

CTD Data Documentation Cruise AMT17 (D299) (15th Oct - 28th Nov, 2005)

Chief Scientist

Patrick Holligan, National Oceanographic Centre, Southampton

Introduction

These notes refer to CTD data collected during the Discovery cruise (D299) AMT17. The cruise departed Govan (UK) on the 15th October and arrived into Port Elizabeth (South Africa) on the 28th November 2005.

CTD metadata

BODC Ref	Originator's Ref.	Start Date and Time (GMT)	Latitude (+ve deg. N)	Longitude (+ve deg. E)	Water depth (m)
721468	CTD001s	18/10/2005 10:37	48.96137	-16.5009	552.5
721470	CTD002t	18/10/2005 12:38	48.93907	-16.4806	3520.7
721474	CTD003s	19/10/2005 03:56	46.22974	-17.4421	4343.8
721478	CTD004s	20/10/2005 03:56	44.34735	-19.3331	4753.3
721482	CTD005t	20/10/2005 11:00	44.06064	-20.1471	3947.5
721496	CTD006t	27/10/2005 14:18	37.33559	-26.5047	2456.9
721498	CTD007s	28/10/2005 05:52	35.92254	-29.1309	1617.6
721500	CTD008t	28/10/2005 14:02	35.73143	-29.4833	3339.7
721504	CTD009s	30/10/2005 05:55	31.29968	-32.0482	4498.3
721506	CTD010t	30/10/2005 13:02	30.84878	-33.1128	4464.7
721630	CTD011s	31/10/2005 06:02	29.52611	-36.2732	2685.1
721632	CTD012t	31/10/2005 13:08	29.33368	-36.7192	3656.5
721516	CTD013s	01/11/2005 06:00	27.78194	-38.8081	4507
721636	CTD014t	01/11/2005 12:55	26.70464	-38.2297	4908.2
721520	CTD015s	02/11/2005 06:05	23.96198	-36.7786	3670
721638	CTD016t	02/11/2005 06:07	23.96148	-36.7807	3751.9
721524	CTD017t	02/11/2005 13:24	23.14059	-36.3499	5005.3
721640	CTD018s	03/11/2005 06:02	21.05351	-35.2727	4595.4
721642	CTD019t	03/11/2005 13:09	20.74314	-35.1222	5503.8
721534	CTD020s	04/11/2005 06:02	18.37798	-33.9145	5290.2
721536	CTD021t	04/11/2005 13:01	17.47927	-33.4652	4733
721646	CTD022s	05/11/2005 06:02	15.12522	-32.2964	5296.2
721542	CTD023t	05/11/2005 12:59	14.2578	-31.8676	6018.8
721544	CTD024s	06/11/2005 05:04	12.06969	-30.8025	5243.7
721652	CTD025t	06/11/2005 12:06	11.68962	-30.6145	5589.5
721550	CTD026s	07/11/2005 04:50	9.43397	-29.5201	4767.7
721552	CTD027t	07/11/2005 11:53	8.61098	-29.1222	5193.2
721554	CTD028t	07/11/2005 18:00	7.9441	-28.7991	4974.6
721656	CTD029s	08/11/2005 04:55	6.50656	-28.1101	4316.3
721558	CTD030t	08/11/2005 13:21	5.45743	-27.606	3957.9
721658	CTD031t	08/11/2005 17:56	4.94895	-27.365	4135.4
721564	CTD032s	09/11/2005 05:00	3.4764	-26.6599	3861
721568	CTD033t	09/11/2005 13:58	2.75433	-26.3171	3619.2

