CTD report

Estelle Dumont, SAMS

1 Shipboard CTD (SBE911)

1.1 Methodology

Two CTDs were used during the cruise: both were housed in standard stainless steel frames, and were equipped with dual T and C sensors, SBE43 oxygen sensor, Chelsea Aqua 3 fluorometer, altimeter, Wetlab CStar transmissometer and Biospherical/Licor PAR/irradiance sensor.
Twenty-four 10 litres Niskin bottles were fitted on the first CTD carousel. The system was deployed from the CTD winch on the starboard side during legs 1, 3 and 4. The second CTD only carried twelve 10 litres bottles and was deployed at the stern of the ship due to ice conditions during leg 2.
The usual procedure was to first lower the CTD to around 10m deep for the pumps to switch on. The system was then brought back up to the surface before starting the cast.

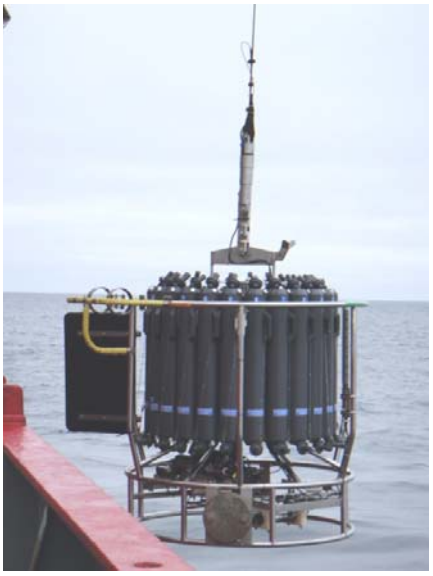

Figure 1.1-1: CTD being deployed from the mid-ship gantry.

1.2 Data processing

The CTD data were processed according the standards described in the SAMS CTD data Processing Protocol (Dumont and Sherwin, 2008, SAMS internal report No 257), using Seabird Data Processing version 7.18b and Matlab R2007a. The processing steps were:

- Step 1(SBE Data Processing, batch processing): modules Data Conversion, Align CTD, Cell Thermal Mass, Filter, Derive, Translate and Bottle Sum.
- Step 2 (Matlab): despiking of the 24Hz data
- Step 3 (SBE Data Processing, batch processing): modules Ascii In,, Bin Average (2db-bins) and Ascii Out
- Step 4 (Matlab): plot of the data
- Step 5 (Matlab): calibration of oxygen and salinity data on both 24Hz and 2db-bin averaged datasets (post-cruise).

1.2.1 Raw data processing (SBEDataProcessing)

Data Conversion converted raw data from engineering units to binary .cnv files and produced the .ros files. Variables exported were scan number, pump status, Julian day, pressure [db], temperature0 [ITS-90, deg C], conductivity0 [mS/cm], temperature1 [ITS-90, deg C], conductivity1 [mS/cm], oxygen [mg/l], beam attenuation [1/m], altimeter [m], fluorescence [µg/l], beam transmission [%], PAR and depth [m].
Please note:
The primary TC sensors were labelled 0, secondary 1.
The depth exported here was only for indicative purposes in the bottle files. Accurate depth calculation was performed at the Derive stage, and this first depth removed in processed files.

AlignCTD was then run to compensate for sensor time-lag.
The secondary conductivity was advanced by 0.073s, as recommended by Seabird.
The oxygen sensor response was advanced relative to pressure (+5s applied here). This ensures that calculations of dissolved oxygen concentration are made using measurements from the same parcel of water.

In **Cell Thermal Mass**, a recursive filter was run to remove conductivity cell thermal mass effects from the measured conductivity. The constants used were the ones given by Seabird: thermal anomaly amplitude α=0.03 and thermal anomaly time constant 1/β=7.

Filter applied a low-pass filter (value of 0.15) on the pressure and depth data, which smoothed the high frequency (rapidly changing) data. To produce zero phase (no time shift), the filter was first run forward through the data and then run backward through the data. This removed any delays caused by the filter.

At the **Derive** stage, twin densities sigma-theta (kg/m3), twin salinities (psu) and depth (m) were calculated.

The data was converted from binary to ASCII format by the module **Translate**. The data had been kept in binary format up to this stage to avoid any loss in precision that could occur when converting to Ascii.

Finally, the module **BottleSum** created the ASCII bottle files (.btl) from the .ros files, for each bottle fired during a cast. These files contain mean, standard deviation, maximum and minimum values for all variables (average of 48 scans, i.e. 2s).

1.2.2 Despiking (Matlab)

The pressure, oxygen, temperature (primary and secondary) and salinity (primary and secondary) data were manually despiked. Any data recorded while the pumps were not on were deleted at this stage.
Notes on the despiking:
- When a spike occurred in the pressure, temperature or salinity data, making that/those point(s) flagged as bad, the whole corresponding scan has been deleted.
- When a spike occurred in the oxygen data, making that point flagged as bad, the erroneous value was set to NaN, and other variables of the scan (i.e. temperature, salinity, etc) were kept in the dataset (if not flagged as bad themselves).

1.2.3 Averaging (SBEDataProcessing)

After going through Matlab, the data files needed to be re-formatted to be recognised by SBE Data Processing. **ASCII In** added a header to the input .asc file and output a .cnv file (XXX_2.cnv).
The module **Bin Average** averaged the 24Hz data into 2db-bins, using the downcast data only.
Ascii Out output the bin-averaged data files as ASCII (with a simplified header).

1.2.4 Datafiles

The different types of files created are (example of cast no 001):
jr219_001_1.cnv : non despiked, non calibrated 24Hz data
jr219_001_2.asc : despiked, non calibrated 24Hz and 2db-bin averaged data
jr219_001_3.asc : despiked, calibrated 24Hz data
jr219_001.CTD: despiked, calibrated 2db-bin averaged data (WOCE format conventions)
jr219_001.btl : bottle data file, non calibrated
jr219_001.hdr : header file, describing the data processing details

1.3 Data calibration

1.3.1 Salinity calibration

Throughout the cruise the CTD was sampled for salinity measurements, in order to calibrate the conductivity sensors. Salinity was measured using a Guildline Autosal8400, in a temperature-controlled room onboard the ship. The CTD data used for calibration comes from the .btl files (created by the Seabird software).

For the first CTD (leg 1, 3 and 4) a total of 90 salinity samples were collected and analysed, including a few duplicate samples. The Autosal and the Seabird values were in good agreement. Six data points had a difference over 0.1 psu and were not used for calibration.

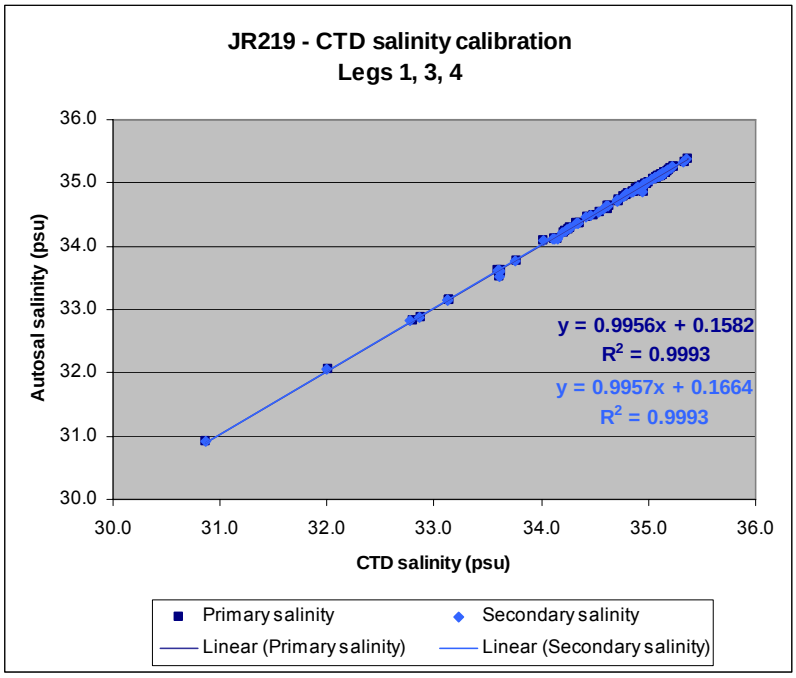

Figure 1.3-1: CTD salinity calibration data and equation for leg 1, 3 and 4.

For the second CTD (leg2) 25 salinity samples were collected and analysed, including a few duplicate samples. The correlation was not as good as for the other CTD, particularly in surface waters. This is probably because the casts were done when the ship was moored to the ice floe, in highly stratified surface waters. Often, the propellers were running to clear the ice drifting at the stern, disturbing the surface layers. Five data points, showing a difference over 0.2 psu between the Autosal and the CTD readings, were removed.

