

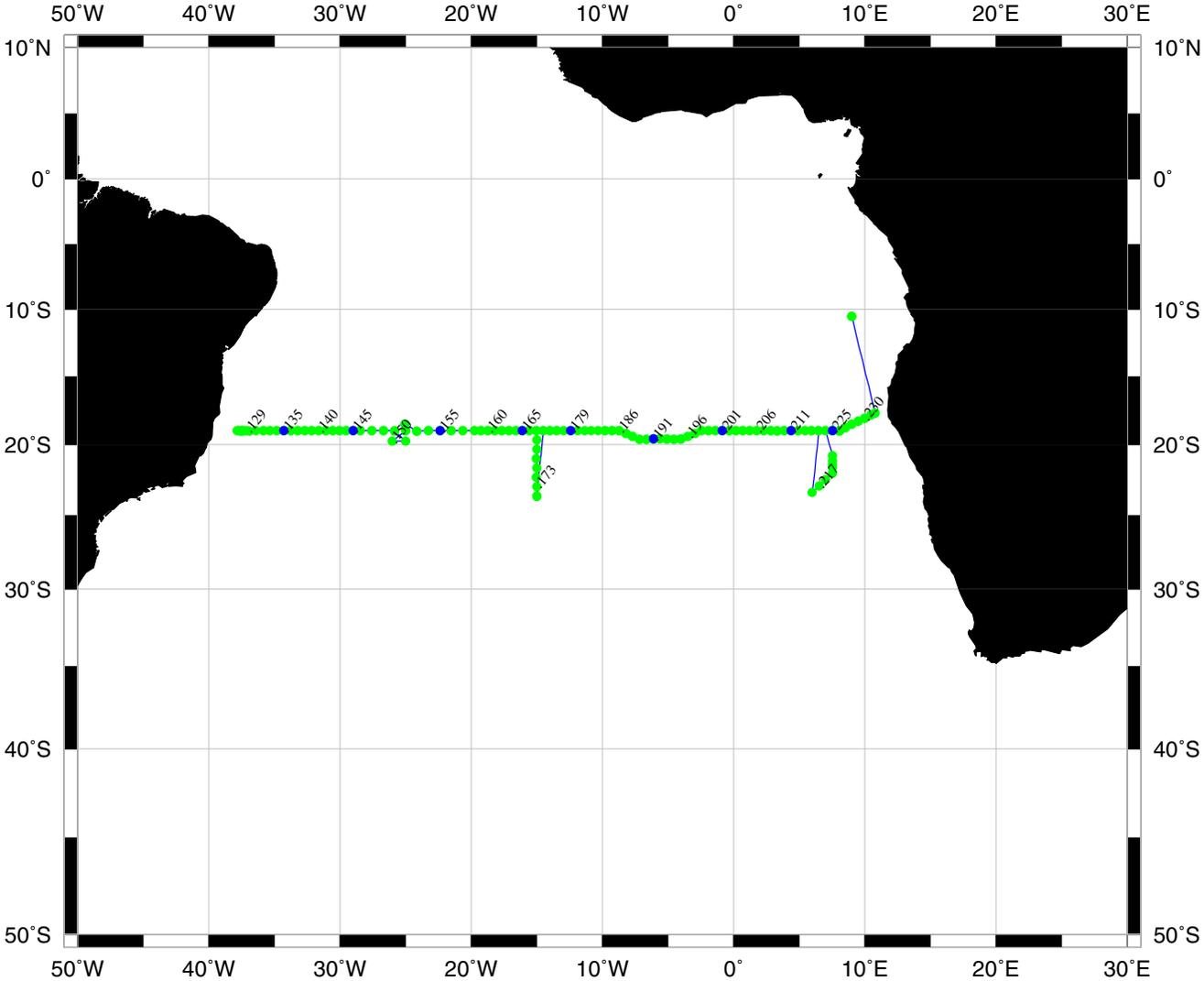
WHP Cruise Summary Information

Last Update 2001.03.29
WOCE section designation A09/AR15
Expedition designation (EXPOCODE) 06MT15_1-3
Chief Scientist(s) and their affiliation Gerold Siedler, IfMK
Dates 1991.02.10 – 1991.03.23
Ship METEOR
Ports of call Rio de Janeiro, Brazil to Vitória, Brazil

Number of stations 121
Geographic boundaries of the stations
10°29.90''S
0°19.60'W 9°31.70''E
23°40.00''S
Floats and drifters deployed 30 Drifters
Moorings deployed or recovered 13

Contributing Authors K. Speer
(In order of appearance) K. Schultz Tokos
W. Erasmí
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L. Veiga
D. Wallace
K.M. Johnson
R.J. Wilke
D.L. Bos
J.C. Jennings
D. Nehring
B. Wachs

Station locations for A09 : SIEDLER



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WHP Cruise and Data Information

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(K. Speer)

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Abstract

The METEOR Expedition no. 15 to the South Atlantic combined the research programs of several different oceanographic disciplines. The main objective was to study the oceanic circulation in the framework of the World Ocean Circulation Experiment (WOCE). The data sets will provide the foundation for the development and verification of improved climate change models. The physical and chemical observations, including tracer measurements, had two aims. First, to determine the transports in the shallow Brazil Current and the deep western boundary current, as well as in the inflow to the Brazil Basin through the Vema and Hunter Channels. Second, to obtain hydrographic and tracer data on the zonal WOCE hydrographic program section A9 at approximately 19°S.

In addition to WOCE investigations the following programs were included: Geological coring in the Hunter Channel between the Rio Grande Rise and the Mid-Atlantic Ridge, ichthyoplankton sampling in the western South Atlantic, CO₂ measurements within the framework of the Joint Global Ocean Flux Study (JGOFS), and air chemistry studies. Satellite-tracked drifters for current observations were launched in selected areas.

The present report summarizes the research goals and includes cruise narratives and tentative results from the observations. The text is supplemented by tables summarizing observations and stations.

Summary

The METEOR Expedition No. 15 to the South Atlantic combined the research programs of several different oceanographic disciplines. The main objective was to study the oceanic circulation in the framework of the World Ocean Circulation Experiment, WOCE, as part of the World Climate Research Program. The data sets are required as a foundation for the development and verification of improved climate change models. The physical and chemical measurements on this cruise had two aims. The first was to determine the transports in the Brazil Current and the deep western boundary current, and also in the inflow from the Argentine to the Brazil Basin. The related observations were part of the Deep Basin Experiment, DBE. The second aim was to obtain hydrographic and tracer data on a zonal section between South America and Africa.

These observations are part of the WOCE Hydrographic Program, WHP. The section (A9) crossed the South Atlantic subtropical gyre.

In addition to the WOCE investigations the following programs were included: Geological coring in the Hunter Channel between the Rio Grande Rise and the Mid-Atlantic Ridge, biological sampling in the western South Atlantic, and CO₂ measurements within the framework of the Joint Global Ocean Flux Study, JGOFS, and also air chemistry observations on the trans-Atlantic zonal section. Satellite-tracked drifters for near-surface current observations were launched in different areas in the western and eastern South Atlantic. Participation included research groups from Germany, Brazil and the U.S.A.

The cruise started on December 30, 1990, in the Brazilian port of Rio de Janeiro. Work during the first leg was performed in the area south of the Santos Plateau up to the Vema Channel which is part of the Rio Grande Rise. Twelve moorings were set on a line between the continental slope and the Vema Channel. They are designed to monitor the current and temperature changes in the transition zone between the Argentine and the Brazil Basin over two years. Furthermore, hydrographic and acoustic Doppler current measurements (ADCP) and biological sampling were part of the program.

Following a port call to Rio de Janeiro from January 16 - 18, 1991, the work continued in the area of the Hunter Channel, during leg 2. The emphasis was laid on HYDROSWEEP echosounding to obtain an improved bottom topography, geological coring and hydrographic observations. The geological studies are aimed at reconstructing the history of bottom water exchange between the Argentine and Brazil Basins during the last one million years. The hydrographic data will be used to investigate the present bottom water flow. Biological sampling was also performed on leg 2.

After an exchange of most scientific personnel in the Brazilian port Vitória between February 7 and 10, 1991, the program started with current measurements in the Brazil Current at 19°S. The shipborne acoustic Doppler current profiler, ADCP, and expendable current profilers, XCPs, were used. This work was followed by the hydrographic WHP stations on the zonal section A9 at 19°S between South America and Africa. In addition to the WHP observations there were CO₂ measurements and an

air chemistry program. The cruise ended in Pointe Noire in the Peoples Republic of Congo on March 23, 1991.

Tab. 1: Fahrtleiter und Fahrtabschnitte der METEOR-Reise Nr. 15
Chief scientists and legs of METEOR Cruise no. 15

Fahrtabschnitt 1 / leg 1	
Rio de Janeiro - Rio de Janeiro, 30.12.1990 - 16.01.1991	
Dr. W. Zenk (Fahrtleiter, chief scientist)	
Fahrtabschnitt 2 / leg 2	
Rio de Janeiro - Vitória, 18.01.1991 - 07.02.1991	
Dr. W. Zenk (Fahrtleiter, chief scientist)	
Fahrtabschnitt 3 / leg 3	
Vitória - Pointe Noire, 10.02.1991 - 23.03.1991	
Prof. Dr. G. Siedler (Fahrtleiter, chief scientist)	
Koordination / coordination:	Prof. Dr. G. Siedler
Kapitän / Master:	Kapitän H. Bruns

2 Participants

The participants are listed in [table 2](#), the institutions in [table 3](#).

Tab 2: Fahrtteilnehmer der METEOR-Reise Nr. 15
Participants of METEOR Cruise no. 15

METEOR 15/1

Name	Scientific field of interest	Institution
Zenk, Walter, Dr. , Fahrtleiter	Meeresphysik	IfMK
Andres, Hans-Georg, Dr.	Biologie	BAH
Brügge, Bernd, Dipl.-Oz.	Physikalische Ozeanographie	IfMK
Carlsen, Dieter, TA	Meeresphysik	IfMK
Döscher, Hans-Joachim, TA	Meteorologie	DWD
Erasmi, Wolfgang, Stud.	Meeresphysik	IfMK
Falcao Veiga, Letícia	Biologie	PETROBRAS
Fleksenhar, Kurt, Dipl.-Met.	Meteorologie	DWD
Hogg, Nelson, Dr.	Physikalische Ozeanographie	WHOI
John, Hans-Christian, Dr.	Biologie	BAH
Kipping, Antonius, TA	Meeresphysik	IfMK
Moreira Lima, José A.	Abteilungsleiter	PETROBRAS
Neto, Daute P., TA	Meerestechnik	IOUSP
Paviglione, Ademildes M.	Physikalische Ozeanographie	IOUSP
Pereira Filho, Nuno	Physikalische Ozeanographie	IOUSP
Pinck, Andreas, Dipl.-Ing.	Meeresphysik	IfMK
Rix, Nils, Stud.	Meeresphysik	IfMK
Simeneau, David, TA	Verankerungstechnik	WHOI
Souza Dias, Roberto	Beobachter	bras. Marine
Speer, Kevin, Dr.	Meeresphysik	IfMK
Worrilow, Scott, TA	Verankerungstechnik	WHOI
Zangenberg, Norbert, Dipl.-Oz.	Meeresphysik	IfMK
Zelck, Clementine, Dipl.-Biol.	Biologie	BAH

METEOR 15/2

Name	Scientific field of interest	Institution
Zenk, Walter, Dr., Fahrleiter	Meeresphysik	IfMK
Andres, Hans-Georg, Dr.	Biologie	BAH
Bickert, Torsten, Dipl.-Geol.	Geologie	UBG
Brück, Liane, TA	Geologie	UBG
Brügge, Bernd, Dipl.-Oz.	Physikalische Ozeanographie	IfMK
Bulsiewicz, Klaus, Dipl.-Phys..	Spurenstoffphysik	UBT
Döscher, Hans-Joachim, TA	Meteorologie	DWD
Erasmi, Wolfgang, Stud.	Meeresphysik	IfMK
Falcao Veiga, Letícia	Biologie	PETROBRAS
Fleksenhar, Kurt, Dipl.-Met.	Meteorologie	DWD
Gaedicke, Christoph, Dipl.-Geol.	Geologie	UBG
Heidland, Klemens, Dipl.-Ing.	Geologie	UBG/AWI
John, Hans-Christian, Dr.	Biologie	BAH
Meinecke, Gerrit, Dipl.-Geol.	Geologie	UBG
Mulitza, Stefan, Stud.	Geologie	UBG
Pätzold, Jürgen, Dr.	Geologie	UBG
Pinck, Andreas, Dipl.-Ing.	Meeresphysik	IfMK
Putzka, Alfred, Dr.	Spurenstoffphysik	UBT
Rix, Nils, Stud.	Meeresphysik	IfMK
Schultz Tokos, Kathy, M. Sc.	Meeresphysik	IfMK
Souza Dias, Roberto	Beobachter	bras. Marine
Speer, Kevin, Dr.	Meeresphysik	IfM
Zangenberg, Norbert, Dipl.-Oz.	Meeresphysik	IfMK
Zelck, Clementine, Dipl.-Biol.	Biologie	BAH

METEOR 15/3

Name	Scientific field of interest	Institution
Siedler, Gerold, Prof. Dr., Koordinator	Meeresphysik	IfMK
Andreae, Meinrat, Prof.	Spurenstoffchemie	MPI
Andreae, Tracey, B. A.	Spurenstoffchemie	MPI
Beckmann, Uwe, TA	Meeresphysik	IfMK
Beining, Peter, Dipl.-Phys..	Tracerozeanographie	UBT
Bos, David, B. Sc	Spurenstoffchemie	SIO
Bulsiewicz, Klaus, Dipl.-Phys..	Tracerozeanographie	UBT
Döscher, Hans-Joachim, TA	Meteorologie	DWD
Flechsenhar, Kurt, Dipl.-Met.	Meteorologie	DWD
Hoffarth, Boris, Dipl.-Phys.	Meeresphysik	IUP
Holfort, Jürgen, Dipl.-Oz.	Meeresphysik	IfMK
Jennings, Joe C. Jr., M. Sc.	Spurenstoffchemie	OSU
Johnson, Kenneth, M. Sc.	Spurenstoffchemie	UNY
Koy, Uwe, TA	Meeresphysik	IfMK
Kublenz, Kay, Stud	Meeresphysik	IfMK
Lass, Hans. U., Dr.	Meeresphysik	IfMW
Meyer, Peter, TA	Meeresphysik	IfMK
Mora, de, Stephen, Dr.	Spurenstoffchemie	MPI
Müller, Thomas J., Dr.	Meeresphysik	IfMK
Nehring, Dietwart, Prof.	Spurenstoffchemie	IfMW
Onken, Reiner, Dr.	Meeresphysik	IfMK
Plep, Wilfried, TA	Tracerozeanographie	UBT
Souza Dias, Roberto	Beobachter	bras. Marine
Wachs, Bernt, TA	Spurenstoffchemie	IfMW
Wallace, Douglas, Dr.	Spurenstoffchemie	UNY
Wilke, Richard, M. Sc.	Spurenstoffchemie	UNY

Tab. 3: Beteiligte Institutionen
Participating institutions

AWI	Alfred-Wegener-Institut für Polar - und Meeresforschung Postfach 12 01 61 W-2850 Bremerhaven 12 Germany
BAH	Bundesforschungsanstalt Helgoland c/o Zoologisches Institut und Museum Martin-Luther-King-Platz 3 W-2000 Hamburg 13 Germany
DWD	Deutscher Wetterdienst - Seewetteramt - Bernhard-Nocht-Str. 76 W-2000 Hamburg 36 Germany
IfMK	Institut für Meereskunde an der Universität Kiel Düsternbrooker Weg 20 W-2300 Kiel 1 Germany
IfMW	Institut für Meereskunde Seestr. 15 O-2530 Rostock-Warnemünde Germany
IOUSP	Universidade de Sao Paulo Instituto Oceanográfico Cidade Universitária CEP 055 08 Sao Paulo Brazil
IUP	Institut für Umweltphysik der Universität Heidelberg Im Neuenheimer Feld 366 W-6900 Heidelberg Germany
MPI	Max-Planck-Institut für Chemie Postfach 30 60 W-6500 Mainz Germany

Tab. 3: Beteiligte Institutionen
Participating institutions

OSU	Oregon State University Department of Oceanography Corvallis, Oregon 97331 U.S.A.
PETROBRAS	Petrobrás / CENPES (Research and Development Center) Cidade Universitária Q7 Ilha do Fundao 21910 Rio de Janeiro-RJ Brazil
SIO	Scripps Institution of Oceanography University of California, San Diego P.O. Box 109, La Jolla, California 92037 U.S.A.
UBG	Universität Bremen Fachbereich Geowissenschaften Postfach 33 04 40 W-2800 Bremen 33 Germany
UBT	Universität Bremen Fachbereich Tracer-Ozeanographie Postfach 33 04 40 W-2800 Bremen 33 Germany
UNY	State University of New York , Stony Brook Stony Brook, NY 11794-5000 U.S.A.
WHOI	Woods Hole Oceanographic Institution Woods Hole, MA 02543 U.S.A.

3 Scientific Programs

3.1 WOCE Programs

3.1.1 Marine Physics

The work was related to two topics. First, we investigated the Brazil Current and its hydrographic environment at the shelf edge east of Rio de Janeiro. Second, we aimed at observing the deep western boundary currents and water exchange between the Argentine and the Brazil Basins. Both studies represent significant components of the international WOCE program. Each was designed, however, in such a way that it could provide a contribution in itself to the study of the circulation in the western subtropical South Atlantic.

During the first two legs we planned up to five surveys of the Brazil Current by acoustic methods (ADCP). Hydrographic stations across the current were added, and 20 satellite-tracked drifters were launched in the area. Deep-water surveys at the continental slope were included.

Work on METEOR was planned to be carried out in close co-operation with two other research vessels. Onboard PROF W. BESNARD, oceanographers from the University of Sao Paulo wanted to perform CTD measurements in the Brazil Current. The Brazilian program had to be cancelled because of technical problems. The vessel VICTOR HENSEN also participated in the Brazil Current work south of Rio de Janeiro. This project was part of the multidisciplinary research program, JOPS '90/91, carried out within the framework of the German-Brazilian cooperation in marine science.

Salinity and temperature measurements were performed to determine the bottom water exchange at the southern entrance to the Brazil Basin, using CTDs and rosette samplers. In addition we launched sub-surface current meter moorings. The German group from Kiel set 3 moorings each at the continental slope and in the Vema Channel. The American group from Woods Hole connected these two observational areas with 6 moorings in the deep western boundary current. The moorings were expected to be in place for almost two years. Finally, we conducted a hydrographic survey in the Hunter Channel east of the Rio Grande Rise during leg 2. This work was done in co-operation with the geological and the bathymetric groups.

The primary objective of work during the third leg was to carry out WHP section (A9) at 19°S. The main goal of the WHP program of WOCE is to obtain a high-accuracy global hydrographic and geochemical tracer data set. In connection with other WOCE data sets these will be used to determine the current field of the ocean and water mass spreading. Such information can then be used for initial conditions and tests of oceanic circulation models and coupled oceanatmosphere models. In addition, the section at 19°S covers the Atlantic from continent to continent and thus provided the opportunity to determine the meridional mass and heat fluxes in the area of the South Atlantic subtropical gyre. Furthermore, the data from the western basin contributed to the Deep Basin Experiment, DBE, of WOCE.

Work during leg 3 started in the western boundary regime at 19°S. After some test runs and acoustic and electromagnetic current measurements (ADCP, XCP) the WHP program followed. Station distances were between 30 and 60 nautical miles, with smaller separation in frontal zones. Short meridional sections in the Brazilian Basin, at the Mid-Atlantic Ridge and at the Walvis Ridge were added. An XBT program was performed in the Angola Dome area at the end of this leg.

3.1.2 Tracers

Measurements of the CFC's F 11 and F 12 and sampling for ^3He and tritium were carried out on legs 2 and 3 in connection with the hydrographic work. Measurable CFC and tritium concentrations were expected through the main thermocline down to about 1000 m depth, as well as in certain western boundary water masses such as those of the Antarctic Bottom Water (AABW) and Upper North Atlantic Deep Water (UNADW) on the South American continental slope, and also in deep waters near the Mid-Atlantic Ridge. ^3He was expected in the Central Waters and of admixture of waters of Pacific origin within the deep and bottom waters due to Tritium decay. The tracer data served to determine transport rates and for water mass analysis.

The emphasis during leg 2 was in the depth range of deep and bottom waters where the tracer data provided information on the exchange of AABW through the Vema and Hunter Channels, and on the southward spreading of UNADW. However, the main part of the program was WOCE section A9 to be carried out during leg 3. We measured the CFC's of the majority of the water samples obtained, i.e. up to about 30 per station. ^3He and tritium sampling was restricted to about every third station, but with similar vertical resolution. No large-volume work was done, because similar work had already been

done in the SAVE program. CFC data were available in preliminary form within 24 h after sampling and could be used in selecting sampling depths further on. Specific rosette casts were required to check CFC sampling blanks at the beginning of both legs.

3.2 Marine Geology

It was considered possible that, in addition to the Vema Channel, the Hunter Channel is another important deep-sea passage for the exchange of bottom water between the Brazil and Argentine Basins. While the Vema Channel had already been studied intensively, only little information was available on the Hunter Channel.

During the second leg sediment samples were taken on 2 profiles with a total of 15 stations using box corer, multisediment sampler and gravity corer. On the southern profile, a bathymetric and geophysical survey of the deepest passage in the Hunter channel was carried out and specific sediment samples were taken. A second profile was chosen on the eastern margin of the Rio Grande Plateau, and the sediments in the Brazil Basin were sampled. The exact positions of the core stations were selected after the HYDROSWEEP and PARASOUND surveys.

The aim of the geological sampling during the second leg was to obtain core material for the reconstruction of the history of the bottom water exchange between the Argentine and Brazil Basins during the last ca. 1 million years. The main interest is in the determination of the location of the boundary between the Antarctic Bottom Water and the North Atlantic Deep Water during interglacial and glacial periods. Earlier results from the Vema Channel gave first indications of a shallower location during the glacial periods.

A prerequisite for this research is a high-resolution stratigraphy for the Quaternary which will be achieved using a combination of oxygen-isotope-, bio- and magnetostratigraphy.

3.3 Biological Oceanography and Marine Taxonomy

The study was part of a long-term program to describe the taxonomy, zoogeography and ecology of ichthyoplankton, planktonic Gammaridea and some other selected invertebrates from the entire Atlantic Ocean. (e.g. JOHN, 1983; ANDRES and JOHN,

1984). Quantitative horizontal plankton sampling was performed in two near-surface micro-layers using a neustonnet, and 5 strata between the surface and 200 m depth using a multi-net with integrated CTD.