721664	CTD034s	10/11/2005 04:59	0.89227	-25.4358	1998.7
721572	CTD035t	10/11/2005 12:16	-0.00124	-25.004	2989
721576	CTD036s	11/11/2005 05:01	-2.88793	-24.9989	5024.4
721666	CTD037t	12/11/2005 11:54	-8.27609	-24.9958	5638.4
721580	CTD038s	13/11/2005 04:48	-11.0002	-24.9992	5324.5
721584	CTD039t	13/11/2005 13:58	-11.9227	-24.9993	5630.8
721672	CTD040s	14/11/2005 04:55	-14.3807	-24.9966	5592.4
721590	CTD041t	14/11/2005 11:57	-15.4872	-24.9956	4972.7
721592	CTD042s	15/11/2005 04:52	-18.5597	-24.9992	5084.9
721676	CTD043t	15/11/2005 12:03	-19.6816	-25.0038	4968.4
721598	CTD044s	16/11/2005 04:53	-21.1293	-22.439	4998.8
721434	CTD045t	16/11/2005 09:19	-21.1163	-22.4186	5145.4
721680	CTD046t	16/11/2005 11:46	-21.1034	-22.3787	5101.6
721436	CTD047s	17/11/2005 04:07	-22.1429	-20.1986	4908
721440	CTD048t	17/11/2005 11:58	-22.6113	-19.1285	4595.3
721442	CTD049s	18/11/2005 03:54	-23.763	-16.5274	3151.5
721686	CTD050t	19/11/2005 10:54	-26.1409	-11.0572	3686.7
721688	CTD051s	20/11/2005 03:58	-27.3968	-8.11673	4058.2
721690	CTD052t	20/11/2005 12:58	-27.7873	-7.22055	3912.1
721456	CTD053s	21/11/2005 02:55	-28.8545	-4.68811	4092.8
721458	CTD054t	21/11/2005 09:54	-29.3196	-3.57947	4422.3
721694	CTD055s	22/11/2005 02:52	-30.6732	-0.2998	2541.3
721464	CTD056t	22/11/2005 09:52	-31.1734	0.923	4368.2
721698	CTD057s	23/11/2005 02:50	-32.528	4.23609	5000.3
721602	CTD058t	23/11/2005 11:24	-33.0209	5.8903	5034.7
721606	CTD059s	24/11/2005 01:49	-33.6458	8.91522	5005.1
721702	CTD060t	24/11/2005 08:58	-33.7816	9.58522	4950.4
721612	CTD061s	24/11/2005 13:19	-33.9068	10.30315	4694.8
721618	CTD062s	25/11/2005 06:54	-34.9846	13.77966	4635.1

A total of 60 successful CTD casts were made during the cruise of which 29 used a stainless steel frame and 31 a titanium frame. Two casts (CTD005t and CTD016t) were abandoned due to technical problems. Tests casts were made with both frames on 17th October 2005 between 12:00 and 13:30 GMT but data were not supplied to BODC.

Flags Definitions

M = Suspect data

T = Interpolated data (used where temperature and salinity are input parameters and are suspect over a particular bin)

N = Null data (no data available)

Content of data series

Parameter	BODC code	units	Comments
Pressure	PRESPR01	decibars	
Temperature	TEMPCU01	°C	Primary temperature channel; manufacturer's calibration applied
Temperature 2	TEMPCU02	°C	Secondary temperature channel; manufacturer's calibration applied
Salinity	PSALCC01	PSU	Primary salinity channel calibrated using salinometer data
Salinity 2	PSALCC02	PSU	Secondary salinity channel calibrated using salinometer data
Sigma-theta	SIGTPR01	kg m ⁻³	Computed using UNESCO SVAN function
Potential temperature	POTMCV01	°C	Computed using UNESCO POTEMP
Chlorophyll	CPHLPS01	mg m ⁻³	Calibration with sample data.
Oxygen Concentration	DOXYSC01	µmol L ⁻¹	Calibrated using oxygen concentration from sample data
Oxygen saturation	OXYSSC01	%	Calibration against sensor data and computation using Benson & Krause algorithm

The following additional parameters can be supplied upon request.

