Preliminary data report
March 28, 1995

A. Cruise Narrative

A.1 Highlights

A.1.a Expedition Designation AR16/AR06

A.1.b EXPOCODE: 07AL991/1 through /4

A.1.c Chief Scientist: Eberhard Hagen, IfMW

A.1.d Ship: R/V A.V.Humboldt

A.1.e Ports of Call: Leg 1: Rostock, Germany to Lisboa, Portugal
Leg 2: Lisboa to Casablanca, Marocco
Leg 3: Casablanca to Lisboa
Leg 4: Lisboa to Rostock

A.1.f Cruise Dates: Leg 1: August 20 to August 30, 1991
Leg 2: September 2 to September 13, 1991
Leg 3: September 17 to October 15, 1991
Leg 4: October 18 to October 25, 1991

A.2 Cruise Summary

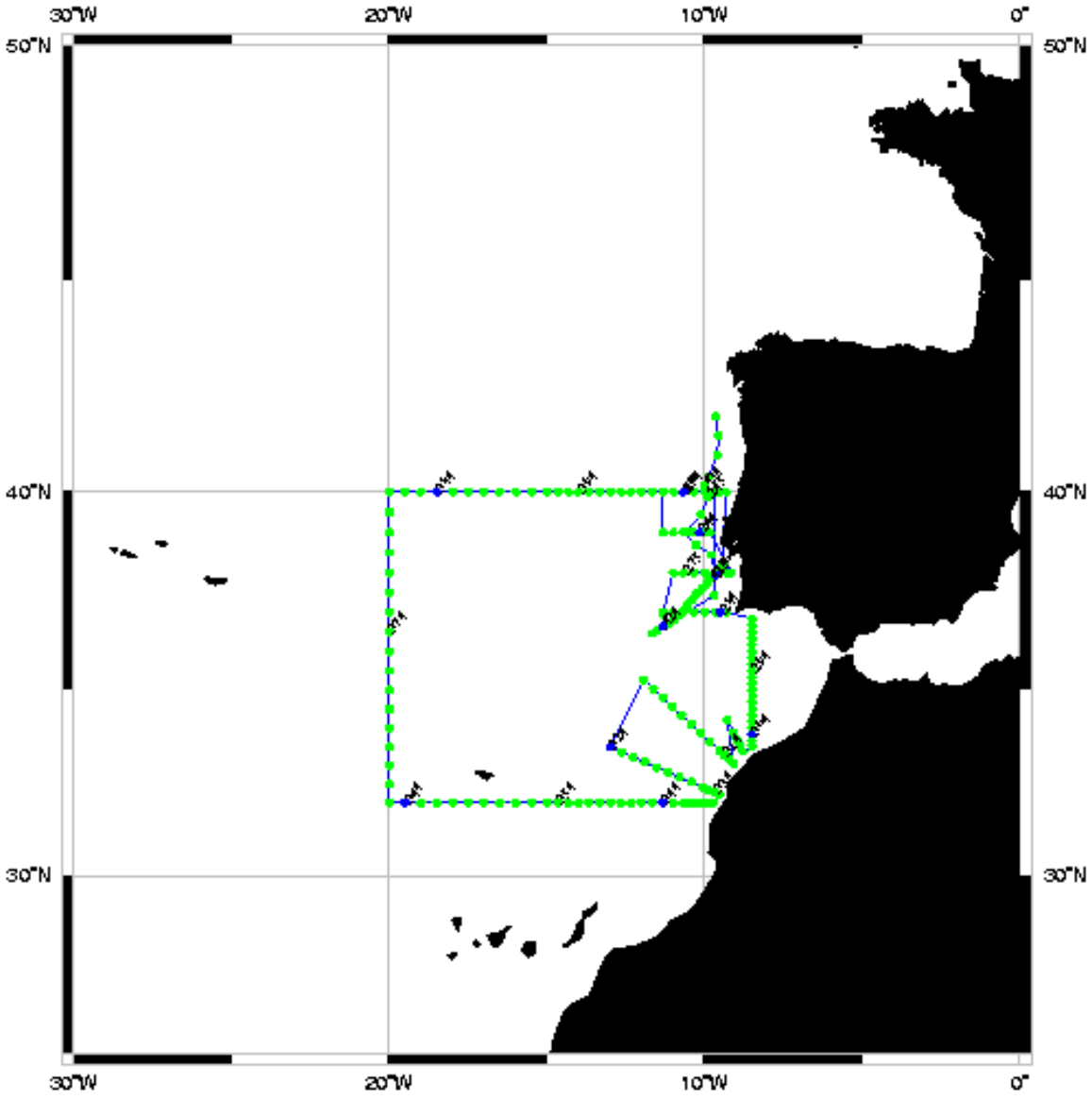
A.2.a Geographic boundaries

A.2.b Number of stations occupied

During the cruise a total of 196 CTD/rosette stations were occupied using a CTDO equipped with a rosette of 12*2.7 l teflon-type water sampling bottles.

- CTDO and sound speed;
- salinity and oxygen of water samples;
- temperature and pressure by reverse deep sea thermometers
- air-pressure, temperature, humidity up to an attitude of about 30 km by radiosondes: 56 starts
- stepwise current meter profiling (0-500 m) using
- GPS navigation system: 58 stations
- temperature/salinity in 2 m depth between stations continuously: 54 days
- skin-SST by means of Heiman KT4 radiometer (10-12 *10**-6 m): 54 days
- meteorological standard parameters: 54 days
- pyranometer: 54 days

Station locations for AR16 : HAGEN



A.3 Principal Investigators

Table 1: Principal Investigators*		
Name	Responsibility	Institution
E. Hagen	CTDO,S,O2,Current Profiles	IfMW
R.Feistel	SST	IfMW
E.Mittelstaedt	Currents	BSH
* See Table 2 for list of Institutions		

Table 2: List of Institutions	
Abbreviation	Institution
BAH	Biologische Anstalt Helgoland
	Martin-Luther-King-Platz 3
	Hamburg, Germany 20146
BSH	Bundesamt fuer Seeschiffahrt und
	Hydrographie
