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Bosei Maru P02W cruise report

Salinity and CTD
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C.3 Hydrographic Measurement Techniques and Calibrations

C.3.1 Sample Salinity Measurements.

On T/V Bosei Maru cruise 9301, the salinity analysis of sampled water was carried out using an IOS DL Guildline Autosal salinometer model 8400B. In the room where the Autosal was placed, room temperature was controlled rather well but it changed within the range of 21 to 23C. The sub-standard sample was prepared in two Cuby Tainer's (flexible vinyl container) which were placed near to the Autosal. The lot number of the Standard which we used was P121. Of other lots of Standard we kept, we decided to use P121 because of its nearest value to 2.00000 and the amount of number of samples. Sea water was sampled in 350ml glass bottle with a rubber cap. Before the measurement it was placed near to the Autosal with the sub standard sample. The intake of sample water into the conductivity cell was controlled by a peripheral pump between the sample bottle and Autosal. Autosal was standardized using the Standard. The standardization process was composed of the first standardization and the second confirmation. The first standardization was carried out following the Autosal manual. The second confirmation was introduced after a test measurement of the sub- standard sample. At each chance of the standardization, the first standardization was reconfirmed by the second confirmation. Samples which were taken at a station ware measured consequently. It took about 1 hour to complete the measurement for sampled of one station. Sub-standard samples were also measured both before and after the consequent measurement of samples to check the machine drift. In present cruise, the drift was 0.003 at maximum. The largest maximum of drift was brought by a fine bubbles trapped by the leftmost anode before the measurement for samples of station 16 started.

Sensor was replaced and the standardization was carried out to recover the status of Autosal. Through out the cruise, Autosal performed very well. Nevertheless, rather many reading were regarded as erroneous ones. It is because there were bottle-leaks (supplemental nutrient analysis also showed the existence of the leakage) especially for samples of stations which were occupied during rough sea state. There were 66 pairs of replicate (i.e. from the same rosette bottle) samples. The standard deviation of the groups of sample pairs was0.000846.

C.3.6 CTD Measurements Gantry and Winch Arrangements

The gantry of R/V Bosei Maru consists of a gallows and CTD fixing equipment which can be retrieved in a house where a water sampling and a preparation for CTD casting are carried out. The gallows was powered by electric oil pressure pump and was operated to hang CTD out of and into the ship. Every time after the CTD operation the CTD package is come into the CTD room and water samples are drawn out from Niskin bottles.

The winch system is driven by oil-pressure. Winch operation room is located above the boat deck from where the whole out-door CTD operation can be looked down. The wire tension, the wire length and the pressure from CTD is monitored both in the winch room and in a CTD operation room. During the cruise, the weather was always severe because of big lows passed 500km west of the observation region. Thus the wire speed was always slow to give an enough tension to the wire. But at the first station when CTD was retrieved, we found that CTD/Niskin under water unit was heavily entwined by CTD cable. Two bottles and four SiS thermometers were lost. More weights were added to the steel frame which encloses CTD and Niskin bottles to prevent the under water unit from such a case mentioned above, nevertheless we had to experience almost the same accident twice. The most serious problem was the fact that CTD cable longer than 200m had to be given up. Both as low speed winch operation and a shortage of the CTD wire under a very rough sea condition made it impossible to lower CTD down to the bottom.

Equipment, calibrations and standards

1 Sea Bird 9/11 plus system with the oxygen sensor.
2 General Oceanics 5 liter 24 bottle rosette which was operated with 23 bottles in this cruise.
3 Four bottles were equipped with SiS thermometers and pressure gauges.

Backup equipment consisted of spare CTD-DO, Temperature, Conductivity sensors and three Niskin bottles.

The shipboard equipment consisted of an integral systems for an acquisition of CTD data as well as the Rosette firing. Demodulated signal which can be drawn out from the system could be back up by DAT recorder. Each system included the following major units:

1. Sea Bird 11/plus demodulator deck unit data terminal.
2. Pro-side486D2 system which is compatible with IBM/DOS machine.
3. SONY DAT recorder.

Laboratory calibrations of the Sea Bird 9 temperature, conductivity and Dissolved oxygen sensors were carried out at Pacific Center of SeaBird Inc. before (24 Jul. 93) and after(17 Mar 94) the Bosei-P2Ccruise. The serial numbers of the temperature sensor and the conductivity sensor were 1028 and 695, respectively Temperature calibration results are tabulated in table C-3-6-1. In this table, even at the time of the post cruise calibration, the set of coefficients for frequency conversion which were decided at the time of the pre cruise calibration gave a good result. The changes in coefficients between at the times of the pre and the post cruise calibration (not shown here)was safely negligible over the whole temperature range as long as the WOCE criterion concerns. (see the column of Diff*1)

Table C-3-6-1. Results of temperature calibrations

pre-cruise Bath Temp. (deg C)	Freq. (Hz)	Temp.*1 (deg C)	Res.*1 (deg C)	Temp.*2 (deg C)	Diff.*1 (deg C)
-1.4892	5732.81	-1.4893	-0.00014	-1.4881	0.0012
1.0185	6062.21	1.0187	0.00015	1.0200	0.0014
4.5056	6542.60	4.5058	0.00018	4.5073	0.0016
8.1009	7065.78	8.1008	-0.00013	8.1024	0.0017
11.5268	7591.41	11.5267	-0.00010	11.5284	0.0017
15.0811	8165.31	15.0810	-0.00011	15.0827	0.0017
18.5802	8759.38	18.5803	0.00006	18.5820	0.0017
22.0742	9381.94	22.0744	0.00016	22.0761	0.0017
25.6319	10046.56	25.6320	0.00012	25.6337	0.0017
29.0393	10712.64	29.0391	-0.00021	29.0408	0.0017
32.5702	11434.07	32.5704	0.00017	32.5721	0.0017

