OMEX II CTD Data Documentation Index

CTD data and data documentation are available on the OMEX II CD-ROM for the following cruises:

1997 Cruises

RRS Charles Darwin	CD105B	10 Jun 1997 to 22 Jun 1997
RV Belgica	BG9714B	18 Jun 1997 to 20 Jun 1997
RV Belgica	BG9714C	21 Jun 1997 to 30 Jun 1997
RV Pelagia	PLG108	23 Jun 1997 to 14 Jul 1997
RV Belgica	BG9714D	02 Jul 1997 to 07 Jul 1997
RV Pelagia	PLG109	15 Jul 1997 to 06 Aug 1997
RV Almeida Carvalho	AC97	05 Dec 1997 to 15 Dec 1997
RRS Charles Darwin	CD110A	23 Dec 1997 to 05 Jan 1998

1998 Cruises

RRS Charles Darwin	CD110B	05 Jan 1998 to 19 Jan 1998
FS Poseidon	PS237_1	26 Feb 1998 to 16 Mar 1998
RV Pelagia	PLG118	25 May 1998 to 12 Jun 1998
RV Belgica	BG9815C	27 Jun 1998 to 07 Jul 1998
RV Belgica	BG9815D	10 Jul 1998 to 14 Jul 1998
RRS Charles Darwin	CD114A	29 Jul 1998 to 11 Aug 1998
RV Pelagia	PLG121	30 Jul 1998 to 16 Aug 1998
RV Professor Shtokman	ST0898	01 Aug 1998 to 11 Aug 1998
RRS Charles Darwin	CD114B	11 Aug 1998 to 24 Aug 1998
RV Pelagia	PLG123	02 Sep 1998 to 18 Sep 1998
FS Meteor	M43_2	28 Dec 1998 to 14 Jan 1999

1999 Cruises

RV Almeida Carvalho	AC99	05 May 1999 to 29 May 1999
RV Pelagia	PLG138	11 May 1999 to 25 May 1999
RV Belgica	BG9919A	30 Aug 1999 to 03 Sep 1999
RV Belgica	BG9919B	04 Sep 1999 to 11 Sep 1999
RV Belgica	BG9919C	14 Sep 1999 to 18 Sep 1999
RV Thalassa	TH1099	13 Oct 1999 to 20 Oct 1999

CTD Data for Charles Darwin Cruise CD105

Leg A: 29th May to 9th June 1997 (no casts)
Leg B: 10th June to 22nd June 1997 (82 casts)

1) Instrumentation and Shipboard Procedures

1.1) Instrumentation

The CTD profiles were taken with a Neil Brown Systems Mk IIIB CTD including a pressure sensor, a conductivity cell, a platinum resistance thermometer and a Beckmann dissolved oxygen sensor. The CTD unit was mounted vertically in the centre of a protective cage approximately 1.5m square.

The following instruments were also attached to the bars of the cage and logged as additional CTD channels:

- Chelsea Instruments Aquatracka configured as a fluorometer.
- SeaTech light backscatter sensor (LBSS nephelometer).
- Two SeaTech 25-cm path-length red (661 nm) light transmissometers.
- Two PML 2π PAR (photosynthetically available radiation) scalar irradiance sensors configured to measure downwelling and upwelling radiation.

Note that the downwelling light sensor was actually mounted on a pole placing it in line with the top of the water bottle rosette, 1.75 m above the pressure head. As a result, there was a vertical separation of some two metres between the upwelling and downwelling sensors. No geometrical correction of the light data has been attempted.

A General Oceanics 12-bottle tone-fire rosette pylon was fitted to the top of the CTD frame. 10-litre Niskin bottles were used throughout the cruise.

The first leg of this cruise was primarily a swath bathymetry survey of the OMEX II working area. Consequently, no CTD work was undertaken.

1.2) Data Acquisition

On each cast, the CTD was lowered continuously at 0.5 to 1.0 m s^{-1} to the closest comfortable proximity to the sea floor. The upcast was done in stages between the bottle firing depths. A tone fire system was installed to minimise the disruption caused to the data stream by the bottle-firing signal.

The data were logged by the RVS ABC data logging system. Output channels from the deck unit were logged at 32 Hz by a microprocessor interface (the Level A) which passed time-stamped averaged cycles at 1 Hz to a Sun workstation (the Level C) via a buffering system (the Level B).

1.3) On-Board Data Processing

The raw data comprised ADC counts. These were converted into engineering units ($\mu Em^{-2}s^{-2}$ for PAR meters, volts for fluorometer, LBSS and transmissometers; ml l^{-1} for oxygen; mmho cm^{-1} for conductivity; °C for temperature; decibars for pressure) by the application of laboratory determined calibrations. Salinity (Practical Salinity Units as defined in Fofonoff and Millard, 1982) was calculated using the standard UNESCO function from the conductivity ratio (conductivity/42.914) and a time lagged temperature.

The data set were submitted to BODC in this form on Quarter Inch Cartridge tapes in RVS internal format for post-cruise processing and data banking.

2) Post-Cruise Processing and Calibration at BODC

2.1) Reformatting

The data were converted into the BODC internal format (PXF) to allow the use of in-house software tools, notably the workstation graphics editor. In addition to reformatting, the transfer program applied the following modifications to the data:

- Dissolved oxygen was converted from ml/l to µM by multiplication by 44.66.

- Transmissometer voltages were corrected to the manufacturer's specified voltage by ratio using transmissometer air readings taken during the cruise (see the calibration section for details). The voltages were then converted to percentage transmission by multiplying them by 20 and to attenuance using the algorithm:

$$\text{attenuance } (m^{-1}) = -4 \log_e (\% \text{ transmission}/100)$$

- The light meter calibration applied on the ship (based on incorrect coefficients) was removed, converting the data back to volts.

2.2) Editing

Reformatted CTD data were transferred onto a high-speed graphics workstation. Using custom in-house graphics editors, downcasts and upcasts were differentiated and the limits of the downcasts and upcasts were manually flagged.

Spikes on all the downcast channels were manually flagged. No data values were edited or deleted; flagging was achieved by modification of the associated quality control flag.

The pressure ranges over which the bottle samples had been collected were logged by manual interaction with the software. Usually, clusters of points recorded while the CTD was held stationary were used to determine this. These pressure ranges were subsequently used, in conjunction with a geometrical correction for the position of the water bottles with respect to the CTD pressure transducer, to determine the pressure range of data to be averaged for calibration values.

Once screened on the workstation, the CTD downcasts were loaded into a database under the ORACLE Relational Database Management System.

2.3) Calibration

With the exception of pressure, calibrations were done by comparison of CTD data against measurements made on water bottle samples or from the reversing thermometers mounted on the water bottles as in the case of temperature. In general, values were averaged from the CTD downcasts but where visual inspection of the data showed significant hysteresis values were manually extracted from the CTD upcasts.

All calibrations described here have been applied to the data.

<u>Pressure</u>

The pressure calibration was derived by averaging pressures logged in air from 78 of the 82 casts. The mean pressure in air was 1.41 db (SD 0.37 db) giving rise to the following pressure correction:

Corrected pressure (db) = Raw pressure – 1.41

<u>Temperature</u>

CTD temperatures were compared with calibrated digital reversing thermometer data from all suitably equipped bottles fired at depths greater than 1000 m. Excellent agreement was obtained with no evidence of drift or sudden offsets at any stage during the cruise. Consequently, no adjustment has been made to the CTD temperature data.

<u>Salinity</u>

The CTD salinity data were calibrated against 47 water bottle samples analysed on a Guildline Autosal bench salinometer. The following correction was obtained:

Corrected salinity = Raw salinity + 0.024 (SD 0.005)

Optical Attenuance

Two transmissometers were used in parallel during the cruise. Instrument SN80D functioned successfully throughout the cruise. The data from this instrument is stored in the database as parameter ATTNZR01. At the start of the cruise, SN79D was fitted as the second instrument, but it failed during cast CTD15. It was replaced in time for cast CTD21 by instrument SN116D.

The air correction data from laboratory measurements immediately prior to the cruise were as follows:

Instrument	New Volts	Cruise Volts	Correction
116D	4.820	4.750	-0.058
80D	4.806	4.795	-0.009
79D	4.744	4.722	-0.019

However, information from the cruise gave a cruise value of 4.795 V for SN116D (giving an attenuance correction of –0.020 per m). This cruise value was applied in the BODC processing of the second attenuance channel.

However, when the data were examined, it could be clearly seen that whilst the data from SN80D and SN79D were both in excellent agreement and perfectly credible (minimum attenuance of 0.35 for SN80D and 0.36 for SN79D), there was a problem with the data from SN116D. The SN116D data were consistently higher than SN80D by roughly 0.04 per m, giving a minimum attenuance of 0.39 per m.

The obvious conclusion was that the air value for SN116D reported from the cruise was incorrect. This was supported by the fact that the air value for SN80D was identical to that reported for SN116D. Taking the laboratory air reading rather than the cruise value decreased the SN116D data by 0.038 per m, bringing them into line with SN80D. This was implemented as a post-load calibration.

Nephelometer

The voltages logged by the ABC system from the SeaTech light backscatter sensor have been included in the database without the application of any further calibration.

Dissolved Oxygen

There were no oxygen water bottle data from this cruise. When this is the case it is normal BODC practice to delete the dissolved oxygen from the data set. However, during this cruise Charles Darwin rendezvoused with Belgica for an intercalibration CTD. The CTD casts were taken within 0.5 miles and at virtually the same time (Belgica was approximately 20 minutes after Darwin).

An oxygen calibration was attempted in which the Darwin CTD data (cast CTD91) were calibrated using bottle data from the Belgica cast. This gave rise to the following equation:

$$\text{Corrected oxygen} = \text{Raw oxygen} * 1.85 + 62.41 \qquad (N=11, R^2=75\%)$$

This calibration was then applied to the whole of the Darwin cruise. The limitations of this approach are obvious. For example, oxygen sensors are extremely prone to drift, which has not been monitored. The surface saturation values computed from the calibrated data varied during the cruise from 95% to 107%, which seems reasonable. However, it is recommended that the oxygen data be treated with caution.

