CTD
Data Documentation

Introduction

During the two Arabesque cruises, nearly 300 CTD casts were taken. This document describes the CTD data from both cruises (Discovery cruise 210, August - September 1994 and Discovery cruise 212, October - November 1994). It includes measurements made from the standard CTD unit (salinity derived from conductivity, temperature and depth) and from additional instrumentation attached to the CTD frame (a fluorometer, transmissometer, dissolved oxygen electrode and downwelling and upwelling PAR sensors). This document details the protocols used during data acquisition and processing.

N.B. Please note that all times given are in GMT which is local ship time minus four hours.

Instrumentation and Rig Geometry

The 289 CTD profiles were taken with an RVS Neil Brown Systems Mk3B CTD incorporating a pressure sensor, conductivity cell, platinum resistance thermometer and a Beckman dissolved oxygen sensor. The CTD unit was mounted vertically in the centre of a protective cage approximately 1.5 m square. Attached to the bars of the frame was a Chelsea Instruments Aquatracka fluorometer and a SeaTech red light (661 nm) transmissometer with a 25 cm pathlength.

A General Oceanics rosette sampler fitted with 12, 10 litre Niskin or lever-action Niskin bottles was mounted above the frame. The bases of the bottles were 0.75 m above the pressure head with their tops 1.55 m above it. One of the bottles was fitted with a holder for up to three digital reversing thermometers mounted 1.38 m above the CTD temperature sensor.

Lowering rates were generally in the range of 0.5-1.0 m/sec but could be up to 1.5 m/sec. Bottle samples were acquired on the ascent of all casts. Reversing thermometer readings were taken on 186 of the 289 casts.

Data Acquisition

The CTD sampled at a frequency of 32 Hz. These data were reduced in real time to a 1-second time series by the RVS Level A microcomputer system. These data were logged as raw counts on the Level C workstation via a Level B data buffer.

On-Board Data Processing

RVS software on the Level C (a SUN workstation) was used to convert the raw counts into engineering units (Volts for the transmissometer and fluorometer, ml/l for oxygen, mmho.cm^{-1} for conductivity and °C for temperature).

Salinity (Practical Salinity Units, as defined by the Practical Salinity Scale (Fofonoff and Millard 1982)) was calculated from the conductivity ratios (conductivity / 42.914) and a time lagged temperature.

Data were written onto Quarter Inch Cartridge tapes in RVS internal format and submitted to BODC for post-cruise processing and data-banking.

Post-Cruise Processing

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 multiplying the values by 44.66.

The raw transmissometer voltages were corrected for light source decay using a correction ratio computed from light readings in air taken during the cruise and the manufacturer's figure for the new instrument (4.802 V). The correction was applied as follows:

	From	To	Air Reading (V)
Cruise DI210			
	27/08/94 18:05	29/08/94 01:46	4.770
	29/08/94 01:46	30/08/94 03:39	4.773
	30/08/94 03:40	01/09/94 04:24	4.763
	01/09/94 04:25	02/09/94 00:09	4.761
	02/09/94 00:10	04/09/94 06:21	4.758
	04/09/94 06:22	06/09/94 08:48	4.763
	06/09/94 08:49	11/09/94 06:54	4.758
	11/09/94 06:55	14/09/94 11:28	4.766
	14/09/94 11:29	27/09/94 07:21	4.758
	27/09/94 07:22	30/09/94 09:23	4.761
Cruise DI212			
	16/11/94 12:56	15/12/94 11:40	4.763

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

$$attenuance = -4 * \ln (percent\ transmittance / 100)$$

Editing

Using a custom in-house graphics editor, the downcasts and upcasts were differentiated and the limits of the downcasts were manually flagged. Spikes on any of the downcast channels were manually flagged 'suspect' by modification of the associated quality control flag. An instrument spike was defined as a single value or small number of values which showed an inexplicable variation of more than the recommended target precision for that particular parameter. "Flagging" involved setting a single character quality control flag to denote the status of the data; in this way none of the original data values were edited or deleted during quality control. The following quality control flags were used :

- G   good data
- S   suspect data (instrument spike or malfunction)
- N   null data (not measured)

The pressure ranges over which the bottle samples were taken were logged by manual interaction with the editor. Usually, the marked reaction of the oxygen sensor to the bottle firing sequence was 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 purposes.