During the first leg, the emphasis was on the analysis of the species composition, abundance and specific vertical distributions of the respective faunas of the shelf, continental slope and in the Brazil Current. This included aspects of diurnal changes in the vertical distribution or sampling availability of certain taxa. Sampling was therefore done with high horizontal and temporal resolution.

The sampling extended into the central South Atlantic during the second leg. It was intended to characterize the differences in species composition, abundance and vertical distribution between the faunas of the Brazil Current and the Central Water regions. A coarser resolution of sampling was selected, based on the experience gained from the first leg.

3.4 CO₂ Observations

There is a growing consensus and alarm that the earth will experience a global climate change over the next 50 to 100 years in response to the increase in atmospheric greenhouse gases caused by human activities. Carbon dioxide (CO₂) now accounts for about half the greenhouse effect and is expected to be more dominant in the future. The ocean stores some 50 times more CO₂ than the atmosphere, and a relatively small change in the oceanic carbon cycle can have large consequences for the atmosphere and climate. The international research program, JGOFS (Joint Global Ocean Flux Study), has been designed to learn more about the oceanic carbon cycle, its sensitivity to change and the regulation of the atmosphere-ocean CO₂ balance.

The scientific basis of the activities of the American CO₂ group from Stony Brook was set by the central goal of JGOFS, that is to determine, and understand on a global scale, the processes controlling the time-varying fluxes of carbon and associated biogenic elements in the ocean, and to evaluate the related exchanges with the atmosphere, sea floor, and continental boundaries. In particular, measurements were performed of total CO₂ content (TC O₂), CO₂ partial pressure (pCO₂) and pH on the majority of water samples collected on the zonal section along 19°S during leg 3.

3.5 Air Chemistry

The topics of this program concerned dimethylsulfide and cloud condensation nuclei over the South Atlantic Ocean. The work during the third leg was devoted to the biogeochemical cycling of sulfur. The hypothesis of the influence of dimethylsulfide produced in the marine biosphere on the number density of cloud condensation nuclei in the atmosphere was tested.

This hypothesis claims a connection between the following processes. Marine phytoplankton, in the presence of sunlight is able to produce a compound which decomposes in seawater and enters the atmosphere as dimethylsulfide (DMS). DMS in turn, is unstable in the atmosphere and oxidizes to sulfate. This sulfate forms particles and thus influences the cloud condensation nuclei density. Ultimately, these nuclei modify cloud formation and consequently the albedo of the earth. This influences the global radiation balance and temperature, and provides a feedback cycle between the ocean and atmosphere by biological processes. The mass flux from the marine biosphere into the atmosphere is approximately 40 Tg sulfur/year and consequently is of global importance. Measurements taken in the South Atlantic Ocean can be used to verify this hypothesis since METEOR cruise no. 15 covered relatively unpolluted areas. Work that had begun during METEOR cruise no. 11 was continued.

Concentrations of DMS in water of the surface layers and in air were determined. Concentrations of total aerosol as well as of cloud condensation nuclei were measured continuously. Stacked filter and impactor samples were taken for the determination of the sulfate content of the aerosol.

4 Course of the journey

4.1 Leg one

During Christmas 1990 METEOR was moored at Praça Mauá in the port of Rio de Janeiro. On December 22 the oceanographer B. Brüggé as a scientific representative had embarked on METEOR. After miscellaneous crew changes the new chief scientist arrived on December 27, the beginning of research cruise no. 15 SÜDATLANTIK WOCE 1991. Until December 30 the following working groups embarked: Marine Physics (9

persons), Woods Hole (3), Planktology BAH Hamburg (3), 4 Brazilian colleagues and the official navy observer (cf. [Table 2](#)).

The time in port was used for extended loading activities including container loadings from Bremen, Kiel, and Woods Hole. A conference with Dr. W. Ekau, AWI Bremerhaven, was held. He was in charge of the VICTOR HENSEN cruise operating simultaneously in the Brazilian shelf waters. Due to the holidays no contacts with the German embassy could be established.

The vessel left Rio in time on December 30, noon. Everybody on board enjoyed the spectacular views of the port entrance of Rio. First oceanographic instruments to be used were the acoustic Doppler profiler and the thermosalinograph. On the evening of the same day we started a section with XBT probes perpendicular to the Brazil Current (see [Fig. 2](#) and [Chapter 6.1](#)).

On New Years Day 1991 mooring BW from Kiel was launched on the continental rise of the Santos Plateau. During the night we started a highly resolved CTD section, including plankton hauls. It connects the South American continent with the Vema Channel (cf. [Fig. 2a](#)). Until January 2 we launched 10 WOCE drifters from Kiel. Under favorable weather conditions we moored one current meter array per day. Details are summarized in [Chapter 6.5](#). Between moorings we took three CTD stations (cf. [Chapter 6.2](#)) in combination with biological sampling.

As planned, we finished the section towards the Vema with nine moorings on January 9 (Stat. 36).

In the following days we worked in a small area west and east of the Vema sill depth. Supported by the crew electronics we obtained a preliminary HYDROSWEEP survey consisting of eight strips with 8 km width each. According to the resulting bathymetric chart we launched three more moorings in the Vema sill. From the remaining reserve mooring components from Kiel and Woods Hole we compiled an excess mooring that originally was not planned. This way we wanted to provide an adequate coverage of the eastern side of the Vema Channel. However, the deployment failed due to technical problems on January 11 (DBK₁). As a result we lost two instruments after we tried a recovery by acoustic release. We suppose that the mooring line caught the current meter and the buoyancy elements. In a further trial we put together a second mooring (DBK₂) which finally was launched on January 12. Strong winds and considerable

waves made this procedure a difficult one (Stat. 38). Shortly afterwards the two remaining moorings DB6 and VB were set together with a highly resolved CTD-section on January 13. Station distances partly were in the order of the water depth. In addition we tested the XCP receiver successfully for leg 3 (Stat. 53). Until then we had moored 59 current meters, 7 transponders in 13 moorings (BW, BM, BE, DB1-6, VM, VM, VE, DBK₂) with 16 acoustic releases. We had occupied 53 hydrographic stations where we took CTD measurements, water samples for oxygen calibration, and biological probes.

On the return leg to Rio we stopped at Stat. 54, 60 nautical miles north of the Vema for taking further biological samples. The journey was directly continued towards Rio. On January 16 after two additional stations a final XBT section followed through the Brazil Current. During early morning of the same day METEOR called for Rio, where she moored again on Praça Mouá, a privileged site close to the business city of Rio. The Brazilian colleagues from Rio and Sao Paulo disembarked.

On January 17 Captain H. Bruns and the chief scientist in cooperation with the German consul Dr. Hans J. Dunker held a reception onboard the METEOR. In spite of the unfavorable weather conditions approximately 150 guests followed our invitation. Diplomatic representatives from the United States, the USSR, from France and Denmark were under the guests as were official representatives of the city of Rio, from the university as well as from the Brazilian Navy. Due to the tide schedule the chief scientist could not follow an invitation to give a lecture in the university.

4.2 Leg two

The mooring groups from Kiel and from Woods Hole had left the ship in Rio. Their bunks were taken by geologists and tracer physicists from Bremen. Immediately after their arrival they started installing their equipment that had been delayed due to a late container delivery on January 18. In addition to the official Brazilian observer METEOR had a biologist from PETROBRAS on board.

On January 18, late afternoon, METEOR again left Rio de Janeiro. On schedule was a CTD section southeast of Cabo Frio. Parallel to the CTD section through the Brazil Current we sampled the plankton distribution here and farther east.

After two more crossings of the Vema sill we were able to compile a complete bathymetric chart of that region (Fig. 3). The combined surveys M15/1 and /2 revealed a so far unknown valley on the northwestern extension of the sill. We assume that this valley may play an active role in the mixing of bottom water after its passage across the sill depth of 4658 m (preliminary).

In spite of the difficulties with the multinet during M15/1, after a successful repair the biologists were able to combine this instrument with neuston hauls. The obtained data considerably supplement their ichthyoplankton distributions in the Brazil Basin. There was a clear correlation between species and natural environmental boundaries.

Unfortunately the geologists obtained only sediment samples with the multicorer on ODP site 516 on January 24. The gravity corer failed three times. This result was no surprise since the PARASOUND records from the Rio Grande Rise showed only "hard" reflectors. Corer stations followed.

METEOR proceeded on an easterly course towards the Hunter Channel. Numerous CTD stations were occupied. On January 26 followed a meridional HYDROSWEEP survey through a morphological gap. The associated CTD station 83 (cf. Fig. 3a), depth 5130 m, showed a lack of bottom water exchange between the Argentine and the Brazil Basin.

On search for additional deep passages north of the Hunter Channel a farther CTD section was occupied on 350 km, Stat. 87, 88, 89, 97. We found repeatedly considerable inconsistencies in the used bathymetric charts on board. The complete hydrographic section, partly supplemented by tracer observations of Freon11 and 12, finally presented clear evidence for a bottom water exchange. However, we would expect lower speeds than those observed in the Vema Channel. The PARASOUND records showed local sediment structures with wave length of 1 - 2 km and heights of 6 - 20 m. Potentially they represent mega ripples which confirm the northward bottom current in the Hunter Channel.

After miscellaneous bottom and core samples were taken on Stat. 88 in the southeast of the channel and in a further north south gap, METEOR left the Hunter Channel on January 29. Everybody had the impression that we only had taken a glimpse at this morphologically and hydrographically very heterogeneous area. We all left with the

desire to return to the "Hunter Channel Zone" at a suitable later time to investigate its importance for the present and past bottom water exchange.

In the following days we concentrated on the geological profile (PARASOUND, multicorer, gravity corer) east of the Rio Grande Rise (Stat. 98 - 105). In the CTD data we detected a northward bottom current labeled by an increased Freon signal. We suppose to have discovered an unknown outflow path for the bottom water into the Brazil Basin (Stat. 97 - 101). On Stat. 105 the biological work was terminated.

After the fast and successful sampling of the eastern Rio Grande Rise the remaining time allowed us a further geological station (106) on the northern plateau of the Rise. Another small CTD section from there into the deep Brazil Basin followed. On the afternoon of the same day METEOR left the Rio Grande Rise in a north westerly direction.

During the return METEOR stopped at ODP Site 515 to make more PARASOUND observations (Stat. 111). On the afternoon of February 4, METEOR continued her journey towards Vitória/Brazil. Final work consisted of an CTD section (Stat. 112 - 121) across the Brazil Current near the shelf margin off Vitória. As scheduled METEOR called for Vitória during the morning of February 7, 1991.

4.3 Leg three

On 8 February 1991 Prof. Dr. G. Siedler took over from Dr. W. Zenk as chief scientist. All other participants (except for one scientist staying on from leg 2) joined the ship on 9 February. Preparatory work on board, however, already started on 8 February. After customs formalities the expected container and all air freight arrived onboard.

The ship left Vitória on 10 February 1991, 9:00. We went to the starting point of the zonal section at 19°S, 38°W and began on 11 February with a short section across the Brazil Current to 19°S, 27°25W (Fig. 4). Narrowly-spaced XBT drops and acoustic ADCP current observations were carried out. In addition the echosounder system HYDROSWEEP was operated during the whole section. At the end point of the short section we performed a square pattern with 6 nautical miles side length for ADCP calibration. A test station followed in order to check the two CTDs and the rosette samplers at 3000 m depth.

The XBT section data provided the information for the selection of the following station. The ship returned to the 500 m isobath, with CTD stations and free-fall XCP current profiler drops on the track. The ship then headed east, continuing the Brazil Current section beyond the earlier test station position. A total of 8 CTD and 8 XCP profiles were obtained.

These observations also contributed the first part of the WOCE Hydrographic Program (WHP) section A9 at 19°S. We now began the standard WHP program with CTD stations at distances of 30 or 50 miles. The sampling scheme changed from station to station because of the limited measurement capacity for tracer and CO₂. The complete series included sampling of the following properties: Freons, CCl₄, He, O₂, CO₂, Tritium, DMS, nutrients, and salinity. The minimum sampling included O₂, nutrients, and oxygen. When station distances were as large as 50 miles in the eastern Brazil Basin, XBT T5 (1800 m) were dropped half-way between CTD stations

At 25°W we added one station each to the north and south of 19°S on 19 and 20 February, with the aim of comparing a total of 3 stations with earlier results of the U.S. SAVE program. The next additional observations followed at 15°W. A total of 7 stations were carried out on 25 to 27 February on a meridional section to 23°40'S, with the aim of determining the Deep Water flow on the western flank of the Mid-Atlantic Ridge.

A technical problem occurred during the night to 1 March. Winch W2, used for CTD operations, developed a bearing defect. The CTD could be recovered from 1000 m depth. Since we were just approaching the shallow depths of about 3000 m at the upper Mid-Atlantic Ridge, we could first use the shallow-level CTD with Winch W3. It turned out, however, that W2 could not be repaired at sea. Starting on 2 March, the deep CTD was lowered with W3 at the stern. This turned out not to be the best way of operation. With the up-and-down motion of the stern, the CTD had to be lowered faster than appropriate in order to avoid short-term upward motion of the sonde during lowering. This led to errors in salinity determinations. Beginning on 5 March we used the mid-ship winch W12 with the horizontal bar instead of an A-frame. The operation was much improved.

South of the British island of St. Helena we moved further south on 3 to 6 March in order to stay outside the 200 mile zone of that island. In the Angola Basin at 4°W we started

with AMS ^{14}C sampling on 5 March and with the launching of 10 ARGOS-drifters in the eastern boundary current system at 1°W on 7 March.

At 5°E we added a meridional section towards the Walfish Ridge on 12 to 15 March, performing 8 stations parallel to the ridge. The zonal section at 19°S was then continued to $08^\circ04.5\text{E}$. The ship then headed towards ENE from 17 March, with a narrowly spaced observational program in the eastern boundary current at the continental slope. The standard CTD stations every 30 miles were supplemented by XBT drops at 10-mile distances and XCP drops, with the section leading to the shelf edge. The zonal 19°S section was finished on 19 March.

We then went to position $10^\circ30\text{S}$, $90^\circ00\text{E}$ where a test of a new CTD NB Mk5 was performed in deep water. The ship then headed towards Pointe Noire. XBTs were dropped from the end of the 19°S section to the shelf edge before arriving in Pointe Noire on 23 March.

All scientific personnel left the ship on 24 March. The transfer of chief scientist duties was carried out during a meeting of Professors Siedler and Wefer in Brazzaville on 24 March.

5 Preliminary results

5.1 Marine Physics

5.1.1 Data acquisition and processing during M15/1-2

(K.Speer, K.Schultz Tokos, W. Erasmi)

Acquisition

All CTD stations were done using a Neil Brown Mark III instrument (IFM Kiel number NB3) with an oxygen sensor and bottom alarm. Pressure, temperature, conductivity, oxygen current, and oxygen sensor temperature are recorded at the full 32 Hz sampling rate on a PC in binary form using in-house software (L. Bellach). Data are also written on a magnetic tape as a back-up. During the cast, plots of temperature and salinity appear on the PC and an HP plotter. Another HP plotter plots oxygen. In addition, data at the reduced sampling rate of 3 Hz are recorded by a MicroVax computer using IFM Kiel software. All subsequent shipboard processing is made with this reduced data set,

including filtering, laboratory calibration corrections, and adjustments to reflect water sample values. No problems occurred with this system. An electrical power blackout interrupted the system once, but fortunately this did not happen during a cast.

Water sampling

Samples were collected in a General Oceanics 24 10 I-Niskin bottle rosette. An extra one was available if necessary. Usually the samples were collected at 12 levels for salinity and oxygen calibration purposes only. Initially, double samples were taken at the surface and bottom, which provides a check on measurement accuracy and repeatability. When the double samples were taken, only 8 levels were sampled. On the second leg a number of tracer stations were made, and on these all 24 bottles were fired at different depths. At these stations Freon, and occasionally Helium/Tritium (4 stns.), Carbon-13, and Oxygen-18 samples were also taken.

The choice of sample depths was governed by the oxygen structure, so that all major extrema could be measured including, for example, the oxygen maxima in the Intermediate Water and North Atlantic Deep Water, and the minima in between.

Salinity

Salinity samples were analysed on a Guildline Autosol model 8400A. Two units were onboard for redundancy (IFM numbers 2 [8400] and 3 [8400A]). Standardizations were done once a week with IAPSO water, batch number P112.

A measure of the accuracy of the entire sampling procedure, including bottles, sample handling, laboratory conditions such as temperature variations, and finally salinometer technique can be obtained from the redundant samples. For these, two bottles were fired at the same depth. A total of 51 double samples showed a mean difference of 0.0009 psu and a standard deviation of 0.0032 psu, which is therefore the expected accuracy of the water sample values.

Both units operated normally until about halfway through leg 2, at which point they both broke. The main salinometer was thought to have drifted by about 0.0014 psu/day, but this was subsequently attributed to evaporation of the substandard. The backup salinometer standardizations jumped around in a random fashion on leg 2 and it was not used. Correction coefficients calculated using data analysed before these problems began were carried over to the later stations.

Oxygen

Oxygen samples were collected in flasks of known volume and analysed according to the Winkler-Grasshoff method. Again double samples were taken and used as an estimate of the total error for the entire sampling procedure, including handling. A total of 45 double samples showed a standard deviation of 0.017 ml/l in the absolute value of the differences, excluding three outliers. This is the expected accuracy of the titrated water sample oxygen values.

Problems occurred using the dispensers when air bubbles were hidden in the tube tips. This leads to lower oxygen values and is probably the reason for the biggest outliers. As the device works satisfactorily after a few tries, most of the time only the first few samples are subject to this error (i.e. the deepest ones).

Calibration Pressure

The pressure sensor requires calibration (in addition to the correction for the offset on deck at zero (atmospheric) pressure) to give results better than about 10 db. The calibration depends on temperature, though, so in principle temperature should be corrected first, then used in the correction formula for pressure. This was not necessary here because the low temperature values all occurred at high pressure, and the correction at high temperatures and low pressure is not too different from that at low temperatures and low pressures. Thus a pressure correction for low temperatures (1°C) was applied to the raw data:

$$P_{\text{cor}} = A \cdot P_{\text{CTD}} + B,$$

where $A = 0.99940009974$, and $B = -0.3275937250$ (assumes that 4.5 db has been subtracted already from the raw files; values obtained using polyfit in MATLAB). The rms differences between the lab reference pressure and the corrected CTD pressure is 1.1 db. This is not the absolute accuracy of the measurement, though, because of other problems with the pressure sensor encountered in situ, e.g. hysteresis and a mysterious 10 db pressure increase on certain casts. In addition, the sensor exhibits a time dependent response to temperature changes, with a response time of several minutes. The amplitude of this effect for the NB3 instrument is about 0.25 db/C, but since the unit

spends many minutes in the rather uniformly cold deep water, this effect is tiny and does not need to be included. Note for interested parties: this effect is at least 4 times greater in the NB MK5, and must therefore be included in the calibration of this instrument. Also, an informal onboard dunk test of the SEABIRD SEACAT pressure sensor showed no apparent time dependent effect at all.

Excluding a few stations with special problems, the pressure values are expected to be accurate to +/- 3 db.

Temperature

Laboratory calibration of the CTD temperature sensor indicated that a correction should be applied, which amounts to about 0.01°C near 0°C and -0.01° C near 30° C on the International Temperature Scale 1990 (ITS 90), with a linear dependence in this range. On all stations with bottle samples, reversing thermometers were also included on bottles 1 and 23, the deepest sample and the mixed layer sample. Each rack consisted of three thermometers, so a total of 6 measurements are available for those stations. This provided a sufficient quantity of data to actually provide a consistency check on the laboratory calibration. According to the reversing thermometers on the bottom bottle at temperatures less than 4°C, the mean offset between their values and the CTD values was 0.017°C with a standard deviation of 0.008°C (Fig. 5). Although the scatter in the mixed layer is naturally higher, the temperature offsets may still be used as a check. The mixed layer mean offset was +0.04°C with std = 0.248°C. These offsets are consistent with the laboratory correction at both high and low temperatures within the error of the measurement. Thus while the error is too great to justify using the thermometers as a calibration standard themselves, they can provide a check if there is some doubt about which calibration to use, or whether or not a correction has already been applied. With TCTD corrected = A * TCTD + B, the laboratory calibration indicated A = 0.999235009 and B = 0.009361540, and these values were used to correct the raw data. Within the above temperature range neither a quadratic nor a cubic polynomial fit the laboratory data with less error, the rms differences between the polynomial fit and the laboratory reference being about 0.001°C in all cases. The maximum difference was 0.002°C and this is considered to be the accuracy of the reported temperature values.

Salinity

Applying a laboratory conductivity calibration consisting mainly of an offset of about 0.02 mmhos (A = 1.00033857, B = 0.012687071) to the raw data results in values which are

too salty by about 0.01 psu (Fig. 6). Under typical oceanographic conditions the characteristics of the conductivity sensor change somewhat, and water sample values are used to calibrate the sensor to in situ data. Thus the application of a laboratory calibration may appear to be irrelevant. The following analysis of the water sample data will show that indeed making the lab correction alone is insufficient and in situ water samples must be used.

The first step was to choose good water samples based on the standard deviation of the salinity differences. The criteria were to eliminate values outside a band of width 0.05 around the mean, and then those which were outside two standard deviations; this last step was done twice. However, we did not correct the (hiev file) T and P with laboratory calibrations, nor have we corrected the pressure for the hysteresis effect. We found no trend with station number (no drift), no trend with salinity (i.e. linear) in the salinity differences SCTD-SROS. Same remarks are true for conductivity. So no improvement is possible by taking other trends into account. Fitting conductivity ($A = 1.000406709612$, $B = 0.00068231988$) and converting the result to salinity produces a standard deviation of 0.0047 psu (Fig. 7).

Surprisingly, the equivalent salinity error obtained from CTD conductivity corrected using water samples turned out to be the same (0.0047 psu) as the salinity error obtained by simply calibrating the CTD salinities directly using the water sample salinities (with calibration coefficients $A = 1.0005006456121$, $B = -0.00065685538$; Fig. 8). In principle this should not be the case but in practice since the conversion between conductivity and salinity depends on pressure and temperature the error in these variables (saved in files at the time of bottle firing) contributes and adds to the error in the conductivity differences. [Note that this unfortunate situation does not depend on how the comparison between water sample values and CTD values is done: whether on pressure surfaces or density surfaces.]

Filtering raw data

Once calibration coefficients of P, T, C, and S were obtained, the raw data files were processed according to standard IfM Kiel procedure. The calibrated data were despiked, made monotonic in pressure, and then sorted into 5 db bins. This procedure should not remove any structure whose vertical scale is greater than about 50 db.

