Preliminary data Report (1992.05.04) and Last PI update (1993.03.18) merged on 1999.11.03

A. Cruise Narrative

A.1 Highlights

A.1.a WOCE designation: AR04E/AR04W/AR15

A.1.b EXPOCODE 06mt22/2

A.1.c Chief Scientist:
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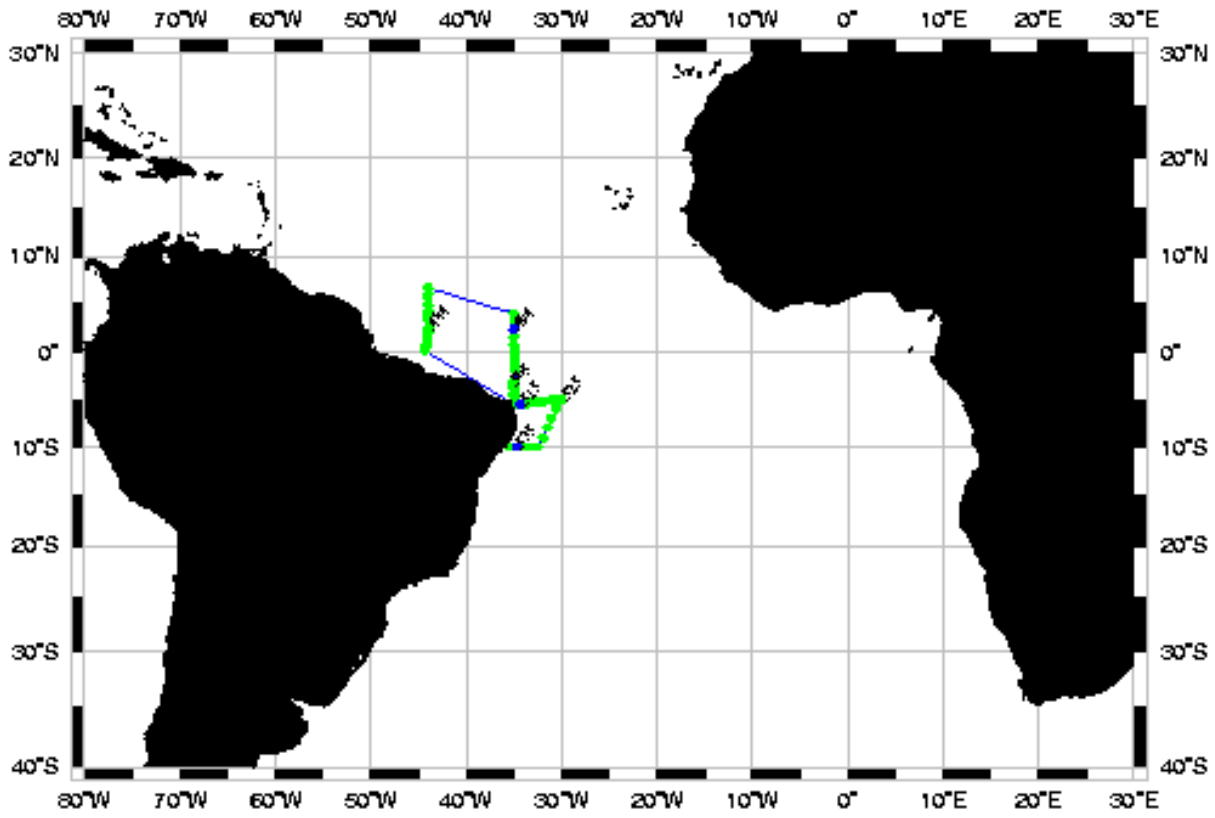
A.1.d Ship name: R/V METEOR

A.1.e Ports of call: Recife, Brazil - Recife, Brazil

A.1.f Cruise Dates: 23 Oct - 15 Nov 1992

A.2 Cruise Summary

A.2.a Geographic Boundaries



A.2.b Total number of stations Occupied

Total number of CTD stations: 65

Sampling equipment: small volume sampling: one 24-place rosette with 10-liter bottles

CTD system:	NBIS Mark III CTD, with O2 sensor and pinger
Salinometer:	2 Guildline Autosal
ADCP:	153 kHz ADCP manufactured by RDI, USA
Pegasus:	Benthos-Pegasus
Chlorofluorocarbons:	GC, Integrator: Shimadzu
Oxygen:	Winkler titration
XBT:	Sippican Deep Blue probes

Sampling: Water sampling on the cruise included measurements of salinity, both by CTD and water bottle samples, CTD and bottle sample oxygen determinations, CTD temperature. Tracer analysis were made for CFC-11 and CF-12.

