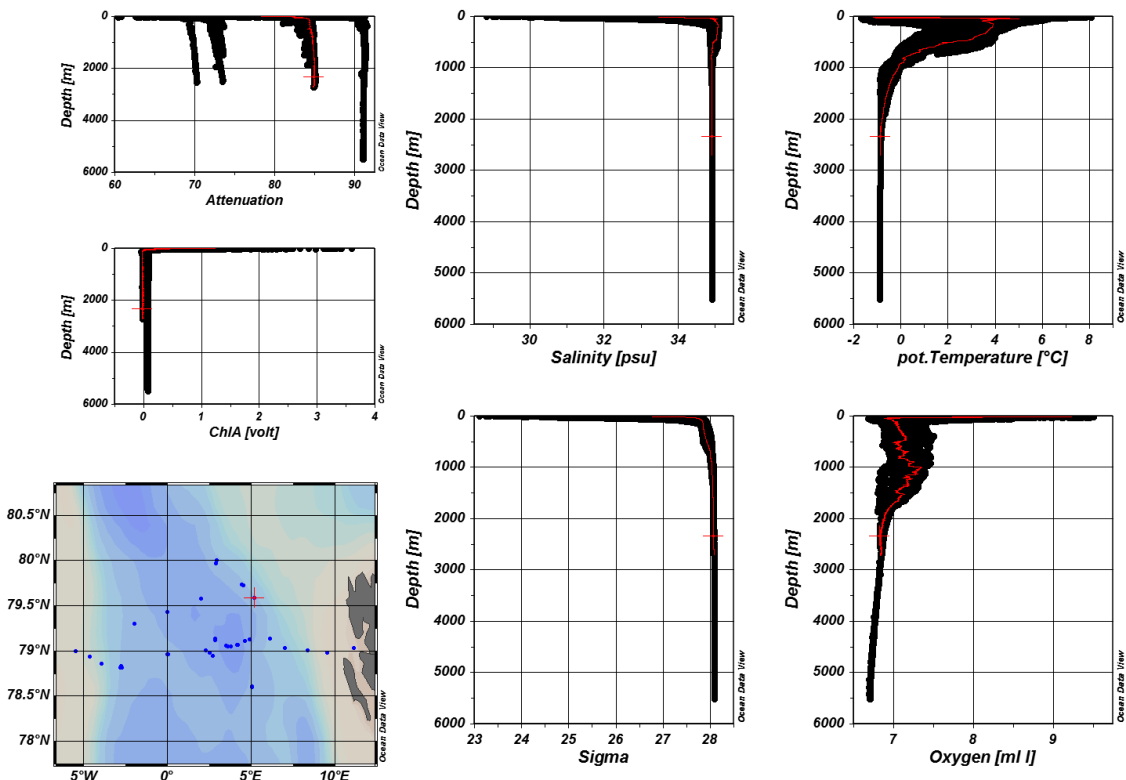


Fig. 4: The scatter plot from all corrected profiles measured with CTD SN485 and SN937 as final quality check.

Appendix

A. Pre-cruise Calibration

The pre-cruise calibration is presented as the copy of the report file create from *SeasaveV7* configuration file.

For CTD SN 485

PSA file: C:\bck\Expedition\PS103\CTD\SeasavePS102.psa

Date: 12/15/2017

Instrument configuration file: C:\CTD\PS107\conf1\raw\PS107_002_01.XMLCON

Configuration report for SBE 911plus/917plus CTD

```
-----  
Frequency channels suppressed : 0  
Voltage words suppressed     : 0  
Computer interface           : RS-232C  
Deck unit                    : SBE11plus Firmware Version >= 5.0  
Scans to average             : 1  
NMEA position data added     : Yes  
NMEA depth data added        : No  
NMEA time added              : Yes  
NMEA device connected to     : PC  
Surface PAR voltage added    : No  
Scan time added              : No
```

1) Frequency 0, Temperature

```
Serial number : 2460  
Calibrated on : 20-Dec-16  
G             : 4.37743910e-003  
H             : 6.47399839e-004  
I             : 2.38208049e-005  
J             : 2.24419047e-006  
F0           : 1000.000  
Slope        : 1.00000000  
Offset       : 0.0000
```

2) Frequency 1, Conductivity

```
Serial number : 2055  
Calibrated on : 22-Nov-16  
G             : -9.95652006e+000  
H             : 1.42794866e+000  
I             : -3.90575893e-003  
J             : 3.61897010e-004  
CTcor        : 3.2500e-006  
CPcor        : -9.57000000e-008  
Slope        : 1.00000000  
Offset       : 0.00000
```

3) Frequency 2, Pressure, Digiquartz with TC

Serial number : 0485
Calibrated on : 04-Feb-14
C1 : -4.853311e+004
C2 : 5.746510e-001
C3 : 1.431180e-002
D1 : 3.777200e-002
D2 : 0.000000e+000
T1 : 2.999560e+001
T2 : -2.287520e-004
T3 : 4.107500e-006
T4 : 2.360000e-009
T5 : 0.000000e+000
Slope : 0.99994579
Offset : -0.95173
AD590M : 1.280810e-002
AD590B : -9.658490e+000

4) Frequency 3, Temperature, 2

Serial number : 2417
Calibrated on : 20-Dec-16
G : 4.38703138e-003
H : 6.48225854e-004
I : 2.38663293e-005
J : 2.23695811e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 2054
Calibrated on : 22-Nov-16
G : -1.01495827e+001
H : 1.43780904e+000
I : -4.19682568e-003
J : 3.83397927e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

6) A/D voltage 0, Oxygen, SBE 43

Serial number : 0880
Calibrated on : 03-Aug-10
Equation : Sea-Bird
Soc : 5.15400e-001
Offset : -4.88700e-001
A : -3.03840e-003
B : 1.29700e-004
C : -2.40910e-006
E : 3.60000e-002
Tau20 : 1.13000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

7) A/D voltage 1, Free

8) A/D voltage 2, Altimeter

Serial number : 1228
Calibrated on : 23-Mar-09
Scale factor : 15.000
Offset : 0.000

9) A/D voltage 3, Free

CTD Data Processing Report



10) A/D voltage 4, Fluorometer, WET Labs ECO-AFL/FL

Serial number : 1670
Calibrated on : 11-Dec-2009
Dark output : 0.0290
Scale factor : 2.50000000e+001

11) A/D voltage 5, Transmissometer, WET Labs C-Star

Serial number : 946
Calibrated on : 31-Jan-2006
M : 20.9732
B : -1.3003
Path length : 0.250