Parameter	BODC code	units	Comments
Fluorometer output	FVLTAQ01	V	Output voltage by in-situ Aquatracka chlorophyll fluorometer
Chlorophyll	CPHLPM01	mg m ⁻³	Nominal manufacturer's calibration only (Not calibrated using sample data)
Upwelling PAR irradiance light meter voltage	LVLTPU01	V	Output voltage by PML/Chelsea Instruments 2-pi PAR upwelling light meter
Downwelling PAR irradiance light meter voltage	LVLTPD01	V	Output voltage by PML/Chelsea Instruments 2-pi PAR downwelling light meter
Transmittance	TVLTZZ01	V	Output voltage by transmissometer of unknown type
Transmittance	TVLTDR01	V	Output voltage by 25cm path length red light transmissometer

Instrumentation

Stainless Steel CTD Frame configuration

Sea-Bird 911*plus* CTD System with SBE 32 Carousel fitted with 24 x 20 litres Ocean Test Equipment External Spring water samplers. The main unit was composed of:

- SBE 9 plus underwater unit SN 0528.
- SBE 5T submersible pumps (SN not provided to BODC).
- Digiquartz temperature compensated pressure sensor SN 73299 calibrated 10/06/2005.
- SBE 3P Temperature sensors SN 4116 (primary) calibrated 22/07/2005 and SN 2919 (secondary) calibrated 22/07/2005.
- SBE 4C conductivity sensors SN 3052 (primary) calibrated 04/08/2005 and SN 2571 (secondary) calibrated 04/08/2005.
- SBE11 plus deck unit (SN not provided to BODC)

Auxiliary sensors:

- Sea-Bird SBE43 Oxygen Sensor SN 0621 calibrated 22/05/2005.
- Chelsea MKIII Aquatracka Fluorometer SN 088195 calibrated 27/03/2003.
- Chelsea MKII Alphatracka 25cm path Transmissometer SN 161047(?) no calibration information.
- Wetlabs SeaStar transmissometer SN 113 on voltage channel V6 from cast 036 onwards; no calibration information.

Additional self-logging instruments:

- RD Instruments Workhorse 300 KHz Lowered ADCP (downward-looking master configuration)
- RD Instruments Workhorse 300 KHz Lowered ADCP (upward-looking slave configuration)
- Chelsea FRRF/Battery Pack/PAR/Pressure Sensor (removed for 1000 m casts)

The main unit's pressure sensor was located 15cm from the bottom of the water samplers, and 132 cm from the top of the water samplers. This frame was used for the pre-dawn casts and was either deployed to 300 m or 1000 m.

Titanium CTD Frame configuration

Sea-Bird 911*plus* CTD System with SBE 32 Carousel fitted with 24 x 10 litres Ocean Test Equipment External Spring trace-metal water samplers. The main unit was composed of:

- SBE 9 plus underwater unit SN 0803.
- SBE 5T submersible pumps SN not supplied.
- Digiquartz temperature compensated pressure sensor SN 93896 calibrated 13/06/2005.
- SBE 3P Temperature sensors SN 4383 (primary) calibrated 28/06/2005 and SN 4593 (secondary) calibrated 21/06/2005.
- SBE 4C conductivity sensors SN 3153 (primary) calibrated 19/07/2005 and SN 3160 (secondary) calibrated 19/07/2005.
- SBE11 plus deck unit SN not supplied.

Auxiliary sensors:

- Sea-Bird 43 Oxygen Sensor SN 0862 calibrated 15/07/2005.
- Chelsea MKIII Aquatracka Fluorometer SN 088108 calibrated 17/11/2004.
- Wetlabs SeaStar transmissometer SN 113 (casts 027-035); no calibration information.
- Chelsea MKII Alphatracka Transmissometer SN 161045 calibrated Aug 2005

- Up-welling PAR sensor SN not provided
- Down-welling PAR sensor SN not provided
- RVS 2 Second Interval Pinger – Fitted for full-depth, near bottom casts

The main unit's pressure sensor was located 30 cm from the bottom of the water samplers, and 119 cm from the top of the water samplers. This frame was used for the midday casts and was either deployed to 300 m or full ocean depth up to 6000 m.