Once screened, the CTD downcasts were loaded into a database under the Oracle relational database management system and further edited as follows:

- on all deep (>300 metres) casts, the upwelling and downwelling PAR channels were all set to suspect as the light meters were taken off for deep casts.

Calibration

Calibration procedures involved comparing the raw output against discrete calibration samples taken concurrently. Particular care was taken to ensure maximum temporal coverage of calibration samples, in order that any time-dependent instrument drift could be fully corrected. Errant calibration points were rejected only if sampling occurred over a considerable gradient and there was reasonable doubt whether the CTD was sampling the same water as the discrete calibration sample. Simple linear regression or multiple linear regression was used to establish the calibration algorithms, apart from in the case of the Aquatrakka fluorometer where the voltage was regressed against log-transformed chlorophyll concentrations.

All calibrations described here have been applied to the data.

Pressure

The pressure offset was determined by looking at the pressures recorded when the CTD was clearly logging in air (readily apparent from the conductivity channel). A mean air value (standard deviation of 0.3 db) was determined for all the data from cruise DI210, giving the correction:

$$P_{corrected} = P_{observed} - 0.82 \text{ db}$$

For cruise DI212, two different pressure corrections were used (standard deviations of 0.29 and 0.27db respectively) as follows :

casts A1/6,9,16,18,22/,A2/6,A7/27,GOM2/3 : $P_{corr} = P_{obs} - 0.25 \text{ db}$

all other casts : $P_{corr} = P_{obs} - 0.35 \text{ db}$

Temperature

The CTD temperatures were in excellent agreement with the digital reversing thermometer readings. Hence no temperature calibration has been applied.

Salinity

Salinity was calibrated against 173 water bottle samples measured on the Guildline 55358 Autolab Salinometer during the two cruises. Samples were obtained from 172 of the 289 casts, usually at the maximum depth of the cast.

Samples were collected in glass bottles filled to just below the neck and sealed with plastic stoppers. Batches of samples were left for at least 24 hours to reach thermal equilibrium in the constant temperature laboratory containing the salinometer before analysis.

The corrections applied were:

Cruise DI210 : $S_{corrected} = S_{observed} + 0.0116$ (s d = 0.02)
Cruise DI212 : $S_{corrected} = S_{observed} + 0.03555$ (s d= 0.021)

Oxygen

The dissolved oxygen sensor was calibrated against 1032 water bottle samples analysed following the Winkler titration procedures outlined in Carpenter (1965). The samples were taken from 86 of the 289 casts, normally at several depths. The probe was stable throughout the cruise and therefore a single calibration has been applied to each cruise:

$$O_{corrected} = O_{raw} * 2.18 + 1.38 \ (R^2 = 95.2\%: n=533)$$
$$O_{corrected} = O_{raw} * 2.82 - 1.04 \ (R^2 = 96.7\%: n=499)$$

Oxygen saturation present in the data files was computed using the algorithm presented in Benson and Krause (1984).

Chlorophyll

Chlorophyll was measured with a Chelsea Mk2 Aquatrakka fluorometer calibrated against discrete samples taken from 654 shallow (<300 metres) CTD bottles. Samples were filtered through Whatman GF/F filters and frozen in liquid nitrogen until analysed on board. The frozen filters were extracted in 2-5 ml of 90% acetone and aliquot injected onto a C-8 reverse phase column. **Analysis was carried out by reverse phase HPLC**. The resultant concentrations of chlorophyll and diavinyl chlorophyll a were summed to give a total calibration concentration. The resulting calibration equations are:

$$\text{chlorophyll (mg/m}^3) = \exp(-1.75 + 0.794 * \text{raw-voltage}) \ (R^2 = 54.8\%)$$
$$\text{chlorophyll (mg/m}^3) = \exp(-3.12 + 1.73 * \text{raw-voltage}) \ (R^2 = 65.35\%)$$

In both cases, no significant quenching effects were observed; therefore there is no light term in either calibration.

NB Due to a zeroing problem with the fluorometer on both cruises, spurious concentrations were occasionally observed at depth. Any concentrations exceeding 0.1 mg/m^3 at depths of 200 metres or more have been flagged suspect.

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 have been computed using the algorithm of Benson and Krause (1984).

Data Warnings

Chlorophyll : Due to a zeroing problem with the fluorometer on both cruises, spurious concentrations were occasionally observed at depth. Any concentrations exceeding 0.1 mg/m^3 at depths of 200 metres or more have been flagged suspect

Bibliography

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