3.1.1 CTD Measurements

(1) Personnel

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(2) Objective

Investigation of oceanic structure and water sampling.

(3) Parameters

Pressure
Temperature
Conductivity
Dissolved Oxygen
Dissolved Oxygen voltage
Transmission %, beam attenuation coefficient and voltage
Fluorescence
Photosynthetically Active Radiation
Altimeter

(4) Instruments and Methods

CTD/Carousel Water Sampling System, which is 24-position Carousel water sampler (CWS) with Sea-Bird Electronics, Inc. CTD (SBE9plus), was used during this cruise. 2.5 litter Niskin Bottles and 8 litter Niskin Bottles were used for sampling seawater. The sensors attached on the CTD were pressure, temperature (Primary and Secondary), conductivity (Primary and Secondary), dissolved oxygen (SBE43), RINKO III (dissolved oxygen sensor, voltage only), fluorescence, PAR, transmission and altimeter. The Practical Salinity was calculated by measured values of pressure, temperature and conductivity. The CTD/CWS was deployed from starboard on working deck.

The CTD raw data were acquired on real time using the Seasave-Win32 (ver.7.23.2) provided by Sea-Bird Electronics, Inc. and stored on the hard disk of the personal computer. Seawater was sampled during the up cast by sending fire commands from the personal computer. We stop at each layer for 30 seconds to stabilize then fire.

6 casts of CTD measurements were conducted (Table 3.1.1-1).

Table 3.1.1-1 CTD cast table

Stnnbr	Castno	Date(UTC)	Time(UTC)		BottomPosition		Depth	Wire Out	HT Above Bottom	Max Depth	Max Pressure	CTD Filename	Remark
		(mmddyy)	Start	End	Latitude	Longitude							
KC1	1	011716	01:19	04:56	40-09.54S	109-53.44E	4712.7	4713.0	13.8	4714.1	4804.0	UM20160117KC1_01	8 litter Niskin Bottles
KC2	1	011916	08:27	10:41	45-29.98S	110-00.04E	3804.4	3796.0	10.4	3796.9	3863.0	UM20160119KC2_01	no Niskin bottles
KC3	1	012016	12:48	14:45	49-59.96S	110-00.07E	3183.8	3172.8	-	3175.1	3227.0	UM20160120KC3_01	no Niskin bottles
KC4	1	012116	23:28	02:44	54-59.97S	110-00.07E	3879.5	3875.9	9.3	3877.3	3949.0	UM20160121KC4_01	2.5 and 8 litter Niskin Bottles
KC5	1	012316	10:05	13:19	60-00.01S	110-00.13E	4363.6	4350.0	11.0	4350.8	4438.0	UM20160123KC5_01	2.5 and 8 litter Niskin Bottles
KC6	1	012716	03:52	05:56	64-58.34S	109-00.97E	2562.2	2565.0	10.3	2555.8	2597.0	UM20160127KC6_01	2.5 and 8 litter Niskin Bottles

Data processing procedures and used utilities of SBE Data Processing-Win32 (ver.7.23.2.) and SEASOFT were as follows:

DATCNV: Convert the binary raw data to engineering unit data. DATCNV also extracts bottle information where scans were marked with the bottle confirm bit during acquisition. The duration was set to 3.0 seconds, and the offset was set to 0.0 seconds. Because CTD data is included bad data at KC1 #19 (123.8 dbar) and KC4 #10 (249.0 dbar), the duration was set to 1.0 seconds and 3.0 seconds, and the offset was set to 0.5 seconds and 1.5 seconds, respectively.

ALIGNCTD: Convert the time-sequence of sensor outputs into the pressure sequence to ensure that all calculations were made using measurements from the same parcel of water. Dissolved oxygen (SBE43) data are systematically delayed with respect to depth mainly because of the long time constant of the dissolved oxygen sensors and of an additional delay from the transit time of water in the pumped pluming line. This delay was compensated by 5 seconds advancing dissolved oxygen sensors output (dissolved oxygen voltage) relative to the temperature data. RINKO-III voltage, transmission data and voltage are also delayed by slightly slow response time to the sensor. RINKO-III voltage was compensated by 1 second, and transmission data was compensated by 2 seconds advancing.

