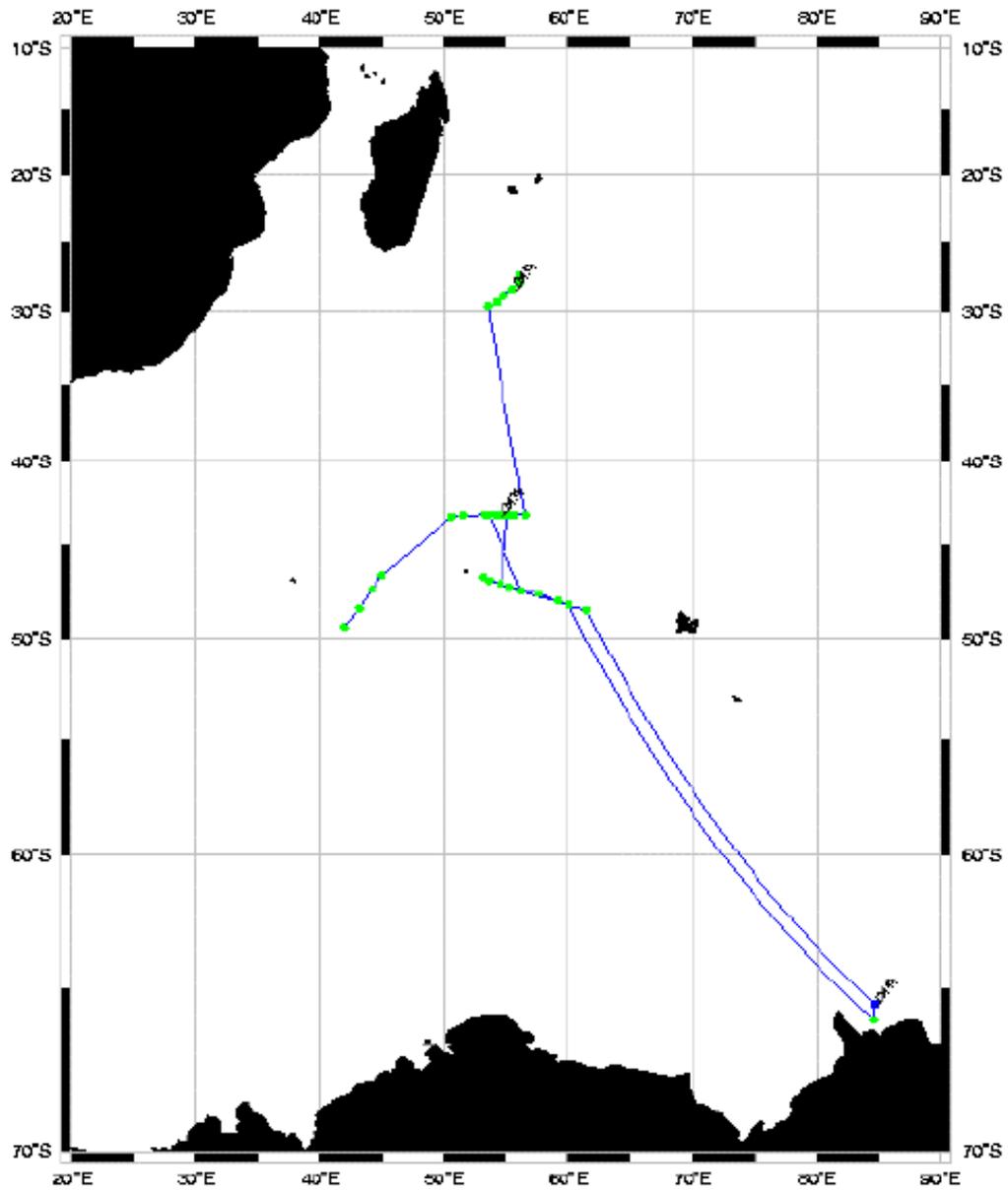# CTD Data for Cruise Discovery 207
(19th February 1994 – 31st March 1994)

Station locations for ISS1 : DICKSON

1. Introduction

CTD profile and bottle data are presented from the ADOX-2 cruise Discovery 207, as reported by Dickson *et al.* (1995).