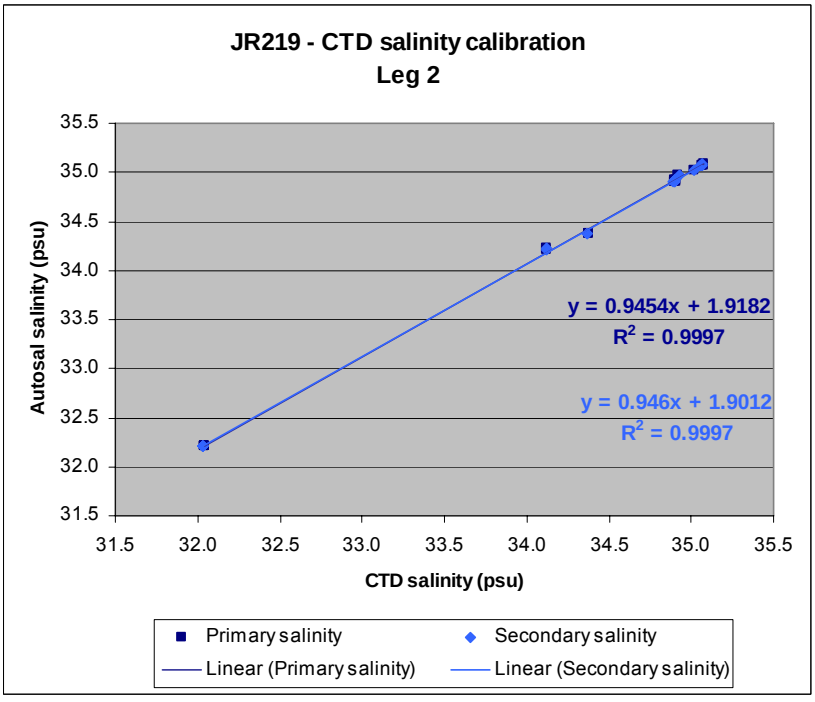

Figure 1.3-2: CTD salinity calibration data and equation for leg 2.

The final calibration equations are summarised below in Table 1.3.1-1.

CTD package	Sensor	Calibration equation	R^2
CTD 1 (leg 1, 3, 4)	Primary	SAL_{calib} = 0.9956 x SAL_{ctd} + 0.1582	0.9993
CTD 1 (leg 1, 3, 4)	Secondary	SAL_{calib} = 0.9957 x SAL_{ctd} + 0.1664	0.9993
CTD 2 (leg 2)	Primary	SAL_{calib} = 0.9454 x SAL_{ctd} + 1.9182	0.9997
CTD 2 (leg 2)	Secondary	SAL_{calib} = 0.9460 x SAL_{ctd} + 1.9012	0.9997

Table 1.3.1-1: CTD salinity calibration equations summary.

1.3.2 Dissolved Oxygen calibration

For the methodology refer to section ?.? by Elena Garcia.

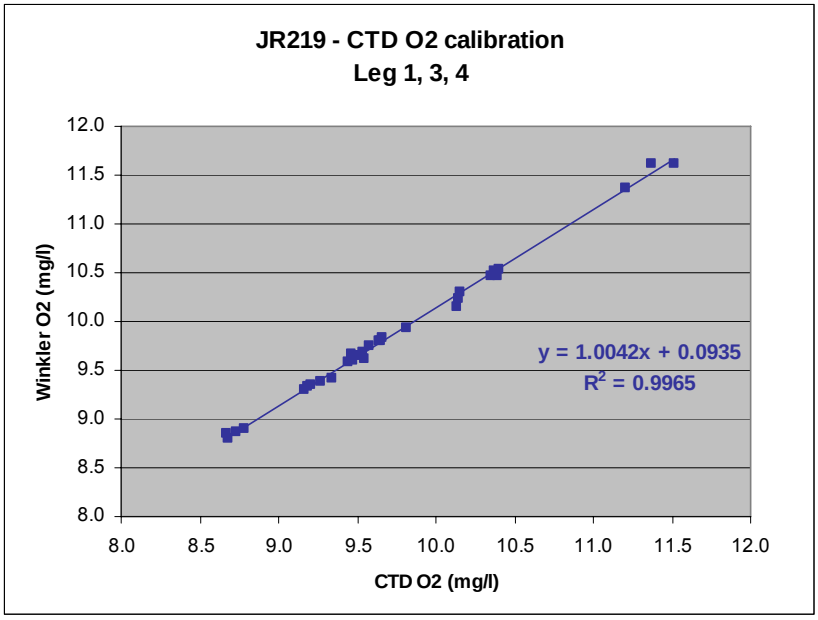

Figure 1.3-3: CTD O_2 calibration data and equation for leg 1, 3 and 4.

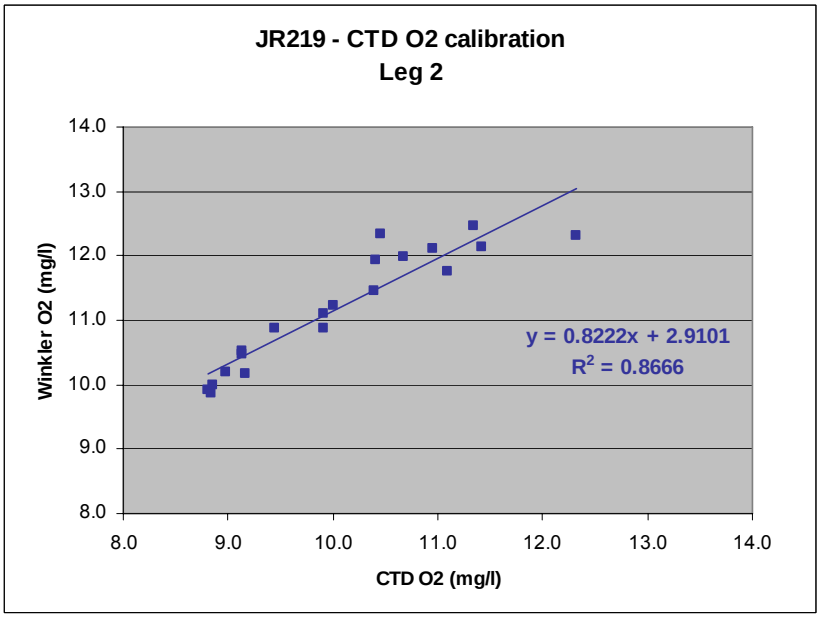

Figure 1.3-4: CTD O_2 calibration data and equation for leg 2.

To follow WOCE data format conventions, the calibrated O_2 values in the final datafiles have been converted from mg/l to µmol/kg using the formula:
[µmol/Kg] = (([mg/L] / 1.42903) * 44660) / (sigma_theta + 1000)

1.3.3 Fluorometer calibration

Please note that the fluorescence data has not been calibrated in the final dataset. Users wishing to use calibrated data should refer to the chlorophyll discrete sampling carried out throughout the cruise to determine a suitable calibration equation.

1.4 Comments

The CTDs have generally performed well during the cruise, although a few points are worth noting:

The dual temperature and conductivity measurements were in good agreement throughout the cruise, except at the beginning of leg 2. The secondary conductivity sensor appeared to be faulty, and was replaced after a few casts. Therefore, the secondary conductivity, salinity and density for CTD013 to 017 should not be used.

The acquisition software (Seasave) installed on the ship's CTD computer was an old version, not supporting the use of the new oxygen calibration method and coefficients. The CON file used for data acquisition was therefore an inaccurate one (keeping the old oxygen calibration method). However, the data processing was performed with a more recent version of the Seabird software, and an up-to-date CON file was used to process the data.
Some errors in the calibration coefficients of the PAR sensor and fluorometer were also found in the original CON file. These were corrected shortly after the start of the cruise, and all the data were processed using the up-to-date CON file.
In the final data, the transmittance values reported were sometimes over 100% (up to 102%), indicating that the transmissometer is probably slightly out of calibration.

A misfiring issue was encountered several times on CTD1 (leg 3 and 4) for bottle 16: the acquisition software would not report the bottle as fired, although it did close correctly. The bottle firing was not recorded in the data either, shifting the bottles recordings in the .btl files (e.g. the bottle recorded as 16 was actually bottle 17, bottle 17 was bottle 18, etc). This happened for casts number 33, 34, 43, 46, 49, 53, 56, 57, 58, 59 and 80. Those .btl files have been corrected post-cruise by re-attributing the correct bottle number to the recordings. As there was no data for bottle 16 on those casts, the data from the previous or following bottle, if fired at the same depth, was used instead. If bottle 16 was the only bottle fired at a certain depth the data has been replaced by a "bad flag" value (99999).

1.5 T-S diagrams

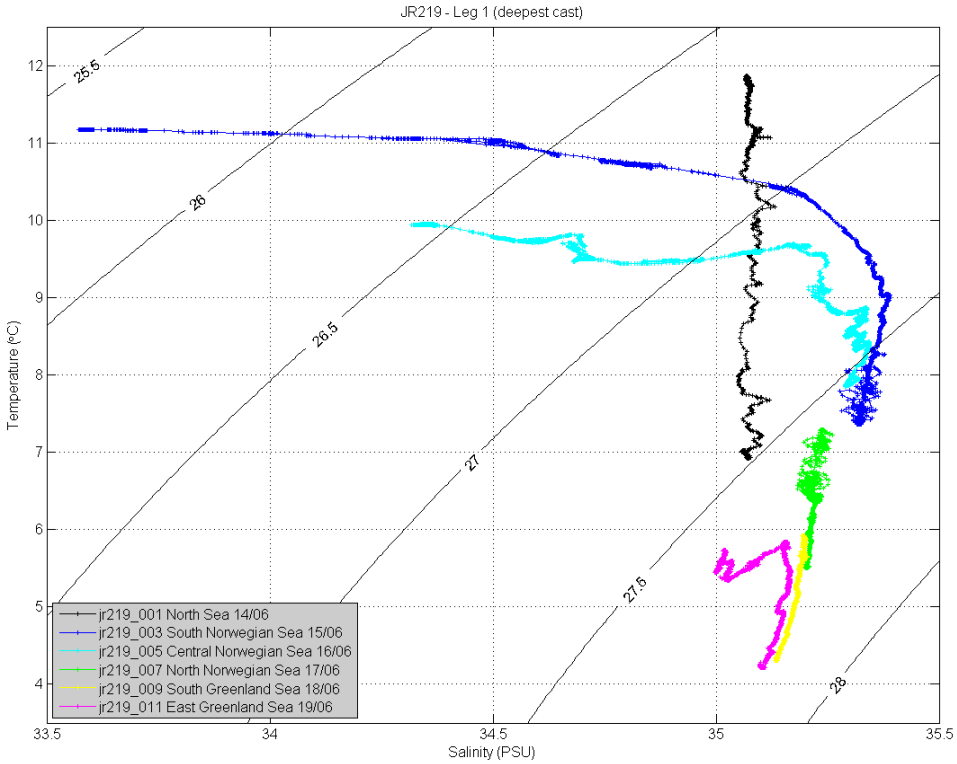

Figure 1.5-1: T-S diagram of the CTD stations in leg 1 (deepest cast).