WILDEDIT: Mark extreme outliers in the data files. The first pass of WILDEDIT obtained an accurate estimate of the true standard deviation of the data. The data were read in blocks of 1000 scans. Data greater than 10 standard deviations were flagged. The second pass computed a standard deviation over the same 1000 scans excluding the flagged values. Values greater than 20 standard deviations were marked bad. This process was applied to pressure, depth, temperature, conductivity and dissolved oxygen (SBE43) voltage.

CELLTM: Remove conductivity cell thermal mass effects from the measured conductivity. Typical values used were thermal anomaly amplitude alpha = 0.03 and the time constant 1/beta = 7.0.

FILTER: Perform a low pass filter on pressure with a time constant of 0.15 second. In order to produce zero phase lag (no time shift) the filter runs forward first then backward

WFILTER: Perform a median filter to remove spikes in the transmission data, beam attenuation coefficient, transmission voltage and fluorescence data. A median value was determined by 49 scans of the window.

SBE_SECTION (SECTION and original module): Select a time span of data based on scan number in order to reduce a file size (SECTION). The minimum number was set to be the starting time when the CTD package was beneath the sea-surface after activation of the pump (original module). The maximum number of was set to be the end time when the package came up from the surface (original module).

LOOPEDIT: Mark scans where the CTD was moving less than the minimum velocity of 0.0 m/s (remove traveling backwards due to ship roll).

DERIVE: Compute dissolved oxygen (SBE43), salinity, potential temperature, sigma-theta and sigma-t.

BINAVG: Average the data into 1-dbar pressure bins.

SPLIT: Separate the data from an input .cnv file into down cast and up cast files.

BOTTLESUM: Create a summary of the bottle data. The data were averaged over 3.0 seconds. At KC1 #19 (123.8 dbar) and KC4 #10 (249.0 dbar), the data were averaged over 1.0 seconds and over 3.0 seconds, respectively.

Specifications of the sensors are listed below.

CTD: SBE911plus CTD system
Under water unit:
SBE9plus (S/N 09P22763-0590, Sea-Bird Electronics, Inc.)
Pressure sensor: Digiquartz pressure sensor (S/N 77509)
Calibrated Date: 29 May 2015
Temperature sensors:
Primary: SBE03Plus (S/N 03P2863, Sea-Bird Electronics, Inc.)
Calibrated Date: 27 May 2015
Secondary: SBE03Plus (S/N 03P5679, Sea-Bird Electronics, Inc.)
Calibrated Date: 20 Feb. 2015
Conductivity sensors:
Primary: SBE04 (S/N 042414 Sea-Bird Electronics, Inc.)
Calibrated Date: 27 May 2015
Secondary: SBE04 (S/N 044376, Sea-Bird Electronics, Inc.)
Calibrated Date: 10 Feb. 2015
Dissolved Oxygen sensors:
SBE43 (S/N 431471, Sea-Bird Electronics, Inc.)
Calibrated Date: 09 Jun 2015
RINKO III (S/N 0197, Alec Electronics Co. Ltd.)
Fluorescence:
Chlorophyll Fluorometer (S/N 3590, Seapoint Sensors, Inc.)
Photosynthetically Active Radiation:
PAR sensor (S/N 70590, Satlantic Inc.)
Calibrated Date: 24 Nov. 2014
Transmissonmeter:
C-Star (S/N CST-1703DR, WET Labs, Inc.)
Calibrated Date: 29 Dec. 2014
Altimeter:
Benthos PSA-916T (S/N 59546, Teledyne Benthos, Inc.)
Carousel water sampler:
SBE32 (S/N 3273491-0949, Sea-Bird Electronics, Inc.)
Submersible Pump:

Primary: SBE5T (S/N 052786, Sea-Bird Electronics, Inc.)

Secondary: SBE5T (S/N 057891, Sea-Bird Electronics, Inc.)

Bottom contact switch: (Sea-Bird Electronics, Inc.)

Deck unit: SBE11plus (S/N 11P90698-0969, Sea-Bird Electronics, Inc.)

Configuration file : 9P-0590_20160113.xmlcon

(5) Post-cruise calibration

i. Pressure

The CTD pressure sensor offset in the period of the cruise was estimated from the pressure readings on the ship deck. For best results the Digiquartz pressure sensor was powered on for at least 20 minutes before the operation. In order to get the calibration data for the pre-cast and post-cast pressure sensor drift, the CTD deck pressure was averaged over first and last one minute, respectively. Then the atmospheric pressure deviation from a standard atmospheric pressure was subtracted from the CTD deck pressure to check the pressure sensor time drift. The atmospheric pressure was measured at the captain deck (5.7 m high from the base line) and sub-sampled one-minute interval as a meteorological data. Time series of the CTD deck pressure is shown in Fig. 3.1.1-1. The CTD pressure sensor offset was estimated from the deck pressure. Mean of the pre-cast and the post-casts data over the whole period gave an estimation of the pressure sensor offset (0.21 dbar) from the pre-cruise calibration. The post-cruise correction of the pressure data is not deemed necessary for the pressure sensor.