<u>Chlorophyll</u>

The fluorometer was calibrated using extracted chlorophyll data assayed by HPLC. CTD voltages were regressed against the natural log of the sum of chlorophyll-a and diavinyl chlorophyll-a. The initial attempt produced a banana-shaped curve. Investigation showed that this was due to the very high noise levels in the fluorometer signal producing massive scatter for low chlorophyll concentrations. The problem was overcome by removing all points where the extracted chlorophyll value was <0.1µg/l. The result was the following calibration equation:

$$\text{Chlorophyll } (\mu g/l) = \exp(\text{voltage}*1.6652 - 2.7584) \qquad (N=254, R^2=41.8\%)$$

<u>Upwelling and Downwelling Irradiance</u>

The calibrations applied on the cruise used the wrong coefficients for upwelling irradiance (calibration for sensor 2 applied). These were removed and the following calibrations applied to the resulting voltages:

Downwelling irradiance ($\mu Em^{-2}s^{-1}$) = exp (-4.900*voltage + 7.237) * 0.0375
Sensor 1

Upwelling irradiance ($\mu Em^{-2}s^{-1}$) = exp (-4.970*voltage + 6.426) * 0.0375
Sensor 8

Note that the scaling factor (0.0375) is an empirically-derived term that converts the data from μWcm^{-2} to $\mu Em^{-2}s^{-1}$. Consequently, the data may be converted to Wm^{-2} if required by dividing by 3.75.

2.4) Data Reduction

Once all screening and calibration procedures were completed, the data set was binned to 2 db (casts deeper than 100 db) or 1 db (casts shallower than 100 db). The binning algorithm excluded any data points flagged suspect and attempted linear interpolation over gaps up to 3 bins wide. If any gaps larger than this were encountered, the data in the gaps were set null.

Oxygen saturation has been computed using the algorithm of Benson and Krause (1984).

3) Warnings

The oxygen calibration was based on bottle data from a single cast collected by another ship on an intercalibration station.

4) References

Benson B.B. and Krause D. jnr. 1984. The concentration and isotopic fractionation of oxygen dissolved in fresh water and seawater in equilibrium with the atmosphere. ***Limnol. Oceanogr.*** 29 pp.620-632.

Fofonoff N.P. and Millard Jr., R.C. 1982. Algorithms for Computation of Fundamental Properties of Seawater. ***UNESCO Technical Papers in Marine Science*** 44.

CTD Data for Cruise Belgica BG9714

Leg B: 18th June to 20th June 1997
Leg C: 21st June to 30th June 1997
Leg D: 2nd July to 7th July 1997

1) Instrumentation and Shipboard Procedures

The CTD profiles were taken with a SeaBird SBE 911 *plus* system. The instrument had enclosed conductivity and temperature sensors supplied with water by a pump. The water inlet was at the base of the bottle rosette. The CTD had a temperature and salinity (TC) duct with inertia balanced pump flow to improve the quality of salinity measurements.

When not in use, the sensors were bathed in MilliQ water. SeaBird temperature sensors are high performance, pressure protected thermistors. Other sensors on the rig were a dissolved oxygen cell (YSI SBE-13-Y polargraphic membrane) and a SeaBird optical backscatter sensor.

The CTD was periodically sent for calibration to SeaBird's NWRCC facility in Washington State. An average of 4 salinity samples were taken per cast, stored in crown-corked beer bottles, and determined on Guildline Portasal laboratory salinometer, calibrated using OSI standard seawater.

A SeaBird rosette sampler fitted with 12, 10 litre Niskin bottles was mounted above the frame. The bases of the bottles were level with the pressure sensor with their tops 0.8 m above it.

2) Data Acquisition

The CTD sampled at 24 Hz but this was automatically reduced to 2 Hz by the deck unit. Data were logged on a PC using the SeaBird SEASAVE program.

The CTD was lowered at 0.8-1 m/s. On the upcast, the hauling rate was approximately the same, but was reduced on approach to a bottle firing depth to minimise wake interference.

3) Post-Cruise Processing

The SeaBird DATCNV software was used to convert the binary raw data files into the calibrated ASCII data files supplied to BODC.

The salinity computation algorithm in the software is based on Fofonoff and Millard (1982). Salinity spiking on thermal gradients was minimised through software realignment of the temperature and conductivity channels.

3.1) Reformatting

The data were converted into the BODC internal format (PXF) to allow the use of in-house software tools, notably the workstation graphics editor. In addition to reformatting, the transfer program converted the dissolved oxygen from μmol/kg to μM by multiplying the values by (1000 + sigma-theta) / 1000.

3.2) Editing

Reformatted CTD data were transferred onto a high-speed graphics workstation for manual inspection using a custom in-house graphics editor. The top and bottom of the downcast were marked to eliminate noisy data logged whilst the instrument was stabilising.

The data were examined point by point and any obvious spikes were flagged 'suspect'.

Once screened on the workstation, the CTD downcasts were loaded into a database under the Oracle relational database management system. Note that the loader only included data from the downcast marked during screening.

3.3) Calibration

<u>Pressure</u>

The pressure calibrations were obtained by looking at the pressure values logged whilst the CTD unit was on the deck. Calibration data were available from legs C and D, which gave the following offsets:

Leg C:	pressure correction = -0.32 db	(S.D.=0.07)
Leg D:	pressure correction = -0.32 db	(S.D.=0.08)

On the basis of this a correction of –0.32 decibars was applied to the pressure values from all three legs.

<u>Temperature</u>

The temperature data are believed to be accurate as supplied and no further calibrations have been applied.

<u>Salinity</u>

The salinity calibrations were derived separately for each leg of the cruise by comparison of the values measured by the CTD with salinometer determinations on water bottle samples.

The following corrections have been applied to the data:

Leg B: Corrected salinity = CTD salinity - 0.016 (n=6; S.D.=0.003)

Leg C: Corrected salinity = CTD salinity - 0.021 (n=73; S.D.=0.006)
Leg D: Corrected salinity = CTD salinity - 0.025 (n=18; S.D.=0.002)

Dissolved Oxygen

The CTD dissolved oxygen data were calibrated against water sample data obtained by the University of Liège using an automated Winkler titration technique. The bottle data were converted to units of µM at in-situ temperature and salinity prior to calibration.

Each leg was calibrated separately, giving rise to the equations below, which have been applied to the data:

Leg B: Corrected oxygen = CTD oxygen * 1.029 - 6.02 (n=12; R^2=96%)
Leg C: Corrected oxygen = CTD oxygen * 0.964 + 13.07 (n=232; R^2=96%)
Leg D: Corrected oxygen = CTD oxygen * 0.915 + 23.18 (n=44; R^2=99%)

Optical Backscatter

The data were calibrated using the SeaBird software, based on a laboratory formazin calibration. No additional calibrations have been applied.

3.4) Data Reduction

Once all screening and calibration procedures were completed, the data set were binned to 2 db (casts deeper than 100 db) or 1 db (casts shallower than 100 db). The binning algorithm excluded any data points flagged suspect and attempted linear interpolation over gaps up to 3 bins wide. If any gaps larger than this were encountered, the data in the gaps were set null.

Downcast values corresponding to the bottle firing depths were incorporated into the database. Oxygen saturations were computed using the algorithm of Benson and Krause (1984).

4) References

Benson B.B. and Krause D. jnr. 1984. The concentration and isotopic fractionation of oxygen dissolved in fresh water and seawater in equilibrium with the atmosphere. ***Limnol. Oceanogr.*** 29, pp.620-632.

Fofonoff N.P., Millard R.C. 1982. Algorithms for computation of fundamental properties of seawater. ***UNESCO Technical Papers in Marine Science***. 44.

CTD Data for OMEX II Pelagia Cruises

Pelagia 108:	**23rd June – 14th July 1997**
Pelagia 109:	**15th July – 6th August 1997**
Pelagia 118:	**25th May – 12th June 1998**
Pelagia 121:	**30th July – 16th August 1998**
Pelagia 123:	**2nd – 18th September 1998**
Pelagia 138:	**11th – 25th May 1999**

1) Instrumentation and Shipboard Procedures

The CTD profiles were taken with a SeaBird SBE911 *plus* system. The instrument was equipped with a SBE-3 temperature sensor, SBE-4 conductivity sensor and SBE-13 oxygen sensor. However, the latter only returned useful data for cruises PLG108 and PLG138.

A SeaTech transmissometer (25 cm path length: 665 nm monochromatic light source) was also included in the CTD package for every cruise. During PLG138 a WET Labs AC3 system that measured optical attenuance at 676 nm was also fitted. This system also estimated the chlorophyll concentration by comparison of attenuance at different wavelengths.

On all cruises other than PLG138 the CTD package included a Chelsea Instruments Aquatracka fluorometer. However, this only returned useful data on cruises PLG108 and PLG109.

The CTD was fitted with a General Oceanics Rosette sampler carrying 24 12-litre NOEX bottles.

The number of CTD casts available for each Pelagia cruise is as follows:

PLG108	13
PLG109	18
PLG118	07
PLG121	03
PLG123	08
PLG138	20

2) Data Acquisition

The data were logged on a PC using the standard SeaBird SeaSave data acquisition software.

3) Post-Cruise Processing

3.1) NIOZ Processing

Hendrik van Aken's group at the Netherlands Institute for Sea Research worked up the CTD data to a very high standard. Temperature, salinity and dissolved oxygen have been calibrated to WOCE standards using the appropriate water bottle data. If there were any doubts about the quality of the oxygen data then the channel was deleted from the data set.

The chlorophyll values given are based upon manufacturer's calibration coefficients, as no extracted chlorophyll data were available from these cruises. Consequently, the absolute concentration values should be treated with a degree of caution. The data from PLG108 and PLG109 appear credible, but the surface mixed layer values seem lower than those returned by other OMEX II cruises in the same area and at the same time of year. The values from PLG138 are high, especially at depth (>1 mg/m^3) and there is a worrying increase of chlorophyll with depth at depths >1000 m. It is recommended for this cruise that the data be considered as having no units and that the deep data be totally ignored.