2. Instrumentation

The CTD profiles were taken with a Neil Brown Systems MkIIIb CTD, mounted beneath a General Oceanics 24 by 10 litre bottle rosette. The CTD was fitted with a pressure sensor, conductivity cell, platinum resistance thermometer, a Beckman dissolved oxygen sensor, a Sea Tech 100cm path transmissometer and a Simrad 200kHz altimeter. 9 SIS (Sensoren Instrumente Systeme) digital reversing thermometers (T219, T220, T228, T238, T401, T714, T743, T746 and T790) were attached to the Niskin bottles. 2 SIS digital pressure meters (6292H and 6293H) were also used. Niskin bottle 24 was a Go-Flow type. No fluorometer was attached to the CTD package.

For the bottle rosette system the bases and tops of the bottles were, respectively, 0.75m and 1.55m above the CTD pressure sensor. The digital reversing thermometers were mounted 1.38m above the CTD temperature sensor.

3. Data Acquisition

Lowering rates for the CTD package were generally in the range $0.5\text{-}1.0\text{ms}^{-1}$ but could be up to 1.5ms^{-1}. CTD data were logged at 16 frames per second. The CTD deck unit passes raw data to a dedicated Level A microcomputer where 1 second averages are assembled. During this process the Level A calculates the rate of change of temperature and a median sorting routine detects and removes pressure spikes. This data is sent to the Level B for archival. The data are then passed to a Level C workstation for conversion to Pstar format and calibration.

Water samples were acquired on the up cast with the winch stopped. The CTD data acquisition system sends out a bottle firing code at the time of bottle firing. The code is logged as serial data by the Level A which timestamps its arrival.

A total of 33 stations were occupied (12628 – 12660). Station 12628 was for CFC calibration with all but one of the bottles firing at 2046db. After station 12632 the transmissometer was removed.

4. Data Processing

4.1. CTD Data

The 1 second data passed to the Level C were converted to Pstar format and initially calibrated with coefficients from laboratory calibrations followed by a number of calibration corrections. The up cast data (down cast for oxygen) were extracted for merging with the bottle firing codes, on time (pressure for oxygen), thus the CTD variables were reconciled with the bottle samples. Final calibrations were applied using the sample bottle data. Finally, down cast data were extracted, sorted on pressure and averaged to 2db values, with any gaps filled by linear interpolation.

Pressure

A quadratic calibration was applied of the form:

$$p \text{ (dbar)} = a \times p_{raw} + b \times p_{raw}^2 + c$$

A correction was applied for the effects of temperature on the pressure sensor:

$$p_{cor} = p - pT_{slope} \times (T_{lag} - T_{zero})$$

where pT_{slope} is the rate of change of deck offset with temperature. T_{zero} is the temperature at which the quadratic calibration of above gives the correct deck offset. T_{lag} is a lagged temperature, in °C, formed from the CTD temperature using a first order equation with a time constant for the rate of change of lagged temperature of t_{const} seconds. Lagged temperature is updated in the following manner. If T is the CTD temperature, t_{del} the time interval in seconds over which T_{lag} is being updated, and t_{const} the time constant, then:

$$W = \exp (-t_{del}/t_{const})$$

$$T_{lag} (t=t_0+t_{del}) = W \times T_{lag} (t=t_0) + (1 - W) \times T (t=t_0+t_{del})$$

During the cruise, the variation of deck pressure value with ambient temperature was monitored.

On the up cast, a further correction is made for the hysteresis of the pressure sensor based on laboratory measurements. For a cast in which the maximum pressure reached is p_{max} dbar, the correction to the up cast CTD pressure (p_{in}) is:

$$p_{out} = p_{in} - (dp5500(p_{in}) - ((p_{in}/p_{max}) \times dp5500(p_{max})))$$

where dp5500(p) is the hysteresis after a cast to 5500db.