12) A/D voltage 6, Free

13) A/D voltage 7, Free

Scan length : 41

For CTD SN 937

PSA file: C:\bck\Expedition\PS103\CTD\SeasavePS102.psa

Date: 12/15/2017

Instrument configuration file:
C:\CTD\PS107\conf2\raw\PS107_020_08.XMLCONConfiguration report for SBE 911plus/917plus CTD

```
Frequency channels suppressed : 0
Voltage words suppressed      : 0
Computer interface            : RS-232C
Deck unit                     : SBE11plus Firmware Version >= 5.0
Scans to average              : 1
NMEA position data added      : Yes
NMEA depth data added         : No
NMEA time added               : Yes
NMEA device connected to     : PC
Surface PAR voltage added     : No
Scan time added               : No
```

1) Frequency 0, Temperature

```
Serial number : 5101
Calibrated on : 13-Dec-16
G              : 4.35093936e-003
H              : 6.37630805e-004
I              : 2.11442661e-005
J              : 1.84941156e-006
F0            : 1000.000
Slope         : 1.00000000
Offset       : 0.0000
```

2) Frequency 1, Conductivity

```
Serial number : 3290
Calibrated on : 13-Dec-16
G              : -9.84305461e+000
H              : 1.51581901e+000
I              : 3.31718659e-004
J              : 8.34284325e-005
CTcor         : 3.2500e-006
CPcor        : -9.57000000e-008
Slope        : 1.00000000
Offset       : 0.00000
```


3) Frequency 2, Pressure, Digiquartz with TC

Serial number : 0937
Calibrated on : 20-Nov-12
C1 : -4.377396e+004
C2 : -6.751446e-001
C3 : 1.352380e-002
D1 : 3.663800e-002
D2 : 0.000000e+000
T1 : 3.012220e+001
T2 : -5.074259e-004
T3 : 3.788210e-006
T4 : 4.207950e-009
T5 : 0.000000e+000
Slope : 0.99993060
Offset : -0.89455
AD590M : 1.281700e-002
AD590B : -9.363100e+000

4) Frequency 3, Temperature, 2

Serial number : 5112
Calibrated on : 13-Dec-16
G : 4.37921371e-003
H : 6.41766875e-004
I : 2.19538579e-005
J : 1.97582042e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 3570
Calibrated on : 13-Dec-16
G : -9.81008189e+000
H : 1.21523642e+000
I : -1.70932198e-003
J : 1.76848989e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

6) A/D voltage 0, Fluorometer, WET Labs ECO-AFL/FL

Serial number : 1853
Calibrated on : 26-May-2010
Dark output : 0.0240
Scale factor : 2.50000000e+001

7) A/D voltage 1, Transmissometer, WET Labs C-Star

Serial number : 1220
Calibrated on : 02-Apr-2009
M : 21.3811
B : -1.2187
Path length : 0.250

8) A/D voltage 2, Oxygen, SBE 43

Serial number : 0467
Calibrated on : 28-Dec-16
Equation : Sea-Bird
Soc : 4.40070e-001
Offset : -5.07700e-001
A : -2.85380e-003
B : 1.23390e-004
C : -2.14710e-006
E : 3.60000e-002
Tau20 : 1.17000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

9) A/D voltage 3, Free

10) A/D voltage 4, Free

11) A/D voltage 5, Free

12) A/D voltage 6, Altimeter

Serial number : 47768
Calibrated on : 23-Mar-09
Scale factor : 15.000
Offset : 0.000

13) A/D voltage 7, Free

Scan length : 41

B. Post-cruise Calibration

The post-cruise calibration is presented as the scan from original SBE calibration sheets.
For CTD SN 485



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SENSOR SERIAL NUMBER: 2460
 CALIBRATION DATE: 28-Oct-17

SBE 3 TEMPERATURE CALIBRATION DATA
 ITS-90 TEMPERATURE SCALE

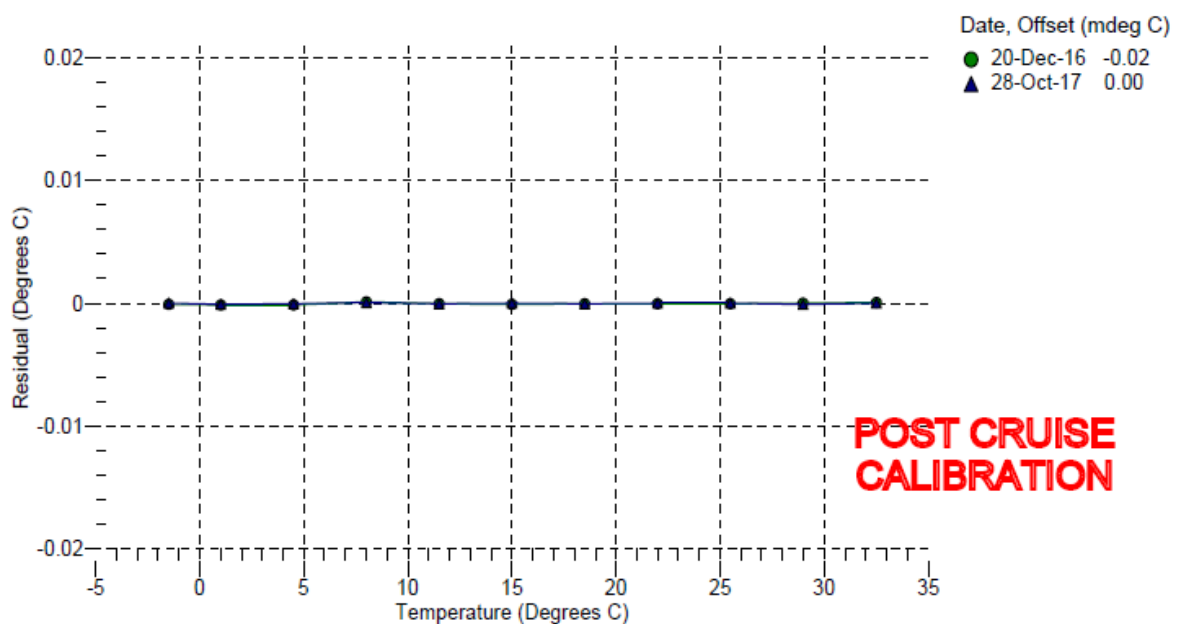
COEFFICIENTS:
 g = 4.37759761e-003
 h = 6.47727294e-004
 i = 2.40452183e-005
 j = 2.29512522e-006
 f0 = 1000.0