A.2.c Floats and drifters deployed
A.2.d Moorings deployed or recovered

A.3 List of Principal Investigators

Table 1: List of Principal Investigators

Parameter/Instrument Measurements	Sampling group	Responsible investigator
CTD / Rosette	IfM Kiel	Lothar Stramma
chlorofluorocarbons	IfM Kiel	Monika Rhein
ADCP	IfM Kiel	Jurgen Fischer
Pegasus	IfM Kiel	Uwe Send
salinity	IfM Kiel	Jurgen Langhof
oxygen	IfM Kiel	Joanna Waniek
XBTs	IfM Kiel	Gerhard Kroll

IfM Kiel
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A.4 Scientific Programme and Methods

During M22/2, the circulation and water mass exchange in the tropical western Atlantic were studied as part of the German WOCE program. The western boundary current is an

important part of the thermohaline circulation, not only for inter-hemispheric water mass transfer, but also for the meridional heat transport. In order to determine the mean transports of the various water masses and their variability, three current meter moorings were deployed in the boundary current at 44W. Shipboard direct velocity measurements were carried out with two acoustic systems, the ADCP (both lowered with the CTD, and vesselmounted) and the Pegasus profiling system. The CTD measurements were completed by oxygen and Freon measurements to determine water mass boundaries and the spreading pattern of the various water masses and their variability. Additionally, XBTs were dropped to improve the spatial resolution.

The METEOR left the harbour of Recife at 23 October, 10:00 a.m., heading north. The measurement systems worked well except for the new broad band ADCP (BBADCP), delivered to the METEOR on 23 October, and designated to measure velocities in the deep ocean only yielded useful velocity profile data in the upper 1500 m, due to small signal to noise ratio at depth where scatterer concentration was low.

After reaching the 44∞W section, the transport of the North Brazil Current (NBC) on the Brazilian shelf was surveyed with the shipboard ADCP on 26 October from 1 00'S, 44 24'W to 0 01'N, 44 24'W. On 27 and 28 October, the three moorings were deployed off the Brazilian coast (mooring K359: 0 14.6'N, 44 18.6'W; K360: 0 37'N, 44 10'W; K361: 1 11.2'N, 44 02.7'W). Each mooring is equipped with upward-looking ADCP which measures the currents in the upper 300m, and with 7-9 conventional Aanderaa current meters.

The CTD and Pegasus profiling along the 44W section was continued till 31 October, when we reached our northernmost position at 6 40'N. Two CTD stations were placed north of the CEARA Rise (5 42.4'N and 60 4.6'N) to estimate a likely flow of lower North Atlantic Deep Water along this northern path.

The 35W section was reached on 12 November and began with 4 CTD stations to 2500 m depth. South of 1S, the CTD was again lowered to the bottom. At the southern end of the 35W section four bottom transponders (at each location two) were deployed at 3 59'S, 34 57'W (S14) and at 4 30'S, 35 05'W (S15) on 6-7 November. The CTD/ADCP work on that section continued till 7 November, 19:00 when we reached the shelf at 5 01'S, 35 00'W.

After proceeding to the 5S section the work began with a shallow CTD cast. On 9 November, the ADCP connected to the rosette failed due to intrusion of water. It could not be fully replaced by the BBADCP, as this instrument was only capable to cover the upper 1500 m. To complement the current measurements of the 5S section, two additional Pegasus stations at 5 15'S, 32 00'W (S16) and 5 10'S, 31 30'W (S17) were installed on 10 November. On this section, also tritium and helium samples were taken from the 10 1 Niskin bottles. They will be analyzed at the Institute fur Umweltphysik, Heidelberg. The easternmost CTD station was done at 5S, 30 0'W, and on 11 November the METEOR headed southwest to 10S, 32 30'W.

The 10S section began on 13 November, 13:00, with CTD stations to the bottom and the BBADCP attached. The BBADCP profiles there were only useful for the upper 1000 m. Altogether, 10 CTD stations were carried out on that section, which ended on 14 November, 23:00. The ship headed north towards Recife, where we arrived at 15 November, 11:00.