The SeaTech transmissometer data have been calibrated using the SeaBird software, which incorporates an air correction. However, the clear water attenuance values are of the order of 0.38 to 0.40 per m, which is slightly higher than expected for Atlantic waters (usually 0.35 to 0.36 per m). This may possibly be explained by the wavelength (665 nm) reported for the beam. The 'standard' Atlantic values were measured at 660 nm.

The WET Labs AC3 system was calibrated in terms of attenuance due to suspended sediment load. Consequently, the data give values of near zero for clear water.

In addition to calibration, the data were thoroughly 'cleaned' to eliminate spikes and smoothed. The processed data were supplied to BODC as 1db binned profiles.

3.2) BODC Data Processing

The data were converted into BODC's standard format (PXF). The only modification made to the data during reformatting was the conversion of dissolved oxygen units from micromoles/kg to micromoles/litre using the sigma-theta channel included with the data.

The data were examined using the BODC in-house graphics editor, which confirmed that they were exceptionally clean. No topping and tailing was required and flagging was confined to a small number of zero values in the attenuance channel.

The screened data were loaded into the Oracle database. Calibration records were set up to indicate that the data had been supplied as fully calibrated.

The only exception to this was a salinity correction of -0.07 applied by BODC to the data from PLG121 following the report of a processing error by Dr. van Aken.

BODC has a standard storage convention for storing CTD data. Shallow (<100 db) casts are held at 1 decibar, but deeper casts are stored at the 2 decibar resolution recommended by SCOR. These data have already been binned, which can cause confusion about what happens when the data are passed through a second binning procedure. Users should therefore be aware how the BODC processing has modified the data.

The BODC binning algorithm defines the top bin as the average of all data with a pressure from zero to 0.9999 (1 db binning) or 1.9999 (2 db binning) and labels these bins as 0.5 or 1.0 respectively. The original data were supplied with the top bin labelled as zero. The following show how the original pressure channel maps to the BODC pressure channel for each of the binning intervals used.

1db binning:	BODC pressure = input pressure + 0.5 (effectively a change in labelling convention from the top to the mid-point of the bin)
2 db binning:	Input pressures 0.0 and 1.0 averaged to give BODC pressure 1.0 Input pressures 2.0 and 3.0 averaged to give BODC pressure 3.0

4) Data Warnings

The chlorophyll data from these cruises have been obtained using manufacturer’s calibrations. The absolute values should therefore be used with caution, particularly for cruise PLG138.

CTD data for Almeida Carvalho cruises

AC97 “CLIMA97” 5^{th} December 1997 to 15^{th} December 1997
AC99 “OMEX99” 5^{th} May 1999 to 29^{th} May 1999

1) Instrumentation

The instrumentation used was a Neil Brown Mk IIIC CTD equipped with an Aquatracka Mk III turbidity sensor and a 12 bottle rosette sampler.

2) Data Acquisition

The raw data were logged on a PC using the standard Neil Brown EG&G software.

3) Post Cruise Processing

The raw data were extensively processed at Instituto Hidrografico, including calibration of conductivity (and hence salinity) against water bottle sample data and laboratory calibration of temperature and turbidity. The worked up data were transferred to BODC as ASCII files as profiles binned at 1 decibar.

At BODC, the data were converted into the BODC internal format (PXF) and inspected using an interactive graphical editor. A small number of spikes were identified and flagged as suspect.

The data were fully calibrated prior to submission to BODC and are believed to be good quality data. This was confirmed by checking the theta-salinity curves from the deep profiles against the nearest known good quality profiles (taken from the OMEX II Pelagia PLG138 and OMEX I Charles Darwin CD83 cruises). The observed agreement for a given value of theta was 0.005 PSU or better in stable water.

BODC has a standard storage convention for storing CTD data. Shallow (<100 db) casts are held at 1 decibar, but deeper casts are stored at the 2 decibar resolution recommended by SCOR. These data have already been binned, which can cause confusion about what happens when the data are passed through a second binning procedure. Users should therefore be aware how the BODC processing has modified the data.

The BODC binning algorithm defines the top bin as the average of all data with a pressure from zero to 0.9999 (1 db binning) or 1.9999 (2 db binning) and labels these bins as 0.5 or 1.0 respectively. The original data were supplied with the top bin labelled as zero. The following show how the original pressure channel maps to the BODC pressure channel for each of the binning intervals used.

1db binning:	BODC pressure = input pressure + 0.5 (effectively a change in labelling convention from the top to the mid-point of the bin)
2 db binning:	Input pressures 0.0 and 1.0 averaged to give BODC pressure 1.0 Input pressures 2.0 and 3.0 averaged to give BODC pressure 3.0.

CTD Data for Cruise Charles Darwin CD110

Leg A: 23rd December 1997 to 5th January 1998
Leg B: 5th January to 19th January 1998

1) Instrumentation and Shipboard Procedures

1.1) Instrumentation

The CTD profiles were taken with a Neil Brown Systems Mk IIIB CTD including a pressure sensor, a conductivity cell, a platinum resistance thermometer and a Beckmann dissolved oxygen sensor. However, the latter did not return any useful data.

The CTD unit was mounted vertically in the centre of a protective cage approximately 1.5m square.

The following instruments were also attached to the bars of the cage and logged as additional CTD channels:

- Chelsea Instruments Aquatracka configured as a fluorometer.
- SeaTech light backscatter sensor (LBSS nephelometer).
- Two SeaTech 20-cm path-length red (661 nm) light transmissometers.
- PML 2π PAR (photosynthetically available radiation) scalar irradiance sensor configured to measure downwelling (after CTD08) or upwelling radiation (up to CTD08).

Both upwelling and downwelling sensors were carried during the cruise. However, because there was a requirement for both an additional transmissometer and an altimeter there was only channel capacity in the multiplexer to log data from one light sensor.

Note that the downwelling light sensor was actually mounted on a pole placing it in line with the top of the water bottle rosette, 1.75 m above the pressure head. As a result, there was a vertical separation of some two metres between the upwelling and downwelling sensor positions. No geometrical correction of the light data has been attempted.

A General Oceanics 12-bottle tone-fire rosette pylon was fitted to the top of the CTD frame. 10-litre Niskin bottles were used throughout the cruise.

1.2) Data Acquisition

On each cast, the CTD was lowered continuously at 0.5 to 1.0 m s^{-1} to the closest comfortable proximity to the sea floor. The upcast was done in stages between the bottle firing depths. A tone fire system was installed to minimise the disruption caused to the data stream by the bottle-firing signal.

The data were logged by the RVS ABC data logging system. Output channels from the deck unit were logged at 32 Hz by a microprocessor interface (the Level A) which passed time-stamped averaged cycles at 1 Hz to a Sun workstation (the Level C) via a buffering system (the Level B).

1.3) On-Board Data Processing

The raw data comprised ADC counts. These were converted into engineering units (volts for PAR meters, fluorometer LBSS and transmissometers; ml l^{-1} for oxygen; mmho cm^{-1} for conductivity; °C for temperature; decibars for pressure) by the application of laboratory determined calibrations. Salinity (Practical Salinity Units as defined in Fofonoff and Millard, 1982) was calculated using the standard UNESCO function from the conductivity ratio (conductivity/42.914) and a time lagged temperature.

The data set were submitted to BODC in this form on Quarter Inch Cartridge tapes in RVS internal format for post-cruise processing and data banking.

2) Post-Cruise Processing and Calibration at BODC

2.1) Reformatting

The data were converted into the BODC internal format (PXF) to allow the use of in-house software tools, notably the workstation graphics editor. In addition to reformatting, the transfer program applied the following modifications to the data:

- Dissolved oxygen was converted from ml/l to µM by multiplication by 44.66.

- Transmissometer voltages were corrected to the manufacturer's specified voltage by ratio using transmissometer air readings taken during the cruise (see the calibration section for details). The voltages were then converted to percentage transmission by multiplying them by 20 and to attenuance using the algorithm:

$$\text{attenuance } (m^{-1}) = -5 \log_e (\% \text{ transmission}/100)$$

2.2) Editing

Reformatted CTD data were transferred onto a high-speed graphics workstation. Using custom in-house graphics editors, downcasts and upcasts were differentiated and the limits of the downcasts and upcasts were manually flagged.

Spikes on all the downcast channels were manually flagged. No data values were edited or deleted; flagging was achieved by modification of the associated quality control flag.

The pressure ranges over which the bottle samples had been collected were logged by manual interaction with the software. Usually, clusters of points recorded while the CTD was held stationary were used to determine this. These pressure ranges were subsequently used, in conjunction with a geometrical correction for the position of the water bottles with respect to the CTD pressure transducer, to determine the pressure range of data to be averaged for calibration values.

Once screened on the workstation, the CTD downcasts were loaded into a database under the ORACLE Relational Database Management System. 39 casts were loaded from leg A, and 12 casts were loaded from leg B.

2.3) Calibration

With the exception of pressure, calibrations were done by comparison of CTD data against measurements made on water bottle samples or from the reversing thermometers mounted on the water bottles as in the case of temperature. In general, values were averaged from the CTD downcasts but where visual inspection of the data showed significant hysteresis values were manually extracted from the CTD upcasts.

All calibrations described here have been applied to the data.

<u>Pressure</u>

The pressure calibration was derived by averaging pressures logged in air from 24 casts (leg A) and 10 casts (leg B). The mean corrections obtained were:

Leg A:	Corrected pressure = Raw pressure – 3.24	(SD 0.28)
Leg B:	Corrected pressure = Raw pressure – 3.52	(SD 0.22)

<u>Temperature</u>

CTD temperatures were compared with calibrated digital reversing thermometer data. Excellent agreement was obtained with no evidence of drift or sudden offsets at any stage during the cruise. Consequently, no adjustment has been made to the CTD temperature data.