Oxygen

The CTD-O2 instrument measures the electrical current through the oxygen sensor (OC) and its temperature (OT). The temperature of the oxygen sensor usually lags the ambient temperature (T) by a substantial amount, because of its thermal inertia. The response time of the oxygen temperature sensor is of the order of several minutes. In addition, the sensor response is thought to depend on pressure and ambient temperature as well, and including the temperature lag correction the relation between OC, OT, and oxygen (O_2) has been modeled by the equation (OWENS and MILLARD, 1985):

$$O_2 = A*(OC + B \frac{dOC}{dt} + c)* Osat(T,S) * \exp(D*T + E*(OT-T) + F*P)$$

where dOC/dt is the rate of change of OC with time (i.e. cycle number), $Osat$ is the oxygen saturation obtained from a standard formula, S is salinity, and P is pressure.

A station dependent offset may be added to account for drift, or the coefficients may alternatively be calculated for smaller groups of, say, 5 stations at time. The time rate of change of OC is not recorded as a matter of standard practice by IfM Kiel acquisition software, so B is set to zero. The first factor can be written as $(A*OC + AC)$ and AC regarded as a new parameter. However, the IfM program CTDKAL which does the fitting does not take this bias term into account; the consequences of this on the goodness of fit are not known. Four parameters are left: A , D , E , F , which must be determined by adjusting an initial guess until the O_2 agrees with the water sample values to within some tolerance.

The ability of the algorithm to find satisfactory values of these parameters depends on having an adequate number of water samples with which a comparison can be made. Not all the water sample values are used in the fitting procedure. To discriminate "bad" values, a choice is made when the calibration program CTDKAL is run to set the limits of variation that a water sample value may have with respect to the computed CTD value. If the difference is greater than 0.5 standard deviations of all the differences the water sample value is ignored. About 30 percent of the bottle data were thus discarded. As there are only 12 water sample values for each station to begin with this constitutes a serious loss of data, and undoubtedly makes the determination of the four parameters more difficult. Sixteen should probably be considered a minimal number of water

samples in future, so that a sufficient number of data are left over after the elimination of outliers.

To compare water sample oxygen to CTD measurements a file consisting of CTD OC and OT, P, T, and S is created when bottles are fired. Standard practice has been to record OC and OT as the instrument is rising the final 20 m or so to the bottle firing level, in order to keep a steady flow past the oxygen sensor. However, this procedure introduces substantial error because it connects OC and OT over some depth interval to an averaged temperature and pressure at the stopping level. In fact the sensor values do not change significantly as the instrument comes to a halt, and all values should be recorded at this point only.

Despite the shortage of data points and unfortunate sampling procedures, the high quality of the water sample analysis allowed a satisfactory calibration to proceed. Typically groups of about ten stations could be run together with the same set of coefficients, but it was occasionally necessary to divide the stations into smaller groups, and even give individual attention (this required much tedious twiddling of the calibration program). The preliminary calibrated CTD values are thought to be accurate to 0.08 ml/l (about half the stations are substantially more accurate than this, but the offset in the others has not been removed).

5.1.2 Data acquisition and processing onboard during M15/3

(T.J. Müller, J. Holfort, N. Zangenberg)

During this leg, station work with two conductivity-temperature-depth (CTD) systems in combination with rosette water samplers built the frame for the WOCE hydrographic investigations. While passing the western and eastern boundary currents, also absolute currents were measured down to 780 m using expendable current profilers, XCPs.

In between stations profiles of temperature down to 760 m and currents down to 200 m were obtained from the moving vessel by means of expendable temperature profilers, XBTs, and an acoustically measuring shipborne current profiler, ADCP. Position, time, meteorological data, bottom depth and near surface temperature and salinity were recorded on the ship's central data acquisition system, DVS.

CTD-rosette

One time sections of the WOCE Hydrographic Programme, WHP, require 30 m nominal station spacing with high quality CTD measurements and up to 36 depth levels of small volume water samples to determine dissolved oxygen, nutrients and some tracers. Two CTDs MKIIB were combined with two rosette samplers carrying up to 24 bottles of 10 l volume each to achieve these requirements.

The main CTD-rosette, NB3 with 24 bottles, was lowered down to 10 m above the bottom to measure continuously the vertical stratification. On the way up, bottles were closed at 20 of the prescribed depth levels, with double sampling at the three depths closest to the bottom and in the mixed layer near the surface. The double samples built the basis for the in situ calibration of the CTD. The second system with up to 18 bottles was used subsidiary on deep stations to achieve the WHP requirements for vertical resolution in water sampling, also with double samples at 2000 m depth and near the surface for calibration purposes.

Both CTDs were calibrated in the laboratory at IfM Kiel 6 months prior to leg 15/3 and recalibrated 11 months after the pre-cruise calibration. The large delay between pre- and post- cruise calibration was necessary for logistic reasons, and subsequently required careful in situ calibration not only of the conductivity cell but continuous in situ checks of temperature and pressure sensors with high resolution reversing thermometers as well.

For both CTDs, data were acquired in two systems: the full data rate of 16 Hz for each cycle (ca. 0.1 m vertical resolution) was stored on hard disk of a personal computer system using IfM Kiel software. A subset of these were plotted on line. As a backup, a subset with ca. 1 m vertical resolution was recorded on a Micro Vax computer. Here also the CTD data at bottle depths were stored. This subset built the basic data set for quality control, preliminary analysis onboard and determination of coefficients for the in situ calibration.

Salinometer

Two AUTOSAL 8400A made by Guildline were in use onboard since four months before leg 15/3. Both salinometers showed unusual high noise level mainly due to low power on the electronics, but also due to badly protected cable connections to the computer

resulting in noise of 0.008 in salinity. In the future a separate power supply for the electronic parts, and optical connections to the computer will overcome these problems.

A total of 2000 samples were measured, and because the noise was almost normally distributed, the resulting error in calibrated CTD salinity is less 0.002 PSU and thus fulfills the requirements of the WHP.

XBT measurements

Three types of XBT probes were launched half way between stations to acquire additional information about variations in the main thermocline. The Deep Blue type is a special version of the T7 and measures the temperature profile down to 760 m provided the ship's speed is less 20 knots. Also, deeper reaching probes T5 (1800 m, 6 knots) and T5-S (1000 m, 20 knots) were used.

All data from these instruments were recorded on personal computer systems with IfM Kiel software. A subset of inflection points was transferred via the German Hydrographic Service into the international WMO network.

XCP measurements

With XCPs, vertical profiles of absolute currents can be obtained down to 1600 m from a moving ship. 8 probes in the western boundary current and 6 in the eastern boundary current were launched. The data were recorded as radio signals on audio tapes. Such measurements of absolute currents are needed for control and adjustment of geostrophically calculated currents and thus for better estimates of heat transport.

Shipborne ADCP measurements

An ADCP was mounted below the ship's hull. Since one of four transducers failed completely there is no redundancy in the system, which is required to get high-quality current measurements. Also, GPS positioning was not optimal in early 1992. Data were recorded on a personal computer system using manufacturer's software. Calibration, validation and processing is still ongoing.

Central Data Acquisition of METEOR, DVS

This systems collects data streams from several sources, the most important being time, positioning, water depth, meteorological data from both sides of the ship, and temperature and salinity from 4 m depth. Salinity data at 4 m depth are calibrated using

samples from the inlet on stations. All data are reformatted and written on magnetic tape as well as supplied to laboratory computer sockets for user's applications. A subset was recorded at 120 s intervals on a personal computer for later scientific investigations.

5.1.3 On the hydrography of the Brazil Current and the Deep Basin Experiment

(K. Speer)

The Rio Grande Rise is thought to have arisen over time from a point on the crest of the MidAtlantic Ridge where the upwelling of magma is especially strong. The resulting topographic high subsequently propagates away from the crest as the ridge spreads, forming the Walvis Ridge on the eastern side and the Rio Grande Rise on the western side. The Rio Grande Rise separates the Argentine Basin from the Brazil Basin and is the transition zone between the distinct water mass structures of the two basins. The Argentine Basin hydrography is dominated by the multiple deep reaching fronts of the Confluence Zone and circumpolar current, which carry northwards the recirculating deep waters of the Southern Ocean. Thus the traditional water masses of the Atlantic: Intermediate Water, North Atlantic Deep Water, and Antarctic Bottom Water are supplemented on the southern side of the Rio Grande Rise by older, lower circumpolar deep water whose distinctive characteristic is low oxygen concentrations. [Confusion often arises over the distinction between AABW and CPDW, since the AABW of the South Atlantic is mostly made up of entrained lower CPDW.] The Rio Grande Rise is also a transition zone for bottom water as it forms a substantial barrier to northward progression. Two major passages exist across the rise, the Vema Channel in the west and the Hunter Channel in the east. The Vema Channel has been known for some time to be the major passage for bottom water, whereas the Hunter Channel has remained relatively unexplored until this expedition.

A number of plots have been prepared to illustrate the water mass characteristics encountered, interesting features, and preliminary results. From the point of view of hydrography the division of the cruise into two legs was artificial, and therefore data from both legs are discussed together. First a general description is given, beginning with the near surface layers and proceeding downward. Then special attention will be paid to the Vema Channel and Hunter Channel.

Thermocline

The Brazil current flows southward more or less along the shelf break of the South American continent. In our profiles it lived up to its reputation as a shallow current and

lay mostly over the shelf (Fig. 9a-b). A total of three CTD sections and three XBT sections across the slope and outer shelf were carried out during legs one and two. All of these were planned to extend far enough onto the shelf in order to quantify the Brazil current transport and to help unravel the dynamical reasons for the unusual ability of the current to flow on and off the shelf. Surface temperatures dropped by about 2°C together with a salinity decrease of 0.6 psu near Stn. 21 (43°W), roughly 500 km offshore. This appears to be the signal of the so-called Brazil Current Front, the inner recirculation of the subtropical gyre.

Farther offshore above the Rio Grande Rise, near 1600 km distance, a weak signal of a large eddy occurred centered at 300 m depth. Its width is nearly 300 km and its origin is unknown. At this point along our track the station spacing was wide and four stations can only give a very incomplete resolution of this structure.

A regular feature of the potential temperature - salinity diagram was a salinity maximum just below the mixed layer, usually found near sigma-theta of 25.5 g/cm³ (Fig. 10). Its density seemed to be quite variable, though. Presumably its origin is the region of surface salinity (and temperature) maximum somewhat to the north, at 20°S.

Intermediate Water

The next deeper extremum on the temperature - salinity diagram occurs below the thermocline. This is the salinity minimum of Antarctic Intermediate Water near 4°C. A salinity section (Fig. 11) shows water fresher than 34.4 psu extending across the entire area measured. No especially low values are apparent at the western boundary, where any meridional flow is expected to be concentrated. Indeed, a deeper reference level suggests southward flow next to the boundary rather than northward flow, perhaps reflecting the extent to which intermediate water is driven around the gyre by the thermocline's circulation.

This layer also corresponds to an oxygen maximum with values typically of 5.2 ml/l (Fig. 12). The oxygen distribution suggests that younger, more highly oxygenated intermediate water occurs farther offshore, just west of the Vema Channel. This is all the more puzzling when considered together with HOGG et al.'s (1982) remark about a southward flow of deep water in a narrow stream above the Vema Channel. Freon was analysed on leg 2, and this may be of great help in answering this question. A

ubiquitous freon maximum was found at the level of intermediate water which could give clues about its age and origin.

North Atlantic Deep Water

At deeper levels the temperature increases slightly as salinity increases toward the salinity maximum of North Atlantic Deep Water. This inversion of temperature (true as well for in situ temperature) is a dramatic effect of South Atlantic hydrography, caused by the very different sea-surface salinities in the respective formation regions of the two water masses. The temperature - salinity plot also shows that despite the inversion, density increases with depth and the water column is stable. While vertical mixing cannot have much effect on temperature since the vertical gradient is small, strong fluxes of salinity presumably exist between the two layers.

The deep water layer is the most highly oxygenated of all the water masses in the region, with values greater than 5.6 ml/l. This is partly because the volume of this water mass is large, and thus the decrease of oxygen away from the source by vertical mixing is slow. Also, the formation region of North Atlantic Deep Water is generally more highly oxygenated than the circumpolar current and it thus does not lose so much at the start through entrainment. At the same time it is low in freon (away from boundary currents) because of its large volume and long replenishment time. Within the density range of the deep water but generally farther south, the circumpolar deep water makes occasional incursions north across the Rio Grande Rise. Its presence is clear by its low oxygen concentrations and, to a lesser extent, by low salinity. One example of this water was found on stn. 97 within the Rio Grande Valley (Fig. 13). Low oxygen near 1°C is correlated with low salinity, relative to the usual temperature - salinity relation for deep water.

Bottom Water, Vema Channel

Bottom water ultimately comes from sinking around Antarctica, although the water which eventually makes it into the Argentine Basin is mostly water which has been entrained along the way. It is fresh relative to the water above it. In the Argentine Basin it has a high oxygen signal relative to circumpolar deep water while in the Brazil Basin it has a low oxygen signal relative to North Atlantic Deep Water. Again the Rio Grande Rise is a transition zone for water characteristics. The high freon signal of bottom has been measured in the past, but never before in the Vema Channel itself. This will provide a nice initial condition for the downstream evolution to be measured during leg 3 of M 15.

The coldest water found was -0.175°C (corrected) potential temperature at Stn. 49. This value seems to be warmer by 0.010°C than that measured by HOGG et al. (1982), although it is not clear if the very coldest water on the eastern side of the Channel was completely sampled (HOGG et al. (1982) did a tow-yo on this side). The curious fact that the coldest water is on the right looking downstream, despite a negative Coriolis parameter was explained by HOGG et al. as a response of the lowest layers to accelerating flow in the layers above them. The isotherm slope reversal would then be an attempt by the flow to conserve the mass flux. We also observe this reversal in our cross-section close to the sill of the Vema Channel (Fig. 14). Also evident on the section is the left turn made by some of the flow as the upper part of the western wall disappears (see hydrosweep map). This seems to carry away some of the water into a previously uncharted side valley of moderate (about 4400 m) depth.

Bottom Water, Hunter Channel

The first section across the Hunter Channel shows the northward flow of Bottom Water through a passage roughly ten times broader than the Vema Channel (Fig. 15). The horizontal gradients are much weaker, and the transport is expected to be substantially less. Nevertheless the flow through the Hunter Channel does appear to be a significant component of the circulation of bottom water in the South Atlantic.

Interestingly, the same pattern of isotherm (or isopycnal) slope reversal is observed in the Hunter Channel as in the Vema Channel. That is, the coldest water is found on the eastern side of the passage. However, the vortex stretching does not appear to be strong enough to go the next step and cancel the flow next to the eastern wall, thereby separating the middle layer from the eastern wall, as happens in the Vema Channel.

Within the Hunter Channel itself the topography turned out to be much more complicated than indicated on the Cherkis map. This is an area which was previously rather poorly controlled by ship tracks and so the chart consisted almost entirely of (incorrect) interpolated contours. The deepest passage came as a surprise and almost remained unsampled by a CTD station, because of time constraints. Nevertheless a cast was made and the bottom temperature was found to be somewhat warmer than two stations on the eastern side of the northern extension of the Hunter Gap (our section was some distance to the north of the indicated Hunter Gap, but similar depths were found). Apparently water does pass through these deeper passages but only that which has spilled into them from a sill depth near 4100 m. The main path is through the northern

extension of the Hunter Gap. The water in the deep Hunter Fracture Zone (stn. 83) is slightly warmer still, which probably reflects the time it takes for water entering at the eastern end to make its way to the western end, where the station was made.

The flow through the Hunter Channel continues north along the eastern flank of the Rio Grande Rise, as determined by a short section near 29°S. It does not, however continue around the rise as a westward flowing boundary current on the northern flank, as we discovered with another short section. The explanation for this flow may be that it is the western boundary current for the portion of the Brazil Basin to the east of the Rio Grande Rise, and therefore constitutes the source of mass for this area as a sort of mini Stommel and Arons circulation pattern.

5.1.4 The WHP section

(G. Siedler, J. Holfort, T.J. Müller, R. Onken)

The zonal section was positioned at 19°S between South America and Africa. Contrary to the earlier plan it had been displaced by 1° to the north in order to ensure sufficient distance to the seamount chain between Brazil and the island of Trindade. The section included 112 stations with CTD measurements and rosette sampling for determining salinity, oxygen and nutrient concentrations. In general the station distance was 30 miles. In the central to eastern Brazil Basin the station distance was increased to 60 miles in order to save time. In this case the CTD stations were supplemented by deep XBT drops half-way between stations. In three areas short meridional sections were added. At 25°W one station each north and south of 19°S served as a data comparison with similar stations from the earlier U.S. SAVE program. At 15°W the meridional section included 7 stations for a study of the Deep Water flow across the MidAtlantic Ridge. At 6 to 7°W the meridional section was placed parallel to the Walvis Ridge for the investigation of Deep Water transports.

Other than the standard measurements were performed at selected positions. Freons F11 and F12 were measured on 66 stations, Helium⁻³ and Tritium (see [5.2.2](#)) on 25 stations and CCl₄, F113 and CO₂ on several stations (see [5.5](#)). In the region of western and eastern boundary currents water mass distribution and current field was further determined by XBTs, free-fall XCP current profilers and the ship-operated ADCP current profiler.

Temperature, salinity and oxygen sections for the western and eastern basins are presented in [Figures 16 - 21](#). The analysis is still in its initial phase now. We will here comment on some properties directly seen in the sections. Near the continental slope in the western basin ([Figures 16 - 18](#)) we recognize inclinations in the isolines in the Upper Deep Water below the Antarctic Intermediate Water, indicating a deep boundary current. In the range of Lower Deep Water and Antarctic Bottom Water we find a bowl-shaped isoline distribution, indicating cyclonic circulation of Bottom Water in the Brazil Basin. In the eastern basin ([Figures 19 - 21](#)) a southward boundary current is identified at the Mid-Atlantic Ridge below ridge levels, and the O₂ distribution indicates a spreading of North Atlantic Deep Water into the Angola Basin.

In [Figures 22](#) and [23](#) we present temperatures and salinities on the first 60 km of the zonal section. The inclination of isolines at 150 - 200 m between km 100 and 30 is an indicator for the southward Brazil Current. The results are consistent with the XCP observations from this section. As examples we present the north-south components of XCP currents in [Figure 24](#). The Brazil Current is recognized between 50 and 200 m in profiles no. 2 - 4.

The measurements on WHP section A9 fulfil the international WOCE requirements. Further data evaluation for later publications in scientific journals is underway.

5.1.5 Surface drifters

(B. Brügge)

During legs 1 and 2 METEOR contributed 20 satellite tracked surface drifters with drogues in 100 m depth. This effort is part of WOCE Core Project 1 global description of circulation and statistics of ocean variability. The M15 drifters are a subset of earlier (35 buoys in 1990) and still planned (app. 150 buoys till 1994) launches. We aim at a data set for the description of the near-surface circulation in the South Atlantic and its eddy statistics. These expected observational results are required for eddy resolving circulation models of the South Atlantic to be run in the near future.

All M15 drifter trajectories are compiled in [Fig. 25](#) for the interval January to September 1991. 20 buoys operated in the Brazil Current. The obtained trajectories indicate a narrow and strong boundary current south of 27°S. All buoys followed the continental shelf southward towards 40°S. There they were caught by the Confluenz-Zone of the Malvinas (Falkland) Current which is marked by high eddy kinetic energy ([Fig. 26](#)).

In contrast to the southern drifters we find a much weaker signal of the Brazil Current near 20°S (Fig. 27). Buoys were caught there preferably within a 150 km wide cyclone. The reason may be caused by a zonal chain of seamounts situated somewhat farther north.

Ten additional buoys were launched in the region between the Angola and the Benguela Currents. Low buoy speeds indicate this region to be low in kinetic energy (Fig. 28).

An extended analysis of the drifter data can not be performed before the complete data set comes in with a sufficient density. Nevertheless, for regional studies in context with the hydrographic data from METEOR cruise no. 15 trajectories are already available now.

5.2 Tracer Measurements and Sampling on M15/2-3

(A. Putzka, P. Beining, K. Bulsiewicz, W. Plep)

The investigated tracers are Helium, Tritium and the chlorofluorocarbons (CFC) F-11, F-12. Within the ocean the distribution of these substances are not in a steady state (transient tracer) and hence their measurement deliver information about time scales of transport and mixing processes. The main part of Tritium (unstable hydrogen isotope decays to ^3He and changes the $^3\text{He}/^4\text{He}$ ratio) and the CFCs are man-made. Their time dependent input at the ocean surface is well known. The concentration is altered by mixing processes and by radioactive decay (in the case of Tritium) when the water descends to deeper levels of the ocean.

The atmospheric CFC content increases monotonously since the early forties. Therefore 'younger' (age since leaving the surface) water is generally tagged with higher CFC concentration compared with 'older' water. The detection limit is 0.005 pmol/kg while the precision for surface water concentration is about 1%.

Sampling

Samples were taken according the WOCE scheme using the common procedures: CFC: glass syringes, Helium: copper tubes, Tritium: glass bottles.

M15/2

Helium/Tritium: On 4 stations (two within the Vema channel, two within the Hunter channel stations no. 71, 86, 95 98) 100 samples were taken for Helium and Tritium measurements. CFC: On twenty stations 500 samples were taken and measured. The route of the M15/2 cruise was confined to the region of the Rio Grande Plateau with the aim to investigate the tracer distribution north (the Brasil Basin) and south (the Argentine Basin) of the Plateau. Especially the two deep channels connecting the basins, the Vema and the Hunter Channel, were probed.

M15/3

Helium/Tritium: on 25 Stations 700 Helium and 700 Tritium samples were taken. CFC: At every third station a complete profile was measured. On stations in between special depths were additionally sampled. Altogether 1700 samples were analyzed.

Results

In the following only CFC measurements are shown since these measurements are done on board while the Helium and Tritium measurements are to be measured later on shore.

M15/2

[Figure 29](#) shows two CFC profiles of station 71 (Vema Channel) and 86 (Hunter Channel). Both profiles reveal at the bottom a slightly higher CFC concentration due to Antarctic bottom water. There is also a CFC maximum at 700 to 800 m depth just above the salinity minimum of the Antarctic intermediate water. North as well as south of the Hunter Channel (stations 95, 88) the bottom water CFC concentrations are also higher similar to station 86 an indication that part of the Antarctic bottom water flows through the Hunter Channel.