BATH TEMP (° C)	INSTRUMENT OUTPUT (Hz)	INST TEMP (° C)	RESIDUAL (° C)
-1.5000	3054.060	-1.5000	0.00005
1.0000	3229.279	0.9999	-0.00006
4.5000	3486.666	4.5000	-0.00003
7.9999	3758.487	8.0000	0.00006
11.5000	4045.134	11.5000	-0.00001
15.0000	4346.977	15.0000	0.00000
18.5000	4664.380	18.5000	-0.00000
22.0000	4997.698	22.0000	0.00002
25.5000	5347.263	25.5000	0.00001
29.0000	5713.394	28.9999	-0.00008
32.5000	6096.433	32.5000	0.00005

f = Instrument Output (Hz)

$$\text{Temperature ITS-90 (°C)} = 1 / \{g + h[\ln(f0 / f)] + i[\ln^2(f0 / f)] + j[\ln^3(f0 / f)]\} - 273.15$$

$$\text{Residual (°C)} = \text{instrument temperature} - \text{bath temperature}$$





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SENSOR SERIAL NUMBER: 2417
 CALIBRATION DATE: 28-Oct-17

SBE 3 TEMPERATURE CALIBRATION DATA
 ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

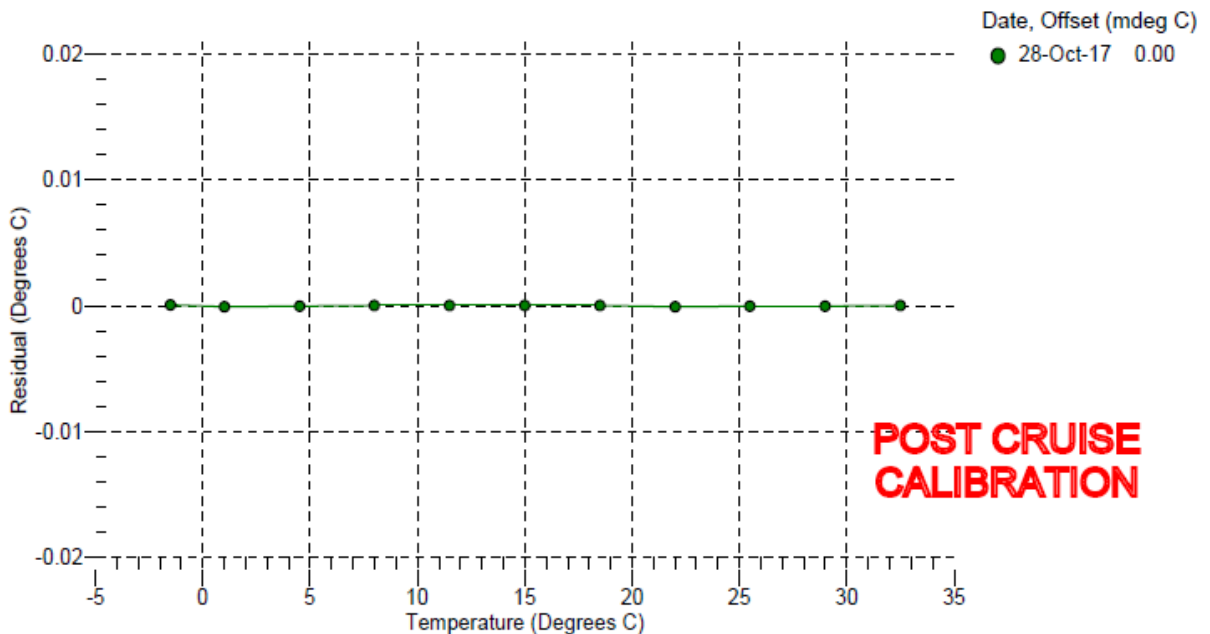
g = 4.38719391e-003
 h = 6.48551826e-004
 i = 2.40888276e-005
 j = 2.28706331e-006
 f0 = 1000.0

BATH TEMP (° C)	INSTRUMENT OUTPUT (Hz)	INST TEMP (° C)	RESIDUAL (° C)
-1.5000	3098.650	-1.4999	0.00006
1.0000	3276.358	0.9999	-0.00007
4.5000	3537.395	4.5000	-0.00003
7.9999	3813.056	7.9999	0.00003
11.5000	4103.749	11.5000	0.00001
15.0000	4409.838	15.0000	0.00004
18.5000	4731.692	18.5000	0.00002
22.0000	5069.662	21.9999	-0.00006
25.5000	5424.110	25.5000	-0.00001
29.0000	5795.346	29.0000	-0.00001
32.5000	6183.693	32.5000	0.00002

f = Instrument Output (Hz)

Temperature ITS-90 (°C) = $1 / \{g + h[\ln(f0 / f)] + i[\ln^2(f0 / f)] + j[\ln^3(f0 / f)]\} - 273.15$

Residual (°C) = instrument temperature - bath temperature





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SENSOR SERIAL NUMBER: 2055
CALIBRATION DATE: 03-Nov-17

SBE 4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -9.95636136e+000
h = 1.42790083e+000
i = -3.91063235e-003
j = 3.64104047e-004

CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

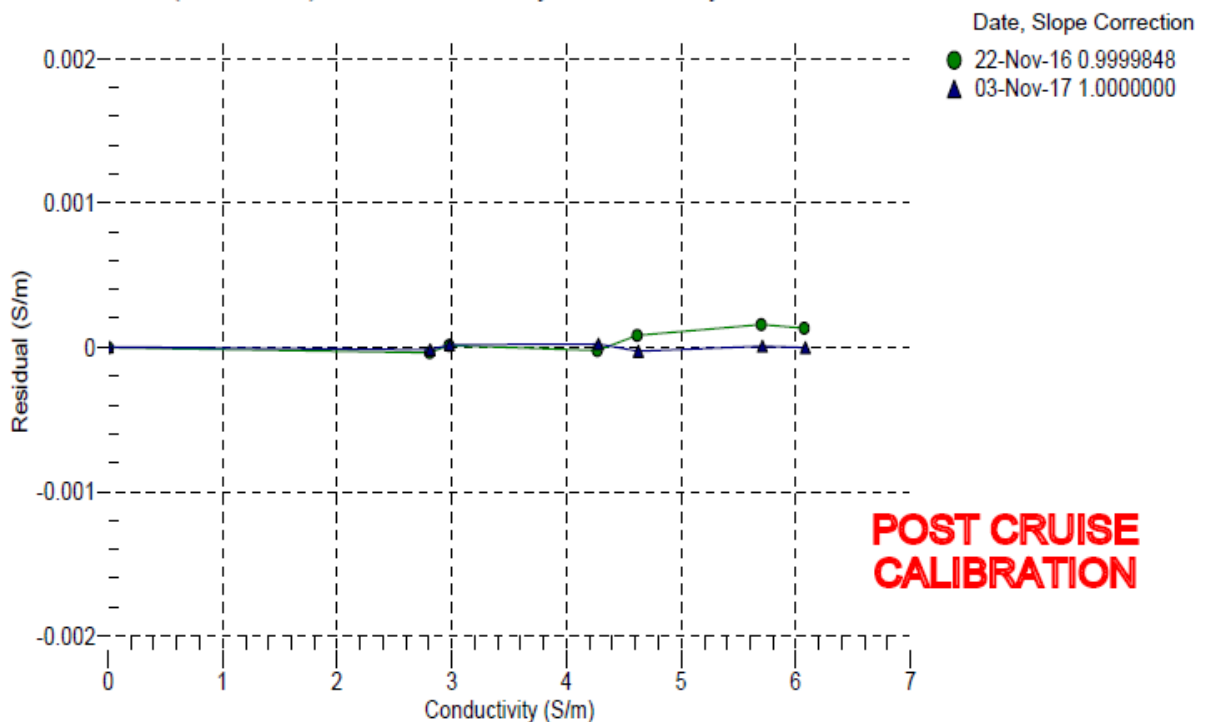
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (kHz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
0.0000	0.0000	0.00000	2.64784	0.00000	0.00000
-1.0000	34.8720	2.80864	5.18068	2.80863	-0.00002
1.0000	34.8719	2.98026	5.29630	2.98028	0.00002
15.0000	34.8717	4.27769	6.09924	4.27771	0.00002
18.5000	34.8715	4.62490	6.29658	4.62487	-0.00003
29.0000	34.8690	5.70998	6.87645	5.70999	0.00001
32.5000	34.8651	6.08354	7.06487	6.08353	-0.00000