Salinity

The CTD salinity data were calibrated against 15 (leg A) and 9 (leg B) water bottle samples analysed on a Guildline Autosal bench salinometer. The following corrections were obtained:

Leg A:	Corrected salinity = Raw salinity + 0.030	(SD 0.005)
Leg B:	Corrected salinity = Raw salinity + 0.031	(SD 0.003)

Optical Attenuance

Two brand new transmissometers, T1010D (ATTNZR01) and T1011D (ATTNZR02), were used in parallel during the cruise. Air readings were made in the laboratory shortly before the cruise, both directly (which confirmed the manufacturer's values) and through the CTD electronics using the same data channels as on the cruise. This gave the following results:

Instrument	Direct	CTD	Correction
T1010D	4.684	4.653	-0.033
T1011D	4.670	4.621	-0.053

These corrections were applied to the data.

The minimum attenuance values from the two instruments were compared, on a cast by cast basis, with the following results:

CTD	T1010D	T1011D	Difference
CTD06	0.49	0.49	-0.01
CTD07	0.44	0.44	0.00
CTD08	0.43	0.47	-0.04
CTD09	0.39	0.40	-0.01
CTD10	0.39	0.41	-0.02
CTD11	0.45	0.47	-0.02
CTD12	0.61	0.62	-0.01
CTD13	0.94	0.93	0.01
CTD14	0.56	0.62	-0.06
CTD15	0.45	0.48	-0.04
CTD16	0.42	0.44	-0.03
CTD17	0.82	0.82	0.00
CTD18	0.47	0.50	-0.03
CTD19	0.48	0.49	-0.02
CTD20	0.41	0.42	0.00
CTD21	0.78	0.72	0.07
CTD22	0.77	0.70	0.07
CTD23	0.70	0.65	0.04
CTD24	0.68	0.66	0.02
CTD25	0.67	0.67	0.00
CTD26	0.67	0.68	-0.01
CTD27	0.79	0.81	-0.02
CTD28	0.86	0.87	-0.01

CTD	T1010D	T1011D	Difference
CTD29	0.76	0.77	-0.01
CTD30	0.77	0.78	-0.01
CTD31	0.62	0.73	-0.11
CTD32	0.60	0.70	-0.10
CTD33	0.85	0.90	-0.05
CTD34	1.00	1.02	-0.02
CTD35	1.03	1.12	-0.09
CTD36	0.97	0.63	0.33
CTD37	1.04	0.53	0.52
CTD38	0.85	0.47	0.38
CTD39	0.71	0.44	0.27
CTD40	0.42	0.41	0.01
CTD41	0.41	0.43	-0.02
CTD42	0.39	0.41	-0.02
CTD43	0.40	0.41	-0.02
CTD44	0.40	0.42	-0.02
CTD45	0.39	0.40	-0.01
CTD46	0.49	0.51	-0.02
CTD47	0.50	0.51	-0.02
CTD48	0.49	0.53	-0.04
CTD49	0.38	0.40	-0.01
CTD50	0.49	0.50	-0.01
CTD51	0.63	0.63	0.00
CTD52	0.64	0.65	-0.01
CTD53	0.58	0.60	-0.01
CTD54	0.39	0.41	-0.01
CTD55	0.40	0.42	-0.01
CTD56	0.43	0.44	-0.02

This table shows the minimum attenuance (excluding values flagged as suspect during quality control) logged by each instrument on each CTD cast, together with the simple arithmetic difference (1010D – 1011D). The green rows have absolute differences <=0.01, the black rows have absolute differences from 0.01 to 0.02, whilst the red rows have absolute differences >0.02.

The general BODC conclusions from examination of these data are as follows:

- Data from T1010D seem more accurate than T1011D for most casts, but there are exceptions. For example, the data from T1010D from casts CTD36-CTD39 are clearly wrong.
- The clear water values from both instruments are higher than expected by approximately 0.02 (T1010D) to 0.04 (T1011D).
- The instruments were more stable on leg B (CTD45 onwards).

However, users are advised to peruse the above table and come to their own conclusion as to whether the optical attenuance data from this cruise are adequate for the proposed purpose.

Further air readings were available from leg B of the cruise. However, these gave more variable results than the laboratory calibration.

Nephelometer

The voltages logged by the ABC system from the SeaTech light backscatter sensor have been included in the database without the application of any further calibration.

Chlorophyll

The fluorometer was calibrated using extracted chlorophyll data assayed by HPLC from leg B of the cruise. CTD voltages were regressed against the natural log of the sum of chlorophyll-a and diavinyl chlorophyll-a. The result was the following calibration equation:

Chlorophyll (µg/l) = exp (voltage*1.01 – 1.6863) (N=42, R^2=60%)

This has been used for both legs of the cruise.

Upwelling and Downwelling Irradiance

The following calibrations were applied to the voltages:

Downwelling irradiance ($\mu Em^{-2}s^{-1}$) = exp (-4.900*voltage + 7.237) * 0.0375
Sensor 1

Upwelling irradiance ($\mu Em^{-2}s^{-1}$) = exp (-4.970*voltage + 6.426) * 0.0375
Sensor 8

Note that the scaling factor (0.0375) is an empirically derived term that converts the data from μWcm^{-2} to $\mu Em^{-2}s^{-1}$. Consequently, the data may be converted to Wm^{-2} if required by dividing by 3.75.

2.4) Data Reduction

Once all screening and calibration procedures were completed, the data set was binned to 2 db (casts deeper than 100 db) or 1 db (casts shallower than 100 db). The binning algorithm excluded any data points flagged suspect and attempted linear interpolation over gaps up to 3 bins wide. If any gaps larger than this were encountered, the data in the gaps were set null.

Oxygen saturation has been computed using the algorithm of Benson and Krause (1984)

3) Warning

Careful consideration should be given to the comparison of the transmissometers given above before making any use of the attenuance data.

4) References

Benson B.B. and Krause D. jnr. 1984. The concentration and isotopic fractionation of oxygen dissolved in fresh water and sea water in equilibrium with the atmosphere. ***Limnol. Oceanogr.*** 29 pp.620-632.

Fofonoff N.P. and Millard Jr., R.C. 1982. *Algorithms for Computation of Fundamental Properties of Seawater.* ***UNESCO Technical Papers in Marine Science*** 44.

CTD Data for Cruise Poseidon PS237_1
26th February to 16th March 1998

1) Instrumentation and Shipboard Procedures

1.1) Instrumentation

The CTD profiles were taken with a Neil Brown Systems Mk V CTD including a pressure sensor, a conductivity cell, a platinum resistance thermometer and a Beckmann dissolved oxygen sensor.

The following instruments were also attached to the bars of the cage and logged as additional CTD channels:

- Chelsea Instruments Aquatracka configured as a fluorometer.
- Chelsea Instruments Aquatracka configured as a nephelometer.
- SeaTech 25-cm path-length red (661 nm) light transmissometer.

The CTD system could only log one auxiliary channel. Consequently, only one of the above instruments could be logged on a given cast. The fluorometer was logged on casts CP02, CP05, CP08, CP25, CP37, CP58, CP71, CP72, CP74, CP78, CP79, C44A and C51D (13 casts). The nephelometer was logged on casts CP77, CP80-CP93, CP95, C51E, C67A, C94A and C94B (20 casts). The transmissometer was logged on the remaining 63 casts.

A General Oceanics 24-bottle tone-fire rosette pylon was fitted to the CTD frame. 10-litre Niskin bottles were used throughout the cruise.

1.2) Data Acquisition and Processing

On each cast, the CTD was lowered continuously at 0.5 to 1.5 m s^{-1} to the required depth. The upcast was done in stages between the bottle firing depths. A tone fire system was installed to minimise the disruption caused to the data stream by the bottle-firing signal.

The data were logged on a PC running the Neil Brown EG&G logging software. The data were converted to ‘calibrated’ 16 Hz ASCII files using the CTDPOST program, which were supplied to BODC. It has been assumed that the calibration included the conversion of fluorometer voltage to nominal chlorophyll concentration.

2) Post-Cruise Processing and Calibration at BODC

2.1) Reformatting

The 16 Hz data supplied were reduced to a sampling frequency of 1 Hz using an averaging procedure designed to reduce the influence of spikes and electrical noise. The 14 data values closest to the median of each group of 16 data values were averaged, whilst the other two values were averaged.

The data were converted into the BODC internal format (PXF) to allow the use of in-house software tools, notably the workstation graphics editor. In addition to reformatting, the transfer program applied the following modifications to the data:

- Dissolved oxygen was converted from ml/l to μM by multiplication by 44.66.

- Transmissometer voltages were converted to percentage transmission by multiplying them by 20 and to attenuance using the algorithm:

$$\text{attenuance } (m^{-1}) = -4 \log_e (\% \text{ transmission}/100)$$

2.2) Editing

Reformatted CTD data were transferred onto a high-speed graphics workstation. Using custom in-house graphics editors, downcasts and upcasts were differentiated and the limits of the downcasts and upcasts were manually flagged.

Spikes on all the downcast channels were manually flagged. No data values were edited or deleted; flagging was achieved by modification of the associated quality control flag.

The pressure ranges over which the bottle samples had been collected were logged by manual interaction with the software. Usually, clusters of points recorded while the CTD was held stationary were used to determine this. These pressure ranges were subsequently used to determine the pressure range of data to be averaged for calibration values.

Once screened on the workstation, the CTD downcasts were loaded into a database under the ORACLE Relational Database Management System.

2.3) Calibration

Pressure

The pressure calibration was determined by averaging pressure values that were logged in air. The result was an unusually large correction of –8.17 decibars (n = 74, SD = 0.26), which has been applied to the data.

Temperature

No independent check on accuracy of the temperature data was available. Consequently, the data have not been modified. Previous experience gives confidence in the accuracy of Neil Brown temperature data, but users should be aware that there is the possibility that the data are inaccurate.

Salinity

Deep salinity bottle data were used to derive an initial salinity offset of –0.202 PSU (N=4, SD=0.004). After this had been applied to the data, theta-salinity plots were generated for the theta range 3-9 °C using all CTD casts encountering theta values below 4 °C, together with data from a Charles Darwin CD105 deep cast. The data showed considerable scatter, with a total spread of approximately 0.07 PSU.