	Postfach 30 12 20
	Hamburg, Germany D-20305
IfMW	Institut fuer Meereskunde Warnemunde
	Seestr. 15
	D-18119 Rostock-Warnemande
	Germany
IOW	Institut fuer Ostseeforschung
	Warnemuende, Germany
	d-18119

A.4 Scientific Programme and Methods

A.5 Major Problems

The CTD data of station 252-253 were disturbed and have been discarded. At station 276 the OM-87 probe No 1 was lost during the up cast when the cable parted. From station 277 to 434 the OM-87 probe No 2 was used.

A.6 Other Incidents of Note

A.7 List of Cruise Participants

Table 3: List of Cruise Participants		
Name	Responsibility	Institution*
Leg 1-4		
Eberhard Hagen	Chief Scientist, radiosondes starts	IfMW(IOW)
Stefan Weinreben	CTD-Software	IfMW(IOW)
Henry Will	CTD-Hardware, current profiling	IfMW(IOW)
Rainer Feistel	Skin-Bulk-SST	IfMW(IOW)
Christoph Zuelicke	Skin-Bulk-SST	HUB
Guenter Plueschke	Salts, CTD Winch	IfMW(IOW)
Wolfgang Hub	Oxygen, CTD Winch	IfMW(IOW)
Dieter Fritsch	Precision Mechanics	IfMW(IOW)
Leg 1-2		
Holger Klein	Moorings	BSH
Holger Giese	Moorings	BSH
Leg 4		
Guido Schmuck	Skin-Bulk-SST	IRSA
*See Table 2 for list of Instituions		

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

C.1 CTDO

The CTDO and the sensors are manufactured at the institu fuer Meereskunde Warnemuende, Germany. The CTDO is an OM-87 = Oceanological Measuring System, consisting of an expandable dividing CTDO-probe, interfaced through a special designed slave-computer, a meteorological subsystem interfaced by a second slave-computer and a master-PC. The IfMW meteorological subsystem interfaced by a second slave-computer and a master-PC. The IfMW began to develop oceanographic measuring systems in the 1960's. The first computer controlled CTD-

system, OM-75 (Moeckel, 1980) was taken into service in 1976. The new generation: OM-87 has been used since 1988.