Temp*1: Instrument temperature converted from the instrument frequency using new coefficients decided at the post cruise calibration.
Temp*2: Instrument temperature converted from the instrument frequency using old coefficients decided at the pre cruise calibration.
Res.*1: The residual computed using Temp*1.
Diff*1: Difference between Temp*1 and Temp*2

As for the conductivity sensor, the result of calibration shows that a set of coefficient for the conversion from the frequency to the conductivity decided at the time of the post cruise calibration was much different from that decided at the time of pre cruise calibration. The difference of 0.001 Siemens/m was common over the conductivity rage from 3 to 5 Siemens/m with a tendency that the old coefficients gave a lower conductivity value.

Equipment performance General

As mentioned before, most problems arose always at the CTD-Rosette lowering operation. Rosette operation(firing) was carried out reliably, but some bottle-leaks were found at almost every station. The bottle-leaks were detected not for specific bottles. The reason for the leak may be attributable to an unimaginably hard movement of the under water assembly. The rolling angle of the ship reached 30 degrees sometimes. The under water unit seemed to encounter so large fluctuation of the lowering speed. Or the CTD cable might hit the under water unit.

CTD

CTD performance was very good through the cruise. We calibrated the salinity values through the comparison with water sampled data. We tried to compared the CTD data with historical data of P3 and 35N CTD data because there was no cross-data point with a historical high quality observation. As a results our data did not show any inconsistency with them at least at depths deeper than 3500m. On the other hand, an inter comparison of our CTD data with Kaiyo-Maru P2 cruise showed some systematic discrepancy. As for this intercomparison, we are preparing an another short report specially.

24-Bottle Rosette System If we focus our attention on the rosette system only, it performed very well without any misfiring. But as mentioned earlier, bottle-leaks were occurred frequently.

C.3.7 CTD Data Collection and Processing

Data Capture and Reporting Full CTD data with 24 per second are stored in a PC and are processed with a CTD processing software provided by Sea Bird Inc. (Sea Soft ver.4.03) The procedure followed the instruction prepared by Sea Bird Inc. exactly but the data sampled at slower lowering speed than 0.4m/sec are rejected. Physical and chemical values of the pressure, the temperature, the conductivity and the dissolved oxygen are stored after a pressure average by 1db pitch.

Temperature calibration

As mentioned in the performance section, the temperature out put from Sea Soft is considered to satisfy the WHP criterion without any calibration. The time drift of the temperature sensor was detected as small as about 0.0017C between at the time of the post cruise calibration and at the time of pre cruise calibration. We did not take any assumption concerning the details of the time drift although some improvement might be expected. It may be notable here that our basic opinion toward the calibration was "we should not assume anything more than the simple statistical theories".

Pressure Calibration

We did not apply a laboratory calibration for the pressure sensor. Instead, SiS pressure gauges which used in the Rosette system were used as a simple in situ calibration facility. Two SiS pressure gauges had been calibrated by SiS in October 1993 and other two SiS pressure gauges by National Institute of Measuring Japan in May and July 1993. As long as our in situ calibration concerns, there was no problem for the CTD pressure sensor, as was told by Pacific Center. It should be noted here that the air pressure which was measured by CTD in the air was taken into account when the salinity was calculated by the CTD processing software, Sea Soft.

Salinity calibration

Salinity was calibrated by comparison with sample salinity. The laboratory calibration of the conductivity sensor showed that about 0.01 psu lower salinity was computed when the old set of conversion coefficient were used. It turned out to be the present case. Our calibration method uses sample salinity values and CTD salinity values (out put of the software Sea Soft) directly. The difference between the CTD values and the sample values was regarded as a function of the pressure. Then a cubic pressure function was fitted to the difference through the least-square method using a weight function of: $w(p)=0.5+ P/2000$ P denotes the pressure at which the sample was taken. The reason why we use the cubic function came from facts:

(1) there is a marked inter mediate salinity minimum in the subtropical North Pacific although no marked structure exist at deeper depths.
(2) our CTD/Rosette system is equipped with Niskin bottles 1m higher than the water intake tube of the conductivity sensor.
(3) when the water was sampled, the under water unit had an upward velocity.

(2) and (3) may produce a cubic distribution of systematic differences between the CTD salinity and the sample salinity under the situation of (1), and the use of a cubic function will prevent the calibrated salinity from having an artificial component in the vertical structure. As a results, at depths deeper than 2500m, rms residuals lower than 0.0015 was achieved at every station. On the other hands, rms residuals lower than 0.0022and 0.01 were derived at depths

between 1000m and 2500m and at depths shallower than 1000m, respectively at every station. Thus, the cubic error function was decided at each station and applied to the salinity output from the software, Sea Soft to make up the final CTD salinity data by 1db pitch.

Oxygen Calibration

Calibration for CTD oxygen were carried out using sample values using the formula(Owens and Millard, 1985). But it turned out that this calibration method did not work well for our data. We got the results of QC of the sample oxygen in August 1996. The result of the CTD oxygen calibration through a different method than we had tried will be reported again.