Further analysis showed that one cast, CP04, was very much 'out on its own', being some 0.03 PSU clear of the rest. There were obviously instrumental problems with this cast: all downcast data in the top 120 m were deleted because there was no resemblance between the forms of the upcast and the downcast. Consequently, this cast was considered to be an aberration and given a unique correction of -0.17 PSU. Examination of overlain salinity profiles at the 500 m salinity minimum indicated that the intermediate depth cast CP07 wasn't affected, but users should bear in mind that the salinity data from the shallow casts CP01, CP02 and CP05 could possibly be too high.

In summary, the CTD salinity data from this cruise, with the exception of a couple of shallow casts at the beginning, are believed to just meet the 0.02 PSU accuracy criterion. The accuracy of some of the casts is significantly better than this, but users are advised against using the salinity data from this cruise for high accuracy applications.

Dissolved Oxygen

The dissolved oxygen data from this cruise showed massive instrumental drift, to the extent that surface downcast and upcast values differed by as much as 50 µM. No oxygen measurements were made on bottle samples and so no additional calibration work was possible. Consequently, the oxygen data have been deleted from the data set.

Chlorophyll

The fluorometer was calibrated against a set of fluorometrically-assayed extracted chlorophyll-a data. The following regression calibration was produced, which has been applied to the data:

Calibrated chlorophyll-a = Raw chlorophyll * 2.925 + 0.15 (n=36, R^2=70.1%)

HPLC data were also available for this cruise and were considered for the fluorometer calibration. However, the results were poor, with an R^2 value of

20%, possibly due to the presence of other chlorophylls and phaeopigments in significant and variable amounts.

<u>Attenuance</u>

The attenuance values were obviously too high with clear water values from deep casts in the region of 1.24 to 1.3 per m. No air readings were taken on the cruise and consequently an alternative calibration strategy had to be devised. It was assumed that the minimum attenuance value (excluding any spikes) for CTD casts deeper than 2000 metres was constant. The fact that the actual CTD data varied between 1.244 and 1.292 per m for these deep casts indicated that the transmissometer was subject to instrumental drift during the cruise. By looking at the deep cast values as a time series, three distinct groups of casts (CP01-CP07, CP08-CP23 and CP24 on) were identified as having 'similar' minimum attenuance values. The following calibrations were derived to normalise the data from each group to a clear water value of 0.36.

CP01 – CP07	Corrected attenuance = Raw attenuance – 0.891
CP08 – CP23	Corrected attenuance = Raw attenuance – 0.905
CP24 – CP74	Corrected attenuance = Raw attenuance – 0.926

The corrected clear water attenuance values lie in the range 0.349 to 0.365 per m, comparing very favourably with the 'ideal' values of 0.35 to 0.36. However, users are advised to carefully consider the influence of the calibrations before using them in high accuracy applications such as quantifying seston gradients perpendicular to the shelf break.

<u>Nephelometer</u>

The values supplied (voltages?) have been included in the database without the application of any further calibration.

2.4) Data Reduction

Once all screening and calibration procedures were completed, the data set was binned to 2 db (casts deeper than 100 db) or 1 db (casts shallower than 100 db). The binning algorithm excluded any data points flagged suspect and attempted linear interpolation over gaps up to 3 bins wide. If any gaps larger than this were encountered, the data in the gaps were set null.

Oxygen saturation has been computed using the algorithm of Benson and Krause (1984).

3) Warnings

The salinity data should not be used if high accuracy is required without careful selection. Whilst some casts are accurate within 0.005 PSU, others only just meet the 0.02 PSU accuracy criterion.

4) References

Benson B.B. and Krause D. jnr. 1984. The concentration and isotopic fractionation of oxygen dissolved in fresh water and sea water in equilibrium with the atmosphere. ***Limnol. Oceanogr.*** 29 pp.620-632.

CTD Data for Cruise Belgica 9815

Leg C: 27th June – 07th July 1998
Leg D: 10th July – 14th July 1998

1) Instrumentation and Shipboard Procedures

The CTD profiles were taken with a SeaBird SBE09 *plus* system. The instrument was equipped with a sensor set comprising an SBE-3 temperature sensor and an SBE-4 conductivity sensor. The system had a Temperature and Conductivity (TC) duct with an inertia-balanced pump flow, designed to improve the performance of the salinity measurements.

When not in use, the sensors were bathed in MilliQ water. SeaBird temperature sensors are high performance, pressure protected thermistors. Other sensors on the rig were a dissolved oxygen cell (YSI SBE-13-Y polargraphic membrane) and a SeaBird optical backscatter sensor.

The CTD was periodically sent for calibration to SeaBird's NWRCC facility in Washington State. An average of 4 salinity samples were taken per cast, stored in crown-corked beer bottles, and determined on Guildline Portasal laboratory salinometer, calibrated using OSI standard seawater.

A SeaBird rosette sampler fitted with 12, 10 litre Niskin bottles was mounted above the frame. The bases of the bottles were level with the pressure sensor with their tops 0.8 m above it.

2) Data Acquisition

The SeaBird SBE09 *plus* CTD system measured the depth of the sensor package, water temperature, conductivity, backscatter and dissolved oxygen at a rate of 24 samples per second. These data were averaged in the SeaBird deck unit over a 0.5-second interval. The resultant data were plotted on a VDU screen and used to decide water-sampling depths. The CTD software automatically marked the depths as part of the bottle firing sequence.

3) Post-cruise Processing

The SeaBird DATCNV software was used to convert the binary raw data files into the calibrated ASCII data files supplied to BODC.

The salinity computation algorithm in the software is based on Fofonoff and Millard (1982). Salinity spiking on thermal gradients was minimised through software realignment of the temperature and conductivity channels.

3.1) Reformatting

The data were converted into the BODC internal format (PXF) to allow the use of in-house software tools, notably the workstation graphics editor. In addition to reformatting, the transfer program converted the dissolved oxygen from µmol/kg to µM by multiplying the values by (1000 + sigma-theta) / 1000.

3.2) Editing

The in-house graphics editor at BODC was used to mark the start and end of the downcasts, to remove noisy data logged whilst the instrument was stabilising.

The data were screened, point-by-point, and any obvious spikes were marked "suspect".

Once screened, the CTD downcasts were loaded into a database under the Oracle relational database management system. 51 and 23 casts were loaded from leg C and D respectively.

3.3) Calibration

Pressure

The pressure calibrations were obtained by looking at the pressure values logged whilst the CTD unit was on the deck. The following corrections were applied:

Leg C: $Pressure_{corrected} = Pressure_{observed} - 0.36$ (N = 46, SD = 0.09)

Leg D: $Pressure_{calibrated} = Pressure_{observed} - 0.31$ (N = 6, SD = 0.04)

Temperature

The temperature data are believed to be accurate as supplied and no further calibrations have been applied.

Salinity

The salinity sensor was calibrated against discrete samples analysed using a Guildline Portasal Model 8410 laboratory salinometer. There was an excellent relationship between the data sets, and the following corrections were applied:

Leg C: $Salinity_{corrected} = Salinity_{observed} – 0.006$ (N = 90, SD = 0.006)

Leg D: $Salinity_{corrected} = Salinity_{observed} – 0.008$ (N = 23, SD = 0.004)

Oxygen

The oxygen sensor was calibrated against discrete samples analysed by the Winkler titration method (data supplied by University of Liège). As for the salinity measurements, there was an excellent relationship between the two data sets, and the following corrections were made to the CTD data:

Leg C: $O_{corrected} = 0.847 * O_{observed} + 17.97$ (N = 256, R^2=0.87)

Leg D: $O_{corrected} = 1.121 * O_{observed} - 44.95$ (N = 23, R^2=0.95)

Optical Backscatter

The data were calibrated using the SeaBird software, based on a laboratory formazin calibration. No additional calibrations have been applied.

3.4) Data Reduction

Once all screening and calibration procedures were completed, the data set was binned to 2 db (casts deeper than 100 db) or 1 db (casts shallower than 100 db). The binning algorithm excluded any data points flagged suspect and attempted linear interpolation over gaps up to 3 bins wide. If any gaps larger than this were encountered, the data in the gaps were set null.

Downcast values corresponding to the bottle firing depths were incorporated into the database. Oxygen saturations were computed using the algorithm of Benson and Krause (1984).

4) References

Benson B.B. and Krause D. jnr. 1984. The concentration and isotopic fractionation of oxygen dissolved in fresh water and seawater in equilibrium with the atmosphere. ***Limnol. Oceanogr.*** 29, pp.620-632.

Fofonoff N.P., Millard R.C. 1982. Algorithms for computation of fundamental properties of seawater. ***UNESCO Technical Papers in Marine Science.*** 44.

CTD Data for Cruise Charles Darwin CD114

Leg A: 29th July to 11th August 1998
Leg B: 11th August to 24th August 1998

1) Instrumentation and Shipboard Procedures

1.1) Instrumentation

The CTD profiles were taken with a Neil Brown Systems Mk IIIB CTD including a pressure sensor, a conductivity cell, a platinum resistance thermometer and a Beckmann dissolved oxygen sensor. The latter returned no useful data for this cruise.

The CTD unit was mounted vertically in the centre of a protective cage approximately 2m square.

The following instruments were also attached to the bars of the cage and logged as additional CTD channels:

- Chelsea Instruments Aquatracka configured as a fluorometer.
- SeaTech light backscatter sensor (LBSS nephelometer).
- SeaTech 20-cm path-length red (661 nm) light transmissometer.
- PML 2π PAR (photosynthetically available radiation) scalar irradiance sensors configured to measure downwelling and upwelling radiation.

Note that the downwelling light sensor was actually mounted on a pole placing it in line with the top of the water bottle rosette, 1.75 m above the pressure head. As a result, there was a vertical separation of some two metres between the upwelling and downwelling sensor positions. No geometrical correction of the light data has been attempted.

A General Oceanics 24-bottle tone-fire rosette pylon was fitted to the top of the CTD frame. 10-litre lever-action or externally sprung Niskin bottles were used throughout the cruise.