The CTD is equipped with frequency-analogous sensors at standard ports, developed and manufactured by IfMW; the oxygen sensor together with FSI "Kurt Schwabe", Meinsberg, Germany.

C.1.a Sensor Configuration List

The various sensors used on the different CTDs are listed in Table 3 by station and CTD number.

Table 4: CTD sensor configuration

CTD/Stat. No.	Parameter	Sensor	Resolution	Precision
CTD No. 1/Sta. 240-276	Pressure	P251	0.1 dbar	2 dbar
CTD No. 2/Sta. 277-311	Pressure	P600	0.2 dbar	5 dbar
CTD No. 2/Sta. 312-342	Pressure	P252	0.1 dbar	2 dbar
CTD No. 2/Sta. 343-434	Pressure	P601	0.2 dbar	5 dbar
CTD No. 1/Sta. 240-276	Temp	T102	0.0015 K	0.01 K
CTD N0. 2/Sta. 277-434	Temp	T106	0.0015 K	0.01 K
CTD No. 1/Sta. 240-251	Conductivity	C854	0.0008 mS/cm	
CTD No. 1/Sta. 254-276	Conductivity	C858	0.0008 mS/cm	
CTD No. 2/Sta. 277-311	Conductivity	C854	0.0008 mS/cm	
CTD No. 2/Sta. 312-434	Conductivity	C884	0.0008 mS/cm	
CTD No. 1/Sta. 240-276	Oxygen	O022	0.01 ml/l	0.1 ml/l
CTD No. 2/Sta. 277-295	Oxygen	O027	damaged	
CTD No. 2/Sta. 312-325	Oxygen	O023	damaged	
CTD No. 1/Sta. 240-276	Speed of Sound	V216	0.025 m/s	0.3 m/s
CTD No. 2/Sta. 277-279	Speed of Sound	V217	0.025 m/s	0.3 m/s
CTD No. 2/Sta. 280-311	Speed of Sound	V217	damaged	

All sensors were calibrated before the cruise at the calibration laboratory of IfMW. The oxygen sensor was recalibrated during the cruise at the first station with water samples. The calibration constants of all sensors were checked up by the in situ comparisons of p, T, C, O2.

B.1.b CTDO

The down cast data were recorded on hard disk.

Sampling rate: 1 record in 1.2s = 0.83 HZ integration time of sensors: 1s lowering speed of CTD: 1.0 m/s time constants: pressure and temperature sensors = 0.1 s conductivity sensor = 0.1 s at 1 m/s lowering speed.

The calibration constants of pressure, temperature, conductivity, sound speed sensors and the recalibration constants of the oxygen sensor were used over the whole cruise. The check measurements of CTDO and water sample data (in situ comparisons) were used for calculating the post-cruise corrections.

B.1.c Post-Cruise CTD Data Processing

The raw data are digitized frequencies, which had been converted to physical units of pressure, temperature, conductivity, oxygen and sound speed. A validation routine was applied to the CTDO down cast data (LASS et al., 1983), to eliminate:
1. data values, which are not physically realizable.

2. Random errors by recursive low-pass filtering (Acheson, 1975).

3. Systematic errors caused by the effect of ship's rolling and pitching on the lowering rate of CTD. Records acquired while CTD is moving down too slowly have been discarded to enforce a strict monotonic sequence in pressure. The so called eddy-algorithm in connected view with the values of sensor integration time and lowering rate reduce the effect of different time lags of the sensors to minor importance.

The calculation of salinity from conductivity and conversion of dissolved oxygen of volumetric to weight concentration were done last after correcting the data as described below. Dissolved oxygen was converted according to the WOCE Operations Manual (1991).

The data haven't been averaged finally in 2 dbar increments because of the low sampling rate of the CTD and a great amount of discarded records in the course of data processing, up to 50% on average.

C.1.d CTD Post-Cruise Corrections

In order to get the CTDO to match the water sample and, respectively, the thermometer data that following fits defined in Table 5 were applied to the CTDO data.