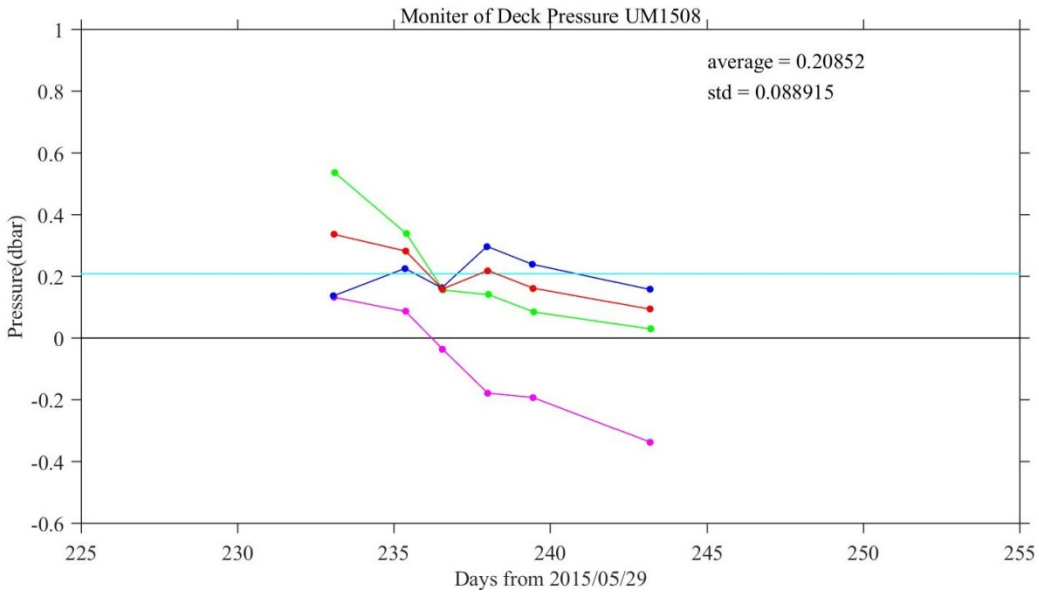

Fig. 3.1.1-1 Time series of the CTD deck pressure. Atmospheric pressure deviation (magenta dots) from a standard atmospheric pressure was subtracted from the CTD deck pressure. Blue and green dots indicate pre-cast and post-cast deck pressures, respectively. Red dots indicate averages of the pre-cast and the post-cast deck pressures.

ii. Temperature

The CTD temperature sensors (SBE 3) were not calibrated because the Deep Ocean Standard Thermometer (SBE35) to calibrate the temperature sensors (SBE3) was not attached on the CTD in this cruise.

iii. Salinity

The discrepancy between the bottle salinity and the CTD salinity calculated from the CTD temperature, conductivity and pressure data is considered to be a function of pressure and time.

The CTD salinity was calibrated as

$$\text{Calibrated primary salinity} = S - (c0 \times P + c1 \times t + c2)$$

$$\text{Calibrated secondary salinity} = S - (c0 \times P + c1 \times t + c2)$$

where S is CTD Salinity, P is pressure in dbar, t is time in days from start date of this cruise and c0, c1, and c2 are calibration coefficients. The best fit sets of coefficients were determined by a least square technique to minimize the deviation from the bottle salinity data. The calibration coefficients are listed in Table 3.1.1-2. The results of the post-cruise calibration for the CTD salinity are summarized in Table 3.1.1-3 and shown in Figs. 3.1.1-2 and 3.1.1-3.

Table 3.1.1-2 Calibration coefficients for the CTD salinity.

Serial Number	c0	c1	c2
2414	3.64238382e-07	-1.29813e-04	3.8193e-03
4376	9.28330314e-07	-9.64654e-05	8.6039e-04

Table 3.1.1-3 Difference between the CTD salinity and the bottle salinity after the post-cruise calibration. Mean and standard deviation (Sdev) (in 10–3) are calculated for the data below and above 950 dbar. Number of data used is also shown.