1.2) Data Acquisition

On each cast, the CTD was lowered continuously at 0.5 to 1.0 m s^{-1} to the closest comfortable proximity to the sea floor. The upcast was done in stages between the bottle firing depths. A tone fire system was installed to minimise the disruption caused to the data stream by the bottle-firing signal.

The data were logged by the RVS ABC data logging system. Output channels from the deck unit were logged at 32 Hz by a microprocessor interface (the Level A) which passed time-stamped averaged cycles at 1 Hz to a Sun workstation (the Level C) via a buffering system (the Level B).

1.3) On-Board Data Processing

The raw data comprised ADC counts. These were converted into engineering units (volts for PAR meters, fluorometer LBSS and transmissometers; ml l^{-1} for oxygen; mmho cm^{-1} for conductivity; °C for temperature; decibars for pressure) by the application of laboratory determined calibrations. Salinity (Practical Salinity Units as defined in Fofonoff and Millard, 1982) was calculated using the standard UNESCO function from the conductivity ratio (conductivity/42.914) and a time lagged temperature.

The data set was submitted to BODC in this form on Quarter Inch Cartridge tapes in RVS internal format for post-cruise processing and data banking.

2) Post-Cruise Processing and Calibration at BODC

2.1) Reformatting

The data were converted into the BODC internal format (PXF) to allow the use of in-house software tools, notably the workstation graphics editor. In addition to reformatting, the transfer program applied the following modifications to the data:

- Dissolved oxygen was converted from ml/l to µM by multiplication by 44.66.

- Transmissometer voltages were corrected to the manufacturer's specified voltage by ratio using transmissometer air readings taken during the cruise (see the calibration section for details). The voltages were then converted to percentage transmission by multiplying them by 20 and to attenuance using the algorithm:

$$\text{attenuance } (m^{-1}) = -5 \log_e (\% \text{ transmission}/100)$$

2.2) Editing

Reformatted CTD data were transferred onto a high-speed graphics workstation. Using custom in-house graphics editors, downcasts and upcasts were differentiated and the limits of the downcasts and upcasts were manually flagged.

Spikes on all the downcast channels were manually flagged. No data values were edited or deleted; flagging was achieved by modification of the associated quality control flag.

The pressure ranges over which the bottle samples had been collected were logged by manual interaction with the software. Usually, clusters of points recorded while the CTD was held stationary were used to determine this. These pressure ranges were subsequently used, in conjunction with a geometrical correction for the position of the water bottles with respect to the CTD pressure transducer, to determine the pressure range of data to be averaged for calibration values.

Once screened on the workstation, the CTD downcasts were loaded into a database under the ORACLE Relational Database Management System. 49 casts were loaded from leg A, including a yo-yo cast that has been loaded to the system as a further 34 casts. 34 casts were loaded from leg B.

2.3) Calibration

With the exception of pressure, calibrations were done by comparison of CTD data against measurements made on water bottle samples or from the reversing thermometers mounted on the water bottles as in the case of temperature. In general, values were averaged from the CTD downcasts but where visual inspection of the data showed significant hysteresis values were manually extracted from the CTD upcasts.

All calibrations described here have been applied to the data.

<u>Pressure</u>

The pressure calibration was derived by averaging pressures logged in air. The data from leg A showed a clear bimodal distribution. Consequently, two calibrations were produced.

The mean corrections obtained were:

Leg A (CTD01-CTD08):	Corrected pressure = Raw pressure + 3.77 (SD 0.27)
Leg A (CTD09-CTD49):	Corrected pressure = Raw pressure + 2.81 (SD 0.34)
Leg B (CTD50-CTD83):	Corrected pressure = Raw pressure + 3.08 (SD 0.33)

<u>Temperature</u>

CTD temperatures were compared with calibrated digital reversing thermometer data. Excellent agreement was obtained with no evidence of drift or sudden offsets at any stage during the cruise. Consequently, no adjustment has been made to the CTD temperature data.

Salinity

The CTD salinity data were calibrated against 8 (leg A) and 11 (leg B) water bottle samples analysed on a Guildline Autosal bench salinometer. The following corrections were obtained:

Leg A:	Corrected salinity = Raw salinity + 0.042	(SD 0.008)
Leg B:	Corrected salinity = Raw salinity + 0.029	(SD 0.006)

Chlorophyll

The fluorometer data were calibrated against extracted chlorophyll data assayed by HPLC, which were available for both legs of the cruise. Note that the data set supplied did not have chlorophyll-a resolved into normal and diavinyl forms.

Two fluorometers were deployed on the CTD during CD114. The instrument originally fitted (SA-254) was replaced by SA-234 after CTD60 on leg B, as the signal from SA-254 was extremely noisy. This can be seen in the calibrated chlorophyll data, especially at low chlorophyll concentrations.

The calibration strategy adopted was to calibrate each instrument rather than each leg, as there were insufficient data to calibrate the casts using SA-254 on leg B separately.

The calibrations obtained were:

SA-254: Chlorophyll (mg m^{-3}) = $0.2572 * e^{voltage} - 0.606$ (N=129, R^2=76%)

SA-234 Chlorophyll (mg m^{-3}) = $1.0248 * e^{voltage} – 1.3735$ (N=72, R^2=85%)

Optical Attenuance

There was a problem with the transmissometer calibration. No air readings were taken on the cruise and the only air readings on the instrument record sheet were taken in the laboratory using a voltmeter attached directly to the transmissometer. The value obtained (4.665 V) was virtually identical to the manufacturer's value (4.669 V).

No readings were available through the CTD electronics, and experience from other cruises has shown that these are significantly lower than direct measurements. The data were initially processed on the basis of the direct reading and the resulting attenuance values were obviously high.

Subsequent research revealed that the transmissometer had been used with the same CTD on a Discovery cruise immediately prior to CD114 for which air readings were available. The final reading from this cruise (4.580 V) was used to determine an attenuance correction of -0.092 per m. This has been applied to the data as a calibration.

Nephelometer

The voltages logged by the ABC system from the SeaTech light backscatter sensor have been included in the database without the application of any further calibration.

Oxygen

There were problems with the dissolved oxygen data for both CD114A and B. Data logged during CTD upcasts were significantly lower and had opposite slopes to the data logged during the corresponding downcasts. An attempt was made to calibrate the downcast data against bottle data assayed by Winkler titration, but the relationship was extremely weak. Individual cast calibrations were then attempted, but the calibrated data made no sense when reviewed in conjunction with the chlorophyll data, which is hardly surprising considering the dramatic hysteresis observed. Consequently, the decision was taken to remove the dissolved oxygen data from the final data set.

Upwelling and Downwelling Irradiance

The following calibrations were applied to the voltages:

Downwelling irradiance ($\mu Em^{-2}s^{-1}$) = exp (-5.000*voltage + 6.536) * 0.0375
Sensor 11

Upwelling irradiance ($\mu Em^{-2}s^{-1}$) = exp (-4.970*voltage + 6.426) * 0.0375
Sensor 8

Note that the scaling factor (0.0375) is an empirically derived term that converts the data from μWcm^{-2} to $\mu Em^{-2}s^{-1}$. Consequently, the data may be converted to Wm^{-2} if required by dividing by 3.75.

2.4) Data Reduction

Once all screening and calibration procedures were completed, the data set was binned to 2 db (casts deeper than 100 db) or 1 db (casts shallower than 100 db). The binning algorithm excluded any data points flagged suspect and attempted linear interpolation over gaps up to 3 bins wide. If any gaps larger than this were encountered, the data in the gaps were set null.

Oxygen saturation has been computed using the algorithm of Benson and Krause (1984)

3) Warnings

The chlorophyll data for casts CTD01-CTD60 are unusually noisy.

4) References

Benson B.B. and Krause D. jnr. 1984. The concentration and isotopic fractionation of oxygen dissolved in fresh water and sea water in equilibrium with the atmosphere. ***Limnol. Oceanogr.*** 29 pp.620-632.

Fofonoff N.P. and Millard Jr., R.C. 1982. Algorithms for Computation of Fundamental Properties of Seawater. ***UNESCO Technical Papers in Marine Science*** 44.

CTD Data for Cruise Professor Shtokman ST0898
1st August 1998 to 11th August 1998

1) Instrumentation and Shipboard Procedures

The CTD profiles were taken with a Neil Brown Systems Mk IIIB CTD including pressure, conductivity, temperature and dissolved oxygen sensors. A fluorometer was also included in the CTD package. A 24-position General Oceanics rosette with 12-litre Niskin bottles was fitted to the CTD frame to collect water samples.

2) Data Acquisition and On-board Processing

The data supplied to BODC conformed to the expected output format from the standard EG&G acquisition and processing software used with Neil Brown instruments. The data were supplied as 1-decibar binned values, labelled with the pressures of the midpoints of the bins. All available information indicates that the raw chlorophyll channel supplied was directly proportional to the chlorophyll concentration. It is not known whether this was from an instrument with a linear response or if it was nominally calibrated data from a logarithmic-response instrument.

3) Post-cruise Processing

3.1) Reformatting and Editing

The data were supplied to BODC as ASCII files, which were converted into the BODC internal format (PXF). The reformatting program converted the units of the dissolved oxygen data from ml/l to µM through multiplication by 44.66.

Each profile was examined using an in-house graphical editing tool and any spikes observed in the data were flagged as suspect. Flags were also applied to the cycle number channel that indicated the start and end of the profile downcast. Twenty-two screened downcasts were loaded into the Oracle relational database management system.

3.2) Calibration

Pressure

No air-logged data were included in the data set. Consequently, the accuracy of the originator's pressure calibration could not be checked. The instrument was reported as calibrated in March 1998. There was no evidence of significant errors in the pressure values.

Temperature

No reversing thermometer data were available and consequently the originator's calibration could not be checked. The instrument was reported as calibrated in March 1998. There was no evidence of significant errors in the temperature values.

Salinity

The salinity data were calibrated against a set of 25 samples taken from two stations and analysed by salinometer. However, the samples were stored for 12 months prior to analysis, which inevitably means a high probability of errors caused by evaporation loss.