f = Instrument Output (kHz)

t = temperature (°C); p = pressure (decibars); δ = CTcor; ε = CPcor;

Conductivity (S/m) = (g + h * f² + i * f³ + j * f⁴) / 10 (1 + δ * t + ε * p)

Residual (Siemens/meter) = instrument conductivity - bath conductivity





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SENSOR SERIAL NUMBER: 2054
 CALIBRATION DATE: 09-Nov-17

SBE 4 CONDUCTIVITY CALIBRATION DATA
 PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -1.01486007e+001
 h = 1.43781099e+000
 i = -4.26502092e-003
 j = 3.89636941e-004

CPcor = -9.5700e-008 (nominal)
 CTcor = 3.2500e-006 (nominal)

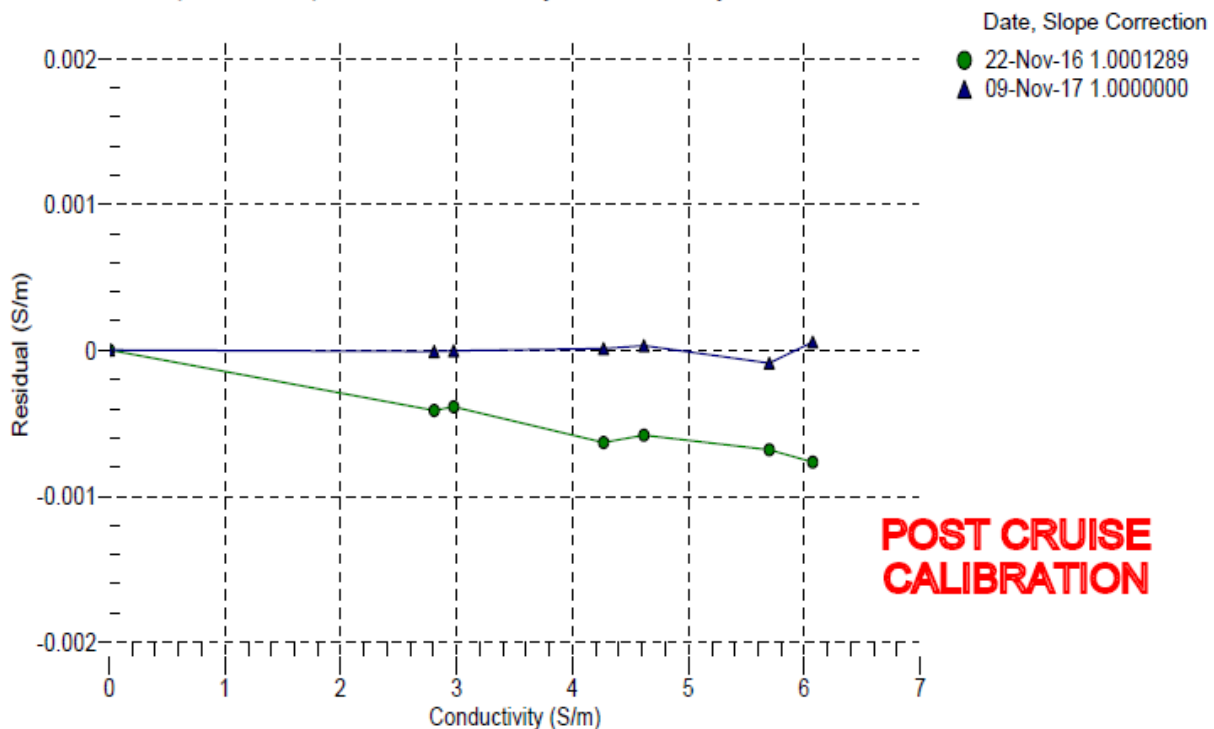
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (kHz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
0.0000	0.0000	0.00000	2.66474	0.00000	0.00000
-1.0000	34.8011	2.80347	5.17427	2.80346	-0.00001
1.0000	34.8019	2.97485	5.28918	2.97485	-0.00000
15.0000	34.8026	4.27011	6.08733	4.27012	0.00001
18.5000	34.8019	4.61666	6.28355	4.61670	0.00003
29.0000	34.7970	5.69951	6.85997	5.69942	-0.00009
32.5000	34.7837	6.07095	7.04674	6.07100	0.00006

f = Instrument Output (kHz)

t = temperature (°C); p = pressure (decibars); δ = CTcor; ε = CPcor;

Conductivity (S/m) = (g + h * f² + i * f³ + j * f⁴) / 10 (1 + δ * t + ε * p)

Residual (Siemens/meter) = instrument conductivity - bath conductivity





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SENSOR SERIAL NUMBER: 0880
 CALIBRATION DATE: 04-Nov-17