A Wetlabs SeaStar transmissometer was trialled on 7th November on the titanium frame, and was later moved to the stainless steel frame on 9 November (cast 36). The results from this instrument were positive, but it should be noted that trials with the SeaStar to deep casts continually have resulted in distortion. This unit is only rated to 1000 m, so it is not a permanent solution.

BODC data processing

SBE processing

The data files were sent to BODC in Sea-Bird SBE data processing software output. Configuration files were also supplied with the data files. After a thorough inspection of the processed files submitted by UKORS it was decided that BODC should carry out the reprocessing of the raw data due to the absence of data channels from several CTD casts. The SBE software was used to reprocess the data. The following procedures were carried out at BODC using the SBE software:

- **Conversion of fluorescence voltage to nominal chlorophyll-a concentrations**

The chlorophyll-a channel was missing from several CTD casts in the files processed by UKORS. The fluorometer channel was extracted as voltage from the original raw data files and the manufacturer's calibration for the fluorometer was applied through the NODB calibration tables as follows:

- **For stainless steel casts**

$$\text{Nominal chl-a conc } (\mu\text{g/l}) = (0.0125 \times 10^{\text{voltage}}) - 0.026$$

- **For titanium casts**

$$\text{Nominal chl-a conc } (\mu\text{g/l}) = (0.0109 \times 10^{\text{voltage}}) - 0.0229$$

- **Cell thermal mass correction**

Cell thermal mass (ctm) uses a recursive filter to remove conductivity cell thermal mass effects from the measured conductivity. In areas with steep temperature gradients, the thermal mass correction is on the order of 0.005 PSU. In other areas the correction is negligible.

The algorithm used is (from SBE processing help):

dt = temperature - previous temperature
 ctm = -1.0 * b * previous ctm + a * (dc/dt) * dt
 corrected conductivity = c + ctm

where:

a = 2 * alpha / (sample interval * beta + 2)
 b = 1 - (2 * a / alpha)
 dc/dt = 0.1 * (1 + 0.006 * [temperature - 20])

Values for alpha and 1/beta were provided in the SBE documentation and were 0.03 and 7 respectively.

- **Checking of alignment of temperature and conductivity signal output**

Align CTD was used to align temperature, conductivity and oxygen measurements relative to pressure. A lag of 3 s was applied to the oxygen channel for both stainless steel and titanium rigs. No other advances were applied.

- **Removal of pressure spikes, loops and soaking depth**

Pressure spikes were removed from the data using the program Wildedit. Turnpoint was used to remove the CTD soaking depth. Loopedit was used to remove loops in the CTD profiles generated by change in pressure due to slow-down or reversal of the CTD usually caused by the ship heave.

- **Derivation of salinity and dissolved oxygen**

Once the alignment of temperature and conductivity channels was checked, the salinity and derived oxygen channels were derived.

- **Binaverage and stripping of superfluous channels**

The data were binned from a resolution of 24Hz to 2Hz using the program Binaverage. The two original salinity and oxygen channels used to derive the new ones were removed from the files using the program Strip.

Reformatting

The data files were sent to BODC in Sea-Bird's data processing software output. The data were converted to QXF, a BODC internal format. During the transfer the SBE oxygen signal was also converted to a concentration in $\mu\text{moles/l}$ using the manufacturer's calibration and the following relationship:

$$\text{oxygen } (\mu\text{moles/l}) = \text{oxygen (ml/kg)} * ((\text{sigma-theta} + 1000)/1000)$$

The data were processed from 1Hz averaged down- and upcast data. Sigma-theta was calculated and output from the primary temperature and salinity data during the conversion to QXF format.

Screening

The QXF data were compared with the original data files to ensure that no errors had been introduced during the conversion process. The data channels were then screened on a graphics workstation using in-house visualisation software (EDSERPLO). This allows multiple channels to be viewed simultaneously. The start and end-points of the downcast were marked. All spurious and null data were flagged with BODC quality control flag ('M' and 'N' respectively). The secondary temperature and salinity channels were used to aid screening of the primary channels only. The primary channels should be used in preference to the secondary channel as they have been quality controlled.