The resulting offset of –0.104 (N=25, SD=0.062) was applied to the data. This calibration gave cause for concern for two reasons. First, the absolute value was unusually large, especially for a recently calibrated instrument. Secondly, the standard deviation was alarmingly large, probably due to the poor quality of the bottle data set. However, there is reason to believe that the accuracy of the calibrated data is better than the statistics indicate. The deep ($\theta<10$) theta-salinity curves from this cruise agreed within 0.02 PSU with data of known good quality (cruise CD105B), which were collected in the vicinity a year earlier. The uncorrected Shtokman salinity data were also reported to be up to 0.1 PSU high with respect to the regional climatology.

However, users should bear in mind the quality limitations of the calibration data if high accuracy salinity data are required.

Oxygen

The CTD oxygen data were calibrated against a bottle data set taken by the University of Vigo. The calibration was difficult because the CTD oxygen sensor was obviously drifting but samples were only available for 7 of the 22 casts and only in the upper 200 metres. The problem was exacerbated because the sensor was slow to equilibrate on some casts, which resulted in further calibration data loss.

Three calibration equations were produced:

CTD01 to CTD10

Calibrated oxygen = Raw oxygen * 0.992 + 83.3 (n=22, R^2=86.8%)

CTD11 to CTD21

Calibrated oxygen = Raw oxygen * 0.491 + 167.7 (n=19, R^2=78.4%)

CTD22

Calibrated oxygen = Raw oxygen * 0.904 + 61.6 (n=7, R^2=90.5%)

These calibrations have been applied to the data. Users should be aware that the R^2 values flatter the calibration quality and are advised to use the absolute calibrated values with caution. The data are believed to be more accurate in the upper 200 m and there is significantly lower confidence in the calibration for CTD11 to CTD21 because of the high values (225-228 μM) produced for the oxygen minimum. The expected value, based on other OMEX II cruises, is 190 μM.

The data values for CTD23 were clearly in error (surface saturation of 182% using the CTD22 calibration) and have been deleted from the data set.

Chlorophyll

The data originator provided the following fluorometer calibration equation:

Calibrated chlorophyll = 1.71 * raw chlorophyll (R^2 = 95%, N=83)

This was based on a set of acetone-extracted chlorophyll data assayed fluorometrically, using a Turner Designs bench fluorometer. The calibration has been applied to the data.

3.3) Data Binning

The final data set has been binned to give a resolution of 2 decibars. The manner in which the input data had been binned means that each binned value in the data set is effectively the average of one bin above and one bin below the pressure label on the output bin. For example, the output bin labelled 1 decibar is the average from the input bins labelled 0.5 and 1.5 decibars.

4) Warnings

The oxygen calibration for this cruise was difficult and users are advised to treat the absolute CTD oxygen concentrations with caution, particularly for CTDs 11 to 21.

CTD Data for Cruise Meteor 43_2
28^{th} December 1998 to 14^{th} January 1999

1) Instrumentation and Shipboard Procedures

The CTD profiles were taken with a SeaBird SBE 911 *plus* system. The instrument had enclosed conductivity and temperature sensors supplied with water by a pump. The water inlet was at the base of the bottle rosette.

When not in use, the sensors were bathed in MilliQ water. SeaBird temperature sensors are high performance, pressure protected thermistors. Other sensors on the rig were a dissolved oxygen cell (YSI SBE-13-Y polargraphic membrane) and a SeaTech red light transmissometer with a 25 cm path length.

The CTD was periodically sent for calibration to SeaBird's NWRCC facility in Washington State.

A SeaBird rosette sampler fitted with 12, 10-litre Niskin bottles was mounted above the frame. The bases of the bottles were level with the pressure sensor with their tops 0.75 m above it.

The standard operational procedure was to deploy the CTD to a depth of 10 m and leave it there until the pump had switched on and cleared the plumbing of bubbles. The instrument was then raised to the surface and the downcast commenced. However, during this cruise there was heavy swell combined with wind sea from a different direction and the ship rolled heavily when on station. Consequently, it was considered too risky to bring the instrument to the surface and the downcasts began at depths between 8 and 15 metres. There were also a small number of casts where additional downcast data were lost due to insufficient time being allowed for the system to equilibrate before lowering commenced.

The instrument was lowered continuously at approximately 1 m/s to the sea floor and then raised at the same rate in stages between bottle firing depths.

2) Data Acquisition

The CTD sampled at 24 Hz but this was automatically reduced to 3 Hz by the deck unit. The data were logged on a PC using the SeaBird SEASAVE program.

3) Post-Cruise Processing

The SeaBird DATCNV software was used to convert the binary raw data files into the calibrated ASCII data files supplied to BODC.

The salinity computation algorithm in the software is based on Fofonoff and Millard (1982). Salinity spiking on thermal gradients was minimised through software realignment of the temperature and conductivity channels.

3.1) Reformatting

The data were converted into the BODC internal format (PXF) to allow the use of in-house software tools, notably the workstation graphics editor. In addition to reformatting, the transfer program converted the dissolved oxygen from µmol/kg to µM by multiplying the values by (1000 + sigma-theta) / 1000.

3.2) Editing

Reformatted CTD data were transferred onto a high-speed graphics workstation for manual inspection using a custom in-house graphics editor. The top and bottom of the downcast were marked to eliminate noisy data logged whilst the instrument was stabilising.

The data were examined point by point and any obvious spikes were flagged 'suspect'.

Once screened on the workstation, the CTD downcasts were loaded into a database under the Oracle relational database management system. Note that the loader only included data from the downcast marked during screening.

Casts CTD23, CTD24 and CTD27 were particularly badly affected by a lack of downcast data, with virtually no temperature, salinity or oxygen in the top 100 m. Data were recovered whenever possible by patching in upcast values.

CTD31 was undertaken to collect water at a depth of 10 m, following a bottle problem on the previous cast. There were no usable downcast data. This was ‘fixed’ by patching in an upcast value. The water column was extremely well mixed allowing a constant value to be used.

3.3) Calibration

<u>Pressure</u>

The pressure calibrations were obtained by looking at the pressure values logged whilst the CTD unit was on the deck, which gave the following offset:

Corrected pressure = Raw pressure + 1.6 (n=40, S.D. = 0.15)

Temperature

The temperature data are believed to be accurate as supplied and no further calibrations have been applied.

Salinity

The salinity calibrations were derived by comparison of the values measured by the CTD with salinometer determinations on water bottle samples.

The following corrections have been applied to the data:

Corrected salinity = CTD salinity + 0.009 (n=13; S.D.=0.004)

Dissolved Oxygen

The CTD dissolved oxygen data were calibrated against water sample data obtained by the University of Liège using an automated Winkler titration technique. The bottle data were converted to units of µM at in-situ temperature and salinity prior to calibration.

The following equation was derived and has been applied to the data:

Corrected oxygen = CTD oxygen * 0.925 + 9.15 (n=161; R^2=97%)

Optical Attenuance

The SeaBird processing software included a source decay correction based on an initial air voltage of 4.664 (-0.001 V blocked) and current air voltage, taken in September 1997, of 4.658 volts (0.006 V blocked). However, measurements taken during the cruise indicated that the air voltage had dropped 4.597 volts (0.001 V blocked)

The data were brought into line with the cruise air reading data by subtracting 0.053 per m from the calibrated values generated by the SeaBird software. This reduced the clear water attenuance values from between 0.4 and 0.41 to a more credible range of 0.35 to 0.36.

3.4) Data Reduction

Once all screening and calibration procedures were completed, the data set was binned to 2 db (casts deeper than 100 db) or 1 db (casts shallower than 100 db). The binning algorithm excluded any data points flagged suspect and attempted linear interpolation over gaps up to 3 bins wide. If any gaps larger than this were encountered, the data in the gaps were set null.

Downcast values corresponding to the bottle firing depths were incorporated into the database. Oxygen saturations were computed using the algorithm of Benson and Krause (1984).

4) References

Benson B.B. and Krause D. jnr. 1984. The concentration and isotopic fractionation of oxygen dissolved in fresh water and seawater in equilibrium with the atmosphere. ***Limnol. Oceanogr.*** 29, pp.620-632.

Fofonoff N.P., Millard R.C. 1982. Algorithms for computation of fundamental properties of seawater. ***UNESCO Technical Papers in Marine Science*****.** 44**.**

CTD Data for Cruise Belgica 9919

Leg A: 30th August to 3rd September 1999
Leg B: 4th September to 11th September 1999
Leg C: 14th September to 18th September 1999

1) Instrumentation and Shipboard Procedures

The CTD profiles were taken with a SeaBird SBE09 *plus* system. The instrument was equipped with a sensor set comprising an SBE-3 temperature sensor and SBE-4 conductivity sensor. The system had a Temperature and Conductivity (TC) duct with an inertia-balanced pump flow, designed to improve the performance of the salinity measurements.

When not in use, the sensors were bathed in MilliQ water. SeaBird temperature sensors are high performance, pressure protected thermistors. Other sensors on the rig were a dissolved oxygen cell (YSI SBE-13-Y polargraphic membrane) and a SeaBird optical backscatter sensor.

The CTD was periodically sent for calibration to SeaBird's NWRCC facility in Washington State. An average of 4 salinity samples were taken per cast, stored in crown-corked beer bottles, and determined on Guildline Portasal laboratory salinometer, calibrated using OSI standard seawater.

A SeaBird rosette sampler fitted with 12, 10 litre Niskin bottles was mounted above the frame. The bases of the bottles were level with the pressure sensor with their tops 0.8 m above it.

2) Data Acquisition

The SeaBird SBE09 *plus* CTD system measured the depth of the sensor package, water temperature, conductivity, backscatter and dissolved oxygen at a rate of 24 samples per second. These data were averaged in the SeaBird deck unit over a 0.5-second interval. The resultant data were plotted on a VDU screen and used to decide water-sampling depths. The CTD software automatically marked the depths as part of the bottle firing sequence.

3) Post-cruise Processing

The SeaBird DATCNV software was used to convert the binary raw data files into the calibrated ASCII data files supplied to BODC.