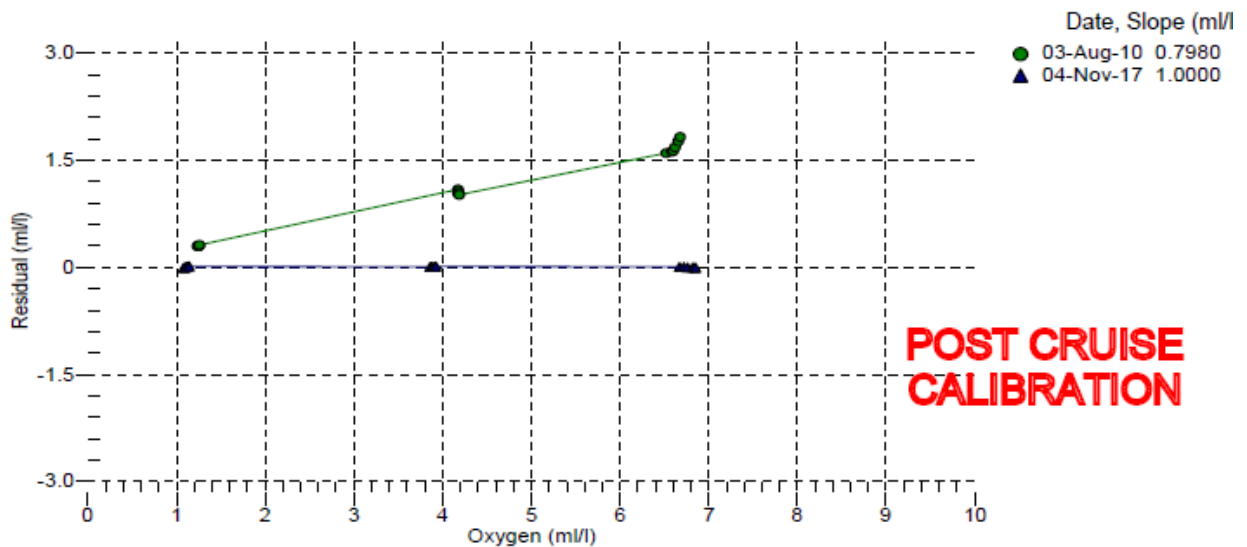
SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS:
 Soc = 0.6611
 Voffset = -0.4953
 Tau20 = 2.11
 A = -5.1301e-003
 B = 1.7352e-004
 C = -2.4487e-006
 E nominal = 0.036

NOMINAL DYNAMIC COEFFICIENTS
 D1 = 1.92634e-4
 D2 = -4.64803e-2
 H1 = -3.300000e-2
 H2 = 5.00000e+3
 H3 = 1.45000e+3

BATH OXYGEN (ml/l)	BATH TEMPERATURE (° C)	BATH SALINITY (PSU)	INSTRUMENT OUTPUT (volts)	INSTRUMENT OXYGEN (ml/l)	RESIDUAL (ml/l)
1.08	2.00	0.00	0.664	1.07	-0.01
1.09	6.00	0.00	0.689	1.09	-0.01
1.10	12.00	0.00	0.725	1.10	-0.00
1.12	20.00	0.00	0.777	1.12	0.00
1.13	26.00	0.00	0.818	1.14	0.01
1.14	30.00	0.00	0.848	1.15	0.01
3.86	2.00	0.00	1.105	3.86	0.00
3.87	6.00	0.00	1.185	3.87	0.00
3.89	12.00	0.00	1.310	3.90	0.00
3.91	20.00	0.00	1.477	3.91	0.00
3.92	26.00	0.00	1.609	3.93	0.01
3.93	30.00	0.00	1.697	3.93	0.01
6.67	2.00	0.00	1.549	6.67	0.00
6.72	6.00	0.00	1.692	6.72	0.00
6.76	12.00	0.00	1.908	6.76	-0.00
6.82	20.00	0.00	2.205	6.81	-0.01
6.85	30.00	0.00	2.585	6.84	-0.01
6.85	26.00	0.00	2.434	6.85	-0.00

V = instrument output (volts); T = temperature (°C); S = salinity (PSU); K = temperature (°K)
 Oxsol(T,S) = oxygen saturation (ml/l); P = pressure (dbar)
 Oxygen (ml/l) = Soc * (V + Voffset) * (1.0 + A * T + B * T² + C * T³) * Oxsol(T,S) * exp(E * P / K)
 Residual (ml/l) = instrument oxygen - bath oxygen



For CTD SN 937



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SENSOR SERIAL NUMBER: 5101
CALIBRATION DATE: 27-Oct-17

SBE 3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

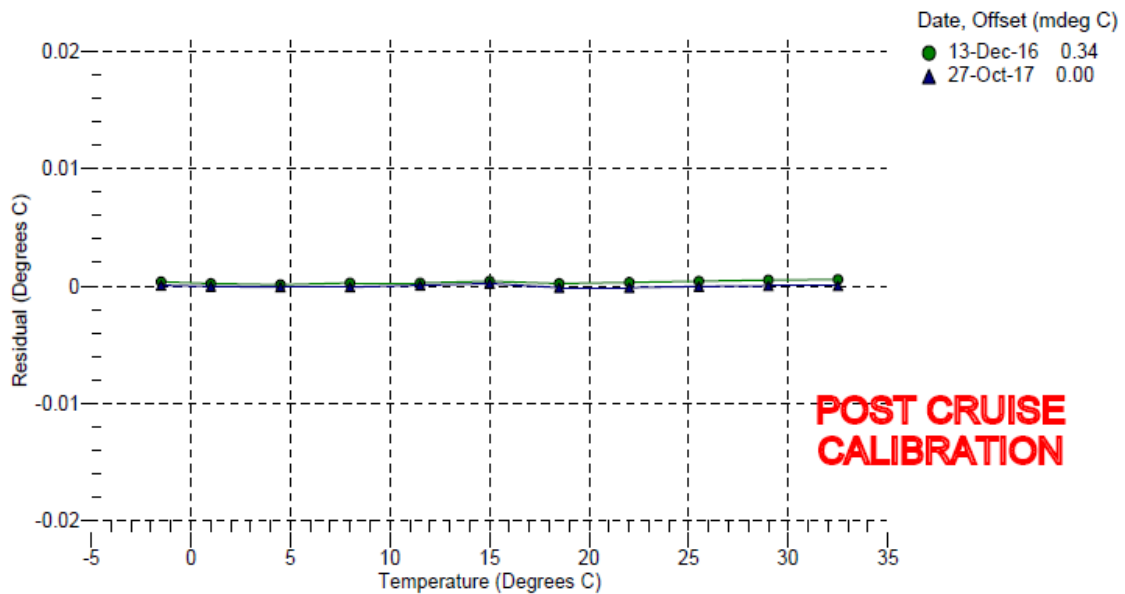
g = 4.35082709e-003
h = 6.37412260e-004
i = 2.10027602e-005
j = 1.82003828e-006
f0 = 1000.0