CFC on M15/3

On the whole 19°South section shown in [Fig. 30](#) CFC concentrations above zero were observed down to 1000 m depth. Below 1000 m depth the concentrations are less than 0.01 pmol/kg except near the western boundary region where higher CFC concentrations in the Antarctic bottom water and in the Upper North Atlantic Deep water were found.

The Upper North Atlantic deep water show within the western boundary current at approx. 1800 m depth an intermediate CFC maximum (highest concentration: 0.03 pmol/kg F-11, extending up to 29°W). Below 4000 m depth the CFC-concentration increases and reaches at 31°W 0.05 pmol/kg F-11. At the western rise of the Midatlantic Ridge the CFC concentrations are below 0.01 pmol/kg.

[Figure 31](#) shows the partial pressure ratios of F-11/F-12 versus the partial pressure of F-11 for the stations 160 to 200. The partial pressure is the equilibrium pressure in air belonging to the measured CFC concentration. For comparison the atmospheric ratios and their corresponding dates are also shown in [Fig. 31](#). The deviations between water and atmospheric ratios are caused by mixing processes, a subject of further investigation. The variation of the ratios over the whole concentration scale is less than 15% which shows the precision demanded for this kind of measurement.

5.3 Marine Geosciences

5.3.1 Profiling Shipborne Measurements

5.3.1.1 Sediment Echosounder Parasound

(C. Gaedicke, L. Brück, K. Heidland)

The echosounding system PARASOUND (developed by ATLAS ELEKTRONIK, Bremen) installed on board the research vessel METEOR was operated routinely during the whole expedition.

The analogous output on the DESO 25 printer gives a first impression of the subbottom structure and the sediment. PARASOUND is therefore invaluable for the selection of geological core stations. The quality of the measurements depends on the sea bottom topography, over slopes decreases the quality of the backscattered signal because of the small sounding cone (angle of 4°). The diameter of the footprint is nearly 7% of the water depth.

Beside the routinely analogous output on the DESO 25 print PARASOUND was connected to the data acquisition system PARADIGMA developed by SPIESS, University of Bremen.

PARADIGMA runs on a HP 3036 computer with 1 MByte memory, which was modular assembled and was equipped during this expedition with a digital voltmeter (detection rate 100 kHz), a multiplexer (24 channels, 100 kHz) and an HP-IB controller. For the high digital solution of the seismograms variable frequencies between 2.5 kHz - 5.5 kHz were detected. The seismograms are sampled at a frequency of 40 kHz with a registration length of 133 ms, which represents a penetration of 100 m. 5320 values were registered for every seismogram. The data were stored on hard disks and for permanent storage on magnetic tapes. During the expedition 12 magnetic tapes each with 90 MBytes were written.

Main work was the registration of digital seismograms on the positions of gravity cores. The registration was performed with various frequencies between 2.5 kHz - 5.5 kHz and different pulse lengths. The correlation of the processed seismograms with the physical characteristics of the sediment is planned after the core processing on the determination of the sediment parameters sound velocity (V_p), water content, porosity, carbon content, density and grain size. The correlation is limited to the core length. [Figure 32](#) shows an sample for the PARASOUND analogous record of a frequency test of the sediment core station GeoB 1314 (station 105). [Figure 32](#) indicates different penetration and solution of the sediment during different frequencies and pulse lengths.

Correlations to deeper sediment structures are planned to the deep sediment cores of the Ocean Drilling Program (ODP) site 515 located in the Brazil Basin and sites 516 and 517 located on the Rio Grande Rise. Therefore frequency tests were carried out at these positions. The comparison of these seismograms with the cores which are in good condition and excellent documented, will improve the connection of seismograms to the sediment characteristics.

The reflection of the seabottom of the Rio Grande Rise indicates a strong amplitude corresponding to the large impedance contrast between water and sediment. Core sampling was very difficult in this area because of the binding carbon rich sediment. Some sediment basins with good reflecting layers could be filled with turbidites from the slopes of the rise.

[Figure 33](#) shows sediment waves north of the Vema Channel with different amplitudes between 5 - 18 m and wave lengths of nearly 500 m produced by bottom water current. Sediment waves in the area of the Hunter Channel were obtained. Difficult sea state

conditions during the survey in the Hunter Channel prevented the determination of the region configuration of sediment waves.

Most parts of the Brazil Basin which were crossed during the way to Vitória, show hemipelagic sedimentation. Good stratified sediments covered with small waves indicate only small lateral sediment transport by Bottom Water.

5.3.1.2 Bathymetric measurements with HYDROSWEEP

(K. Heidland)

During the expedition M 15/2 bathymetric surveys of the sea bottom with the HYDROSWEEP system were carried out in the areas of the Vema and Hunter Channel. HYDROSWEEP worked permanently during the whole expedition. Watchkeeping of HYDROSWEEP was performed together with the PARASOUND system.

Vema Channel

The survey of the Vema Channel was carried out already during the expedition M 15/1 in December 1990. The survey was expanded in the north of the surveyed area with two HYDROSWEEP profiles. Morphological structures, which were discovered in the first survey, could be completed in the northern profiles.

The distance between the profiles was 4 nm, depending on the water depth of 4000 m in this area.

Hunter Channel

The Hunter Channel is beside the Vema Channel an important flow area for Antarctic Bottom Water (AABW) between the Argentine Basin and the Brazil Basin. The Hunter Channel is located between the Mid Atlantic Ridge and the Rio Grande Rise.

The knowledge of the bathymetry in this area is very poor because only a few ship tracks were available for the interpolation of isolines in this area. The bathymetry is shown in the chart "Bathymetry of the South Atlantic Ocean", published in 1989 by the Geological Society of America, Boulder, Colorado, U.S.A.

Aim of the HYDROSWEEP survey was the validation of the bathymetry in the chart and the improvement of the bathymetry in the area of the Hunter Channel for the determination of bottom flow of Antarctic Bottom Water. The main flow was expected

between 29°W and 27°W. The east boundary is the Mid Atlantic Ridge and the west boundary is the Rio Grande Rise.

A detailed survey of a small area of the Hunter Channel was carried out between 31°4'W - 30°52'W and 33°42'S - 34°32'S. First results of the hydrographical measurements (station 83, profile 79) and the bathymetry show that bottom flow is not probable in this area.

The Hunter Channel was covered with four long profiles for discovering of the important morphological structures (fig. 3b). Along the profile in south-eastern direction between 27°40'W - 27°30'W and east of 27°30'W the sea bottom is deeper than 4000 m. The northern profile shows depths which are deeper than 4000 m, between 27°35'W - 26°54'W. This area is an important passage for the bottom flow of Antarctic Bottom Water. Two profiles east of the station 87 (34°24'S, 27°56'W) show depths of 4700 m (fig. 34). It seemed possible that this area is connected to the northern fracture zone. Therefore an additional CTD-profile was performed. This measurement showed that bottom flow in this area seems not to be important.

The bathymetric survey offers together with the oceanographic measurements a good base for the balance of the water flow in the area of the Hunter Channel. A detailed survey in this area was not possible because of the bad sea state conditions for the HYDROSWEEP system.

For a detailed survey of the Hunter Channel in the area between 29°W 27°W and 34°10'S - 35°20'S nearly 10 days with good sea state conditions are necessary.

5.3.1.3 Navigation and Positioning

Precise navigation and positioning is necessary for bathymetric surveys. The Global Positioning System (GPS) is now the best tool for this work. The status of GPS was good during the expeditions and for the most time enough satellites were available for the determination of positions. If GPS was not available, navigation and positioning were carried out with INS, the Integrated Navigation System (INS), which works with satellite fixes of the TRANSIT system.

5.3.1.4 HYDROSWEEP Postprocessing

The HYDROSWEEP system is installed on board of METEOR for the postprocessing of the HYDROSWEEP measurements. During the expedition M 15/2 the survey of the Vema Channel and a detail of the Hunter Channel were processed. Results were 3D images of these areas ([fig. 34](#)).

5.3.2 Equipment operation and sample collection

(T. Bickert, G. Meinecke, S. Mulitza, J. Pätzold)

5.3.2.1 On-station geological work

The coring objectives for this cruise included the acquisition of sediment cores from the region of the Rio Grande Rise and the Hunter Channel in order to reconstruct the history of watermass circulation, especially the deep- and bottom-water circulation in the area of the Hunter Channel. Another aim was to collect samples on the Central Rio Grande Rise in the area of Antarctic Intermediate Water influx. The area of the Hunter Channel was to be sampled at three stations to the north and south of the central channel. The collection of geological samples was concentrated on an east-west profile at about 31°S, running from the Brazil Basin over the eastern ridge of the Rio Grande Rise, and into a northward-oriented extension of the Argentin Basin.

In order to document the history of the water masses, stations were chosen at depth intervals of 300 - 400 m in water depths of 2900 to 4100 m. It was also possible to take a sediment sample at 1950 m depth from the north slope of the eastern ridge of the Rio Grande Rise. The choices for core locations were based on the results of PARASOUND and HYDROSWEEP records also obtained during this cruise.

5.3.2.2 Sample Collection

The collection of sediment samples was carried out by a combination of multicorer and gravitycore operations. The multicorer served in the retrieval of undisturbed surface sediments, while the gravity corer provided for the collection of longer sediment cores. A summary of the instruments used at individual stations is shown in the list in [chapter 6.6.1](#).

The multicorer is outfitted with six tubes of 10.0 cm diameter and four tubes of 6.5 cm diameter. This instrument was employed a total of 12 times, with 100% successful acquisition of surface sediments. As a rule, the penetration depth was 20 to 30 cm. At

one station the instrument was employed a second time, due to partly disturbed surface sediments on the first attempt. In most tubes, the sediment column remained intact and allowed the retrieval of completely undisturbed surface sediments. The overlying clear bottom water was sampled for the analysis of stable isotopes of dissolved carbon. The multicorer proved itself to be a reliable sampling tool on this cruise in spite of sediments which were difficult to sample.

The gravity corer, with a 2.5 t weight and either 6 or 12 m long tubes, was fed by 12 cm diameter PVC lines and was employed for the retrieval of sediment cores up to 9.5 m long. Four unsuccessful gravity-core attempts were made on the central Rio Grande Rise in water depths of about 1000 m and 1300 m. Parallel sampling in this area with the Multicorer retrieved fairly coarse unconsolidated foraminiferal sands. In this material the gravity core presumably achieved only poor penetration, and the sediment obtained was probably further washed out as the core was raised to the surface.

During a coring operation in 1950 m of water on the northern slope of the Rio Grande Rise, a 12 m tube broke off at about 2.5 m above a 1.8 m long sediment core. Depending to some extent on water depth, the core material obtained during this cruise is relatively coarse and in part tightly consolidated with consistently high carbonate content. A 2 cm thick layer of pteropod shell fragments was encountered at the sediment surface at two stations on the eastern Rio Grande Rise in water depths of 1950 and 2900 m. The sediment-core lengths ranged from 1.7 to 9.5 m. A total of 14 core operations were carried out resulting in the retrieval of 57.9 m of core material.

5.3.2.3 Multicorer Sampling

After the Multicorer is brought to the deck the core tubes are removed and plugged with rubber stoppers. After sampling of the overlying water for ^{13}C analysis the individual cores are sampled according to the following routine:

25 cm² surface sediment for magnetic investigation

20 cm² surface sediment for clay-mineral analysis

10 cm² surface sediment for Be/Th analysis

1 syringe sample (10 cm³) surface sample for faunal analysis (0-1 cm)

240 cm² for investigation of the distribution of benthic foraminifera, preserving with ethanol and dyeing with Rose Bengal (in 1 cm layers from 0-10 cm, 12 - 13 cm and 15 - 16 cm.

80 - 160 cm² for radiolarian investigations (0 - 1 cm) preserving with methanol

- 25 cm² for diatom investigation (0 - 1 cm)
- 2 series of syringe samples of 10 cm³ each for geochemical, isotope and faunal investigations (1, 4, 7 cm, etc.)
- smear slides (parallel to syringe samples - 1, 4, 7 cm, etc)
- bag samples for large-fraction analysis (1 - 5, 5 - 10, 10 - 20 cm, 20 to total penetration depth), cooled to 4°C
- 2 archive cores (6.5 cm), frozen at -18°C
- 1 core (6.5 cm) for organic geochemistry, organic carbon, frozen at -18°C
- 1 core (6.5 cm) for sediment physics, cooled to 4°C

5.3.2.4 Gravity core processing

Before insertion into the gravity-core tubes the liners are marked with vertical lines for later orientation of the individual core segments. After retrieval of the cores, the liners are cut into 1 m lengths, capped at the ends, and inscribed according to [figure 35](#). The cores are then stored at a temperature of 4°C until further sampling and processing. Sedimentologic, sediment physics, faunal, and isotopic investigations are planned.

5.3.3 Water samples for ¹³C analysis

(T. Bickert)

The basis for paleoceanographic reconstruction is the image of the present-day circulation in the sediment. One source of information for this is the ¹³C/¹²C ratio, measured both in the dissolved carbon in the water and in the carbonate of foraminifera tests in the surface sediments.

The clear overlying water in the multicorer tubes is sampled at every core station ([chapter 6.6.2](#)). Additionally, water samples were drawn from the IfM Kiel rosettes from five stations in the area of the Hunter Channel and eastern Rio Grande Rise, at 20 chosen water depths ([chapter 6.6.3](#)). For the respective water samples 250 ml of water is released bubblefree into brown glass bottles, poisoned with 1 ml of saturated HgCl₂ solution, and the screw-on tops sealed airtight with liquid wax. Until further work on the samples in the laboratory - extraction and cleaning the CO₂ out of the water under vacuum and subsequent isotope measurement with the mass spectrometer - they are stored at 4°C.

5.3.4 Testing the Data storage - CTD

(T. Bickert)

The combination of physical oceanographers from the IfM Kiel and geoscientists from Bremen University on this cruise allowed the opportunity to test the performance of the newly acquired Datastorage-CTD Seacat SBE 19-02 from Sea-Bird Electronics, Inc. This probe is equipped with a pressure sensor (0 - 6800 m), a conductivity cell (0 - 7 S/m), a temperature sensor (-1 - +31°C) and a sensor for dissolved oxygen. The data are time-controlled with a pre-chosen measured frequency of 2/n Hz in a 256 kByte storage unit (corresponding to 28,800 measured cycles), binary based, and subsequently output through a serial port. The software package Seasoft 3.4 then allows the conversion of raw data to ASCII format with simultaneous interpolation of the data in 5 dbar intervals.

The IfM Kiel rosette samples were used to make a direct comparison between the Kiel CTD Mark III and the Datastorage-CTD. The five test profiles resulted in good agreement of the measured values. The deviations in the values - with measurements compared respectively for the same times - lay within the Seacat specified accuracy limits of 0.5% of the total pressure after the initial incidence of the "switch-on" offset of - 13.5 dbar (after about 120 sec) is corrected for. A temperature dependency of the pressure sensor could be rejected after a special test was performed (fig. 36). The temperature and salinity deviations of the Datastorer probe were, on the average, smaller than 0.02°C and 0.008 respectively. Larger fluctuations of up to 0.15°C (fig. 37) and 0.12 respectively, occurred mainly in the profiles with large gradients, possibly as a result of the low pressure sensor deviation. The oxygen values of the Seacat were surprisingly within +/-0.5 ml/l of values obtained by colleagues of the IfM Kiel using titration techniques. It is necessary to be aware, however, that with increasing age of the sensor, the deviation can quickly become greater, so that continuous calibration is required.

On future expeditions the Datastorage-CTD will routinely give support to geologic sample collection with oceanographic data. The probe will be fastened to the line about 100 m above the multicorer, boxcore or multinet, thereby saving time at the station. The procedure has been successfully tested at one station.

5.4 Biological Oceanography and marine Taxonomy

(H.G. Andres, H.-Ch. John, C. Zelck)

5.4.1 Introduction

This report is based on a preliminary analysis of 41 surface plankton samples (upper neuston net, NEU) and 20 plankton tows (multiple closing net, MCN, generally 200 - 0 m) out of a total of 49 NEU hauls and 48 MCN tows actually made. Details are listed in [chapter 6](#).

The analysis lays emphasis on those stations forming a coast-normal transect from the shelf at about Santa Catarina to ship station no. 91 (27°01'W) plus some additional "reference stations" northwards of this transect. The location of all analyzed stations together with respective surface temperatures is shown by [Fig. 38](#). Results from the transect are presented in [Figs. 39, 40 and 41](#).

5.4.2 Taxonomy and Vertical Distributions

According to a recent synopsis by BARNARD and THOMAS (1989), fairly abundant catches of *Synopia* (Amphipoda, Gammaridea) were formed by a species to be described as new (*Synopia* sp. n.). Of 71 fish taxa so far identified, larvae of the myctophids *Hygophum hanseni* and *Symbolophorus barnardi* were previously unknown. Known to science, but lacking or rare in German collections were larvae of *Bolinichthys* sp., *Lampanyctus pusillus* and *Myctophum selenops* (all Myctophidae); *Mola mola* (Molidae) and *Barathronus* sp. (Aphyonidae).

Those MCN-samples with vertical resolution yielded a comparatively small total catch of fishes (N = 476) and Gammaridea (N = 15). While Gammaridea appeared to be somewhat more abundant in the deeper strata, fish larvae occurred almost exclusively above 100 m depth, only 5.9% of their total catch came from 200 - 100 m. Fish larvae preferred the depth range above the thermocline even at the highest surface temperatures encountered.

5.4.3 Zoogeography and Ecology

Specific

Synopia sp. n. resembles its northern Atlantic congener *Synopia scheeleana* in morphology, dominance, nocturnal surface preference and affinity to warm, highly saline

water masses, as elucidated by a comparison of Figs. 38, 39 and 43 with respective data by ANDRES and JOHN (1984). Probably *Synopia* sp. n. is the ecologically corresponding species in the South Atlantic Subtropical Gyre. A revision of those prevailing meridional transects made during "Walter Herwig" cruise 36 (December 1970; JOHN 1975) could test this hypothesis.

Halobates micans (Hexapoda, Gerridae) had high frequencies but generally low abundance. This supports an earlier result by CHENG and SCHULTZ-BALDES (1981), where the sampling method previously was subject to discussion. Following SAVILOV (1967), the generally low abundance could be explained by the strong rainfalls encountered - both surveys fell into the rainy season, whilst the recent higher abundance values at the eastern part of the transect (Fig. 39e) as well as at reference station no. 100 (35.1 ind./1000 m²) coincided with the subtropical high-pressure-zone.

Holofaunistic

From an overall spectrum of 71 fish taxa and 3 Gammaridea, new or some conspicuous taxa have already been mentioned. The two other Gammaridea belong to the family Pandaliscidae and genus *Cyphocaris* (Fam. Lysianassidae). On board so far, some fish larvae of shelf biota were only identifiable to family level (Gadidae, Macrouridae, Mullidae, Callionymidae, Scombridae, Bothidae, Balistidae). Among Myctophidae endemic species were encountered, according to HULLEY (1981) *S. barnardi* is a southern subtropical species, *H. hanseni* and *Gonichthys barnesi* are species of the southern subtropical convergence. A further conspicuous feature of these samples was the paucity of subthermocline larvae (e.g. of family Sternoptychidae or suborder Alepisauroidi) even in the deep plankton tow.

Nevertheless, the majority of taxa was conform with previous largescale surveys of the tropicalsubtropical Atlantic (JOHN, 1975) or faunistic inventories of the worldwide epipelagic zone (PARIN, 1970). Therefore the following zoogeographical groups were defined by characteristic taxa listed in about their rank order:

Neritic-tropical complex:	Mullidae, <i>Dactylopterus volitans</i> , Balistidae, <i>Makaira nigricans</i> , <i>Coryphaena hippurus</i>
Distant-neritic complex:	Clupeioidi, <i>Maurolicus muelleri</i> , Callionymidae, Bothidae

Oceanic-tropical complex:	Halobathes micans, Vinciguerria nimbaria, Oxyporhamphus micropterus, Hygophum reinhardti, Coryphaena equiselis, Myctophum nitidulum, M. selenops, Chiasmodontidae
Oceanic-subtropical complex:	Synopia sp. n., Nanichthys simulans, L. pusillus, S. barnardi, Myctophum phengodes
Thermophile (tropical and subtropical >20°C) complex:	Exocheilichthys volitans, E. obtusirostris, Lepidophanes spp.
Subtropical convergence:	Gonichthys barnesi, H. hansenii, Protomyctophum sp.

According to the zoogeographical classifications given by HENTSCHEL (1944), our plankton survey (except for the reference stations nos. 56 - 67) coincided with the "southern subtropical border area" along the "subtropical convergence" (BÖHNECKE, 1936). In plankton abundance values presented by HENTSCHEL (1933) this boundary is pronounced as an extended zonal belt protruding from an otherwise narrow and meridional "central minimum area". This border- or convergence area became not apparent in the more modern treatise on zoogeography by BACKUS et al. (1977), but results by HULLEY (op. cit.) on the very same family compare well with the above discussed data and generally (small scale deviations will be discussed below) our quantitative findings. The data presented by HENTSCHEL (1933) seem to be the most detailed available so far. It is suggested that the deviating findings by BACKUS et al. may have been hampered by their low data density from the SW-Atlantic.

Along the western part of our transect (Figs. 39, 40 and 41) average abundances of Amphipoda and fish have been found. Lagging behind the decrease in surface temperature (sta. 21 - 22, about 43°W), the abundance values decrease by about one order of magnitude at sta. 27/28 (about 42°W). A similar zonal tongue in HENTSCHEL's data (1933), however, reached only to about 46°W and had minimum values. In our data, this tongue is obviously discernible from the oceanic minimum zone, but it is in no way uniform in species composition (see tables below Figs. 40 and 41).

At nearshore stations several taxa of the combined neritic complexes dominated with specific percentages of often 16 - 35% of the total catch. At the very same stations specimens of highoceanic taxa (of both the tropical and subtropical complex) were encountered as well as oceanicubiquitous taxa like *Cyclothone* spp., *Diogenichthys atlanticus* and *Notolychnus valdiviae*. However, these prevailing oceanic Myctophidae nearshore had low percentages in total catch (Fig. 41). Otherwise our samples did not allow a reasonable quantitative description of the shelf and slope area: Stations above less than 2500 m bottom depth showed extremely variable abundance values from 7.0 - 439.9 specimens/1000 m² (NEU) or 2.0 - 95.3 specimens/1 m² (MCN), and the NEU-maximum at sta. 60 off Cabo Frio coincided with an MCN-minimum. For this area HENTSCHEL (1933) depicted relatively high abundances. The percentages of myctophids at these MCN-stations were 33.9 - 50.5%.