- **Dissolved oxygen**

Profiles for this sensor looked fine overall and concordant with the oxygen saturation sensor. No particular spikes were observed along the profiles. There were possibly features related to

water entrainments but they were judged as not very conspicuous and therefore they were not flagged.

Specific Casts

CTD47: two large spikes present on both sensors, not flagged.

- **Upwelling and downwelling PAR sensor**

The UKORS report mentions that the PAR sensors were mounted on the titanium casts. The UKORS notes/data files, however, did not specify the units and data types for a number of the voltage channels for the sensors present on the titanium casts. Therefore the irradiance parameters were attributed to these channels provisionally. Analysis of PAR profiles shows that in numerous casts the channel attributed to up-welling irradiance are larger than down-welling irradiance below the euphotic zone. Therefore the validity of these data are unclear. The sensors were removed for casts deeper than 500m.

Specific Cast details

CTD10: down-welling very noisy at top.

CTD14: up-welling some large spikes flagged below euphotic zone. Down-welling noisy on bottom and flagged.

CTD17: upwelling with large spikes in lower part causing shift in signal flagged. Data in down-welling channel are all zero.

CTD19 downwelling strange large spikes between 150-180 m not flagged

CTD21 downwelling strange large spikes between 220-270 m not flagged

CTD33, 35, 37 and 39: suspicious upwelling profile.

CTD45 and 46: channels are both zero.

CTD48, 50, 52 and 56: downwelling very noisy at the bottom, not flagged.

- **Attenuance**

Stainless Steel CTD Frame Deployment Notes (extracted from the UKORS report) stated there was the usual warm-water hysteresis problem with the Chelsea transmissometers were encountered on the cruise. Past cruise reports refer to a 25°C maximum operating temperature for this instrument, however there is no such temperature specification present in the manufacturer's manual for the instrument. It should be noted that considerable hysteresis was observed below this temperature.

In addition the CON files provide by UKORS indicate that the transmissometer settings were unreliable for both stainless steel and titanium rigs. Therefore the voltages were transferred from the CNV files.

TVLTDR01: The sensor deployed on the stainless steel rig was reported by UKORS as not performing very well. Visual analysis of the profile by BODC confirmed UKORS suspicions: the up- and down-cast profiles often appear very different. The down-cast, however, appears more reliable than the up-cast and its profile is often similar to that of the auxiliary transmittance sensor. Comparison between the two sensors also reveals that for a number of casts (25t, 27t, 28t, 30t, 31t, 32s, 35t, 36s, 37t and 46t) the profile presents a strange minimum which does not match the other more reliable TVLTZZ01 sensor.

Similar strange minimum present for the profiles of casts 24s and 26s but auxiliary channel not available for comparisons here.

Specific Casts

CTD018s: large shift flagged

CTD023t: constant value of 0.0049 not flagged

CTD025t and 28t have a suspicious profile.

TVLTZZ01: This channel is the voltage from the Wetlabs (SN113) transmissometer was added to the stainless steel rig from cast CTD036s for the duration of the cruise given UKORS concerns over performance of the Aquatracka MkII sensor (SN161047). Prior to use on the stainless steel rig, the Wetlabs sensor was deployed on the titanium rig from CTD027t to CTD035t to check its performance against the Aquatracka MkII (SN161045) already in use and believed to be performing reliably.

The zero values were all flagged Null to indicate the absence of the sensor on the titanium casts prior to cast CTD027t and after cast CTD035t.

Loading into the BODC database

After the data had been screened and quality controlled, the data were loaded into the BODC database under the Oracle RDBMS. 62 entries containing the metadata for each of the CTD casts were made in the database. The start and end times were taken from the original data files. The position was taken from the ship's navigation stored in the underway file at the start time of the CTD cast. The data from all 60 casts were loaded into the data tables. The 2 casts that were abandoned had no data to be loaded but the metadata were retained in BODC's database.

Calibrations

- **Temperature**

Temperature sensor calibrated using the manufacturer calibration. No correction has been applied to the data at BODC.