BATH TEMP (° C)	INSTRUMENT OUTPUT (Hz)	INST TEMP (° C)	RESIDUAL (° C)
-1.5000	2961.560	-1.4999	0.00006
1.0000	3132.734	1.0000	-0.00004
4.5000	3384.236	4.4999	-0.00008
8.0000	3649.927	7.9999	-0.00007
11.5000	3930.201	11.5001	0.00009
15.0000	4225.422	15.0002	0.00024
18.5000	4535.910	18.4999	-0.00012
22.0000	4862.096	21.9999	-0.00011
25.5000	5204.300	25.5000	-0.00000
29.0000	5562.833	29.0000	0.00001
32.5000	5938.023	32.5000	0.00003

f = Instrument Output (Hz)

$$\text{Temperature ITS-90 (°C)} = 1 / \{g + h[\ln(f_0 / f)] + i[\ln^2(f_0 / f)] + j[\ln^3(f_0 / f)]\} - 273.15$$

$$\text{Residual (°C)} = \text{instrument temperature} - \text{bath temperature}$$





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SENSOR SERIAL NUMBER: 5112
 CALIBRATION DATE: 27-Oct-17

SBE 3 TEMPERATURE CALIBRATION DATA
 ITS-90 TEMPERATURE SCALE

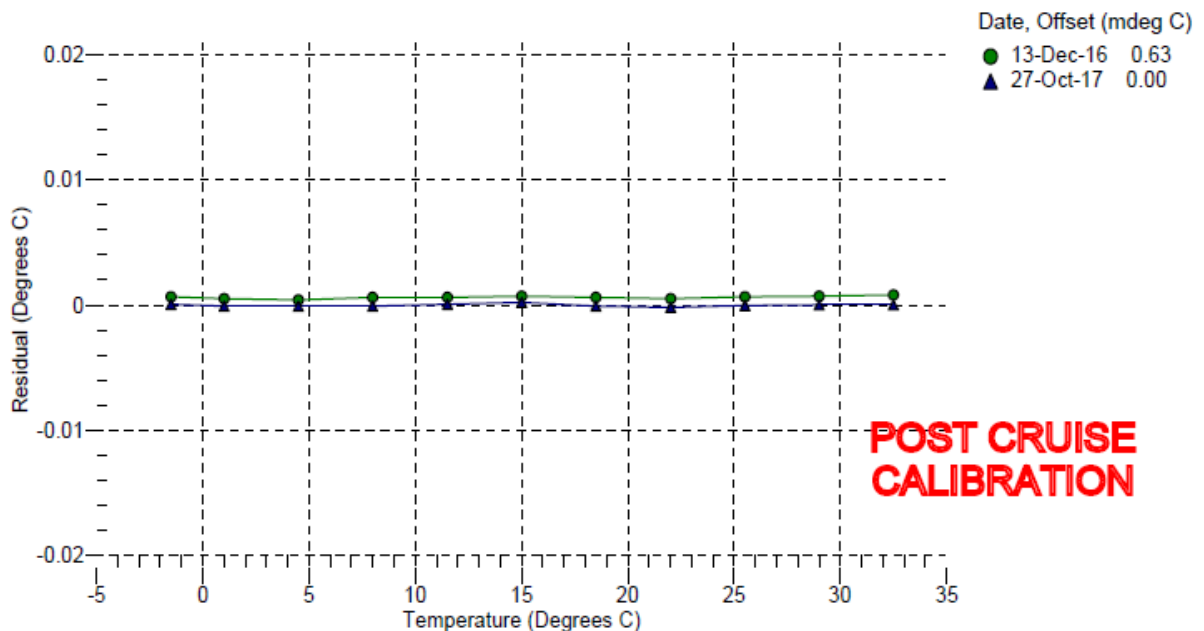
COEFFICIENTS:
 g = 4.37919132e-003
 h = 6.41749014e-004
 i = 2.19514488e-005
 j = 1.97760735e-006
 f0 = 1000.0

BATH TEMP (° C)	INSTRUMENT OUTPUT (Hz)	INST TEMP (° C)	RESIDUAL (° C)
-1.5000	3085.273	-1.4999	0.00008
1.0000	3263.115	0.9999	-0.00006
4.5000	3524.379	4.4999	-0.00009
8.0000	3800.332	7.9999	-0.00007
11.5000	4091.376	11.5001	0.00010
15.0000	4397.883	15.0002	0.00024
18.5000	4720.181	18.4999	-0.00008
22.0000	5058.695	21.9998	-0.00016
25.5000	5413.775	25.5000	-0.00000
29.0000	5785.719	29.0000	0.00003
32.5000	6174.854	32.5000	0.00002

f = Instrument Output (Hz)

$$\text{Temperature ITS-90 (°C)} = 1 / \{g + h[\ln(f0 / f)] + i[\ln^2(f0 / f)] + j[\ln^3(f0 / f)]\} - 273.15$$

Residual (°C) = instrument temperature - bath temperature





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SENSOR SERIAL NUMBER: 3290
 CALIBRATION DATE: 08-Nov-17

SBE 4 CONDUCTIVITY CALIBRATION DATA
 PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -9.84050613e+000
 h = 1.51479602e+000
 i = 6.33008739e-004
 j = 6.07978828e-005

CPcor = -9.5700e-008 (nominal)
 CTcor = 3.2500e-006 (nominal)