The salinity computation algorithm in the software is based on Fofonoff and Millard (1982). Salinity spiking on thermal gradients was minimised through software realignment of the temperature and conductivity channels.

3.1) Reformatting

The data were converted into the BODC internal format (PXF) to allow the use of in-house software tools, notably the workstation graphics editor. In addition to reformatting, the transfer program converted the dissolved oxygen from µmol/kg to µM by multiplying the values by (1000 + sigma-theta) / 1000.

3.2) Editing

The in-house graphics editor at BODC was used to mark the start and end of the downcasts, to remove noisy data logged whilst the instrument was stabilising.

The data were screened, point-by-point, and any obvious spikes were marked "suspect".

Once screened, the CTD downcasts were loaded into a database under the Oracle relational database management system.

3.3) Calibration

Pressure

The pressure calibrations were obtained by looking at the pressure values logged whilst the CTD unit was on the deck. Data were available from legs A and C. The mean of the corrections from these legs was used for leg B.

The following corrections were applied:

Leg A: $\text{Pressure}_{\text{corrected}} = \text{Pressure}_{\text{observed}} - 0.51$ (N = 4, SD = 0.03)

Leg B: $\text{Pressure}_{\text{calibrated}} = \text{Pressure}_{\text{observed}} - 0.48$

Leg C: $\text{Pressure}_{\text{calibrated}} = \text{Pressure}_{\text{observed}} - 0.45$ (N =10, SD = 0.04)

Temperature

The temperature data are believed to be accurate as supplied and no further calibrations have been applied.

Salinity

The salinity sensor was calibrated against discrete samples analysed using a Guildline Portasal Model 8410 laboratory salinometer. There was excellent agreement between the CTD and bottle data, with a mean difference of 0.001

PSU (N=67, SD=0.005). As this correction is statistically insignificant, no salinity calibration has been applied to the data.

<u>Oxygen</u>

There were serious problems with the CTD dissolved oxygen sensor on this cruise. This was particularly obvious during leg A, where the bottle data showed the surface dissolved oxygen concentration to vary between 248 and 254 µM, whereas the CTD data ranged from 245 to 299 µM. The following strategy was adopted to salvage as much data as possible whilst ensuring that no poor quality data remained in the final data set.

Leg A

There was one deep cast with oxygen bottle data (05A) during leg A, which was calibrated using the equation:

Corrected oxygen = Raw oxygen * 1.88 – 308.8 (N=6, R^2=0.96)

The CTD oxygen data from all other casts on leg A were deleted from the data set.

Leg B

The oxygen sensor was more stable on this leg than the previous leg. However, data from the following casts were rejected either because there were no oxygen bottle data or data check (e.g. oxygen minimum) or because there was serious disagreement between the CTD and bottle data:

11A, 11B, 11C, 13A, 24A, 25A, 26A, 29B, 29C, 30C, 33B, 38A, 39A, 40A, 44B, 45C.

The following calibration was obtained from the remaining casts and has been applied to the data:

Corrected oxygen = Raw oxygen * 0.8732 – 25.74 (N=222, R^2=0.92)

Leg C

None of the problems observed in the Leg A data were present in the data from this leg of the cruise. No data have been deleted and the following calibration has been applied to all CTD casts from this leg:

Corrected oxygen = Raw oxygen * 0.823– 16.5 (N=63, R^2=0.94)

<u>Optical Backscatter</u>

The data were calibrated using the SeaBird software, based on a laboratory formazin calibration. No additional calibrations have been applied.

There is reason to query the data from casts taken on leg B after midday on 09/09/1999 and on leg C. The data values are exceptionally high and, more significantly, much higher at depth than at the surface. It is therefore recommended that these data be used with caution.

3.4) Data Reduction

Once all screening and calibration procedures were completed, the data set was binned to 2 db (casts deeper than 100 db) or 1 db (casts shallower than 100 db). The binning algorithm excluded any data points flagged suspect and attempted linear interpolation over gaps up to 3 bins wide. If any gaps larger than this were encountered, the data in the gaps were set null.

Downcast values corresponding to the bottle firing depths were incorporated into the database. Oxygen saturations were computed using the algorithm of Benson and Krause (1984).

4) Data Warnings

Some oxygen data have been deleted from the data set where the quality was questionable. However, the data that remain may be used with confidence.

The nephelometer data from the later part of leg B (after midday on 09/09/1999) and from leg C should be used with caution.

5) References

Benson B.B. and Krause D. jnr. 1984. The concentration and isotopic fractionation of oxygen dissolved in fresh water and seawater in equilibrium with the atmosphere. ***Limnol. Oceanogr.*** 29, pp.620-632.

Fofonoff N.P.and Millard R.C. 1982. Algorithms for computation of fundamental properties of seawater. ***UNESCO Technical Papers in Marine Science.*** 44.

CTD Data for Cruise Thalassa TH1099
13th October to 20th October 1999

1) Instrumentation and Shipboard Procedures

The CTD profiles were taken with a Neil Brown Systems Mk IIIB CTD including pressure, conductivity, temperature and dissolved oxygen sensors. A fluorometer and a transmissometer (type and path length unknown) were also included in the CTD package. A 24-position General Oceanics rosette with 12-litre Niskin bottles was fitted to the CTD frame to collect water samples.

2) Data Acquisition and On-board Processing

The data supplied to BODC conformed to the expected output format from the standard EG&G acquisition and processing software used with Neil Brown instruments. The data were supplied as 1-decibar binned values, labelled with the pressures of the midpoints of the bins. The transmissometer values were obviously raw voltages. The data from ST0898 included fluorometer data in the form of nominal chlorophyll concentrations. It has been assumed that the data from this cruise are also supplied as nominal chlorophyll concentrations.

3) Post-cruise Processing

3.1) Reformatting and Editing

The data were supplied to BODC as ASCII files, which were converted into the BODC internal format (PXF). Each profile was examined using an in-house graphical editing tool and any spikes observed in the data were flagged as suspect. Flags were also applied to the cycle number channel that indicated the start and end of the profile downcast. Twenty-two screened downcasts were loaded into the Oracle relational database management system.

3.2) Calibration

<u>Pressure</u>

No air-logged data were included in the data set. Consequently, the accuracy of the originator's pressure calibration could not be checked. The instrument was reported as calibrated in June 1999. There was no evidence of significant errors in the pressure values.

Temperature

No reversing thermometer data were available and consequently the originator's calibration could not be checked. The instrument was reported as calibrated in June 1999. There was no evidence of significant errors in the temperature values.

Salinity

No salinity sample data were taken on this cruise. However, a calibration data set, based on Autosal bottle salinity determinations, was made available from the second (non-OMEX) leg of this cruise. The overall calibration for this cruise leg was an offset of –0.044 (N=42, SD=0.020). This calibration has been applied to the data.

There is strong evidence from this calibration data set of drift in the CTD conductivity sensor, which can be seen in the variation of the individual cast calibrations:

CTD40	27/10/1999	Offset = -0.056	SD = 0.008
CTD77	31/10/1999	Offset = -0.021	SD = 0.007
CTD78	31/10/1999	Offset = -0.024	SD = 0.007
CTD102	05/11/1999	Offset = -0.062	SD = 0.008

The uncertainty in the calibration is relatively high, so the data from this cruise should not be used for applications that require top quality data. However, the calibration quantifies the accuracy of the data and consequently they may be used with confidence for some purposes.

Note that the deepest cast from this cruise was 500m. Consequently, theta-salinity plots couldn't be used to improve the quality of the salinity calibration.

Attenuance

The data supplied had values in the range 4.38 to 4.82, which are the values one would associate with transmissometer output values. Inspection of the data showed that the high values were associated with 'clear water', which confirmed that the data were voltages and not attenuance values.

The optical path length of the transmissometer was not supplied with the data. A simple modelling exercise showed that the only path length out of 5, 10, 20, 25 and 100 cm that gave anything like sensible attenuance values was 10cm. Consequently, a 10cm path length was assumed and the following equation was used to convert voltage to attenuance:

$$\text{Attenuance} = -10.0 * \ln(\text{Voltage}/5.0)$$

This resulted in attenuance values spanning the range from 0.375 to 1.541, which are of the correct order of magnitude for the OMEX II box.

No air correction data were available. A nominal air correction of –0.025 per metre was applied to the data, normalising the data to a clear water minimum value of 0.35 per m.

The data from the deep (500m) casts show a trend of increasing attenuance at depth as the cruise progresses. This is believed to be an artefact, but no attempt has been made to correct it.

Oxygen

There were no oxygen bottle data from this cruise. Normal BODC practice in such cases is to delete the CTD oxygen data from the data set. However, visual examination of the data gave the overall impression that the profiles were reasonable and it was considered worthwhile to produce a qualitative data set.

The data supplied were obviously not in any meaningful units, with data values in the region of 2. Such out of range values can cause all sorts of problems for any bespoke software that is more used to conventional oxygen concentrations. Consequently, the data were scaled to bring them into reasonable range. A scaling factor of 109.6 (based on normalising the data at 500m to data at the same depth from Belgica cruise BG9919) was used, which produces surface saturations in the range 90-100%.

Users should be under no illusion about these data. **They are NOT calibrated** and should be used for **QUALITATIVE** purposes only.

Chlorophyll

The only extracted chlorophyll data set available for this cruise was size-fractionated chlorophyll-a data from a trichromatic spectrophotometric assay. The fluorometer values were regressed against the summed size-fraction values, resulting in the following calibration equation:

Chlorophyll (mg/m^3) = Nominal chlorophyll * 0.3937 – 0.01 (n=77, R^2= 86.3%)

This has been applied to the data.

3.3) Data Binning

The final data set has been binned to give a resolution of 2 decibars. The manner in which the input data had been binned means that each binned value in the data set is effectively the average of one bin above and one bin below the pressure label on the output bin. For example, the output bin labelled 1 decibar is the average from the input bins labelled 0.5 and 1.5 decibars.

4) Warnings

The salinity data should not be used in high accuracy applications because there is strong evidence for drift between casts of up to 0.02 PSU.

The dissolved oxygen data are **NOT** calibrated. They should only be used qualitatively.