Serial number	Pressure ≥ 950 dbar			Pressure < 950 dbar		
	Number	Mean	Sdev	Number	Mean	Sdev
2414	32	–0.0	0.4	59	0.1	1.5
4376	32	–0.0	0.3	59	0.2	1.5

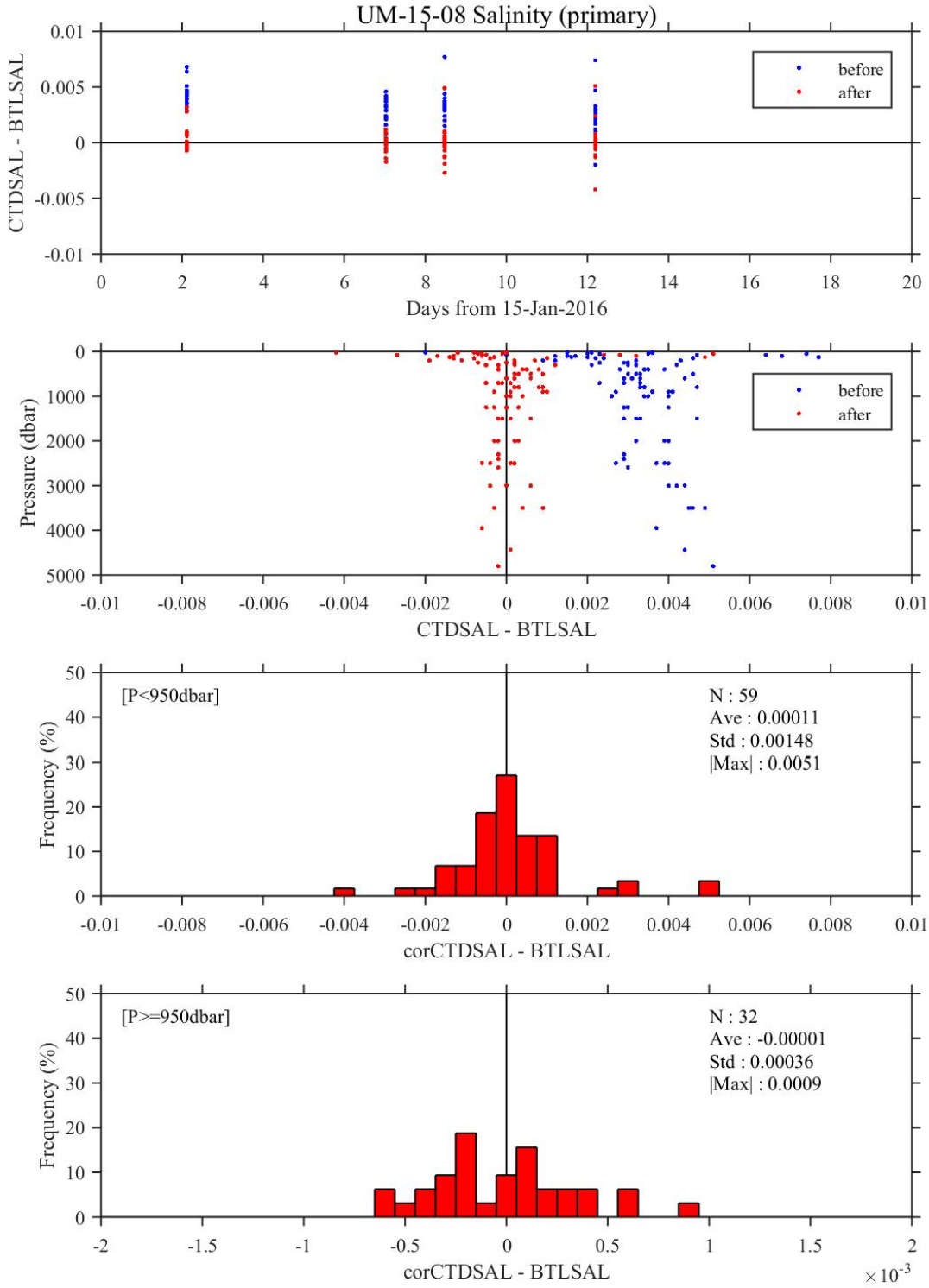

Fig. 3.1.1-2 Difference between the CTD salinity (primary, s/n 2414) and the bottle salinity. Blue and red dots indicate before and after the post-cruise calibration, respectively. Lower two panels show histogram of the difference after the calibration.