The percentages of myctophids along the transect increased almost linearly until sta. 18 and oscillated in the oceanic realm around about 75%. A literature study in progress (JOHN and ZELCK, in preparation; following a hint by LOEB, 1979) shows for the subtropical gyres in the world ocean percentages of myctophid larvae around 45% as normal. NEU-samples are due to the inherent diurnal periodicity less discrete than MCN-tows, but generally the abundance values along stations 10 - 27 differed by less than one order of magnitude. MCN-samples (only to sta. 25) showed abundances between 65.8 - 111.9 fishes/ 1 m². In contrast, NEU-samples yielded more discrete qualitative results or at smaller geographical scales (perhaps as a consequence of the higher data density). The neritic-tropical complex showed a strong decline at sta. 8 (that is the deeper slope), and vanished at sta. 11. At sta. 8 the oceanic-tropical indicator *O. micropterus* appears. Thus the boundary described on base of the faunistic composition of NEU-samples was similar as found by HENTSCHEL (1933). The thermophile complex, as well as the tropical *H. micans*, spread farther to the coast. The western boundary of the tropical-oceanic complex was found at sta. 27.

From sta. 27 onwards faunistic elements of the subtropical and convergence complexes increased in frequency, but occasional intrusions backwards to sta. 12 occurred. By quantitative terms this zone was relatively uniform at 1.6 - 13.5 specimens/1000 m² (NEU) or 5.0 - 12.9 spec./1 m² (MCN) until sta. 91. Two invertebrates regularly encountered before disappeared or became rare along the stations sequence 29 - <81 (Fig. 39). However, MCN sta. 83 deviates by 29.7 fish/1 m² and only 40.9% Myctophidae, MCN sta. 100 showed 38.0 fish/1 m² and 46.6% myctophids.

Gonostomatidae had percentages of 48.2 or 44.4. Both stations had thus more "normal" values in the MCN, for NEU 100 a higher abundance of *H. micans* has already been mentioned. Whilst the above discussed faunistic boundary between the neritic and tropical complexes can thus be described from the samples at hand only qualitatively, low abundance values in the subtropical and convergence complexes can probably be statistically corroborated for both invertebrate- and ichthyoplankton.

To enhance understanding of these complex patterns, Fig. 42 reduces quantitative individual distributions to a two-dimensional qualitative figure of pooled distributions and overlap. Besides the location of station surface temperatures (Fig. 38) and the vertical structure of salinity 0 - 200 m (Fig. 43; in situ MCN-CTD data stations 6 - 32, distances scaleless as for Figs. 39 and 40) facilitate interpretation. A comparison of this set of figures suggested, that the complex patterns encountered can only partly be related to the horizontal distribution of temperature alone. Advective processes must have contributed.

5.4.4 Conclusions

Along the western part of the transect exclusively species of the neritic and oceanic-tropical complexes were found without intrusions of subtropical elements or the fauna of the convergence zone. Together with teleplanktonic neritic larvae of probably higher ages (LOPES and JOHN, 1986) young larvae of oceanic origin cooccurred above the shelf. Beyond the 25°C isotherm along the transect proper subtropical species appeared, but closely adjacent reference stations yielded exclusively tropical indicators even when surface temperatures were distinctly lower (of <24°C). The abundance values of *Synopia* sp. n. decreased immediately after declining temperatures by one order of magnitude.

Subsequently subtropical species occurred continuously besides tropical taxa (in reduced abundance), and neritic taxa were absent along the transect as well as at the northeastern reference stations. There occurred scattered intrusions of the convergence fauna. The centre of this belt coincides approximately with the 23°C surface isotherm, points approximately into the direction 100°, and extends probably beyond the easternmost stations sampled.

Conspicuous differences were found along the already discussed stations sequence 28 - 38 (probably including also 74), which yielded exclusively taxa of cooler waters. The

western boundary of this sequence corresponded at the surface with 36.2 psu, and below 60 m depth salinity was 36.0 psu. From [Fig. 43](#) (as well as very similar patterns of temperature and density) can be concluded, that up to sta. 27 water masses were sampled which had been transported southwards by the Brazil Current. Faunistically these water masses did not have neither a distinct oceanic nor neritic character, but were mixed, and above described small scale discrepancies between these results and those by HENTSCHEL (1933) can be explained by temporary discontinuities of the Brazil Current (e.g. is the Cabo Frio area generally an upwelling area). The subsequent stations yielded indicators of cooler water, probably after advection from the south, as described for this geographical longitude by PETERSON and STRAMMA (1991, Fig. 18). The southeasternmost stations then fell into an area of comparatively uniform hydrographical and faunistical conditions. Probably a distinctly tropical fauna would have been encountered again only slightly north of reference station 100.

5.4.5 Some Notes about the Tarball Pollution at the Water Surface

(L. Veiga, C. Zelck)

Clumps of tar, representing aged petroleum, are found on all seas (GERLACH, 1981; THEOBALD et al., 1987).

On the METEOR cruise 15/1 and /2 tarballs (bigger than 0.3 mm) were found in 91.8% of 49 biological surface water samples (for methods see [chapter 5.4.1](#)).

[Figure 42](#) shows the distribution and the relative amount of tarballs in the sampling area. To get an idea how old the tarballs are, the classification included microscopic observations to indicate the presence of organisms living on the tarball surface (in figure shown with +). The following groups of organisms used the tarballs as a substratum: Bryozoa, Lepas, Amphipoda, Algae and eggs from seaskater *Halobates micans* (in order of abundance).

Station with "many" to "a lot" of tarballs (in over 20% of the sampled stations) were mostly located in the Brazilian Current (see [Fig. 44](#)).

While "fresh", sticky tarballs were found in stations next to Cabo Frio, older tarballs (with organisms) were found only in the southern portion of the sampling area.

It is important to emphasize that the absence of tarballs does not necessarily mean there was no oil in the surface waters.

5.5 CO₂ Observations

(D.Wallace, K.M. Johnson, R. J. Wilke)

5.5.1 Activities

A global survey of inorganic carbon in the world ocean is being co-ordinated by JGOFS in close collaboration with WOCE. The aim of this survey is to collect a data set of sufficient quality and extent that the transport of carbon within the ocean and between the ocean and the atmosphere can be better estimated. Much of the survey will take place on WOCE legs. The US Department of Energy, Office of CO₂ Research, is playing a major role in supporting this survey through funding of sea-going analytical teams and shore-based quality control activities. The M 15/3 cruise on WOCE line A9 represents the first cruise of DOE's new program, and also represents the first cruise for the recently-formed BNL-CO₂ group. The primary goal during this cruise was to collect a high quality data set for the parameters Ct (total dissolved inorganic carbon) and pCO₂ (partial pressure of carbon dioxide). For quality control, additional samples were collected from selected stations for shore-based manometric analyses at Dr. C.D. Keeling's laboratory at the Scripps Institution of Oceanography. Analysis of these samples represents one stage of the DOE data quality-control procedures for the CO₂ survey. Samples were also collected from several stations for alkalinity analyses by Dr. Catherine Goyet of the Woods Hole Oceanographic Institution. In addition to Ct and pCO₂, experimental measurements of pH, and some new transient tracers were attempted.

The experimental tracer program was undertaken in close collaboration with the Bremen University Freon program.

5.5.2 Methods

CO₂

The Ct analyses were performed using an automated, dynamic headspace, coulometric CO₂ analyser. This instrument, designed by K. M. Johnson, and constructed at BNL and the University of Rhode Island, is capable of exceptionally accurate and precise measurements at sea. The pCO₂ analyses were made using a new static-headspace

equilibration technique together with gas chromatography. This technique, developed at BNL after a method developed for methane by Johnson (Anal. Chem., 62: 2408, 1990) proved to be highly convenient for use at sea.

Experimental pH measurements were attempted using a custom pH cell interfaced to the dynamic headspace analyser. In support of the CO₂ program, Secchi disk readings were performed in order to provide an estimate of depth-integrated biomass.

Tracers

In conjunction with the CO₂ program, our group made exploratory measurements of a suite of transient halocarbon tracers: notably F113 (CCl₂FCClF₂) and CCl₄. A new technique based on wide-bore capillary chromatography was utilised which gives good separation for the compounds of interest from naturally produced halocarbons such as methyl halides and chloroform. The technique was developed at BNL in collaboration with colleagues at the Bedford Institute of Oceanography (Canada) and Chalmers Univ. Technology (Sweden).

5.5.3 Preliminary Results

CO₂

Approximately 1000 coulometric analyses of Ct were made of samples from a total of 28 stations, with an estimated accuracy of approx 1 mol/kg. In general, samples were analyzed from almost every depth sampled during a cast. The pCO₂ data were collected from approximately 18 depths per CO₂ station. The Ct data show considerable differences between water masses and between the two deep basins as shown in the composite plots presented ([Figure 45](#)). In general the Antarctic-derived water masses are marked by high carbonate levels whereas the North Atlantic Deep Water exhibits a local minimum.

The total carbonate data exhibit clear differences between the Brazil and Angola Basins, as demonstrated in the composite plot of all the data collected during the cruise (see [Figure 45](#)). In addition there were strong zonal gradients in properties within each basin.

The differences are particularly pronounced between the bottom water masses. In particular, note the relatively low and uniform carbonate values of the deep Angola Basin which reflect the influence of North Atlantic Deep Water in ventilating this basin.

Surface water $p\text{CO}_2$ was close to equilibrium with the atmosphere throughout most of the section, with the exception of stations in the upwelling region off the African coast which displayed considerable supersaturation. Further analyses will require close cooperation with colleagues responsible for the nutrient, oxygen and hydrographic measurements: we expect that the Ct data will prove useful for water mass studies in the region.

Tracers

At selected stations, samples were analysed for F12, F11, F113 and CCl_4 . These measurements represent the first successful measurements of dissolved F113 in the Southern Hemisphere and probably the first reliable depth profiles of CCl_4 outside of highlatitude oceans. While the technique is still under development, sufficient data were collected to emphasise both the potential and some limitations of F113 and CCl_4 as tracers. Considerable data analysis will be required before firm conclusions can be drawn, but we can tentatively suggest the following: (1) $\text{CCl}_4/\text{F11}$ ratios over the Brazilian continental slope are consistent with an AABW age of approximately 25 years; (2) There appeared to be traces (0.04-0.07 pmol/kg) of above-background CCl_4 in the deep water over the Mid-Ocean Ridge in the absence of detectable F11 or F12. This might be a result of a longer input function for anthropogenic CCl_4 which was introduced into the environment in significant quantities since the early 1900's; (3) CCl_4 levels in the Angola Basin bottom waters were very low (approx. 0.01 pmol/kg) but always above detection limit. It is unclear whether this level reflects a preindustrial, natural background, or slight contamination; (4) $\text{CCl}_4/\text{F11}$ ratios in subsurface waters >13 C, were lower than expected and suggest that chemical removal of CCl_4 (e.g. hydrolysis) is probably significant in warm waters; (5) Detectable F113 was confined to the upper 300m of the water column: contrary to previous belief there were no major contamination problems for F113 sampling. A more severe problem appears to be chromatographic interferences by natural halocarbons (e.g. CH_3I).

5.6 Air chemistry

(M.O. Andreae, T. Andreae, St. de Mora)

The investigations concerned dimethylsulfide (DMS) and cloud condensation nuclei, with emphasis on the biogeochemical cycling of sulfur. The study was based on the

hypothesis that the density of cloud condensation nuclei is influenced by dimethylsulfide produced in the marine biosphere.

This hypothesis claims a connection between the following processes. Marine phytoplankton, in the presence of sunlight is able to produce a compound which decomposes in sea water and enters the atmosphere as dimethylsulfide (DMS). DMS in turn, is unstable in the atmosphere and oxidizes to sulfate. This sulfate forms particles and thus influences the cloud condensation nuclei density. Ultimately, these nuclei modify cloud formation and consequently the albedo of the earth. This influences the global radiation balance and temperature, and provides a feedback cycle between the ocean and atmosphere by biological processes. The mass flux from the marine biosphere into the atmosphere is approximately 40 Tg sulfur/year and consequently is of global importance.

The following measurements were performed: DMS in sea water and in air, total number of aerosol particles in air, size spectra of aerosol particles in air, size spectra of aerosol particles, number of cloud nuclei and oversaturation spectrum, carbon in air, ozone and phase distribution of MSA.

The lowest DMS concentrations were found in the western part of the section (ca. 1 nmol/L), the highest values in the east (up to 44 nmol/L). Values were particularly large and variable in the Benguela Current region.

Particle concentrations decreased with distance from the South American continent, with lowest values of 60 cm^{-3} in the western basin and then increasing values up to $400 - 600 \text{ cm}^{-3}$ in the east. Carbon values were usually as low as $1 - 5 \text{ ng m}^{-3}$, with higher values near the continents.

The size distribution of aerosol showed that only 75% of particles in the western region were below $0.2 \text{ }\mu\text{m}$. In the eastern region with larger total numbers the contribution of this size class increased to 90%.

Cloud nuclei numbers had a fairly constant ratio to particles $<0.2 \text{ }\mu\text{m}$ everywhere. With water vapor oversaturation of 0.5% the number of nuclei was four times the number of the large particles. The ratio of cloud nuclei to total particle number varied between 20

and 80%. The nuclei number depends much less on the DMS oxydation rate than the total particle number.

5.7 Nutrient Chemistry

(D.L.Bos, J.C.Jennings)

Chemists from the Scripps Institution of Oceanography (SIO) and Oregon State University (OSU) carried out measurements for the dissolved inorganic nutrients; nitrate, phosphate, silicate and nitrite. Samples were drawn from all depths at every rosette cast, and analyzed with a continuous flow analyzer. SIO provided an Alpkem Corporation RFA 300 analyzer which was used in conjunction with a data acquisition system supplied by OSU. Data from most stations were available within 24 hours, and a complete set of preliminary data was made available before the end of the cruise for merging with other bottle data.

The inorganic nutrient data are important in the interpretation of CO₂ system data and as additional tracers of the movements of water masses. The large vertical and zonal variations in concentration of nitrate and silicate in the water masses of the South Atlantic make nitrate and silicate particularly useful as water mass tracers in the deep and bottom water masses. [Figures 46](#) and [47](#) are profiles from the deep, central regions of both basins, and graphically illustrate the different water mass properties encountered along the METEOR 15/3 section. Silicate concentrations in the bottom waters of the Brazil and Angola basins differ by over 50 micromoles/liter. In the Brazil basin, concentrations of nitrate, phosphate and silicate increase below the broad minimum associated with NADW.

The topographically isolated bottom waters of the Angola Basin, in contrast, are nearly homogeneous in their nutrient concentrations below 3500 meters. The nutrient maximum which is associated with the oxygen minimum below the main pycnocline is increasingly strongly developed along the West to East A9 cruise track. Nitrate and phosphate concentrations in the nutrient maxima increase in the eastern South Atlantic, but silicate concentrations exhibit little variation. The broad nutrient minimum in the 2000 - 3000 meter depths of the western South Atlantic is still present but much less pronounced in the east.

The nutrient measurements during M 15/3 were supported by the US WOCE Hydrographic Program. In addition to obtaining the nutrient data from the WOCE A9 leg as part of the core hydrographic measurements, it was intended that the two participating chemists compare the methods and laboratory procedures in use by their respective institutions. The goal is to develop standardized procedures which can be implemented in upcoming US WOCE cruises in the South Pacific.

Additional dissolved oxygen samples were collected and analyzed at 21 stations along the A9 cruise track to provide a comparison of the dissolved oxygen procedures used by IFMW with those of SIO. This comparison included an exchange of reagents and comparison of blanks and standards. Although the chemical methods employed by both institutions are the same, there are several procedural differences in the manner in which the samples are handled. Postcruise calibrations and careful comparison of the dissolved oxygen data will be necessary to determine if there are any systematic differences in the two methods.

5.8 Observations of dissolved oxygen (D. Nehring, B. Wachs)

On all stations and from all bottles dissolved oxygen contents were determined using the methods of WINKLER (1888) and GRASSHOFF (1976). More than 10 % were double samples at all concentrations to estimate a relative measurement error (standard deviation) of less 0.5 %. The WOCE requirements are therefore fulfilled. A more detailed description is given in the following table.

Depth/m	double samples	MO ₂ /cm ³ dm ⁻³	standard deviation	relative error
10	8	4.753	+/-0.0055	+/-0.12%
500	8	2.176	+/-0.0044	+/-0.20%
800	7	3.125	+/-0.0069	+/-2.22%
2500	8	5.377	+/-0.0061	+/-0.11%

The method described in the 'WHP Operations and Methods' differs slightly from the older WINKLER/GRASSHOFF methods used here. However, comparison with measurements on synoptic samples taken sporadically by Bos (Scripps Institution of Oceanography) during this cruise show no systematic differences in the results obtained

from both methods, with differences being usually less 0.03 ml/l. Nevertheless, for future precise measurements the WHP methods (WHP, 1990; CARPENTER, 1967) should be applied. This not only recommended for consistency, but also because this method requires less concentrations of thiosulfate which may lead to lower errors in reading and less offset errors in titration.

The oxygen measurements also served to calibrate the oxygen sensor on the main CTD.

WHP section A9 on 19°S is placed between profiles VI (15-18 S) and VII (21-24 S) obtained from May to August 1926 on the German METEOR during her Atlantic Expedition. The present vertical distribution of oxygen is comparable almost everywhere with that from profile VII. Only close to the African coast where section A9 turns NE, the present measurements approximate those from profile VI. No significant differences between oxygen distributions observed in 1926 and 65 years later in 1991 can be detected so far.

It may be noted that on the whole section an intermediate oxygen maximum can be identified. In the Brazil Basin, it is found between 60 and 100 m depth, in the eastern part of the section at 150 to 250 m depth. This supports the idea of an eastward undercurrent below the South Equatorial Benguela Current system.

6 Lists

6.1 XBT Drops

XBT Drops M 15/1-2

STATION	DATE	TIME	LATITUDE	LONGITUDE
001	30-DEC-1990	21:01	23° 47.00' S	43° 38.00' W
002	30-DEC-1990	21:15	23° 48.50' S	43° 37.10' W
003	30-DEC-1990	21:53	23° 54.50' S	43° 33.80' W
004	30-DEC-1990	22:56	24° 4.00' S	43° 28.50' W
005	30-DEC-1990	23:55	24° 13.10' S	43° 23.40' W
006	31-DEC-1990	0:54	24° 22.40' S	43° 18.20' W
007	31-DEC-1990	1:54	24° 31.90' S	43° 12.90' W
008	31-DEC-1990	2:56	24° 41.80' S	43° 7.30' W
009	31-DEC-1990	3:56	24° 51.40' S	43° 1.90' W
010	31-DEC-1990	4:51	25° 0.30' S	42° 56.90' W
011	31-DEC-1990	5:47	25° 9.20' S	42° 51.90' W
012	15-JAN-1991	20:22	24° 26.50' S	42° 39.90' W

STATION	DATE	TIME	LATITUDE	LONGITUDE
013	15-JAN-1991	20:52	24° 22.10' S	42° 41.60' W
014	15-JAN-1991	21:22	24° 17.30' S	42° 44.10' W
015	15-JAN-1991	21:50	24° 13.40' S	42° 46.30' W
016	15-JAN-1991	22:21	24° 8.90' S	42° 48.90' W
017	15-JAN-1991	22:50	24° 4.00' S	42° 51.60' W
018	15-JAN-1991	23:20	23° 59.70' S	42° 54.50' W
019	15-JAN-1991	23:55	23° 54.10' S	42° 57.70' W
020	16-JAN-1991	0:21	23° 49.90' S	43° 0.20' W
021	16-JAN-1991	0:57	23° 44.60' S	43° 0.30' W
022	16-JAN-1991	1:26	23° 39.80' S	43° 5.70' W
023	16-JAN-1991	1:55	23° 34.80' S	43° 8.60' W
025	27-JAN-1991	16:24	34° 13.10' S	28° 54.40' W
026	27-JAN-1991	20:37	34° 17.50' S	28° 29.20' W
027	28-JAN-1991	1:25	34° 23.60' S	27° 55.70' W
028	28-JAN-1991	16:26	35° 12.10' S	26° 45.50' W
029	28-JAN-1991	21:25	34° 40.00' S	26° 24.90' W
030	29-JAN-1991	0: 7	34° 38.50' S	26° 32.50' W
031	29-JAN-1991	2:52	34° 33.00' S	26° 57.90' W
032	29-JAN-1991	9:25	34° 30.50' S	27° 15.20' W
033	29-JAN-1991	14: 5	34° 26.90' S	27° 37.60' W
034	29-JAN-1991	19:14	34° 22.30' S	27° 42.00' W
035	30-JAN-1991	8: 4	33° 36.30' S	27° 40.30' W
036	31-JAN-1991	1:57	32° 0.90' S	28° 23.40' W
037	31-JAN-1991	11:10	32° 0.90' S	28° 39.70' W
038	1-FEB-1991	1:53	26° 13.50' S	36° 30.50' W
039	1-FEB-1991	2:52	26° 4.20' S	36° 33.80' W
040	1-FEB-1991	3:54	25° 52.50' S	36° 38.70' W
041	1-FEB-1991	4:56	25° 42.00' S	36° 39.90' W
042	1-FEB-1991	5:52	25° 32.50' S	36° 42.90' W
044	1-FEB-1991	6:59	25° 20.80' S	36° 46.70' W
045	1-FEB-1991	7:53	25° 12.00' S	36° 49.50' W
047	5-FEB-1991	9:55	24° 49.50' S	36° 55.00' W
048	5-FEB-1991	10:53	24° 39.80' S	36° 57.80' W
049	5-FEB-1991	11:53	24° 28.80' S	37° 0.70' W
050	5-FEB-1991	13: 3	24° 17.30' S	37° 5.50' W
051	5-FEB-1991	13:14	24° 15.40' S	37° 6.10' W
052	5-FEB-1991	13:59	24° 7.90' S	37° 8.10' W
053	5-FEB-1991	14:59	23° 57.60' S	37° 11.10' W
055	5-FEB-1991	16:10	23° 45.90' S	37° 14.70' W
056	5-FEB-1991	16:58	23° 37.50' S	37° 17.30' W
057	5-FEB-1991	17:57	23° 27.20' S	37° 20.30' W
058	5-FEB-1991	18:57	23° 16.60' S	37° 23.50' W
059	5-FEB-1991	19:58	23° 5.30' S	37° 26.90' W
060	5-FEB-1991	20:57	22° 55.30' S	37° 28.20' W
061	5-FEB-1991	21:54	22° 44.00' S	37° 30.50' W
062	5-FEB-1991	22:57	22° 33.40' S	37° 33.50' W
064	6-FEB-1991	0: 9	22° 19.90' S	37° 37.80' W
065	6-FEB-1991	0:59	22° 11.10' S	37° 41.30' W
066	6-FEB-1991	2: 0	22° 2.10' S	37° 45.50' W