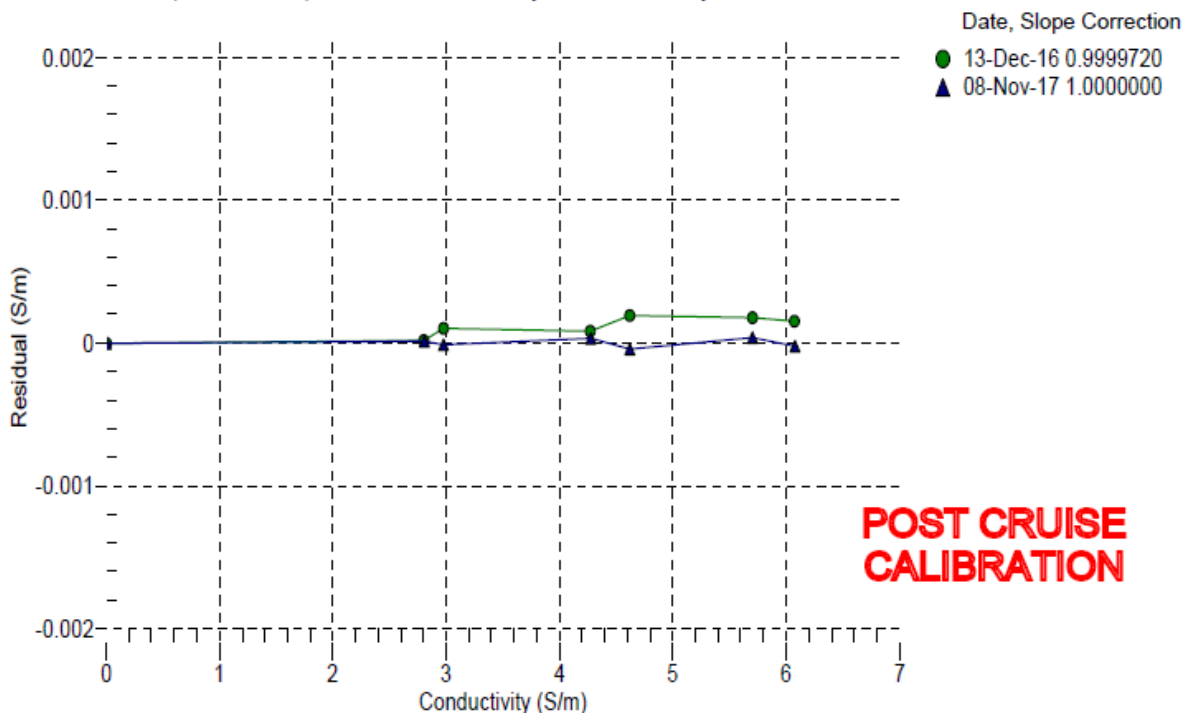
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (kHz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
0.0000	0.0000	0.00000	2.54709	0.00000	0.00000
-1.0000	34.8391	2.80624	4.99447	2.80625	0.00001
1.0000	34.8395	2.97776	5.10599	2.97775	-0.00001
15.0000	34.8385	4.27405	5.88049	4.27408	0.00003
18.5000	34.8381	4.62095	6.07085	4.62091	-0.00004
29.0000	34.8317	5.70456	6.63020	5.70459	0.00004
32.5000	34.8204	6.07662	6.81154	6.07660	-0.00002

f = Instrument Output (kHz)

t = temperature (°C); p = pressure (decibars); δ = CTcor; ε = CPcor;

Conductivity (S/m) = (g + h * f² + i * f³ + j * f⁴) / 10 (1 + δ * t + ε * p)

Residual (Siemens/meter) = instrument conductivity - bath conductivity





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SENSOR SERIAL NUMBER: 3570
 CALIBRATION DATE: 03-Nov-17

SBE 4 CONDUCTIVITY CALIBRATION DATA
 PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -9.80575078e+000
 h = 1.21383100e+000
 i = -1.33960638e-003
 j = 1.52693919e-004

CPcor = -9.5700e-008 (nominal)
 CTcor = 3.2500e-006 (nominal)

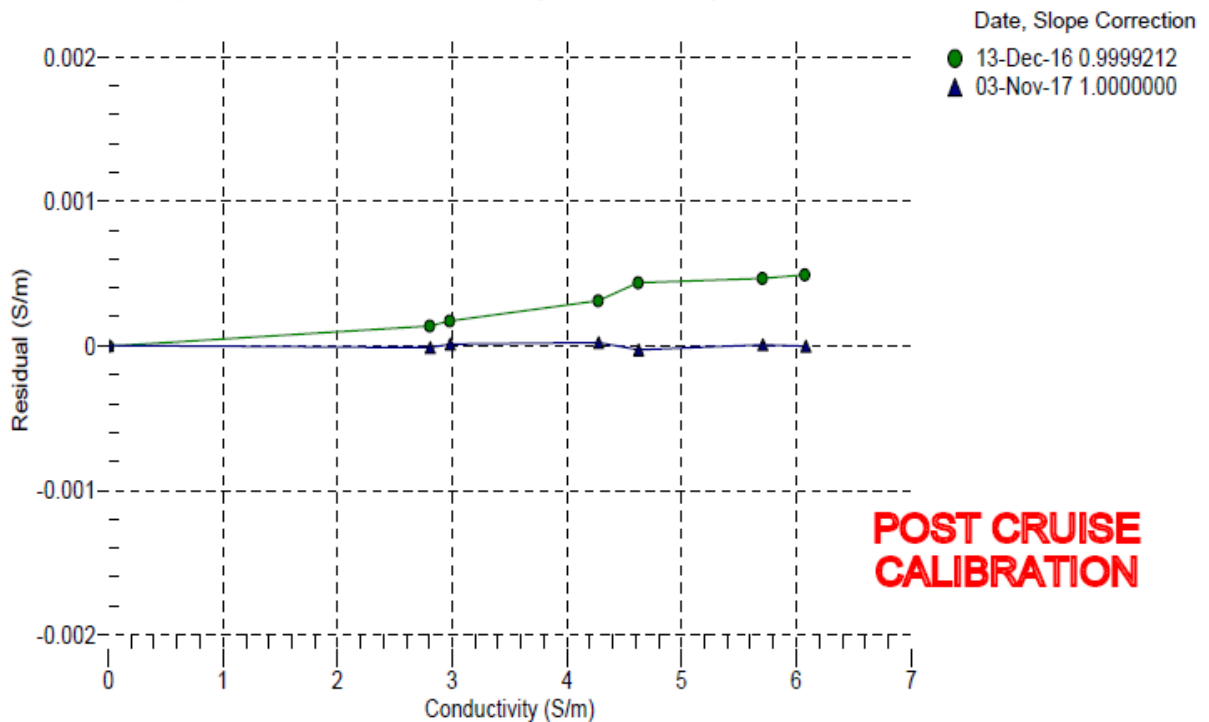
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (kHz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
0.0000	0.0000	0.00000	2.84526	0.00000	0.00000
-1.0000	34.8720	2.80864	5.59346	2.80863	-0.00001
1.0000	34.8719	2.98026	5.71865	2.98028	0.00001
15.0000	34.8717	4.27769	6.58787	4.27771	0.00002
18.5000	34.8715	4.62490	6.80148	4.62487	-0.00003
29.0000	34.8690	5.70998	7.42921	5.70999	0.00001
32.5000	34.8651	6.08354	7.63321	6.08353	-0.00000

f = Instrument Output (kHz)

t = temperature (°C); p = pressure (decibars); δ = CTcor; ε = CPcor;

Conductivity (S/m) = (g + h * f² + i * f³ + j * f⁴) / 10 (1 + δ * t + ε * p)

Residual (Siemens/meter) = instrument conductivity - bath conductivity





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SENSOR SERIAL NUMBER: 0467
CALIBRATION DATE: 14-Nov-17