A.5 Major Problems and Goals not Achieved
A.6 Other Incidents of Note
A.7 List of Cruise Participants

B. Underway Measurements

B.1 Navigation and bathymetry
B.2 Acoustic Doppler Current Profiler (ADCP)
B.3 Thermosalinograph
B.4 XBT and XCTD
B.5 Meteorological observations
B.6 Atmospheric chemistry

C. Hydrographic Measurements

D. Acknowledgments

E. References

Unesco, 1983. International Oceanographic tables. Unesco Technical Papers in Marine Science, No. 44.

Unesco, 1991. Processing of Oceanographic Station Data, 1991. By JPOTS editorial panel.

F. WHPO Summary

Several data files are associated with this report. They are the metr22l2.sum, metr22l2.hyd, metr22l2.csl and *.wct files. The metr22l2.sum file contains a summary of the location, time, type of parameters sampled, and other pertinent information regarding each hydrographic station. The metr22l2.hyd file contains the bottle data. The *.wct files are the ctd data for each station. The *.wct files are zipped into one file called metr22l2wct.zip. The metr22l2.csl file is a listing of ctd and calculated values at standard levels.

The following is a description of how the standard levels and calculated values were derived for the metr22l2.csl file:

Salinity, Temperature and Pressure: These three values were smoothed from the individual CTD files over the N uniformly increasing pressure levels using the following binomial filter-

$$t(j) = 0.25ti(j-1) + 0.5ti(j) + 0.25ti(j+1) \quad j=2....N-1$$

When a pressure level is represented in the *.csl file that is not contained within the ctd values, the value was linearly interpolated to the desired level after applying the binomial filtering.

Sigma-theta(SIG-TH:KG/M3), Sigma-2 (SIG-2: KG/M3), and Sigma-4(SIG-4: KG/M3): These values are calculated using the practical salinity scale (PSS-78) and the international equation of state for seawater (EOS-80) as described in the Unesco publication 44 at reference pressures of the surface for SIG-TH; 2000 dbars for Sigma-2; and 4000 dbars for Sigma-4.

Gradient Potential Temperature (GRD-PT: C/DB 10-3) is calculated as the least squares slope between two levels, where the standard level is the center of the interval. The interval being the smallest of the two differences between the standard level and the two closest values. The slope is first determined using CTD temperature and then the adiabatic lapse rate is subtracted to obtain the gradient potential temperature. Equations and Fortran routines are described in Unesco publication 44.

Gradient Salinity (GRD-S: 1/DB 10-3) is calculated as the least squares slope between two levels, where the standard level is the center of the standard level and the two closes values. Equations and Fortran routines are described in Unesco publication 44.

Potential Vorticity (POT-V: 1/ms 10-11) is calculated as the vertical component ignoring contributions due to relative vorticity, i.e. pv=fN2/g, where f is the coriolius parameter, N is the bouyancy frequency (data expressed as radius/sec), and g is the local acceleration of gravity.

Bouyancy Frequency (B-V: cph) is calculated using the adiabatic leveling method, Fofonoff (1985) and Millard, Owens and Fofonoff (1990). Equations and Fortran routines are described in Unesco publication 44.

Potential Energy (PE: J/M2: 10-5) and Dynamic Height (DYN-HT: M) are calculated by integrating from 0 to the level of interest. Equations and Fortran routines are described in Unesco publication, Processing of Oceanographic station data.

Neutral Density (GAMMA-N: KG/M3) is calculated with the program GAMMA-N (Jackett and McDougall) version 1.3 Nov. 94.

G. Data Quality Evaluation

Cruise Plan

Line AR4E 35°W - 2°N to Brazil

Logistical requirements:
Length (nm): 420
Small Volume Stations: 15
Repeats/Yr: 4x No. of Yrs: 1
Program constraints: Once each season with 30 nm station spacing.

Operator: GERMANY
Chief scientist: Rhein/IfMK
Ship: METEOR (POST-7/64) Cruise/leg: 06MT22/2
Cruise date: Oct. 23-Nov. 15 1992
Cruise plan received:
Cruise report received: March 93
ADCP: Fischer/IfMK
CTD: Stramma/IfMK
Chlorofluorocarbons-all types: Rhein/IfMK
Moorings - any type: Unknown
Oxygen: Waniek/IfMK
Pegasus instrument: Send/IfMK
Salinity: Langhof/IfMK
XBT: Kroll/IfMK
Notes: Broad band ADCP and lowered ADCP on rosette used for most of cruise.