STATION	DATE	TIME	LATITUDE	LONGITUDE
067	6-FEB-1991	12:24	21° 13.30' S	38° 44.90' W
068	6-FEB-1991	16: 9	20° 59.90' S	39° 7.10' W
069	6-FEB-1991	18:44	20° 52.00' S	39° 19.50' W
070	6-FEB-1991	21: 2	20° 45.30' S	39° 29.70' W
071	6-FEB-1991	22:53	20° 42.50' S	39° 35.30' W
072	7-FEB-1991	0:58	20° 39.00' S	39° 40.00' W

XBT Drops M 15/3

STATION	DATE	TIME	LATITUDE	LONGITUDE
01	11-FEB-1991	4:38	19° 0.00' S	38° 0.00' W
02	11-FEB-1991	4:59	18° 59.30' S	37° 57.90' W
03	11-FEB-1991	5:20	19° 0.00' S	37° 55.50' W
04	11-FEB-1991	5:40	19° 0.10' S	37° 52.40' W
05	11-FEB-1991	6: 0	19° 0.10' S	37° 49.90' W
06	11-FEB-1991	6:20	19° 0.20' S	37° 47.60' W
07	11-FEB-1991	6:40	19° 0.10' S	37° 45.30' W
08	11-FEB-1991	7: 0	19° 0.00' S	37° 42.90' W
09	11-FEB-1991	7:20	19° 0.70' S	37° 41.10' W
10	11-FEB-1991	7:40	19° 0.00' S	37° 38.40' W
11	11-FEB-1991	8: 0	19° 0.00' S	37° 36.10' W
12	11-FEB-1991	8:20	19° 0.00' S	37° 33.70' W
13	11-FEB-1991	8:40	18° 59.30' S	37° 30.90' W
14	11-FEB-1991	9: 0	19° 0.10' S	37° 29.10' W
15	11-FEB-1991	9:20	19° 0.10' S	37° 26.90' W
16	11-FEB-1991	9:40	19° 0.00' S	37° 24.10' W
17	17-FEB-1991	10:47	18° 59.70' S	29° 27.40' W
18	17-FEB-1991	10:56	18° 59.80' S	29° 26.30' W
19	18-FEB-1991	3:41	19° 0.00' S	28° 0.00' W
20	18-FEB-1991	13:37	18° 60.00' S	27° 7.50' W
21	18-FEB-1991	23: 6	19° 0.00' S	26° 15.00' W
22	19-FEB-1991	8:59	18° 60.00' S	25° 22.50' W
23	20-FEB-1991	15:16	19° 0.00' S	24° 33.80' W
24	21-FEB-1991	0:36	18° 60.00' S	23° 41.30' W
25	21-FEB-1991	10:28	19° 0.00' S	22° 48.80' W
26	21-FEB-1991	19:30	19° 0.00' S	21° 56.50' W
27	22-FEB-1991	4:41	19° 0.00' S	21° 3.80' W
28	22-FEB-1991	13:48	19° 0.00' S	20° 11.30' W
29	23-FEB-1991	16:37	19° 0.00' S	18° 11.00' W
30	24-FEB-1991	6:11	19° 0.00' S	17° 7.40' W
31	5-MAR-1991	23:21	19° 35.90' S	4° 31.60' W
32	5-MAR-1991	7:15	19° 35.70' S	4° 0.50' W
33	9-MAR-1991	11:58	19° 0.00' S	1° 15.20' E
34	10-MAR-1991	2:48	19° 0.00' S	3° 52.30' E
35	11-MAR-1991	10:33	19° 0.00' S	4° 23.90' E
36	11-MAR-1991	18: 3	19° 0.00' S	4° 55.40' E
37	11-MAR-1991	19: 9	18° 60.00' S	5° 5.50' E

STATION	DATE	TIME	LATITUDE	LONGITUDE
38	11-MAR-1991	20:12	18° 60.00' S	5° 16.60' E
39	12-MAR-1991	1:50	19° 0.00' S	5° 26.80' E
40	12-MAR-1991	9:58	18° 58.80' S	5° 58.50' E
41	17-MAR-1991	1:29	18° 55.40' S	8° 14.10' E
42	17-MAR-1991	2:35	18° 50.80' S	8° 23.80' E
43	17-MAR-1991	9: 7	18° 41.50' S	8° 43.10' E
44	17-MAR-1991	10: 9	18° 36.90' S	8° 52.70' E
45	17-MAR-1991	16:38	18° 27.70' S	9° 12.00' E
46	17-MAR-1991	17:37	18° 23.00' S	9° 21.70' E
47	17-MAR-1991	23:34	18° 13.80' S	9° 40.90' E
48	18-MAR-1991	0:37	18° 9.20' S	9° 50.60' E
49	18-MAR-1991	6:16	18° 0.00' S	10° 0.20' E
50	18-MAR-1991	6:26	17° 59.60' S	10° 10.70' E
51	18-MAR-1991	7:36	17° 55.30' S	10° 19.50' E
52	18-MAR-1991	16: 1	17° 46.10' S	10° 38.80' E
53	18-MAR-1991	22:17	17° 36.90' S	10° 58.10' E
54	18-MAR-1991	23:24	17° 32.20' S	11° 7.70' E
55	18-MAR-1991	0:26	17° 27.60' S	11° 17.40' E
56	19-MAR-1991	1:42	17° 23.00' S	11° 27.00' E
57	19-MAR-1991	1:58	17° 21.30' S	11° 26.70' E
58	19-MAR-1991	4: 0	17° 0.00' S	11° 19.00' E
59	19-MAR-1991	5:59	16° 38.00' S	11° 11.00' E
60	19-MAR-1991	7:59	16° 17.40' S	11° 3.40' E
61	19-MAR-1991	10: 0	15° 56.60' S	10° 55.80' E
62	19-MAR-1991	12: 2	15° 36.30' S	10° 48.70' E
63	19-MAR-1991	13:58	15° 14.50' S	10° 40.70' E
64	19-MAR-1991	15:59	14° 53.70' S	10° 32.70' E
65	19-MAR-1991	17:59	14° 32.50' S	10° 25.80' E
66	19-MAR-1991	20: 0	14° 10.80' S	10° 17.90' E
67	19-MAR-1991	21:59	13° 49.50' S	10° 10.00' E
68	19-MAR-1991	23:59	13° 29.40' S	10° 3.90' E
69	20-MAR-1991	1:58	13° 9.00' S	9° 55.90' E
70	20-MAR-1991	3:59	12° 48.00' S	9° 48.70' E
71	20-MAR-1991	5:59	12° 26.80' S	9° 41.30' E
72	20-MAR-1991	7:59	12° 6.00' S	9° 33.50' E
73	20-MAR-1991	9:59	11° 45.00' S	9° 26.00' E
74	20-MAR-1991	11:59	11° 24.80' S	9° 19.20' E
75	20-MAR-1991	14: 2	11° 4.00' S	9° 11.80' E
76	20-MAR-1991	15:59	10° 43.00' S	9° 4.60' E
77	20-MAR-1991	23:59	10° 17.20' S	9° 6.40' E
78	21-MAR-1991	1:59	9° 56.90' S	9° 16.10' E
79	21-MAR-1991	3:59	9° 36.90' S	9° 25.50' E
80	21-MAR-1991	5:59	9° 17.50' S	9° 35.40' E

6.2 CTD Stations

CTD Stations M 15/1-2

Station Nr.	Datum	Beginn UTC	Ende UTC	Position		Tiefe 1500 m/s	Arbeiten Bemerkungen	
				Breite	Länge			
1	1.01.1991	12:06	13:05	27 53.86 S	46 42.48 W	2187	CT	Neu MSN
2	1.01.1991	16:04	17:40	27 50.00 S	46 55.10 W	1150	CT	Neu
3	1.01.1991	18:38	19:12	27 47.04 S	47 6.25 W	646	CT	Neu MSN
4	1.01.1991	21:37	22:01	27 44.14 S	47 15.05 W	(255)	CT	Neu MSN
5	1.01.1991	23:50	00:10	27 42.35 S	47 20.81 W	192	CT	Neu MSN
6	2.01.1991	2:59	03:18	27 40.05 S	47 30.00 W	141	CT	
7	2.01.1991	9:09	10:19	27 56.98 S	46 28.21 W	(1735)	CT	
8	2.01.1991	14:23	17:53	28 0.04 S	46 21.20 W	2248	CT	Neu
9	2.01.1991	20:27	21:50	28 3.99 S	46 2.12 W	2488	CT	Neu MSN
10	3.01.1991	0:34	02:58	28 5.98 S	45 52.84 W	2734	CT	Neu MSN
11	3.01.1991	5:32	07:31	28 11.12 S	45 33.02 W	2863	CT	Neu MSN
12	3.01.1991	14:05	16:06	28 16.07 S	45 12.84 W	3273	CT	Neu MSN
13	3.01.1991	17:00	18:44	28 18.98 S	45 6.04 W	3369	CT	Neu MSN
14	3.01.1991	20:58	22:45	28 21.90 S	44 51.81 W	3445	CT	Neu MSN
15	4.01.1991	0:56	03:10	28 26.92 S	44 38.44 W	3596	CT	Neu MSN
16	4.01.1991	5:14	07:16	28 29.07 S	44 29.02 W	3634	CT	Neu MSN
17	4.01.1991	17:30	19:33	28 37.01 S	44 14.36 W	3700	CT	Neu MSN
18	4.01.1991	23:14	01:17	28 42.67 S	44 5.56 W	3772	CT	Neu MSN
19	5.01.1991	3:24	05:37	28 50.06 S	43 45.66 W	3805	CT	Neu MSN
20	5.01.1991	15:51	18:00	29 2.88 S	43 31.03 W	3922	CT	Neu MSN
21	5.01.1991	19:58	22:05	29 10.47 S	43 18.88 W	4020	CT	G Neu MSN
22	6.01.1991	0:07	02:35	29 17.38 S	43 7.11 W	4020	CT	G Neu MSN
23	6.01.1991	4:54	07:00	29 24.43 S	42 55.02 W	4021	CT	G Neu MSN
24	6.01.1991	16:45	16:53	29 32.97 S	42 42.36 W	4022	CT	G Neu MSN
25	6.01.1991	20:34	22:45	29 40.31 S	42 28.34 W	4020	CT	G Neu MSN
26	7.01.1991	1:05	03:14	29 48.50 S	42 14.05 W	3938	CT	G Neu MSN
27	7.01.1991	5:28	07:21	29 56.47 S	41 59.27 W	3873	CT	G Neu MSN
28	7.01.1991	15:45	17:46	30 5.85 S	41 41.57 W	3782	CT	G Neu MSN
29	7.01.1991	19:05	21:06	30 12.49 S	41 31.17 W	3842	CT	G Neu MSN
30	7.01.1991	23:23	01:35	30 20.05 S	41 17.07 W	3874	CT	G Neu MSN
31	8.01.1991	3:59	06:03	30 27.80 S	41 2.80 W	3714	CT	G Neu MSN
32	8.01.1991	12:08	14:19	30 34.91 S	40 47.37 W	3736	CT	G Neu MSN

Station Nr.	Datum	Beginn UTC	Ende UTC	Position		Tiefe 1500 m/s	Arbeiten	
				Breite	Länge		Bemerkungen	
33	8.01.1991	16:40	18:15	30 45.72 S	40 31.95 W	3720	C	G
34	8.01.1991	20:03	21:40	30 55.78 S	40 16.90 W	3834	C	G
35	8.01.1991	23:37	01:12	31 6.50 S	40 0.10 W	3708	C	G
36	9.01.1991	13:10	16:03	31 11.81 S	39 45.87 W	4979	CT	G
37	9.01.1991	18:37	20:43	31 9.44 S	39 26.74 W	4321	CT	G Neu MSN
39	11.01.1991	12:28	14:47	31 4.93 S	39 9.23 W	4172	CT	G Neu MSN
40	11.01.1991	19:54	21:52	31 9.79 S	39 25.75 W	4668	C	G
41	11.01.1991	23:03	01:40	31 11.99 S	39 25.98 W	4575	C	G
42	12.01.1991	4:20	06:20	31 12.01 S	39 23.97 W	4605	C	G
43	12.01.1991	6:57	08:55	31 12.06 S	39 21.08 W	4618	C	G
44	12.01.1991	12:38	14:15	31 8.96 S	38 49.52 W	3614	CT	G
46	12.01.1991	19:51	21:54	31 10.64 S	39 4.62 W	4207	C	G
47	12.01.1991	22:56	00:53	31 11.49 S	39 14.50 W	4067	C	
48	13.01.1991	1:15	02:59	31 12.01 S	39 16.04 W	4067	C	G
49	13.01.1991	3:27	05:23	31 12.00 S	39 19.00 W	4480	C	G
50	13.01.1991	6:35	08:25	31 12.02 S	39 28.01 W	4153	C	G
51	13.01.1991	9:01	10:48	31 9.15 S	39 31.58 W	4414	C	G
52	13.01.1991	11:34	14:00	31 5.86 S	39 32.36 W	4461	CT	G
53	13.01.1991	14:46	17:00	31 4.93 S	39 38.08 W	4268	CT	G
54	14.01.1991	4:15	04:47	29 24.90 S	39 38.00 W	(4300)	C	G Neu MSN
55	14.01.1991	16:32	17:02	27 56.50 S	40 22.00 W	(4000)	C	G Neu MSN
56	15.01.1991	18:47	19:42	24 27.99 S	42 37.98 W	1549	CT	G Neu MSN
57	19.01.1991	4:42	04:59	23 27.84 S	41 34.84 W	130	CT	G
58	19.01.1991	5:55	06:10	23 33.95 S	41 31.04 W	139	CT	G
59	19.01.1991	7:17	07:30	23 41.10 S	41 26.87 W	158	CT	G
60	19.01.1991	8:09	08:32	23 45.02 S	41 25.05 W	549	CT	G 2Neu 2MSN
61	19.01.1991	11:07	11:57	23 47.99 S	41 22.06 W	964	CT	G
62	19.01.1991	12:58	14:06	23 54.72 S	41 18.16 W	1417	CT(FR)	G
63	19.01.1991	15:01	16:34	24 3.02 S	41 15.00 W	2019	CT	G
64	19.01.1991	18:13	19:33	24 16.01 S	41 6.98 W	2398	CT	G Neu MSN
65	19.01.1991	22:12	23:48	24 29.51 S	40 58.48 W	2674	CT(FR)	G
66	20.01.1991	5:25	07:28	25 19.03 S	40 33.10 W	3178	CT(FR)	G
67	20.01.1991	15:25	17:44	26 35.05 S	39 44.98 W	4279	CT(FR)	G Neu MSN
68	21.01.1991	3:45	06:20	27 55.00 S	38 50.07 W	4244	CTFR	G Neu MSN
69	21.01.1991	14:11	16:55	29 7.99 S	38 59.94 W	4686	CTFR	G Neu MSN
70	21.01.1991	23:01	01:17	30 0.05 S	39 20.05 W	4785	CT(FR)	G

Station Nr.	Datum	Beginn UTC	Ende UTC	Position		Tiefe 1500 m/s	Arbeiten Bemerkungen	
				Breite	Länge			
71	22.01.1991	9:02	11:45	30 59.05 S	39 28.92 W	4700	CTFR HE 3H	G
72	22.01.1991	23:20	01:50	31 9.71 S	38 46.81 W	3568	CTFR	G
73	23.01.1991	3:53	05:47	31 2.93 S	38 24.25 W	3254	CT	G
74	23.01.1991	9:15	11:10	30 56.83 S	38 2.58 W	2983	CTFR	G Neu MSN
75	23.01.1991	16:27	17:44	30 43.44 S	37 7.93 W	1868	CTFR	G
76	23.01.1991	22:25	23:18	30 30.48 S	36 12.78 W	1073	CTFR	G
77	24.01.1991	7:46	08:46	30 16.73 S	35 17.02 W	1312	CT	G 2Neu 2MSN
78	24.01.1991	22:29	22:56	31 0.03 S	33 59.98 W	940	C	G
79	25.01.1991	4:24	05:25	31 43.01 S	33 26.88 W	2225	C	G
80	25.01.1991	6:51	08:15	31 54.06 S	33 15.85 W	2225	C	G
81	25.01.1991	12:59	15:21	32 35.08 S	32 36.95 W	(4180)	CTFR	G Neu MSN
82	25.01.1991	21:15	22:35	33 15.11 S	31 54.95 W	3118	C	G
83	26.01.1991	14:16	17:04	33 51.91 S	30 53.92 W	5164	CTFR	G Neu MSN
84	27.01.1991	11:27	12:53	34 11.67 S	29 13.63 W	3554	C	G
85	27.01.1991	14:36	16:15	34 13.00 S	28 55.00 W	3923	C	G
86	27.01.1991	18:29	20:35	34 17.33 S	28 30.13 W	4068	CFR HE 3H	G
87	27.01.1991	23:25	01:15	34 23.52 S	27 55.47 W	4142	C(FR)	G
88	28.01.1991	14:03	16:20	35 12.31 S	26 45.39 W	4056	CTFR	G
89	28.01.1991	20:18	21:20	34 39.99 S	26 24.94 W	2378	C	G
90	28.01.1991	22:27	00:00	34 38.88 S	26 32.04 W	3504	C	G
91	29.01.1991	3:12	03:02	34 32.55 S	26 59.98 W	4362	C	G Neu MSN
92	29.01.1991	7:25	09:20	34 30.14 S	27 15.06 W	4280	C	G
93	29.01.1991	11:43	14:00	34 26.97 S	27 37.11 W	4143	C	G
94	29.01.1991	17:13	19:15	34 22.24 S	27 41.31 W	4489	C	G
95	30.01.1991	5:40	08:02	33 36.00 S	27 39.88 W	4051	CTFR HE 3H	G
96	30.01.1991	13:07	15:17	32 47.20 S	27 45.00 W	3622		G
97	31.01.1991	0:03	01:48	32 0.93 S	28 22.96 W	4125	C	G
98	31.01.1991	4:33	06:44	31 39.93 S	28 40.08 W	3961	CTFR HE 3H	G
99	31.01.1991	12:10	15:00	31 37.43 S	28 47.75 W	3783	CTFR	G
100	31.01.1991	20:48	22:15	31 35.30 S	28 54.14 W	3348	C	G Neu MSN
101	1.02.1991	4:29	06:00	31 30.72 S	29 5.94 W	2903	C	G
102	1.02.1991	9:06	10:33	31 39.88 S	29 39.42 W	3435	C	G
103	1.02.1991	22:49	01:06	31 39.64 S	30 2.03 W	3703	CTFR	G
104	2.02.1991	2:55	04:58	31 29.41 S	30 19.49 W	4946	CT	G
105	2.02.1991	12:53	13:21	31 9.93 S	30 54.93 W	4073	CTFR	G Neu MSN
106	3.02.1991	6:03	07:00	28 50.15 S	31 4.94 W	1970	C	G

Station Nr.	Datum	Beginn UTC	Ende UTC	Position		Tiefe 1500 m/s	Arbeiten Bemerkungen
				Breite	Länge		
107	3.02.1991	12:08	13:20	28 35.48 S	31 23.07 W	2853	C G
108	3.02.1991	14:32	16:30	28 27.15 S	31 30.55 W	3577	CTFR G
109	3.02.1991	18:25	20:40	28 16.41 S	31 40.46 W	4232	CTFR G
110	3.02.1991	22:07	00:35	28 6.88 S	31 49.98 W	4881	CT(FR) G
111	3.02.1991	00:33	01:35	26 14.60 S	36 30.00 W	()	G
112	6.02.1991	3:20	05:27	21 47.25 S	37 50.98 W	3657	CTFR G
113	6.02.1991	9:50	11:07	21 19.88 S	38 34.07 W	2721	C G
114	6.02.1991	13:30	14:48	21 6.81 S	38 54.99 W	2492	C G
115	6.02.1991	17:16	18:15	20 54.13 S	39 16.02 W	2215	C G
116	6.02.1991	19:40	20:42	20 46.93 S	39 27.01 W	2075	C G
117	6.02.1991	21:31	22:27	20 44.24 S	39 33.35 W	1985	C G
118	6.02.1991	23:19	00:14	20 40.98 S	39 38.01 W	1840	C G
119	7.02.1991	1:38	02:38	20 40.61 S	39 37.14 W	1587	C G
120	7.02.1991	3:50	04:22	20 33.07 S	39 51.12 W	1121	C G
121	7.02.1991	5:25	05:35	20 30.08 S	39 56.09 W	61	C