Table 5: CTD calibration Coefficients

CTD No./Sta. No.	Sensor	Fitting Parameter	Fitting Polynomials
	pressure	linear fit	PRESfitted=A0+A1*PRES
		A0	A1
240-251	P251	3.8	1.006
254-276	P251	3.8	1.006
	pressure: data discarded		
252-253	P251		
	pressure: temperature correction		PREScorr.=PRES+A0+A1*TEMP
	A0	A1	
277-311	P600	36.2	1.38
	pressure: linear fit:		PRESfitted=A0+A1*PRES
	A0	A1	
312-342	P252	1.41	1.019
343-434	P601	30.44	0.96943
	Temperature: no fit; measured data were of higher quality than the thermometer data		
240-251	T102		
254-276	T102		
277-434	T106		
	temperature: data discarded		
252-253	T102		
	conductivity: pressure correction:		CONDcorr.=COND+A0+A1*PRES
	A0	A1	
240-251	C854	-7.315E-2	7.409864E-5
	conductivity: data discarded		
252-253	C853		
	conductivity: time dependend correction		CONDcorr.=COND+A0+A1*TIME
TIME/hours=Beginning time of cast(in continuously caunted hours of the year: January 1; 0 o'clock:			

TIME=0 hours)

		A0	A1
254-268	C858	13.03789	-2.20388E-2
269-276	C858	-1.30243	2.178216E-4

conductivity: quadratic fit:
CONDfitted=A0+A1*COND+A2*COND**2

		A0	A1	A2
277-311	C854	1.8108	0.921699	8.507983E-4

conductivity: time dependend correction
CONDcorr.=COND+A0+A1*TIME
TIME/hours=Beginning time of cast(in continuously caunted hours of the year: January 1; 0 o'clock:
TIME=0 hours)

		A0	A1
312-339	C884	9.41769	-1.496255E-3
340-350	C884	-42.25939	6.661E-3
351-381	C884	1.72513	-2.265E-4
382-426	C884	-2.18171	3.68E-4
427-434	C884	-1.410598	2.52E-4

oxygen: linear fit: OXYGfitted=A0+A1*OXYG

	(ml/l) A0	A1	
240-251	O022	0.654	0.9744

oxygen: pressure correction
OXYGcorr.=OXYGfitted+A0+A1*PRES

	(ml/l) A0	A1	
254-276	O022	0.694	1.3549E-4

oxygen: data discarded

252-253	O022
277-295	O027
312-325	O023

sound speed: no fit

240-251	V216
254-276	V216
277-279	V116

sound speed: data discarded

252-253	V216
280-311	V217

C.1.e Calibration

All sensors were precalibrated at the calibration laboratory of IfMW. Each oxygen sensor was recalibrated with water samples during the cruise at the first station when it was taken. The calibration constants of all sensors were checked up by in situ comparisions of p, T,C, O2.

C.1.f CTD Errors and Noise

During the cruise located faulty sensors were replaced as listed above in the CTD sensor configuration list. After the cruise following sensor failures were detected and the data were discarded:

Oxygen from station 277-434 Speed of sound from station 280-311

C.2 Water sampling for In Situ Comparisons

After finishing the down cast (CTDO-recording), the CTD was lifted and stopped within well mixed layers. After 10 minutes waiting to let the deep-sea thermometers adapt to the surrounding temperature two water bottles were tripped while a short time CTDO recording. The deep sea thermometers (2 protected and 2 unprotected) were reversed simultaneously with the first bottle tripping.

When the first bottle of each sampling depth tripped correctly the water samples (2 dissolved oxygen and 2 salinity) were drawn from these bottles, otherwise from the second ones.

The S and O data of the water samples so as the reverse temperature and pressure data were used for the post-cruise corrections of CTDO data.

C.3 Salinity

The water sample salinities were measured with a Guildline Autosal Model 8400A salinometer, manufactured by Guildline Instruments Ltd., Smiths Falls, Canada. The salinometer was standardized weekly with IAPSO Standard Seawater (SSW) Batch P 111. Differences in standardization readings were less than 3.

The salinometer manufacturer claims a precision of 0.0002 and an accuracy of better than 0.003; better than 0.001 when the laboratory temperature is constant (=/- 1K) and about 1-2 K below the bath temperature of the salinometer.

C.4 Oxygen

The dissoloved oxygen samples were analysed by the Winkler Titration Method modificated by CARRITT and CARPENTER (1966).