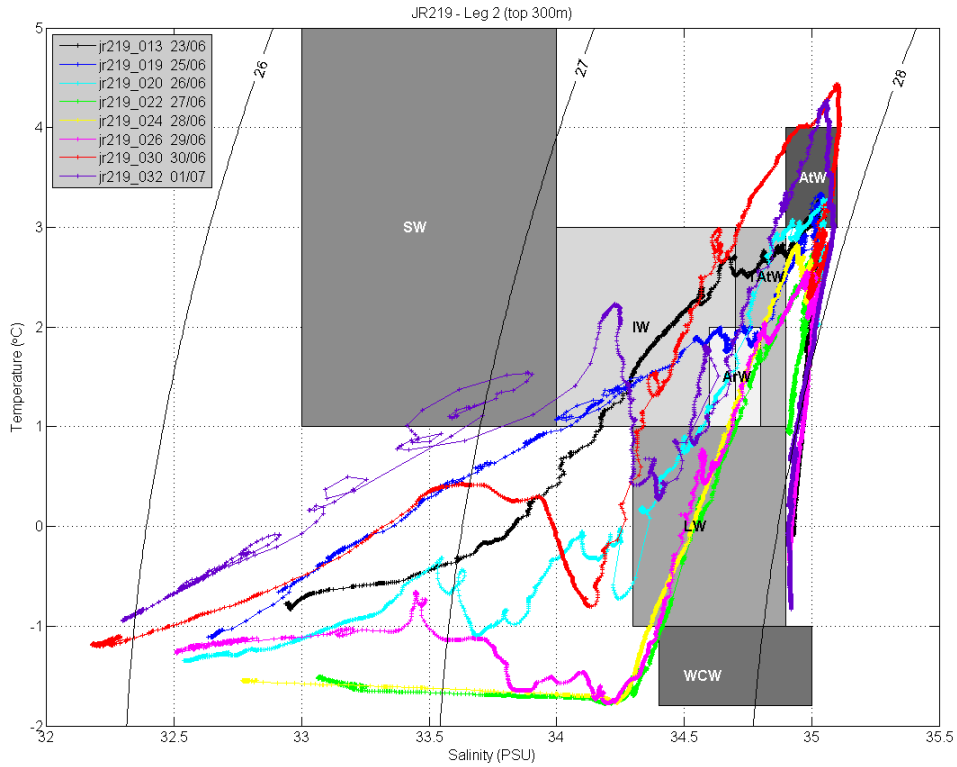

Figure 1.5-2: T-S diagram of the CTD stations in leg 2 (top 300m of the water column).

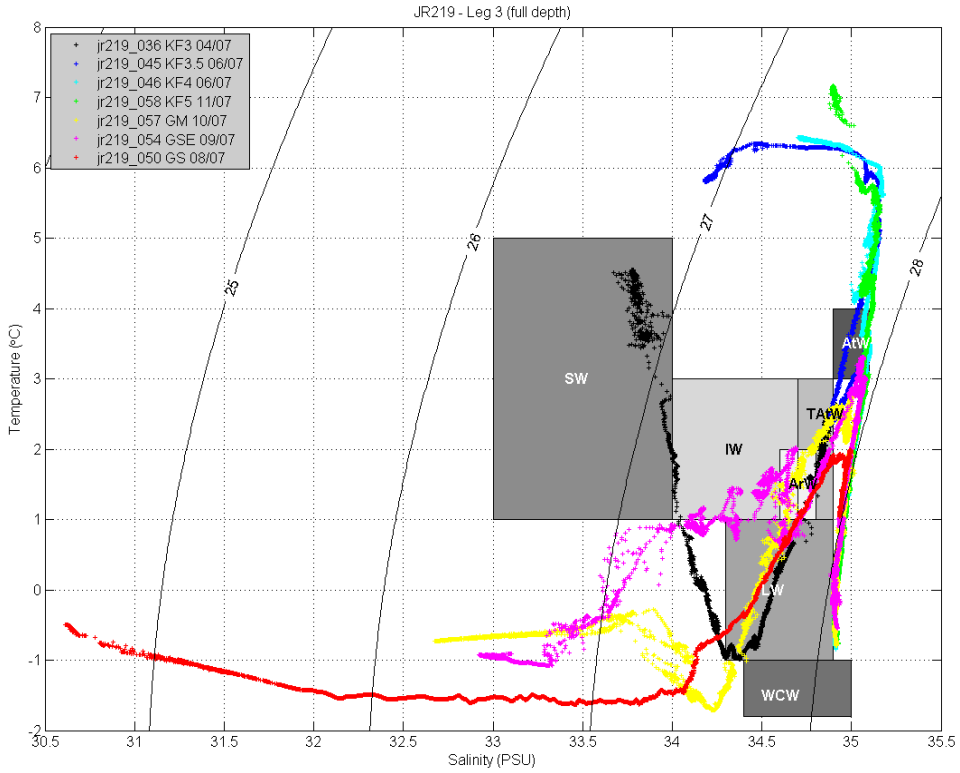

Figure 1.5-3: T-S diagram of the CTD stations in leg 3 (full depth casts).

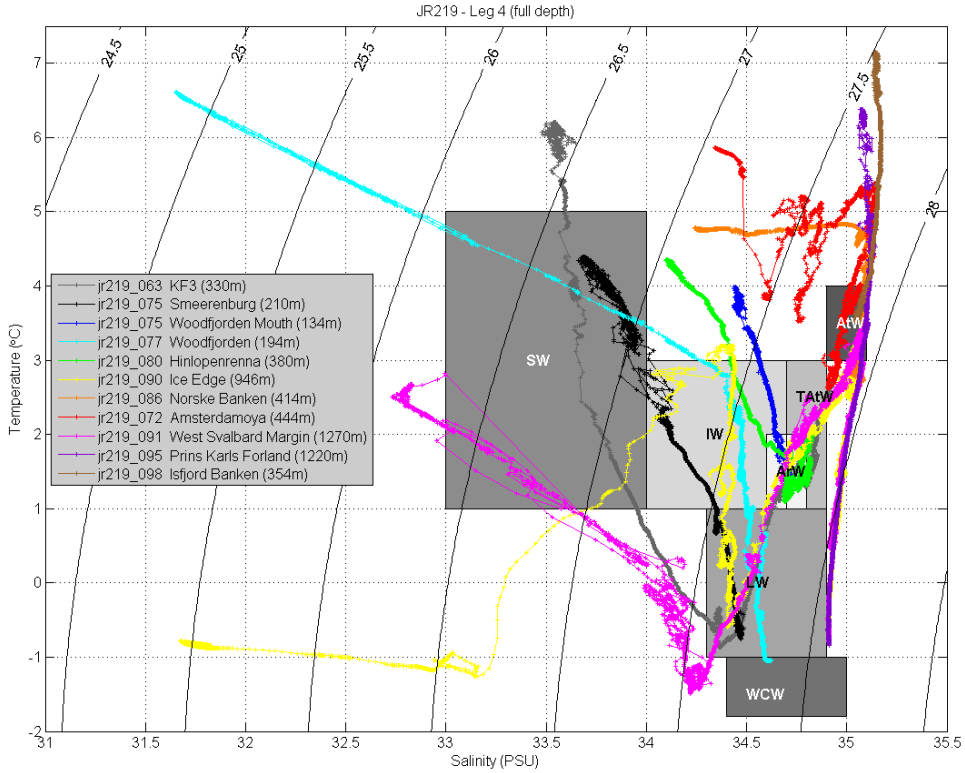

Figure 1.5-4: -S diagram of the CTD stations in leg 4 (full depth casts).

The water masses represented on the diagrams are: AtW = Atlantic Water; ArW = Arctic Water; SW = Surface Water; LW = Local water; WCW= Winter Cooled Water IW = Intermediate Water; TAtW = TYransforemed Atlantic Water.