6.2 CTD Stations M 15/3

EXPOCODE	WHP -ID	STN NBR	CAST NO	TYPE	DATE	TIME	CODE	LATIUDE	LONGITUDE	CODE	DEPTH	WHEEL	Comments
06MT15/3	A9	122	1	ROS	021191	1021	BO	19 0.00 S	37 25.40 W	DR	3514	3472	CTD 3
06MT15/3	A9	122	2	ROS	021191	1339	BO	19 0.30 S	37 25.80 W	DR	3510	2970	CTD 2
06MT15/3	A9	123	3	ROS	021191	1813	BO	19 0.30 S	37 35.40 W	DR	3370	3375	CTD 3
06MT15/3	A9	124	4	ROS	021191	2158	BO	19 0.00 S	37 40.30 W	DR	3376	3327	CTD 3
06MT15/3	A9	125	5	ROS	021291	0217	BO	19 0.10 S	37 45.00 W	DR	2354	2311	CTD 3
06MT15/3	A9	126	6	ROS	021291	0616	BO	19 0.10 S	37 49.10 W	DR	349	340	CTD 3
06MT15/3	A9	127	7	ROS	021291	1008	BO	18 59.60 S	37 26.40 W	DR	3477	3476	CTD 3
06MT15/3	A9	127	8	ROS	021291	1305	BO	19 0.00 S	37 27.10 W	DR	3522	2971	CTD 2
06MT15/3	A9	128	9	ROS	021291	1636	BO	19 0.10 S	37 15.60 W	DR	3522	3530	CTD 3
06MT15/3	A9	129	10	ROS	021291	2132	BO	18 59.40 S	37 5.30 W	DR	3627	3617	CTD 3
06MT15/3	A9	130	11	ROS	011391	0233	BO	19 0.20 S	36 54.30 W	DR	3707	3704	CTD 3
06MT15/3	A9	131	12	ROS	011391	0847	BO	18 59.70 S	36 23.10 W	DR	3872	3880	CTD 3
06MT15/3	A9	132	13	ROS	011391	1425	BO	19 0.00 S	35 50.60 W	DR	4002	690	CTD 2
06MT15/3	A9	132	14	ROS	011391	1622	BO	19 0.00 S	35 50.50 W	DR	4000	4017	CTD 3
06MT15/3	A9	133	15	ROS	011391	2148	BO	19 0.00 S	35 18.70 W	DR	4115	487	CTD 2
06MT15/3	A9	133	16	ROS	021391	2327	BO	19 0.00 S	35 18.80 W	DR	4111	4138	CTD wrong
06MT15/3	A9	134	17	ROS	021491	0440	BO	19 0.00 S	34 46.90 W	DR	4420	514	CTD 2
06MT15/3	A9	134	18	ROS	021491	0621	BO	19 0.00 S	34 47.10 W	DR	4221	4198	CTD 3
06MT15/3	A9	135	19	ROS	021491	1126	BO	19 0.10 S	34 15.30 W	DR	4257	492	CTD 2
06MT15/3	A9	135	20	ROS	021491	1312	BO	18 59.90 S	34 15.30 W	DR	4274	4221	CTD 3
06MT15/3	A9	136	21	ROS	021491	1816	BO	18 59.90 S	33 43.10 W	DR	4307	494	CTD 2
06MT15/3	A9	136	22	ROS	021491	1951	BO	18 59.70 S	33 43.40 W	DR	4304	4275	CTD 3
06MT15/3	A9	137	23	ROS	021591	0106	BO	19 0.00 S	33 11.60 W	DR	4292	493	CTD 2
06MT15/3	A9	137	24	ROS	021591	0245	BO	18 59.90 S	33 11.50 W	DR	4288	4248	CTD 3
06MT15/3	A9	138	25	ROS	021591	0808	BO	18 59.90 S	32 40.10 W	DR	4190	492	CTD 2
06MT15/3	A9	138	26	ROS	021591	0935	BO	18 59.90 S	32 39.90 W	DR	4190	4183	CTD 3
06MT15/3	A9	139	27	ROS	021591	1440	BO	19 0.00 S	32 8.40 W	DR	4272	481	CTD 2
06MT15/3	A9	139	28	ROS	021591	1622	BO	19 0.10 S	32 8.40 W	DR	4365	4225	CTD 3
06MT15/3	A9	140	29	ROS	021591	2152	BO	18 59.70 S	31 36.30 W	DR	4337	585	CTD 2
06MT15/3	A9	140	30	ROS	021591	2333	BO	18 59.50 S	31 36.30 W	DR	4352	4308	CTD 3
06MT15/3	A9	141	31	ROS	021691	0445	BO	19 0.00 S	31 4.80 W	DR	4457	594	CTD 2
06MT15/3	A9	141	32	ROS	021691	0643	BO	18 59.80 S	31 4.80 W	DR	4454	4433	CTD 3
06MT15/3	A9	142	33	ROS	021691	1201	BO	18 59.90 S	30 33.10 W	DR	4648	691	CTD 2
06MT15/3	A9	142	34	ROS	021691	1352	BO	19 0.10 S	30 33.20 W	DR	4645	4619	CTD 3

EXPCODE	WHP -ID	STN NBR	CAST NO	TYPE	DATE	TIME	CODE	LATIUDE	LONGITUDE	CODE	DEPTH	WHEEL	Comments
06MT15/3	A9	143	35	ROS	021691	1916	BO	19 0.00 S	30 1.40 W	DR	4796	790	CTD 2
06MT15/3	A9	143	36	ROS	021691	2100	BO	18 59.60 S	30 1.20 W	DR	4793	4786	CTD 3
06MT15/3	A9	144	37	ROS	021791	0221	BO	19 0.10 S	29 29.70 W	DR	4868	693	CTD 2
06MT15/3	A9	144	38	ROS	021791	0433	BO	19 0.00 S	29 29.70 W	DR	4869	4866	CTD 3
06MT15/3	A9	145	39	ROS	021791	1004	BO	18 59.80 S	28 57.90 W	DR	5029	892	CTD 2
06MT15/3	A9	145	40	ROS	021791	1154	BO	18 59.60 S	28 58.00 W	DR	5013	5009	CTD 3
06MT15/3	A9	146	41	ROS	021791	1716	BO	19 0.10 S	28 26.20 W	DR	5079	892	CTD 2
06MT15/3	A9	146	42	ROS	021791	1918	BO	18 59.90 S	28 26.30 W	DR	5084	5078	CTD 3
06MT15/3	A9	147	43	ROS	021891	0238	BO	19 0.00 S	27 33.70 W	DR	5343	990	CTD 2
06MT15/3	A9	147	44	ROS	021891	0451	BO	19 0.00 S	27 33.50 W	DR	5345	5331	CTD 3
06MT15/3	A9	148	45	ROS	021891	1232	BO	18 59.90 S	26 41.30 W	DR	5568	1088	CTD 2
06MT15/3	A9	148	46	ROS	021891	1432	BO	18 59.90 S	26 41.10 W	DR	5562	5560	CTD 3
06MT15/3	A9	149	47	ROS	021991	0011	BO	18 59.90 S	25 48.70 W	DR	5774	1386	CTD 2
06MT15/3	A9	149	48	ROS	021991	0220	BO	19 0.20 S	25 48.40 W	DR	5771	5774	CTD 3
06MT15/3	A9	150	49	ROS	021991	1239	BO	19 45.10 S	24 59.90 W	DR	5548	987	CTD 2
06MT15/3	A9	150	50	ROS	021991	1435	BO	19 45.10 S	25 59.90 W	DR	5516	5439	CTD 3
06MT15/3	A9	151	51	ROS	021991	2153	BO	18 59.90 S	24 59.90 W	DR	5861	1192	CTD 2
06MT15/3	A9	151	52	ROS	021991	2358	BO	18 59.70 S	24 59.70 W	DR	5874	5863	CTD 3
06MT15/3	A9	152	53	ROS	022091	0520	BO	18 31.90 S	25 0.10 W	DR	5462	1087	CTD 2
06MT15/3	A9	152	54	ROS	022091	0733	BO	18 31.90 S	25 0.10 W	DR	5488	5491	CTD 3
06MT15/3	A9	153	55	ROS	022091	1623	BO	19 1.00 S	24 7.20 W	DR	5687	880	CTD 2
06MT15/3	A9	153	56	ROS	022091	1820	BO	19 0.90 S	24 7.40 W	DR	5692	4927	CTD 2
06MT15/3	A9	154	57	ROS	022191	0129	BO	19 0.10 S	23 14.90 W	DR	5724	888	CTD 2
06MT15/3	A9	154	58	ROS	022191	0327	BO	19 0.10 S	23 14.90 W	DR	5728	5676	CTD 3
06MT15/3	A9	155	59	ROS	022191	1120	BO	18 59.90 S	22 22.50 W	DR	5318	889	CTD 2
06MT15/3	A9	155	60	ROS	022191	1310	BO	18 59.90 S	22 22.50 W	DR	5301	5252	CTD 3
06MT15/3	A9	156	61	ROS	022191	2018	BO	18 59.90 S	21 29.80 W	DR	5356	892	CTD 2
06MT15/3	A9	156	62	ROS	022191	2212	BO	18 59.80 S	21 30.00 W	DR	5281	5303	CTD 3
06MT15/3	A9	157	63	ROS	022291	0527	BO	19 0.00 S	20 37.50 W	DR	4916	707	CTD 2
06MT15/3	A9	157	64	ROS	022291	0720	BO	19 0.10 S	20 37.50 W	DR	4910	4899	CTD 3
06MT15/3	A9	158	65	ROS	022291	1432	BO	19 0.10 S	19 45.00 W	DR	4718	690	CTD 2
06MT15/3	A9	158	66	ROS	022291	1612	BO	19 0.00 S	19 45.00 W	DR	4724	4633	CTD 3
06MT15/3	A9	159	67	ROS	022291	2145	BO	18 59.90 S	19 13.40 W	DR	5015	691	CTD 2
06MT15/3	A9	159	68	ROS	022291	2327	BO	18 59.90 S	19 13.40 W	DR	5016	4944	CTD 3
06MT15/3	A9	160	69	ROS	022391	0436	BO	19 0.00 S	18 41.90 W	DR	4457	494	CTD 2
06MT15/3	A9	160	70	ROS	022391	0622	BO	19 0.00 S	18 42.00 W	DR	4444	4389	CTD 3

EXPCODE	WHP -ID	STN NBR	CAST NO	TYPE	DATE	TIME	CODE	LATIUDE	LONGITUDE	CODE	DEPTH	WHEEL	Comments
06MT15/3	A9	161	71	ROS	022391	1230	BO	19 0.10 S	18 10.70 W	DR	3987	3983	CTD 3
06MT15/3	A9	161	72	ROS	022391	1408	BO	19 0.10 S	18 10.90 W	DR	3938	490	CTD 2
06MT15/3	A9	162	73	ROS	022391	1755	BO	19 0.00 S	17 39.00 W	DR	4164	593	CTD 2
06MT15/3	A9	162	74	ROS	022391	1929	BO	19 0.00 S	17 39.00 W	DR	4164	4157	CTD 3
06MT15/3	A9	163	75	ROS	022491	0052	BO	19 0.00 S	17 7.60 W	DR	3663	393	CTD 2
06MT15/3	A9	163	76	ROS	022491	0223	BO	19 0.00 S	17 7.60 W	DR	3672	3631	CTD 3
06MT15/3	A9	164	77	ROS	022491	0720	BO	19 0.00 S	16 36.00 W	DR	3514	329	CTD 2
06MT15/3	A9	164	78	ROS	022491	0843	BO	19 0.00 S	16 36.00 W	DR	3516	3514	CTD 3
06MT15/3	A9	165	79	ROS	022491	1339	BO	19 0.10 S	16 4.70 W	DR	3701	292	CTD 2
06MT15/3	A9	165	80	ROS	022491	1454	BO	19 0.00 S	16 4.80 W	DR	3706	3704	CTD 3
06MT15/3	A9	166	81	ROS	022491	1932	BO	19 0.00 S	15 32.90 W	DR	3678	295	CTD 2
06MT15/3	A9	166	82	ROS	022491	2047	BO	18 59.90 S	15 32.90 W	DR	3672	3651	CTD 3
06MT15/3	A9	167	83	ROS	022591	0155	BO	19 0.00 S	15 1.60 W	DR	3715	293	CTD 2
06MT15/3	A9	167	84	ROS	022591	0315	BO	18 59.70 S	15 1.50 W	DR	3676	3662	CTD 3
06MT15/3	A9	168	85	ROS	022591	1014	BO	19 40.00 S	14 59.90 W	DR	3723	3712	CTD 3
06MT15/3	A9	169	86	ROS	022591	1645	BO	20 20.00 S	14 59.80 W	DR	3656	3551	CTD 3
06MT15/3	A9	170	87	ROS	022591	2337	BO	21 0.10 S	15 0.50 W	DR	3892	3915	CTD 3
06MT15/3	A9	171	88	ROS	022691	0617	BO	21 40.00 S	15 0.00 W	DR	4277	4253	CTD 3
06MT15/3	A9	172	89	ROS	022691	1311	BO	22 20.00 S	15 0.10 W	DR	4113	4101	CTD 3
06MT15/3	A9	173	90	ROS	022691	1950	BO	23 0.10 S	15 0.00 W	DR	4738	4818	CTD 3
06MT15/3	A9	174	91	ROS	022791	0208	BO	23 40.00 S	15 0.00 W	DR	3875	246	CTD 2
06MT15/3	A9	174	92	ROS	022791	0329	BO	23 39.80 S	14 59.70 W	DR	3876	3834	CTD 3
06MT15/3	A9	175	93	ROS	022891	1029	BO	18 59.90 S	14 29.90 W	DR	3581	247	CTD 2
06MT15/3	A9	175	94	ROS	022891	1140	BO	18 59.90 S	14 30.10 W	DR	3575	3575	CTD 3
06MT15/3	A9	176	95	ROS	022891	1637	BO	18 59.90 S	13 58.60 W	DR	3271	244	CTD 2
06MT15/3	A9	176	96	ROS	022891	1755	BO	19 0.00 S	13 59.00 W	DR	3231	3234	CTD 3
06MT15/3	A9	177	97	ROS	022891	2303	BO	19 0.00 S	13 27.00 W	DR	3981	329	CTD 2
06MT15/3	A9	177	98	ROS	030191	0027	BO	18 59.80 S	13 26.80 W	DR	3863	3846	CTD 3
06MT15/3	A9	178	99	ROS	030191	0922	BO	18 59.70 S	12 54.90 W	DR	3197	3065	CTD 3
06MT15/3	A9	179	100	ROS	030191	1452	BO	19 0.00 S	12 24.20 W	DR	2329	2209	CTD 3
06MT15/3	A9	180	101	ROS	030191	2005	BO	19 0.00 S	11 52.50 W	DR	2879	2835	CTD 3
06MT15/3	A9	181	102	ROS	030291	0144	BO	19 0.00 S	11 20.90 W	DR	3122	3122	CTD 3
06MT15/3	A9	182	103	ROS	030291	0730	BO	18 59.90 S	10 49.50 W	DR	3499	3400	CTD 3
06MT15/3	A9	183	104	ROS	030291	1349	BO	18 59.80 S	10 18.00 W	DR	3644	3410	CTD 2
06MT15/3	A9	184	105	ROS	030291	1856	BO	19 0.00 S	9 46.50 W	DR	3829	391	CTD 2
06MT15/3	A9	184	106	ROS	030291	2023	BO	18 59.90 S	9 46.50 W	DR	3836	3818	CTD 3

EXPCODE	WHP -ID	STN NBR	CAST NO	TYPE	DATE	TIME	CODE	LATIUDE	LONGITUDE	CODE	DEPTH	WHEEL	Comments
06MT15/3	A9	185	107	ROS	030391	0142	BO	18 59.30 S	9 14.40 W	DR	4055	398	CTD 2
06MT15/3	A9	185	108	ROS	030391	0311	BO	18 59.60 S	9 13.60 W	DR	4082	4115	CTD 3
06MT15/3	A9	186	109	ROS	030391	0840	BO	18 59.90 S	8 43.40 W	DR	3997	993	CTD 2
06MT15/3	A9	186	110	ROS	030391	1009	BO	18 59.50 S	8 43.30 W	DR	4093	3993	CTD 3
06MT15/3	A9	187	111	ROS	030391	1542	BO	19 12.00 S	8 11.90 W	DR	4166	992	CTD 2
06MT15/3	A9	187	112	ROS	030391	1718	BO	19 11.60 S	8 11.80 W	DR	4181	4141	CTD 3
06MT15/3	A9	188	113	ROS	030391	2254	BO	19 24.10 S	7 40.50 W	DR	4622	998	CTD 2
06MT15/3	A9	188	114	ROS	030491	0036	BO	19 23.80 S	7 40.20 W	DR	4619	4633	CTD 3
06MT15/3	A9	189	115	ROS	030491	0626	BO	19 36.00 S	7 9.10 W	DR	4540	1030	CTD 2
06MT15/3	A9	189	116	ROS	030491	0814	BO	19 35.90 S	7 9.10 W	DR	4542	4520	CTD 3
06MT15/3	A9	190	117	ROS	030491	1341	BO	19 35.90 S	6 37.60 W	DR	4323	1001	CTD 2
06MT15/3	A9	190	118	ROS	030491	1513	BO	19 36.20 S	6 37.30 W	DR	4327	4274	CTD 3
06MT15/3	A9	191	119	ROS	030491	2008	BO	19 36.10 S	6 5.80 W	DR	4676	1183	CTD 2
06MT15/3	A9	191	120	ROS	030491	2151	BO	19 35.60 S	6 6.20 W	DR	4656	4693	CTD 3
06MT15/3	A9	192	121	ROS	030591	0330	BO	19 35.40 S	5 34.80 W	DR	4792	989	CTD 2
06MT15/3	A9	192	122	ROS	030591	0530	BO	19 35.50 S	5 34.90 W	DR	4795	4801	CTD 3
06MT15/3	A9	193	123	ROS	030591	1125	BO	19 35.90 S	5 3.00 W	DR	4791	990	CTD 2
06MT15/3	A9	193	124	ROS	030591	1314	BO	19 35.50 S	5 3.00 W	DR	4891	4887	CTD 3
06MT15/3	A9	194	125	ROS	030591	1858	BO	19 35.90 S	4 31.30 W	DR	5079	1034	CTD 2
06MT15/3	A9	194	126	ROS	030591	2050	BO	19 35.80 S	4 31.50 W	DR	5077	5067	CTD 3
06MT15/3	A9	195	127	ROS	030691	0256	BO	19 35.80 S	4 0.10 W	DR	4854	790	CTD 2
06MT15/3	A9	195	128	ROS	030691	0500	BO	19 35.60 S	4 0.50 W	DR	4957	4939	CTD 3
06MT15/3	A9	196	129	ROS	030691	1107	BO	19 24.00 S	3 28.60 W	DR	5306	1098	CTD 2
06MT15/3	A9	196	130	ROS	030691	1257	BO	19 23.90 S	3 28.60 W	DR	5308	5241	CTD 3
06MT15/3	A9	197	131	ROS	030691	1829	BO	19 11.80 S	2 56.90 W	DR	4802	894	CTD 2
06MT15/3	A9	197	132	ROS	030691	2026	BO	19 11.90 S	2 56.80 W	DR	4759	4678	CTD 3
06MT15/3	A9	198	133	ROS	030791	0209	BO	19 0.00 S	2 25.40 W	DR	4961	897	CTD 2
06MT15/3	A9	198	134	ROS	030791	0352	BO	18 59.90 S	2 24.60 W	DR	5029	4970	CTD 3
06MT15/3	A9	199	135	ROS	030791	0916	BO	19 0.00 S	1 54.10 W	DR	5126	995	CTD 2
06MT15/3	A9	199	136	ROS	030791	1259	BO	18 59.90 S	1 53.90 W	DR	5128	5019	CTD 3
06MT15/3	A9	200	137	ROS	030791	1811	BO	19 0.00 S	1 22.50 W	DR	4795	888	CTD 2
06MT15/3	A9	200	138	ROS	030791	2003	BO	19 0.00 S	1 22.50 W	DR	4778	4711	CTD 3
06MT15/3	A9	201	139	ROS	030891	0131	BO	19 0.00 S	0 51.00 W	DR	5142	790	CTD 2
06MT15/3	A9	201	140	ROS	030891	0314	BO	18 59.90 S	0 51.20 W	DR	5119	5106	CTD 3
06MT15/3	A9	202	141	ROS	030891	0901	BO	18 59.90 S	0 19.60 W	DR	4523	891	CTD 2
06MT15/3	A9	202	142	ROS	030891	1043	BO	18 59.80 S	0 20.00 W	DR	4565	4482	CTD 3

EXPCODE	WHP -ID	STN NBR	CAST NO	TYPE	DATE	TIME	CODE	LATI UDE	LONGI TUDE	CODE	DEPTH	WHEEL	Comments
06MT15/3	A9	203	143	ROS	030891	1610	BO	19 0.00 S	0 11.80 E	DR	5530	1087	CTD 2
06MT15/3	A9	203	144	ROS	030891	1815	BO	18 59.90 S	0 12.00 E	DR	5530	5474	CTD 3
06MT15/3	A9	204	145	ROS	030991	0002	BO	18 59.90 S	0 43.50 E	DR	5537	1186	CTD 2
06MT15/3	A9	204	146	ROS	030991	0155	BO	18 59.70 S	0 43.70 E	DR	5539	5477	CTD 3
06MT15/3	A9	205	147	ROS	030991	0744	BO	18 59.90 S	1 15.00 E	DR	5500	1187	CTD 2
06MT15/3	A9	205	148	ROS	030991	0946	BO	19 0.00 S	1 15.00 E	DR	5497	5468	CTD 3
06MT15/3	A9	206	149	ROS	030991	1525	BO	19 0.00 S	1 46.50 E	DR	5497	1186	CTD 2
06MT15/3	A9	206	150	ROS	030991	1732	BO	19 0.00 S	1 46.20 E	DR	5490	5424	CTD 3
06MT15/3	A9	207	151	ROS	030991	2310	BO	19 0.00 S	2 18.00 E	DR	5516	1189	CTD 2
06MT15/3	A9	207	152	ROS	031091	0117	BO	19 0.00 S	2 18.00 E	DR	5514	5459	CTD 3
06MT15/3	A9	208	153	ROS	031091	0716	BO	19 0.00 S	2 49.60 E	DR	5504	1186	CTD 2
06MT15/3	A9	208	154	ROS	031091	0916	BO	19 0.00 S	2 49.60 E	DR	5507	5449	CTD 3
06MT15/3	A9	209	155	ROS	031091	1503	BO	19 0.00 S	3 21.00 E	DR	5491	1185	CTD 2
06MT15/3	A9	209	156	ROS	031091	1651	BO	19 0.20 S	3 20.80 E	DR	5492	5446	CTD 3
06MT15/3	A9	210	157	ROS	031091	2225	BO	18 59.90 S	3 52.60 E	DR	5474	1190	CTD 2
06MT15/3	A9	210	158	ROS	031191	0025	BO	18 59.70 S	3 52.60 E	DR	5471	5426	CTD 3
06MT15/3	A9	211	159	ROS	031191	0630	BO	18 59.80 S	4 23.90 E	DR	5462	1088	CTD 2
06MT15/3	A9	211	160	ROS	031191	0838	BO	18 59.70 S	4 24.00 E	DR	5461	5409	CTD 3
06MT15/3	A9	212	161	ROS	031191	1405	BO	19 0.10 S	4 55.50 E	DR	5249	991	CTD 2
06MT15/3	A9	212	162	ROS	031191	1555	BO	18 59.80 S	4 55.10 E	DR	5248	5245	CTD 3
06MT15/3	A9	213	163	ROS	031191	2145	BO	18 59.90 S	5 27.20 E	DR	5161	999	CTD 2
06MT15/3	A9	213	164	ROS	031191	2333	BO	19 0.00 S	5 27.00 E	DR	5159	5101	CTD 3
06MT15/3	A9	214	165	ROS	031291	0544	BO	18 59.90 S	5 58.50 E	DR	5362	1090	CTD 2
06MT15/3	A9	214	166	ROS	031291	0747	BO	19 0.00 S	5 58.40 E	DR	5364	5310	CTD 3
06MT15/3	A9	215	167	ROS	031291	1357	BO	18 59.50 S	6 30.30 E	DR	5317	1095	CTD 2
06MT15/3	A9	215	168	ROS	031291	1544	BO	18 59.50 S	6 30.30 E	DR	5314	5273	CTD 3
06MT15/3	A9	216	169	ROS	031491	0500	BO	23 23.80 S	6 0.50 E	DR	2284	2225	CTD 3
06MT15/3	A9	217	170	ROS	031491	1110	BO	22 56.90 S	6 31.00 E	DR	2395	2359	CTD 3
06MT15/3	A9	218	171	ROS	031491	1724	BO	22 30.10 S	7 1.70 E	DR	2054	2032	CTD 3
06MT15/3	A9	219	172	ROS	031491	2353	BO	22 3.00 S	7 33.00 E	DR	3047	2996	CTD 3
06MT15/3	A9	220	173	ROS	031591	0452	BO	21 38.60 S	7 32.90 E	DR	3164	3122	CTD 3
06MT15/3	A9	221	174	ROS	031591	0903	BO	21 24.00 S	7 33.10 E	DR	3156	3123	CTD 3
06MT15/3	A9	222	175	ROS	031591	1305	BO	21 9.10 S	7 33.10 E	DR	2903	2822	CTD 3
06MT15/3	A9	223	176	ROS	031591	1744	BO	20 47.30 S	7 33.10 E	DR	3028	2979	CTD 3
06MT15/3	A9	224	177	ROS	031691	0537	BO	18 59.60 S	7 1.30 E	DR	5306	995	CTD 2
06MT15/3	A9	224	178	ROS	031691	0737	BO	18 59.70 S	7 1.40 E	DR	5308	5206	CTD 3