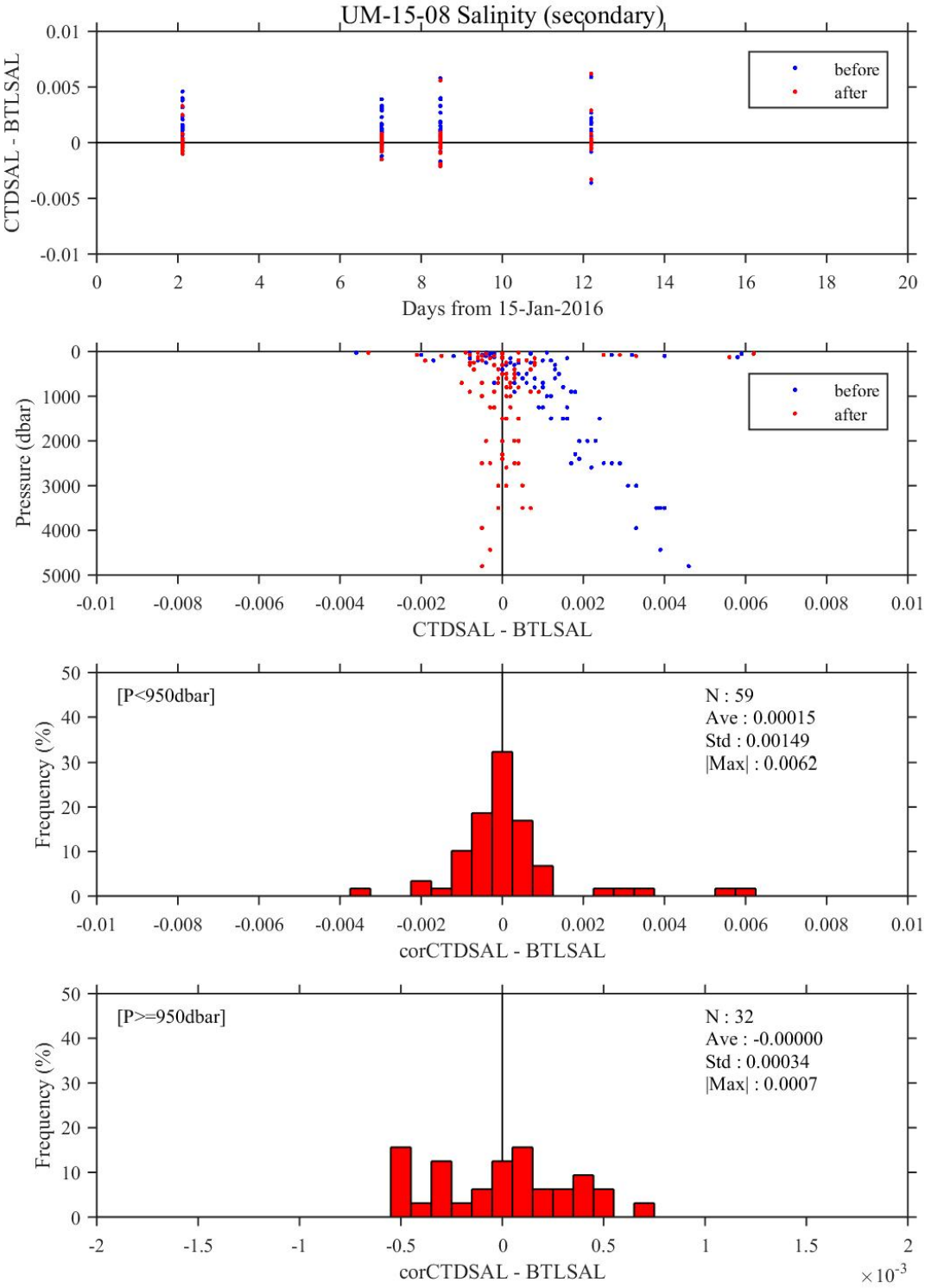

Fig. 3.1.1-3 Same as Fig. 3.1.1-2, but for secondary salinity (s/n 4376).

(6) Data archive

During this cruise, 6 casts of CTD observation were carried out. Date, time and locations of the CTD casts are listed in Appendix. All raw and preliminary processed data files were copied onto HDD provided by Tokyo Kaiyo University of Marine Science and Technology (TUMSAT). All data will be quality checked and corrected after this cruise.