1.6 CTD Transects

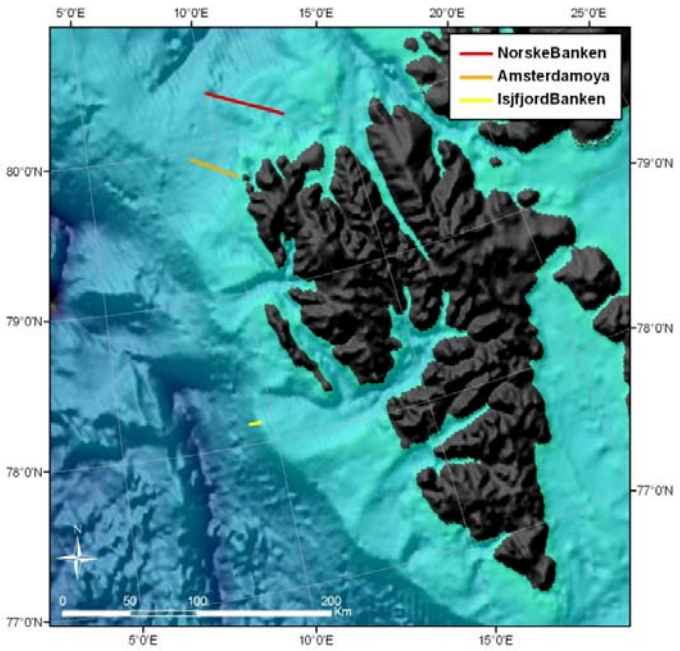

Figure 1.6-1: Location of the CTD transects realised during leg 4.

1.6.1 Amsterdamøya (14/07/10 – 15/07/10)

Data (left to right) from casts 64, 65, 66, 76, 68, 69, 70 and 71.

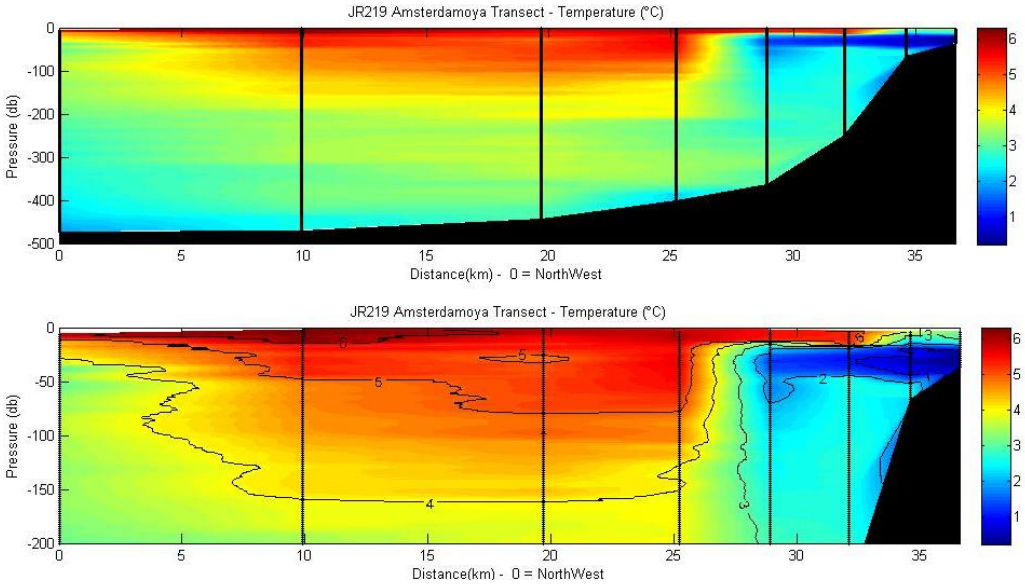

Figure 1.6.1-1: Amsterdamoya transect temperature, for the whole depth and close-up on the 200m surface layer.

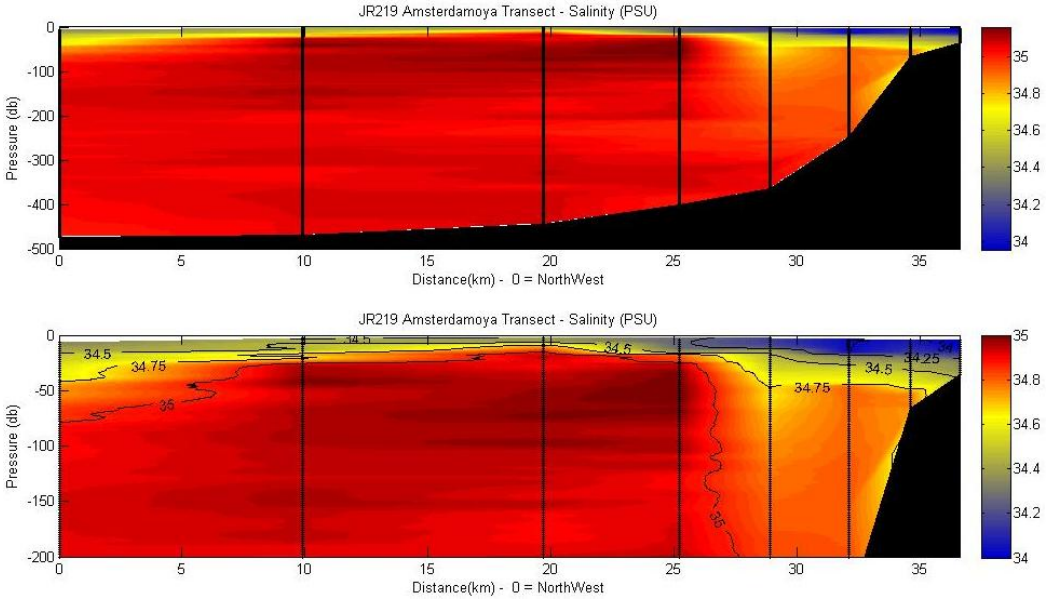

Figure 1.6-2: Amsterdamoya transect salinity, for the whole depth and close-up on the 200m surface layer.

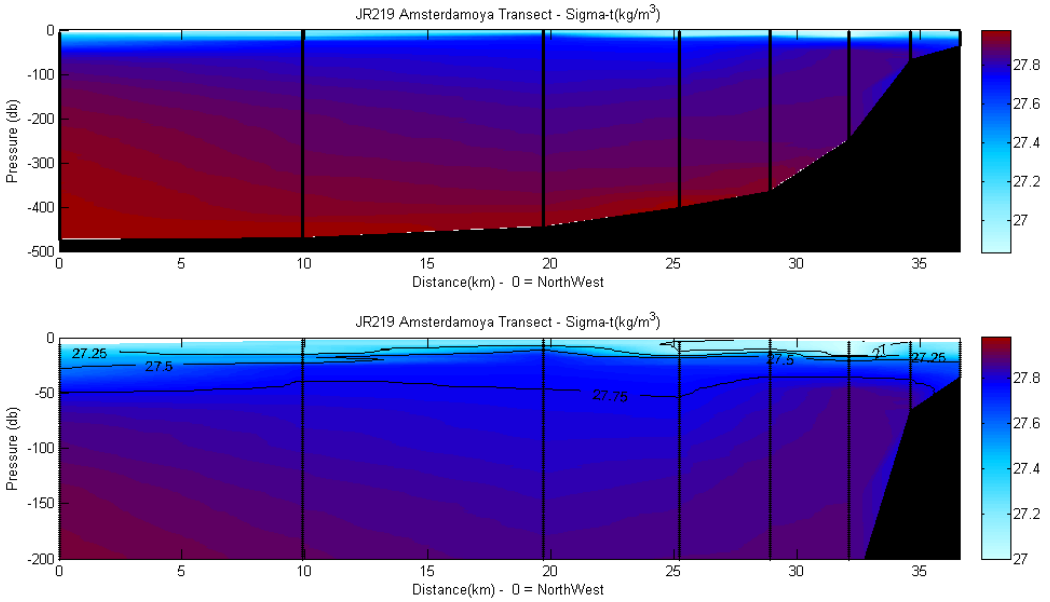

Figure 1.6-3: Amsterdamoya transect sigma-theta, for the whole depth and close-up on the 200m surface layer.

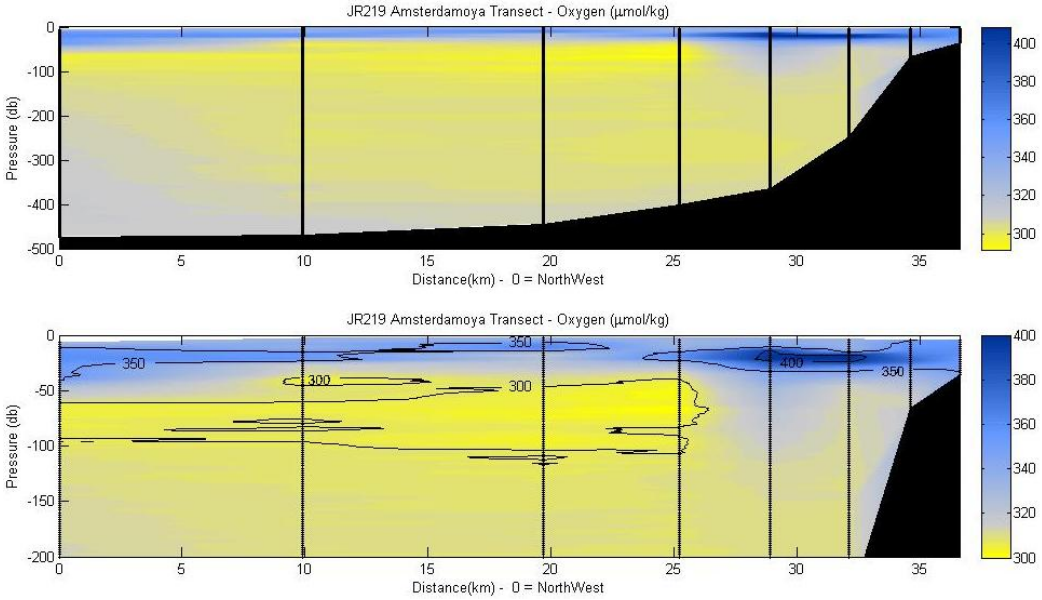

Figure 1.6-4: Amsterdamoya transect dissolved oxygen, for the whole depth and close-up on the 200m surface layer.