Temperature (reverse thermometers) The following reverse thermometers were used: manufactured by: VEB Thermometerwerk Geraberg,Germany

	scale	graduated in
pressure protected	-2...+30degC	0.1K
unprotected	-2...+30degC	0.1K

Duplicate Water Samples

Two or three duplicate salinity and oxygen samples were drawn from a bottle usually. The differences between the salinity and oxygen measurements of the duplicate water samples and the standard deviation of the differences are shown in the following table:

	average difference between samples	maximum diff.	standard deviation of all differences
salinity	0.0015 PSU	0.009 PSU	0.0018
oxygen	0.011 ml/l	0.03 ml/l	0.0189

C.5 Laboratory and Sample Temperatures

The laboratory was temperature controlled :24...26 degC. The bath temperature of the Autosal salinometer was set to 27 degC. Salinity and oxygen samples had been tempered at room temperature when measured.

C.5.a Standards used

I.A.P.S.O Standard Seawater ,Batch P111 , 7.2.89 During the cruise this batch was used only.

D. Acknowledgments

E. References

Acheson, D.T., 1975. Data Editing--Subroutine EDITQ. NOAA Technical Memorandum EDS CEDDA-6.

Lass, H.U., Wulff, C., Schwabe, R., 1983. Methoden und Programme zur automatischen Erkennung und Korrektur von Messfehlern in ozeanologischen Vertikalprofilen. Beitrage zur Meereskunde, Heft 48, pp 95-111, Berlin.

Moeckel, F., 1980. Die ozeanologische Messkette OM 75, eine universelle Datenerfassungsanlage fuer Forschungsschiffee. Beitraege zur Meereskunde, Heft 43, pp 5-14, Berlin.

Wlost, K.-P., 1993. The OM-87-System: a brief description. Institut of Baltic Reasearch Warnemnde, Germany. unpublished paper.

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.

WOCE Operations Manual, Vol. 3, Sec.3.1, Part 3.1.2, 1991. WHP Office Report WHPO 90-1, WOCE Report No. 67/91, Woods Hole, Mass., USA.

WOCE Operations Manual, Vol. 3, Sec 3.1, Part 3.1.3: WHP Operations and Methods; C.H. Culberson: Dissolved Oxygen, WHP Office Report WHPO 91-1, WOCE Report No. 68/91,1991, Woods Hole, Mass., USA.

F. WHPO Summary

Several data files are associated with this report. They are the ebc2.sum, ebc2.hyd, ebc2.csl and *.wct files. The ebc2.sum file contains a summary of the location, time, type of parameters sampled, and other pertient information regarding each hydrographic station. The ebc2.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 ebc2.wct.zip. The ebc2.csl file is a listing of ctd and calculated values at standard levels.

NOTE Preliminary *.csl files were not created due to the CTD data being provided with non-uniform levels.

Cruise Plan

Line AR6 Lisbon to Madeira to Morocco

Logistical requirements:
Length (nm): 1590
Small Volume Stations: 54
Repeats/Yr: 4x No. of Yrs: 1
Program constraints: Vessel to be equipped with GPS and ADCP and done once in each season with 30 nm station spacing. Accuracy requirements spelled out by CP1-4.

Operator: GERMANY
Chief scientist: Hagen/IOW
Ship: VON HUMBOLDT, Cruise/leg: 07AL991/2
Cruise date: Sept. 2-Sept. 1 1991
Cruise plan received: Sept. 90
Cruise report received: Sept. 93
ADCP: Mittelstaedt/BSH
CTD: Hagen/IOW
Meteorological measurements: Unknown
Oxygen: Hagen/IOW
Salinity: Hagen/IOW
Thermosalinograph: Feistel/IOW
Notes: Work also done in AR16 area.

Operator: GERMANY
Chief scientist: Hagen/IOW
Ship: VON HUMBOLDT, Cruise/leg: 07AL991/3
Cruise date: Sept. 17-Oct. 1 1991
Cruise plan received: Sept. 90
Cruise report received: Sept. 93
ADCP: Mittelstaedt/BSH
CTD: Hagen/IOW
Meteorological measurements: Unknown
Oxygen: Hagen/IOW
Salinity: Hagen/IOW
Thermosalinograph: Feistel/IOW
Notes: Work also done in AR16 area.