A comparison of the CTD pressures with measurements from the SIS digital reversing pressure meters suggested that there was no change required in the CTD calibration.

Temperature

Initial calibration to the temperature was applied of the form:

$$T \text{ (°C)} = a \times (0.0005 \times T_{raw}) + b$$

Temperatures are given on the ITS90 scale. For the purpose of computing derived oceanographic variables, temperatures were converted to the 1968 scale ($T_{68} = 1.00024\ T_{90}$).

In order to allow for the mismatch between the time constants of the temperature and conductivity sensors, the temperatures were further corrected according to the

procedure described in the SCOR WG51 report (Crease *et al.* 1988). The time constant used was 0.20s giving a correction of:

$$\Delta T = T + (0.20 \times \Delta T)$$

where ΔT is the change in temperature over one second calculated by the Level A.

A comparison of the CTD temperatures with measurements from the SIS digital reversing thermometers suggested that there was no change required in the CTD calibration.

Salinity

Initial calibration of the conductivity using the cell ratio (cfac) was applied:

$$C \ (mmho/cm) = cfac \times (0.001 \times C_{raw})$$

The conductivity was then corrected for the effects of pressure and temperature in the manner described in the SCOR WG51 report (Crease *et al.* 1988) with nominal values employed for the temperature expansion and pressure contraction coefficients of the material of the cell:

$$C_{new} = C_{old} \times (1 + (Cp_{slope} \times p) + CT_{slope} \times (T - T_{org})$$

where Cp_{slope} (rate of change of cell ratio with pressure) = 1.5×10^{-8}, CT_{slope} (rate of change of cell ratio with temperature) = -6.5×10^{-6} and $T_{org} = 15°C$ (cfac is the cell ratio at pressure zero and temperature T_{org}). Salinity for both the down and up casts was then calculated from the corrected temperature, pressure and conductivity.

For each station the differences between the bottle sample salinities (S_{bot}) and the up cast CTD salinity (S_{ctd}) were calculated. A routine was used to derive coefficients for the relationship:

$$S_{bot} - S_{ctd} = a + (b \times press) + (c \times potemp)$$

The derived a, b, c coefficients were then used to correct all CTD salinities for both the up and down cast.

Oxygen

CTD oxygen was calibrated by fitting to sample values using the formula:

$$O_2 = oxsat(T,S) \times \ \times (oxyc + offset) \times \exp(\ \times (W \times T_{ctd} + (1 - W) \times oxyT) + \ \times p)$$

where the coefficients ,   and   were chosen on a station by station basis to minimise the rms residual.

4.2. Sample Data

Sampling from the Niskin bottles was done in the following sequence: CFCs, oxygen, salinity, nutrients, followed by oxygen/hydrogen isotope ratios. CFC samples were not drawn from the Go-Flow type bottle 24.

Chlorofluorocarbons

Samples were taken for analysis of CFCs 11, 12, 113 and CCl_4. The instrument was based on a gas chromatograph used by the PML CFC group previously. The main separation element was a megabore fused silica pre-column (DB-624), whose exhaust was delivered directly to an electron capture detector (ECD). Seawater samples were stripped of volatile dissolved gases by bubbling in a sparging tower. An unpacked trap was used to concentrate these compounds as they were liberated from the seawater prior to injection into the column. The ECD was calibrated by using samples of standard gas containing established proportions of the tracers. During the cruise the CCl_4 concentration of the standard was poorly established and marine air was used as the effective standard.

Oxygen

Bottle oxygen samples were taken in calibrated clear glass bottles. The pickling reagents were added on deck immediately after drawing and before capping. The temperature of the water at the time of chemical fixation was measured to allow corrections to be made for the change in density of the sample between the closure of the rosette bottle and the fixing of the dissolved oxygen. Analysis followed the Winkler whole bottle method with an automatic photometric endpoint detection. Standardisation of the thiosulphate titrant was done using a primary standard iodate solution supplied by WAKO Chemicals GmbH, Germany, and guaranteed by the Sagami Chemical Research Centre. The thiosulphate was checked on each day of use using the secondary standard iodate solution prepared from potassium iodate, UNIVAR product no. 504 48 00 batch 27986, SAARCHEM (pty) Ltd.