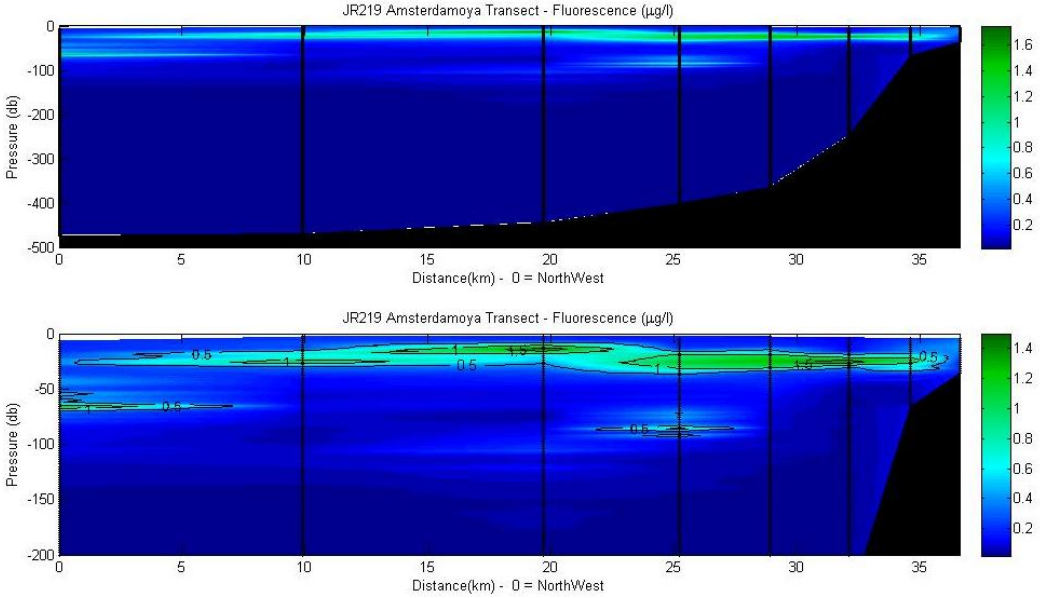

Figure 1.6-5: Amsterdamoya transect fluorescence, for the whole depth and close-up on the 200m surface layer.

1.6.2 Norske Banken (17/07/10 – 18/07/10)

Data (left to right) from casts 81, 82, 83, 84, 85, 86, 87, 88 and 89.

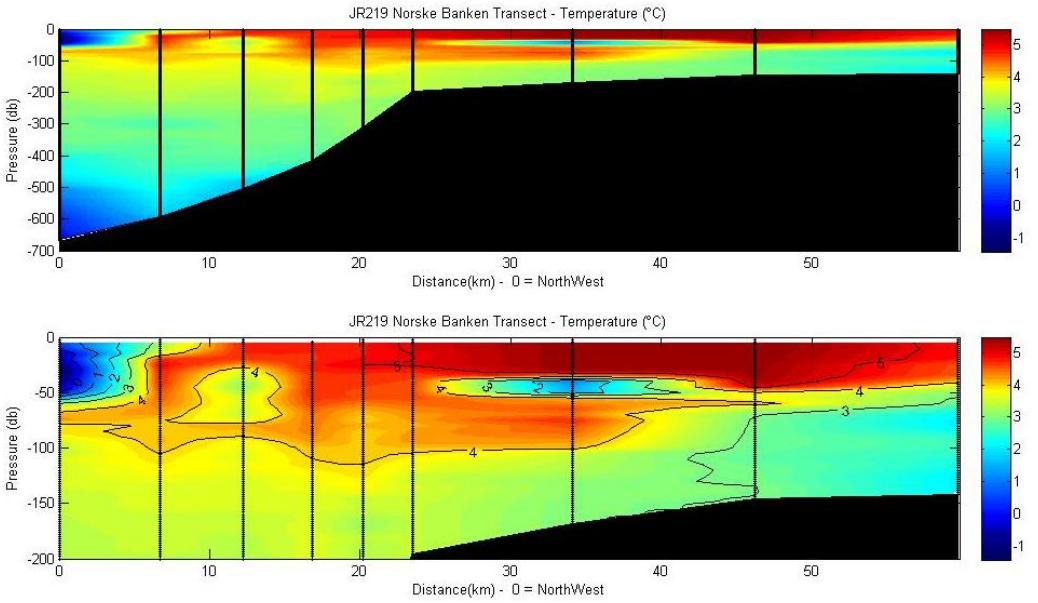

Figure 1.6.2-1: Norske Banken transect temperature, for the whole depth and close-up on the 200m surface layer.

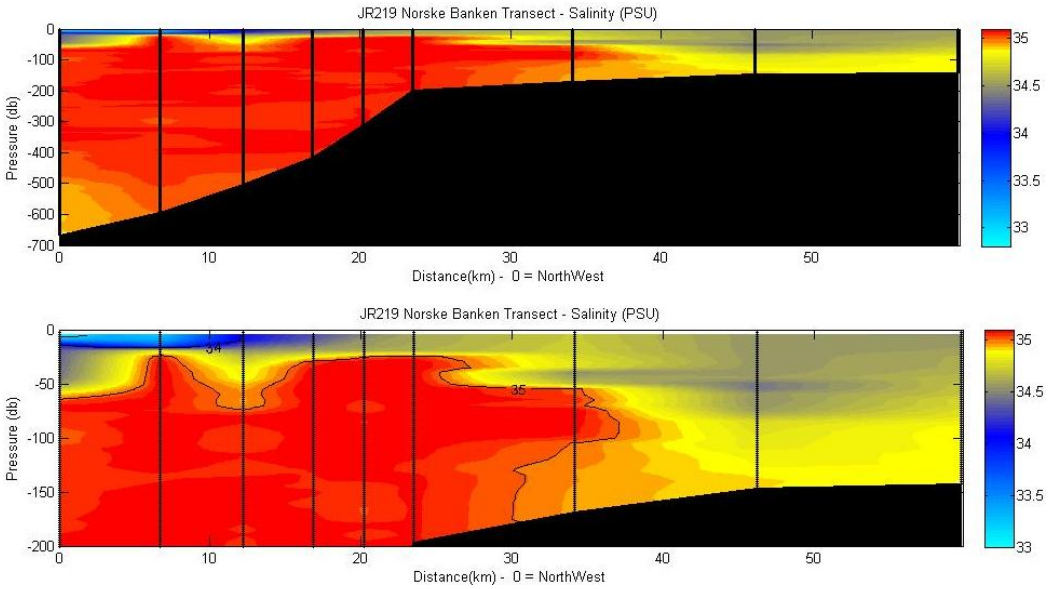

Figure 1.6.2-2: Norske Banken transect salinity, for the whole depth and close-up on the 200m surface layer.

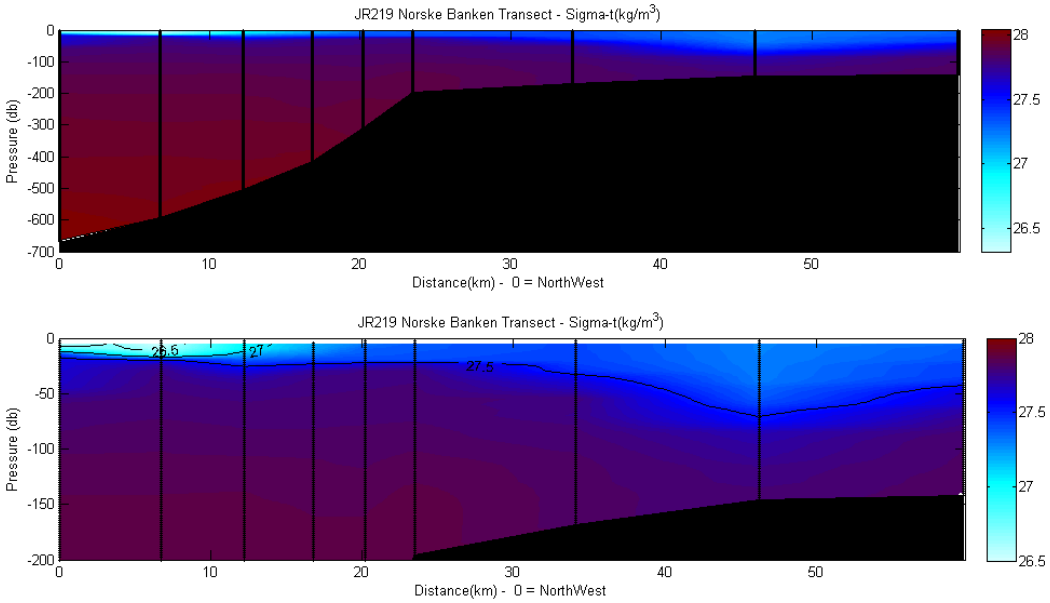

Figure 1.6.2-3: Norske Banken transect sigma-theta, for the whole depth and close-up on the 200m surface layer.