- **Salinity**

Bench salinometer data were provided by UKORS. The salinometer data was compared with CTD values from the primary and secondary sensor of the stainless steel and titanium casts on the up-cast at the time of bottle firing.

Casts	Calibration Equation	BODC Cal. Ref.	N	SD
Stainless steel	PSALCC01 = PSALCU01 + 0.002955	6168	40	0.0052
Stainless steel	PSALCC02 = PSALCU02 + 0.000784	6169	37	0.0063
Titanium	PSALCC01 = PSALCU01 + 0.016993	6185	46	0.0212
Titanium	PSALCC02 = PSALCU01 + 0.016009	6186	46	0.0209

- **Dissolved oxygen**

The oxygen sensors were calibrated using dissolved oxygen data from CTD bottle samples measured by Winkler titration and the sensor readings from the up cast at the point when the bottle was fired.

Casts	Calibration Equation	BODC Cal. Ref.	N	R ²
Stainless steel	DOXYSC01= 1.0661 x DOXYSU01 + 1.8543	6166	211	99.57 %
Titanium	DOXYSC01= 1.0132 x DOXYSU01 + 6.6963	6167	133	99.40 %

- **Chlorophyll-*a* and Fluorescence**

The fluorometer was calibrated using extracted chlorophyll-*a* data from CTD bottle samples and the nominal chlorophyll-*a* values derived from the fluorometer voltages from the up cast at the point when the bottle was fired. Water samples (300-500 ml) from CTD bottles were filtered on 25 mm GFF filters. Filters were extracted in 90% acetone for 24 hrs and total chlorophyll-*a* measured with a TD-700 Turner Designs fluorometer following the procedure of Welschmeyer (1994), which minimises interference by chlorophyll-*b*. The fluorometer was calibrated with dilutions of a solution of pure chlorophyll-*a* (Sigma, UK) in 90% acetone, the concentration of which was determined spectrophotometrically after the cruise. The casts were split into 3 regions for calibration.

Casts	Calibration Equation	BODC Cal. Ref.	N	R ²
Stainless steel 1 - 21	$CPHLPS01 = 1.6909 \times CPHLPM01 - 0.0061$	6176	66	77.53 %
Stainless steel 22 - 37	$CPHLPS01 = 2.1441 \times CPHLPM01 + 0.0054$	6177	40	74.53 %
Stainless steel 38 - 62	$CPHLPS01 = 1.3033 \times CPHLPM01 + 0.0001$	6178	75	88.44 %
Titanium 1 - 21	$CPHLPS01 = 2.7755 \times CPHLPM01 + 0.0214$	6179	29	83.88 %
Titanium 22 - 37	$CPHLPS01 = 2.8629 \times CPHLPM01 + 0.0487$	6180	34	81.73 %
Titanium 38 - 62	$CPHLPS01 = 1.5451 \times CPHLPM01 + 0.0368$	6181	49	90.37 %

- **Upwelling and downwelling PAR sensor**

Calibration certificates were provided to BODC for 5 PAR sensors. Only the upwelling sensor serial number was able to be verified from the supporting documentation and files. Since the voltage channels for each sensor could not be confirmed and linked to a calibration by sensor serial number both channels have been left as voltages.

- **Attenuance**

No calibration details provided to BODC, therefore channels retained as voltages.

Data quality notes and outstanding issues

There were the usual occasions of the 20 l water bottles not sealing properly. There were never more than a couple per cast and the scientists sampling from these casts were informed and so did not take water from these bottles. This is an unfortunate design flaw of these particular bottles and there is no method of getting 100% closures.

There was a consistent discrepancy for CTD cast 17 between information from the Sea-bird log files (used by BODC as a main reference for CTD rosette bottle metadata information) and the data originator record regarding the depth of the bottle firing. The depths from the Sea-bird log files were ~10 m deeper than those in the data originator records and the log sheets supplied to BODC.

Date of document creation: 17/10/2008

Document updated: 18/12/2008

09/01/2009

08/12/2009