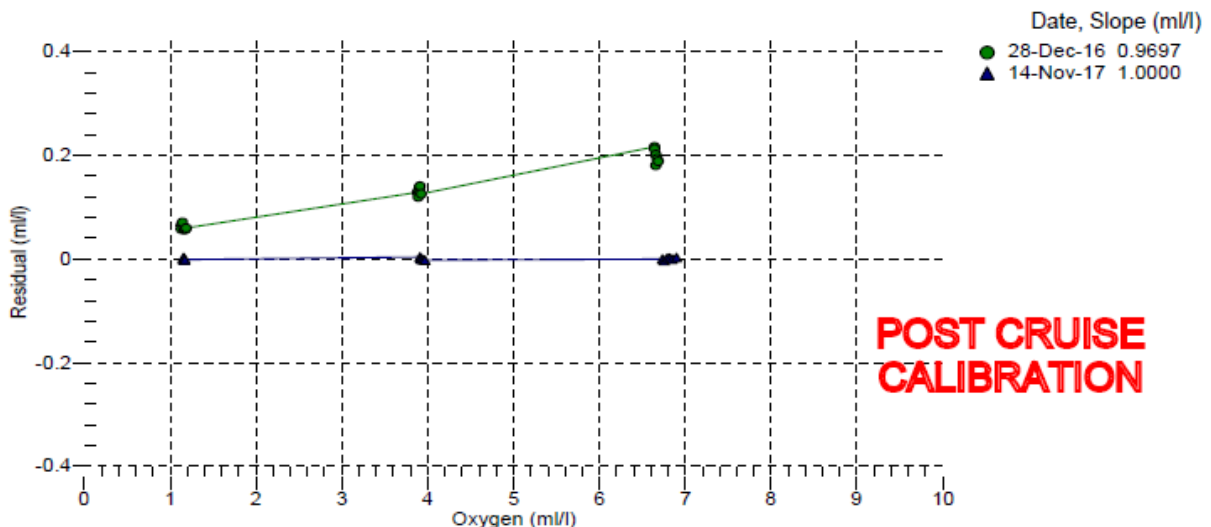
SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS: A = -3.5870e-003
Soc = 0.4511 B = 1.7508e-004
Voffset = -0.4977 C = -2.8965e-006
Tau20 = 1.00 E nominal = 0.036

NOMINAL DYNAMIC COEFFICIENTS
D1 = 1.92634e-4 H1 = -3.300000e-2
D2 = -4.64803e-2 H2 = 5.00000e+3
H3 = 1.45000e+3

BATH OXYGEN (ml/l)	BATH TEMPERATURE (° C)	BATH SALINITY (PSU)	INSTRUMENT OUTPUT (volts)	INSTRUMENT OXYGEN (ml/l)	RESIDUAL (ml/l)
1.15	12.00	0.00	0.844	1.15	-0.00
1.15	6.00	0.00	0.796	1.15	-0.00
1.16	20.00	0.00	0.911	1.16	-0.00
1.16	2.00	0.00	0.765	1.16	0.00
1.17	26.00	0.00	0.964	1.16	-0.00
1.17	30.00	0.00	1.002	1.17	-0.00
3.91	2.00	0.00	1.401	3.92	0.00
3.91	6.00	0.00	1.510	3.92	0.00
3.92	12.00	0.00	1.677	3.92	0.00
3.93	20.00	0.00	1.901	3.93	-0.00
3.95	26.00	0.00	2.079	3.94	-0.00
3.97	30.00	0.00	2.209	3.97	-0.00
6.74	2.00	0.00	2.051	6.73	-0.00
6.75	6.00	0.00	2.243	6.75	-0.00
6.79	12.00	0.00	2.542	6.79	0.00
6.82	20.00	0.00	2.935	6.82	0.00
6.85	26.00	0.00	3.243	6.85	-0.00
6.90	30.00	0.00	3.475	6.90	0.00

V = instrument output (volts); T = temperature (°C); S = salinity (PSU); K = temperature (°K)
Oxsol(T,S) = oxygen saturation (ml/l); P = pressure (dbar)
Oxygen (ml/l) = Soc * (V + Voffset) * (1.0 + A * T + B * T² + C * T³) * Oxsol(T,S) * exp(E * P / K)
Residual (ml/l) = instrument oxygen - bath oxygen





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SENSOR SERIAL NUMBER: 2292
 CALIBRATION DATE: 14-Nov-17

SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS:
 Soc = 0.5204
 Voffset = -0.4973
 Tau20 = 1.27

A = -4.3708e-003
 B = 2.1717e-004
 C = -3.2443e-006
 E nominal = 0.036

NOMINAL DYNAMIC COEFFICIENTS
 D1 = 1.92634e-4
 D2 = -4.64803e-2
 H1 = -3.300000e-2
 H2 = 5.00000e+3
 H3 = 1.45000e+3

BATH OXYGEN (ml/l)	BATH TEMPERATURE (°C)	BATH SALINITY (PSU)	INSTRUMENT OUTPUT (volts)	INSTRUMENT OXYGEN (ml/l)	RESIDUAL (ml/l)
1.15	12.00	0.00	0.798	1.15	-0.00
1.15	6.00	0.00	0.756	1.15	-0.00
1.16	20.00	0.00	0.856	1.16	-0.00
1.16	2.00	0.00	0.729	1.16	-0.00
1.17	26.00	0.00	0.902	1.17	0.00
1.17	30.00	0.00	0.933	1.17	0.00
3.91	2.00	0.00	1.281	3.92	0.00
3.91	6.00	0.00	1.378	3.92	0.00
3.92	12.00	0.00	1.524	3.92	0.00
3.93	20.00	0.00	1.716	3.93	0.00
3.95	26.00	0.00	1.865	3.94	-0.00
3.97	30.00	0.00	1.975	3.97	0.00
6.74	2.00	0.00	1.845	6.74	-0.00
6.75	6.00	0.00	2.016	6.75	-0.00
6.79	12.00	0.00	2.276	6.79	-0.00
6.82	20.00	0.00	2.612	6.82	-0.00
6.85	26.00	0.00	2.873	6.85	0.00
6.90	30.00	0.00	3.063	6.90	-0.00

V = instrument output (volts); T = temperature (°C); S = salinity (PSU); K = temperature (°K)
 Oxsol(T,S) = oxygen saturation (ml/l); P = pressure (dbar)
 $Oxygen (ml/l) = Soc * (V + Voffset) * (1.0 + A * T + B * T^2 + C * T^3) * Oxsol(T,S) * exp(E * P / K)$
 Residual (ml/l) = instrument oxygen - bath oxygen