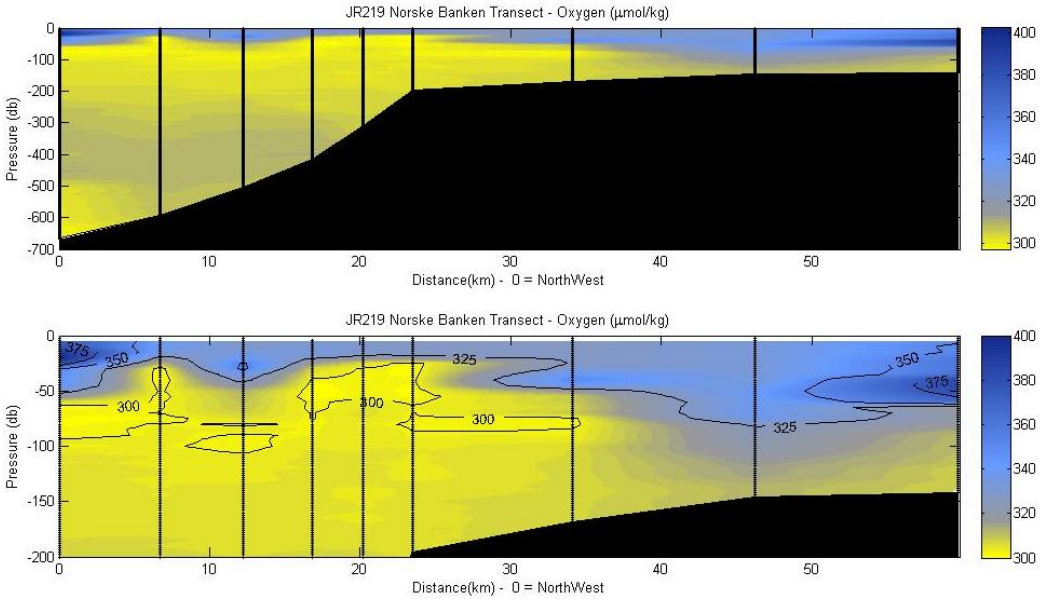

Figure 1.6.2-4: Norske Banken transect dissolved oxygen, for the whole depth and close-up on the 200m surface layer.

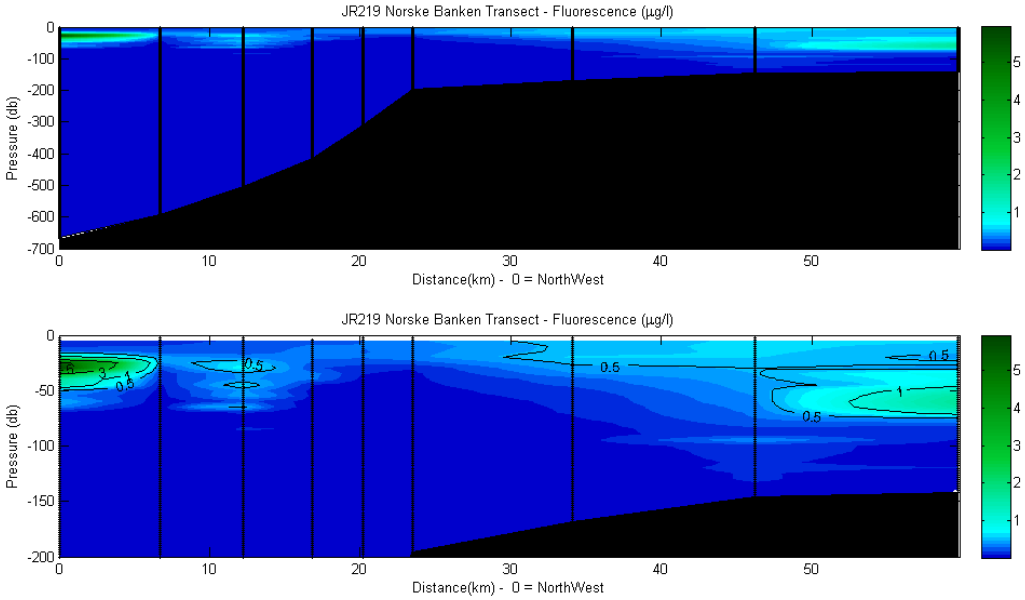

Figure 1.6.2-5: Norske Banken transect fluorescence, for the whole depth and close-up on the 200m surface layer.

1.6.3 Isfjord Banken (20/07/10)

Data (left to right) from casts 100, 99, 98, 97 and 96.

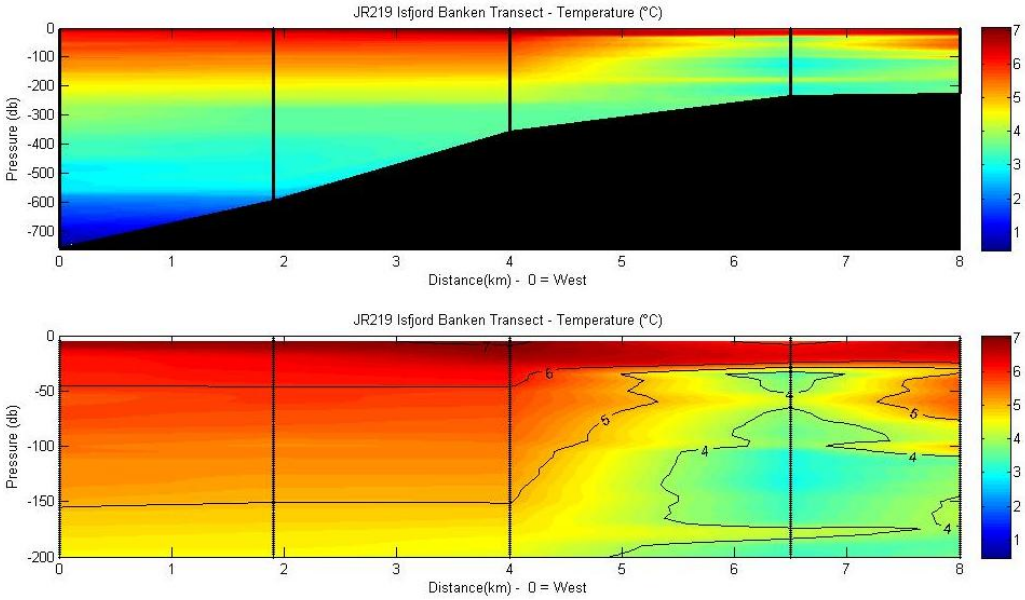

Figure 1.6.3-1: Isfjord Banken transect temperature, for the whole depth and close-up on the 200m surface layer.

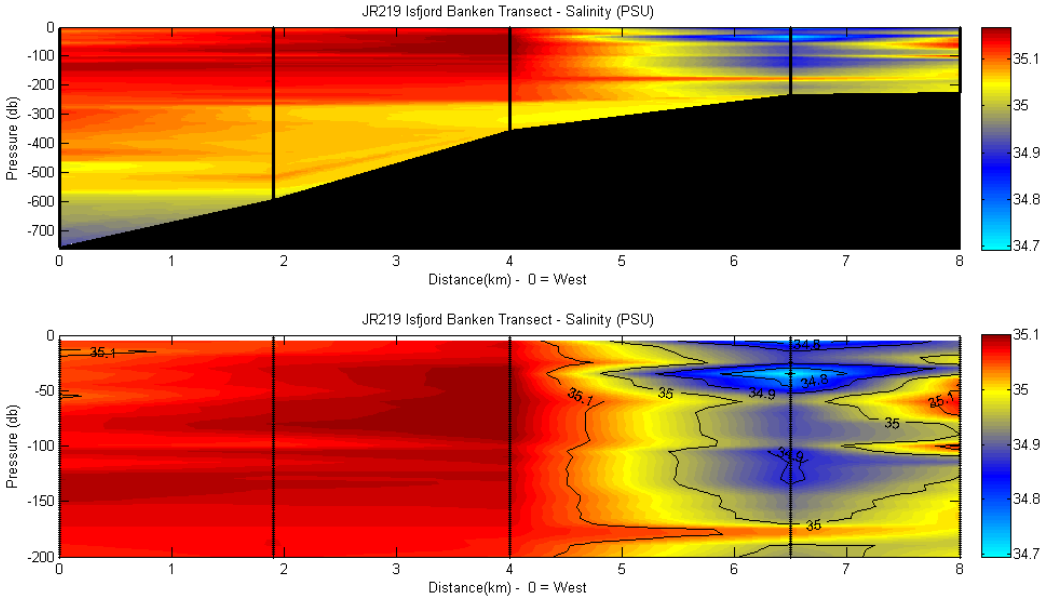

Figure 1.6.3-2: Isfjord Banken transect salinity, for the whole depth and close-up on the 200m surface layer.