Problems with the analytical system meant that the endpoint had to be detected visually. Using the magnetic stirring and illuminating facilities of the instrument and manually operating the Metrohm 665 Dosimat, enabled titration to a visual endpoint with starch indicator.

Salinity

Salinity samples were analysed using MAFF Guildline 8400A and IOSDL Guildline 8400A bench salinometers set to run at 24°C in the temperature controlled laboratory (21°C). Standardisation was done using IAPSO Standard Seawater batches P120 and P123.

Replicate salinity samples (samples from the same bottle) were taken from rosette bottles 12 and 24. Bottle 2 was closed at the same depth as bottle 1, enabling duplicate samples to be taken. The differences between the bottle 12 replicates was

0.0000 ±0.0007, and for bottle 24 it was 0.0001 ±0.0005. The differences for the duplicate samples (bottle 1 – bottle 2) was 0.0001 ±0.0021.

Nutrients

Samples were drawn into 1 litre polyethylene bottles and analysed without filtration. Samples were analysed for nitrate, silicate and phosphate using the MAFF SKALAR SA4000 continuous flow auto-analyser. The auto-analyser carousel uses 8ml cups which were thoroughly rinsed with the sample.

Mean concentrations (μmol/l) and relative standard deviations (%) for sub-samples from the consistent bottles (21 of the 23 fired) of the CFC calibration station 12628 were:

Nitrate	Phosphate	Silicate
28.20 (0.64)	1.92 (2.60)	59.96 (1.80)

A bulk quality control sample was obtained by draining about 2 litres from each of the first 12 of these consistent bottles into a 25 litre polyethylene carboy. 2 aliquots of this sample were analysed among the samples from the subsequent CTD stations. Mean concentrations (μmol/l) and relative standard deviations (%) for the 60 analyses of this sample were:

Nitrate	Phosphate	Silicate
28.197 (0.938)	1.929 (1.981)	61.19 (0.847)

Oxygen and Hydrogen Isotope Ratios

Samples were collected into 250ml salinity bottles with plastic neck inserts, 250ml salinity bottles of the older metal screw top type and 150ml sample bottles also with metal screw tops. The latter 2 types of bottles were sealed with paraffin wax.

Delta oxygen-18 of water was measured using a mass spectrometer. No analyses were conducted for hydrogen isotope ratio.

Reversing Thermometers

9 SIS digital reversing thermometers were attached to the Niskin bottles.

5. BODC Data Processing

No further calibrations were applied to the data received by BODC. BODC were mainly concerned with the screening and banking of the data.

5.1. CTD Data

The CTD data were received as 2db averaged pressure sorted down cast data. The data were converted into the BODC internal format (PXF) to allow the use of in-

house software tools, notably the graphics editor. Spikes in the data were manually flagged 'suspect' by modification of the associated quality control flag. In this way none of the original data values were edited or deleted during quality control. These data from cruise Di207 required little flagging and just a few points were set suspect.

Once screened, the CTD data were loaded into a database under the Oracle relational database management system. The start time stored in the database is the CTD deployment time, and the end time is the time the CTD was removed from the water. Actually these times are more precisely the start and end of data logging. Latitude and longitude are the mean positions between the start and end times calculated from the master navigation in the binary merged file.

5.2. Sample Data

BODC conducted extensive quality control to eliminate rosette misfiring and any incorrectly assigned flag codes. Before loading to the database the data were averaged if bottles fired within ±4.0db of each other. At station 12643 the 2 bottles firing at 4002.06db and 4006.12db were also averaged.

6. References

Crease, J. *et al.* (1988). *The acquisition, calibration and analysis of CTD data*. UNESCO Technical Papers in Marine Science. No. 54, 96pp.

Dickson, R.R. *et al.* (1995). *RRS Discovery Cruise 207.* Ministry of Agriculture Fisheries and Food Directorate of Fisheries Research, Cruise Report, 79pp.