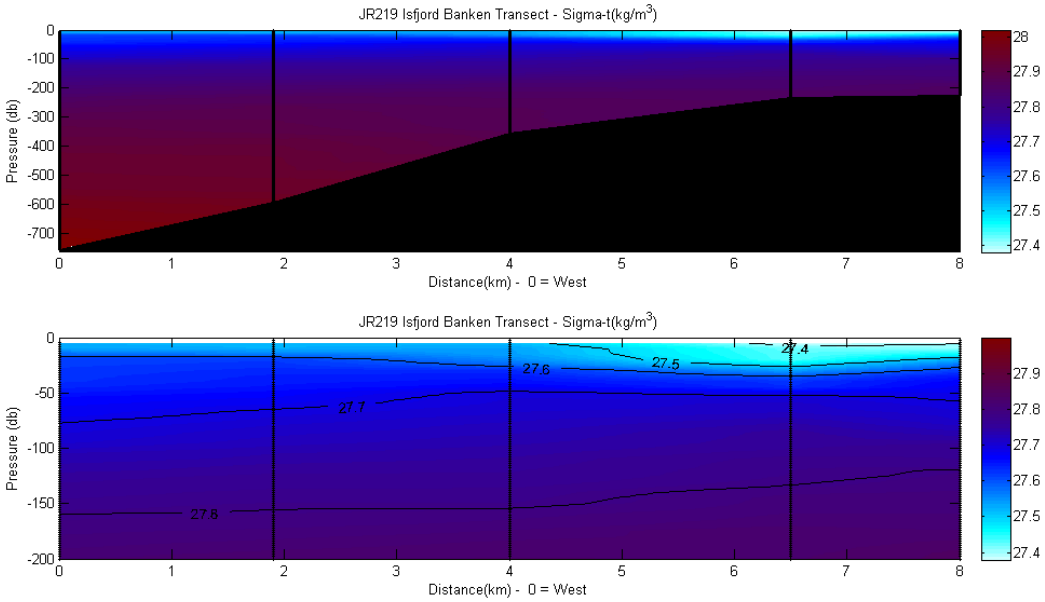

Figure 1.6.3-3: Isfjord Banken transect sigma-theta, for the whole depth and close-up on the 200m surface layer.

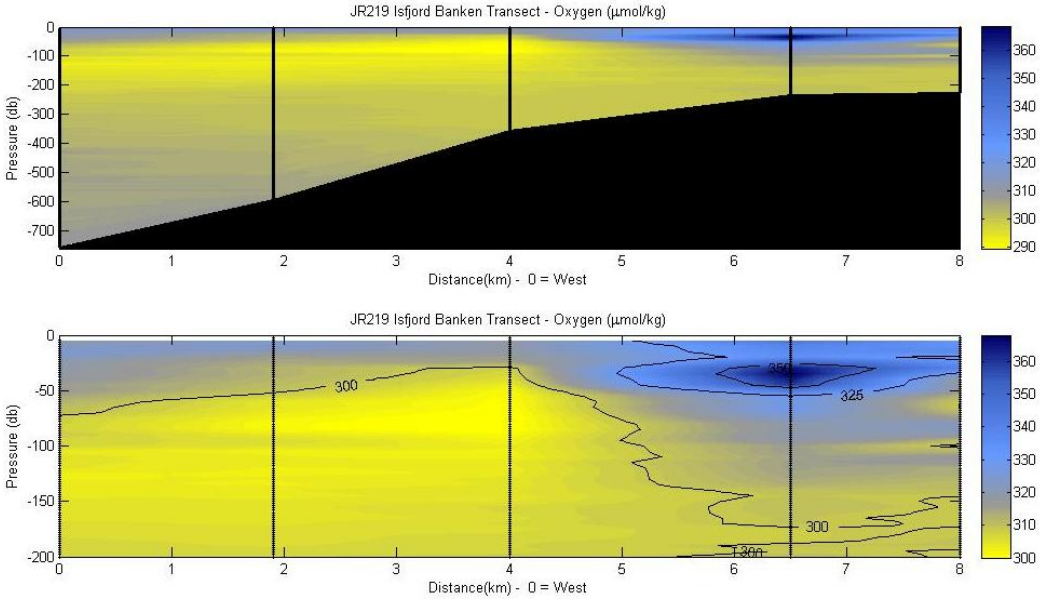

Figure 1.6.3-4: Isfjord Banken transect dissolved oxygen, for the whole depth and close-up on the 200m surface layer.

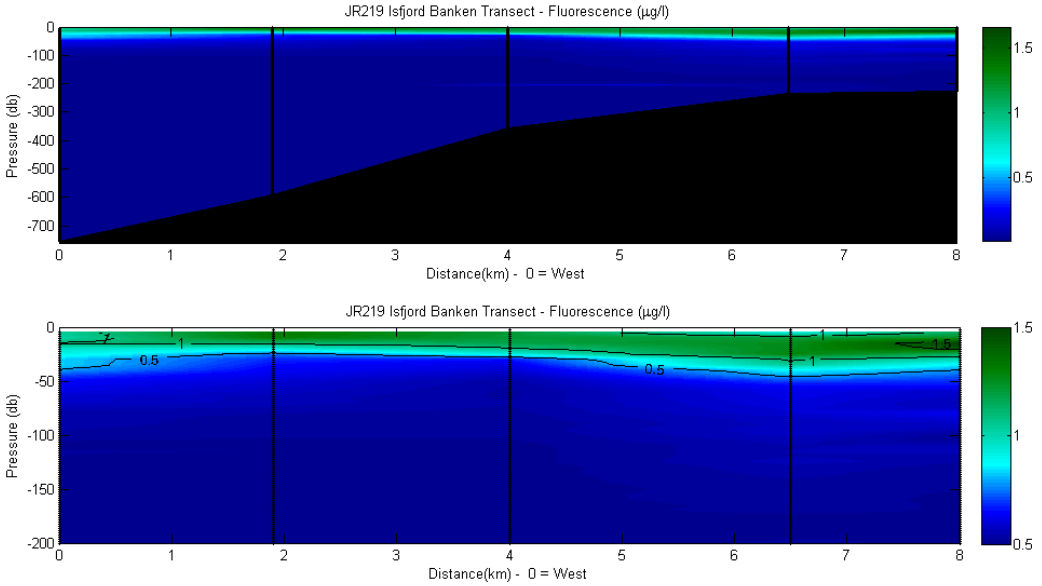

Figure 1.6.3-5: Isfjord Banken transect fluorescence, for the whole depth and close-up on the 200m surface layer.

1.7 Instrument specifications

1.7.1 SBE911 Leg 1, 3, 4

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Configuration report for SBE 911plus/917plus CTD
-------------------------------------------------------------------------------

Frequency channels suppressed : 0
Voltage words suppressed      : 0
Computer interface            : RS-232C
Scans to average              : 1
NMEA position data added      : No
NMEA depth data added         : No
NMEA time added               : No
Surface PAR voltage added     : No
Scan time added               : No

1) Frequency 0, Temperature
   Serial number : 5042
   Calibrated on : 12/04/2008
   G             : 4.33201372e-003
   H             : 6.33549986e-004
   I             : 2.08531346e-005
   J             : 1.84440097e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 1, Conductivity
   Serial number : 3488
   Calibrated on : 22/04/2008
   G             : -1.02006618e+001
   H             : 1.56812636e+000
   I             : -2.01455756e-003
   J             : 2.36866095e-004
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00000000
   Offset        : 0.00000

3) Frequency 2, Pressure, Digiquartz with
TC
   Serial number : 0541-75429
   Calibrated on : 18/07/2007
   C1            : -4.398881e+004
   C2            : -5.551403e-001
   C3            : 1.279490e-002
   D1            : 3.603000e-002
   D2            : 0.000000e+000
   T1            : 2.986716e+001
   T2            : -5.274889e-004
   T3            : 4.092900e-006
   T4            : 1.616590e-009
   T5            : 0.000000e+000
   Slope         : 0.99994000
   Offset        : 0.52570
   AD590M        : 1.287420e-002
   AD590B        : -8.793390e+000

4) Frequency 3, Temperature, 2
   Serial number : 5043
   Calibrated on : 09/04/2008
   G             : 4.34448076e-003
   H             : 6.34699898e-004
   I             : 2.11669515e-005
   J             : 1.90896423e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

5) Frequency 4, Conductivity, 2
   Serial number : 3491
   Calibrated on : 22/04/2008
   G             : -1.01164027e+001
   H             : 1.55766840e+000
   I             : -1.88282087e-003
   J             : 2.27423366e-004
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00000000
   Offset        : 0.00000

6) A/D voltage 0, PAR/Irradiance,
Biospherical/Licor
   Serial number        : 7274
   Calibrated on        : 12/1/2009
   M                    : 1.00000000
   B                    : 0.00000000
   Calibration constant :
55248618784.50000000
   Multiplier           : 1.00000000
   Offset               : -0.02596740

7) A/D voltage 1, Free

8) A/D voltage 2, Oxygen, SBE 43
   Serial number : 0245
   Calibrated on : 10/12/2008
   Equation      : Sea-Bird
   Soc           : 3.97100e-001
   Offset        : -4.31400e-001
   A             : -4.94730e-004
   B             : 1.36160e-004
   C             : -2.43420e-006
   E             : 3.60000e-002
   Tau20         : 1.20000e+000
   D1            : 1.92630e-004
   D2            : -4.64800e-002
   H1            : -3.30000e-002
   H2            : 5.00000e+003
   H3            : 1.45000e+003

9) A/D voltage 3, Altimeter
   Serial number : 2130.27001
   Calibrated on : no calibration
available
   Scale factor  : 15.000
   Offset        : 0.000

10) A/D voltage 4, Fluorometer, Chelsea
Aqua 3
    Serial number : 088-249
    Calibrated on : 27/08/2009
    VB            : 0.154130
    V1            : 2.015700
    Vacetone      : 0.199600
    Scale factor  : 1.000000
    Slope         : 1.000000
    Offset        : 0.000000

11) A/D voltage 5, Free

12) A/D voltage 6, Transmissometer,
Chelsea/Seatech/Wetlab CStar
    Serial number : CST-396DR
    Calibrated on : 23/08/2007
    M             : 22.2100
    B             : -1.3104
    Path length   : 0.250

13) A/D voltage 7, Free
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1.7.2 SBE911 Leg 2

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Configuration report for SBE 911plus/917plus CTD
-------------------------------------------------------------------------------

Frequency channels suppressed : 0
Voltage words suppressed      : 0
Computer interface            : RS-232C
Scans to average              : 1
NMEA position data added      : No
NMEA depth data added         : No
NMEA time added               : No
Surface PAR voltage added     : No
Scan time added               : No

1) Frequency 0, Temperature
   Serial number : 2307
   Calibrated on : 20/7/2007
   G             : 4.33439937e-003
   H             : 6.44608874e-004
   I             : 2.37793994e-005
   J             : 2.31412704e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 1, Conductivity
   Serial number : 1913
   Calibrated on : 17/7/2007
   G             : -4.02881844e+000
   H             : 5.32503936e-001
   I             : -6.89373545e-004
   J             : 6.23129385e-005
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00000000
   Offset        : 0.00000

3) Frequency 2, Pressure, Digiquartz with
TC
   Serial number : 09p30856-0707
   Calibrated on : 13/06/2007
   C1            : -4.925971e+004
   C2            : -2.136250e-001
   C3            : 9.435710e-003
   D1            : 3.900400e-002
   D2            : 0.000000e+000
   T1            : 2.983458e+001
   T2            : -3.883229e-004
   T3            : 3.262440e-006
   T4            : 3.429810e-009
   T5            : 0.000000e+000
   Slope         : 1.00005000
   Offset        : -0.81450
   AD590M        : 1.277500e-002
   AD590B        : -9.391460e+000

4) Frequency 3, Temperature, 2
   Serial number : 4472
   Calibrated on : 11/7/2007
   G             : 4.41422567e-003
   H             : 6.43319527e-004
   I             : 2.23249357e-005
   J             : 1.96317455e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0000

5) Frequency 4, Conductivity, 2
   Serial number : 2255
   Calibrated on : 17/7/2007
   G             : -1.02637082e+001
   H             : 1.41424921e+000
   I             : -2.97291304e-003
   J             : 3.13705184e-004
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00000000
   Offset        : 0.00000

6) A/D voltage 0, PAR/Irradiance,
Biospherical/Licor
   Serial number        : 7275
   Calibrated on        : 26/7/2007
   M                    : 1.00000000
   B                    : 0.00000000
   Calibration constant :
59523809523.80999800
   Multiplier           : 1.00000000
   Offset               : -0.02516571

7) A/D voltage 1, Free

8) A/D voltage 2, Oxygen, SBE 43
   Serial number : 0242
   Calibrated on : 12/06/2007
   Equation      : Owens-Millard
   Soc           : 3.8420e-001
   Boc           : 0.0000
   Offset        : -0.4887
   Tcor          : 0.0003
   Pcor          : 1.35e-004
   Tau           : 0.0

9) A/D voltage 3, Altimeter
   Serial number : 2130.27001
   Calibrated on : no calibration
available
   Scale factor  : 15.000
   Offset        : 0.000

10) A/D voltage 4, Fluorometer, Chelsea
Aqua 3
    Serial number : 088-249
    Calibrated on : 13/09/2007
    VB            : 0.181000
    V1            : 2.097600
    Vacetone      : 0.202800
    Scale factor  : 1.000000
    Slope         : 1.000000
    Offset        : 0.000000

11) A/D voltage 5, Free

12) A/D voltage 6, Free

13) A/D voltage 7, Free
```

2 Hand-help CTD (SBE19+)

2.1 Methodology

This CTD was used during leg 2 for a) profiling in the water sampling hole drilled in the ice; and b) in association with under-ice light sensors for profiles and overnight deployments from the diving hole (see details in the PAR/ Under-ice light measurements section). It was also deployed once from the ship on leg 3 in association with the light spectrometer and SAtlantics sensors.
All data was recorded at 4Hz (maximum sampling rate).

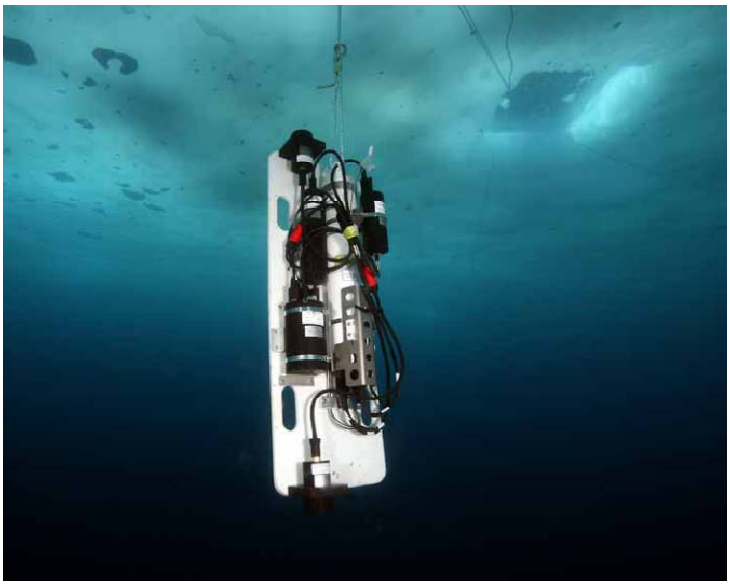

Figure 2.1-1: SBE19+ and SAtlantics light sensors installed on the board and profiling under ice.

2.2 Data processing

The CTD data were processed according the recommended Seabird procedures, using Seabird Data Processing version 7.18b. The processing steps were: Data Conversion, Filter, Align CTD, Cell Thermal Mass, Derive, Translate, Bin Average (1 second) and Ascii Out.

2.3 Data summary

Data file	Date	Start Time	Event No	Description
sbe19+_5215_260610_a	26-Jun-10	08:13	I18	Cast associated with water sampling
sbe19+_5215_260610_b	26-Jun-10	18:07	I25	Under-ice CTD/light profile (test)
sbe19+_5215_270610	27-Jun-10	11:41	I31	Under-ice CTD/light profile
sbe19+_5215_280610	28-Jun-10	12:41	I36	Under-ice CTD/light profile
sbe19+_5215_290610_a	29-Jun-10	10:00	I41	Cast associated with water sampling
sbe19+_5215_290610_b	29-Jun-10	11:52	I44	Cast associated with water sampling
sbe19+_5215_290610_c	29-Jun-10	17:34	I45	Under-ice CTD/light overnight deployment
sbe19+_5215_300610_a	30-Jun-10	08:48	I47	Under-ice CTD/light profiles
sbe19+_5215_300610_b	30-Jun-10	15:05	I55	Under-ice CTD/light profiles
sbe19+_5215_300610_c	30-Jun-10	19:35	I56	Under-ice CTD/light profile + overnight deployment
sbe19+_5215_100710	10-Jul-10	10:02	145	CTD/light profile from ship

2.4 Instrument specifications

```
Configuration report for SBE 19plus Seacat CTD
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Pressure sensor type      : Strain Gauge
External voltage channels : 4
Mode                      : Profile
Scans to average          : 1
NMEA position data added  : No
NMEA depth data added     : No
NMEA time added           : No
Surface PAR voltage added : No
Scan time added           : No

1) Count, Temperature
   Serial number : 5215
   Calibrated on : 07-Aug-07
   A0            : 1.20495500e-003
   A1            : 2.77321400e-004
   A2            : -1.96517300e-006
   A3            : 2.21643700e-007
   Slope         : 1.00000000
   Offset        : 0.0000

2) Frequency 0, Conductivity
   Serial number : 5215
   Calibrated on : 07-Aug-07
   G             : -1.02557600e+000
   H             : 1.57749000e-001
   I             : -5.98424400e-004
   J             : 7.12694500e-005
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00000000



Offset        : 0.00000

3) Count, Pressure, Strain Gauge
   Serial number : 5215
   Calibrated on : 01-Aug-07
   PA0           : 1.34278800e+000
   PA1           : 2.63258600e-003
   PA2           : 1.71027200e-011
   PTEMPA0       : -6.22525800e+001
   PTEMPA1       : 5.25907100e+001
   PTEMPA2       : -2.89748100e-001
   PTCA0         : 5.24870500e+005
   PTCA1         : 3.67886900e+001
   PTCA2         : -6.45002600e-001
   PTCB0         : 2.56046200e+001
   PTCB1         : -4.75000000e-004
   PTCB2         : 0.00000000e+000
   Offset        : 0.000000

4) A/D voltage 0, Fluorometer, Wetlab
Wetstar
   Serial number : 1359
   Calibrated on : 10/05/2010
   Vblank        : 0.071
   Scale factor  : 15.000

5) A/D voltage 1, Free

6) A/D voltage 2, Free

7) A/D voltage 3, Free
```