EXPOCODE	WHP -ID	STN NBR	CAST NO	TYPE	DATE	TIME	CODE	LATIUDE	LONGITUDE	CODE	DEPTH	WHEEL	Comments
06MT15/3	A9	225	179	ROS	031691	1331	BO	19 0.10 S	7 33.00 E	DR	5223	2456	CTD 2
06MT15/3	A9	225	180	ROS	031691	1451	BO	19 0.10 S	7 33.00 E	DR	5224	986	CTD 2
06MT15/3	A9	225	181	ROS	031691	1646	BO	18 59.70 S	7 33.10 E	DR	5225	5138	CTD 3
06MT15/3	A9	226	182	ROS	031691	2210	BO	19 0.10 S	8 4.50 E	DR	5132	1015	CTD 2
06MT15/3	A9	226	183	ROS	031691	2409	BO	19 0.50 S	8 4.90 E	DR	5131	5056	CTD 3
06MT15/3	A9	227	184	ROS	031791	0608	BO	18 46.80 S	8 32.90 E	DR	4928	896	CTD 2
06MT15/3	A9	227	185	ROS	031791	0803	BO	18 46.80 S	8 33.30 E	DR	4958	4899	CTD 3
06MT15/3	A9	228	186	ROS	031791	1335	BO	18 32.20 S	9 2.20 E	DR	4770	795	CTD 2
06MT15/3	A9	228	187	ROS	031791	1519	BO	18 32.20 S	9 1.90 E	DR	4772	4696	CTD 3
06MT15/3	A9	229	188	ROS	031791	2058	BO	18 18.40 S	9 31.50 E	DR	4424	607	CTD 2
06MT15/3	A9	229	189	ROS	031791	2240	BO	18 18.50 S	9 31.70 E	DR	4417	4334	CTD 3
06MT15/3	A9	230	190	ROS	031891	0357	BO	18 4.70 S	10 0.30 E	DR	4128	498	CTD 2
06MT15/3	A9	230	191	ROS	031891	0532	BO	18 4.30 S	10 0.40 E	DR	4124	4046	CTD 3
06MT15/3	A9	231	192	ROS	031891	1056	BO	17 51.10 S	10 29.00 E	DR	3590	412	CTD 2
06MT15/3	A9	231	193	ROS	031891	1218	BO	17 51.10 S	10 29.00 E	DR	3598	3523	CTD 3
06MT15/3	A9	231	194	ROS	031891	1529	BO	17 50.70 S	10 29.10 E	DR	3589	3516	CTD 3
06MT15/3	A9	232	195	ROS	031891	1931	BO	17 41.50 S	10 48.40 E	DR	3047	304	CTD 2
06MT15/3	A9	232	196	ROS	031891	2051	BO	17 41.50 S	10 48.30 E	DR	3045	2975	CTD 3
06MT15/3	A9	233	197	ROS	032091	2041	BO	10 29.90 S	9 0.00 E	DR	4760	4696	CTD 3
06MT15/3	A9	233	198	ROS	032091	2319	BO	10 30.10 S	9 0.10 E	DR	4756	3345	CTD 2

6.3 XCP Drops (M 15/3)

XCP-Nr. XCP#	Datum Date	Zeit Time UTC	Breite Latitude	Länge Longitude
01	11-FEB-1991	20:17	19 S 00.00'	37 W 30.00'
02	12-FEB-1991	00:25	18 S 59.99'	37 W 37.77'
03	12-FEB-1991	04:16	19 S 00.00'	37 W 42.50'
04	12-FEB-1991	09:19	19 S 00.00'	37 W 47.50'
05	12-FEB-1991	11:03	19 S 00.71'	37 W 48.64'
06	12-FEB-1991	18:44	19 S 00.06'	37 W 19.94'
07	12-FEB-1991	23:47	19 S 00.01'	37 W 09.98'
08	13-FEB-1991	04:33	18 S 59.99'	36 W 59.91'
09	17-MAR-1991	00:18	19 S 00.18'	08 E 05.20'
10	17-MAR-1991	15:36	18 S 31.80'	09 E 01.20'
11	18-MAR-1991	06:43	17 S 59.22'	10 E 11.88'
12	18-MAR-1991	16:10	17 S 45.44'	10 E 39.89'
13	18-MAR-1991	22:27	17 S 36.44'	10 E 58.96'
14	19-MAR-1991	00:43	17 S 26.86'	11 E 18.41'

6.4 Surface drifters

Following drifters with sails had been dropped in 100 m depth

Drifter Nr./#	Datum/Date 1991	Zeit/Time UTC	Breite Latitude	Länge Longitude	Temperatur Temperature °C
M 15/1					
06904	1. Jan.	14.07	27°S 52,71	46°W 43,82	24,8
12267	1. Jan.	14.10	27°S 52,67	46°W 44,00	24,8
12283	1. Jan.	17.00	27°S 50,14	46°W 55,42	25,1
12282	1. Jan.	17.03	27°S 50,14	46°W 55,42	25,1
12268	1. Jan.	19.45	27°S 47,10	47°W 06,27	24,3
12288	1. Jan.	19.50	27°S 47,10	47°W 06,27	24,3
12259	1. Jan.	22.10	27°S 44,11	47°W 15,00	24,2
12284	1. Jan.	22.15	27°S 44,11	47°W 15,00	24,2
12286	2. Jan.	10.30	27°S 56,59	46°W 29,11	24,8
12253	2. Jan.	10.35	27°S 56,59	46°W 29,11	24,8
M 15/2					
12277	7. Feb.	00.21	20°S 40,80	39°W 37,40	26,0
12287	7. Feb.	00.24	20°S 40,80	39°W 37,40	26,0
12262	7. Feb.	02.33	20°S 36,90	39°W 46,20	26,8
12281	7. Feb.	02.37	20°S 36,90	39°W 46,20	26,8
12270	7. Feb.	03.07	20°S 35,80	39°W 47,70	26,7
12285(no data)	7. Feb.	03.25	20°S 34,50	39°W 48,50	26,8
12242	7. Feb.	04.25	20°S 33,00	39°W 50,30	26,7
12252	7. Feb.	04.30	20°S 33,00	39°W 50,30	26,7
12240	7. Feb.	06.10	20°S 31,40	39°W 53,40	26,5
12289	7. Feb.	06.15	20°S 31,40	39°W 53,40	26,5
M 15/3					
12263	7. März	22.00	19°S 00,00	01°W 22,40	23,96
12250	8. März	20.30	18°S 59,80	00°E 11,90	23,97
12256	9. März	19.40	18°S 59,80	01°E 46,50	23,69
06905(no data)	10. März	18.55	19°S ?,00	03°E 21,30	23,41
06901(no data)	11. März	18.00	19°S 00,40	04°E 55,30	22,90
12260	12. März	20.05	18°S 59,40	06°E 30,50	22,90
12241	17. März	00.12	19°S 00,50	08°E 04,80	21,55
12244	17. März	15.23	18°S 32,10	09°E 01,10	20,77
12247	18. März	06.38	17°S 59,40	10°E 11,60	20,84
12272	19. März	00.39	17°S 27,10	11°E 18,10	18,62

6.5 Moorings

The following moorings were launched from West to East

Stat. no.	Ext. no.	Int. no.	Date 1991	Time UTC-2h	Latitude	Longitude	Depth (m)	Instruments Number	Argos ID	Sender Mhz
1	BW	IfM 333	1.Jan.	9.37	27S54,06	46W42,40	1179	1 ADCP 4 ACM	15171	27030
8	BM	IfM 334	2.Jan.	11.45	27S59,20	46W20,50	2187	5 ACM	-	27030
12	BE	IfM 335	3.Jan.	11.47	28S16,20	45W13,80	3258	1 ADCP 6 ACM	15172	27030
16	DB1	WHOI 906	4.Jan.	11.57	28S28,00	44W27,80	3633	5 VACM 1 XP	5365	26995
20	DB2	WHOI 907	5.Jan.	12.05	29S02,60	43W29,00	3953	5 VACM 1 XP	5362	26995
24	DB3	WHOI 908	6.Jan.	10.25	29S32,00	42W42,15	4017	2 VACM 1 XP	-	26995
28	DB4	WHOI 909	7.Jan.	11.45	30S05,20	41W44,20	3798	5 VACM 1 XP	5360	26995
32	DB5	WHOI 910	8.Jan.	9.26	30S35,30	40W47,30	3720	2 VACM 1 XP	-	26995
36	VM	IfM 336	9.Jan.	11.26	31S12,30	39W46,00	3965	5 ACM	-	27040 27035
37	VM	IfM 337	9.Jan.	16.25	31S09,80	39W26,50	4637	3 ACM	-	26995

Stat. no.	Ext. no.	Int. no.	Date 1991	Time UTC-2h	Latitude	Longitude	Depth (m)	Instruments Number	Argos ID	Sender Mhz
40	VE	IfM 338	11.Jan.	17.32	31S08,40	39W26,00	4646	7ACM	-	[27095] defect
39	DB6	WHOI 912	11.Jan.	9.31	31S05,05	39W09,10	4140	3 VACM 1 XP	-	26995
44	DBK2 IfM	WHOI 3422	12.Jan.	15.27	31S09,30	38W49,60	3652	5 ACM 1 XP	-	27140
38 lost because of a material defect										

6.6 List of geoscientific observations (M 15/2)

6.6.1 Station list Geosciences University of Bremen

GeoB-Nr./no.	METEOR Nr./no.	Datum date	Gerät instrument	Zeit time	Breite latitude	Länge longitude	Wassertiefe depth	Bemerkungen comments
NÖRDLICHER VEMA KANAL/Northern Hunter Channel								
1301-1	67/91	20.01.	CTD	16.29	26°34.9'S	39°45.0'W	4279	1. Probelauf der FSCTD an der CTD/RO/KIEL 2. Probelauf der FS-CTD an der CTD/RO/KIEL
1302-1	68/91	21.01.	CTD	03.55	27°55.0'S	38°50.2'W	4244	
RIO GRANDE SCHWELLE/Rio Grande Rise								
1303-1	77/91	24.01.	MC	11.04	30°16.5'S	35°17.0'W	1313	Gewinn 9/10 Rohren (Kerngewinn 5-12 cm) Fehlversuch (umgekippt) Fehlversuch (umgekippt) Fehlversuch (umgekippt) Fehlversuch (umgekippt)
1303-2			SL12	12.27	30°16.6'S	35°17.1'W	1314	
1303-3			SL12	13.17	30°16.7'S	35°17.3'W	1312	
1303-4			SL6	14.23	30°16.7'S	35°17.3'W	1313	
1304-1	78/91	24.01.	SL6	23.28	31°00.0'S	34°00.0'W	940	
NÖRDLICHER HUNTER KANAL/Nothern Hunter Channel								
1305-1	85/91	27.01.	CTD	14.30	34°13.0'S	28°55.1'W	3923	3. Probelauf der FS-CTD an der CTD/RO/KIEL
SÜDLICHER HUNTER KANAL/Southern Hunter Channel								
1306-1	88/91	28.01.	MC	09.32	35°12.4'S	26°45.9'W	4057	Gewinn 6/10 Rohren (Kerngewinn 35 cm) 6,97 m Kerngewinn 20 Wassrproben à 250 ml für Delta 13C
1306-2			SL12	12.28	35°12.4'S	26°45.8'W	4058	
1306-2			RO	14.15	35°12.2'S	26°45.5'W	4056	

GeoB-Nr./no.	METEOR Nr./no.	Datum date	Gerät instrument	Zeit time	Breite latitude	Länge longitude	Wassertiefe depth	Bemerkungen comments
HUNTER KANAL/Hunter Channel								
1307-1	95/91	30.01.	SL12	01.53	33°36.1'S	27°39.9'W	4017	Kerngewinn 6,77 m Gewinn 10/10 Rohren (Kerngewinn 33 cm) 20 Wasserproben à 250 ml für Delta 13C
1307-2			MC	04.36	33°36.1'S	27°39.9'W	4006	
1307-3			RO	05.50	33°36.2'S	27°40.0'W	4051	
ÖSTLICHE RIO GRANDE SCHWELLE/Eastern Rio Grande Rise								
1308-1	96/91	30.01.	MC/CTD	14.10	32°47.2'S	27°45.0'W	3622	MC und Seabird FS-CTD (100 m über dem MC) Gewinn 8/10 Rohren (Kerngewinn 28 cm) Kerngewinn 3,44 m
1308-2			SL12	16.40	32°47.1'S	27°45.0'W	3613	
1309-1	98/91	31.01.	RO	03.25	31°40.0'S	28°40.0'W	3961	20 Wasserproben à 250 ml für Delta 13C Kerngewinn 9,48 m Gewinn 9/10 Rohren (Kerngewinn 27 cm)
1309-2			SL12	07.45	31°40.0'S	28°40.0'W	3963	
1309-3			MC	09.57	31°40.0'S	28°39.9'W	3963	
1310-1	100/91	31.01.	MC	17.06	31°35.3'S	28°54.2'W	3346	Gewinn 8/10 Rohren (Kerngewinn 14 cm) Kerngewinn 5,35 m
1310-2			SL12	19.32	31°35.3'S	28°54.1'W	3348	
1311-1	101/91	01.02.	SL12	01.04	31°30.7'S	29°05.9'W	2901	Kerngewinn 7,42 m Gewinn 10/10 (Kerngewinn 15cm)
1311-2			MC	03.14	31°30.8'S	29°05.9'W	2899	
1312-1	102/91	01.02	MC	11.28	31°39.7'S	29°39.4'W	3436	Gewinn 4/10 Rohren (Kerngewinn 7 cm) Kerngewinn 4,13 m Gewinn 5/10 Rohren (Kerngewinn 7 cm)
1312-2			SL12	13.30	31°39.7'S	29°39.4'W	3436	
1312-3			MC	15.30	31°39.7'S	29°39.4'W	3436	

GeoB-Nr./no.	METEOR Nr./no.	Datum date	Gerät instrument	Zeit time	Breite latitude	Länge longitude	Wassertiefe depth	Bemerkungen comments
ÖSTLICHE RIO GRANDE SCHWELLE/Eastern Rio Grande Rise								
1313-1	103/91	01.02.	MC	19.33	31°39.7'S	30°02.0'W	3698	Gewinn 8/10 Rohren (Kerngewinn 8 cm)
1313-2			SL12	21.49	31°39.8'S	30°02.2'W	3700	Kerngewinn 3,73 m
1314-1	105/91	02.02.	SL12	09.26	31°10.0'S	30°55.0'W	4071	Kerngewinn 8,82 m
1314-2			MC	11.36	31°10.1'S	30°55.0'W	4073	Gewinn 10/10 Rohren (Kerngewinn 16 cm)
1314-3			RO	11.55	31°09.9'S	30°55.1'W	4073	20 Wasserproben à 250 ml für Delta 13C
NÖRDLICHE RIO GRANDE SCHWELLE/Northern Rio Grande Rise								
1315-1	108/91	03.02.	SL12	07.45	28°50.1'S	31°05.0'W	1947	Kernrohr bei 2,50 m abgeknickt Kern i.O. (Kerngewinn 1,76 m)
1315-2			MC	09.01	28°50.1'S	31°05.0'W	1949	Gewinn 8/10 Rohren (Kerngewinn 10 cm)
1315-3	109/91	03.02.	RO		28°15.8'S	31°41.1'W	4226	18 Wasserproben à 250 ml für Delta 13C
Abkürzungen:	RO	Multi-Wasserschöpfer/multi water samples						
Abbreviations:	SL 6	Schwerelot 6 m Länge/gravity corer 6 m length						
	SL 12	Schwerelot 12 m Länge/gravity corer 12 m length						
	MC	Multicorer/multicorer						
	FS-CTD	Festspeicher-CTD-Sonde (Seabird)/ CTD Seabird						

6.6.2 Liste der Wasserproben aus Multicorer-Rohren für $\delta^{13}\text{C}$ -Bestimmungen

List of water samples from multicorer for the determination of $\delta^{13}\text{C}$

GeoB-Nr./no.	METEOR Nr./no.	Datum date	Gerät instrument	Zeit Boden berührung bottom contact time	Breite latitude	Länge longitude	Wasser tiefe water depth(m)	Probengewinn Sample no.	Bemerkungen comments
1303-1	077/91	24.01.	01	11.04	30°16.6'S	35°17.0'W	1313	Rohr 7	
			02					Rohr 7	
1306-1	088/91	28.01.	03	09.32	35°12.4'S	26°45.9'W	4050	Rohr 1	
			04					Rohr 1	
1307-2	095/91	30.01.	05	04.36	33°36.1'S	27°39.9'W	4010	Rohr 1	
			06					Rohr 1	
1308-1	096/91	30.01.	07	14.10	32°47.2'S	27°45.0'W	3618	Rohr 1	
			08					Rohr 1	
1309-3	098/91	31.01.	09	09.57	31°40.0'S	28°39.9'W	3963	Rohr 1	
			10					Rohr 1	
1310-1	100/91	31.01.	11	17.06	31°35.2'S	28°54.1'W	3347	Rohr 1	
			12					Rohr 1	
1311-2	101/91	01.02.	13	03.14	31°30.7'S	29°05.9'W	2899	Rohr 1	
			14					Rohr 1	
1312-1	102/91	01.02.	15	11.28	31°40.0'S	29°39.6'W	3436	Rohr 7	
			16					Rohr 7	
1313-1	103/91	01.02.	17	19.33	31°39.7'S	30°01.9'W	3698	Rohr 7	
			18					Rohr 7	
1314-2	105/91	02.02.	19	11.36	31°10.1'S	30°55.0'W	4072	Rohr 1	
			20					Rohr 1	
1315-2	106/91	03.02.	101	09.01	28°50.2'S	31°05.0'W	1948	Rohr 1	
			102					Rohr 1	

6.6.3 Liste der Wasserproben aus der Rosette des IfM Kiel für $\delta^{13}\text{C}$ -Bestimmungen

List of water samples from IfM Kiel rosette for determination of $\delta^{13}\text{C}$

GeoB-Nr./no.	METEOR Nr./no.	Pr. Nr. no.	RO Nr. no.	Druck pressure (db)	GeoB-Nr./no.	METEOR Nr./no.	Pr. Nr. no.	RO Nr. no.	Druck pressure (db)
1306-2	88/91	21	01	4068.5	1307-3	95/91	41	01	4053.0
		22	03	3896.8			42	02	3932.0
		23	04	3700.1			43	03	3698.0
		24	05	3498.8			44	05	3498.0
		25	07	2899.6			45	06	3199.0
		26	08	2599.3			46	07	2996.0
		27	09	2296.9			47	-	
		28	10	2102.3			48	10	2099.8
		29	11	1904.0			49	11	1890.0
		30	12	1704.9			50	12	1699.8
		31	13	1499.9			51	13	1499.6
		32	15	1202.9			52	15	1199.9
		33	17	902.1			53	17	900.6
		34	18	750.7			54	18	749.0
		35	19	600.4			55	-	
		36	20	436.3			56	20	449.9
		37	21	301.6			57	21	300.1
		38	22	202.6			58	22	199.4
		39	23	101.0			59	23	99.6
		40	24	29.8			60	24	33.0
1309-1	98/91	61	01	4020.4	1314-3	105/91	81	01	4088.9
		62	03	3694.0			82	03	3900.0
		63	04	3495.9			83	04	3648.3
		64	05	3202.3			84	05	3403.2
		65	06	2901.9			85	06	3150.6
		66	07	2588.3			86	07	2897.6
		67	08	2293.1			87	08	2600.4
		68	09	2101.0			88	09	2298.5
		69	10	1897.9			89	10	1998.7
		70	11	1699.5			90	12	1649.0
		71	12	1499.8			91	14	1247.4
		72	13	1352.3			92	15	1001.3
		73	14	1199.3			93	17	729.5
		74	15	1049.8			94	18	648.0
		75	16	900.1			95	19	550.8
		76	18	599.4			96	20	400.0
		77	20	299.7			97	21	198.4
		78	21	199.7			98	22	148.5
		79	22	99.4			99	23	79.9
		80	23	24.8			100	24	29.4

GeoB- Nr./no.	METEOR Nr./no.	Pr. Nr. no.	RO Nr. no.	Druck pressure (db)
1316-1	109/91	103	01	4290.0
		104	03	4099.2
		105	04	3900.2
		106	05	3699.7
		107	07	3299.8
		108	10	2700.4
		109	11	2397.5
		110	12	2096.1
		111	13	1795.9
		112	14	1498.3
		113	16	1096.6
		114	18	800.7
		115	19	649.3
		116	20	500.2
		117	21	350.0
		118	22	199.7
		119	23	99.2
		120	24	25.3

6.7 Liste der Planktonproben (M 15/1 und M 15/2)

List of Plankton samples (M 15/1 and M 15/2)

Stat. Nr. stat. no.	Bemerkungen comments	Stat. Nr. stat. no.	Bemerkungen comments
1	Neu MSN	27	Neu MSN
2	Neu ---	28	Neu MSN
3	Neu MSN	29	Neu MSN
4	Neu MSN	30	Neu MSN
6	Neu MSN	31	Neu MSN
8	Neu ---	32	Neu MSN
9	Neu MSN	37	Neu MSN
10	Neu MSN	38	Neu MSN
11	Neu MSN	54	Neu MSN
12	Neu MSN	55	Neu MSN
13	Neu MSN	56	Neu MSN
14	Neu MSN	60	Neu MSN + Neu MSN
15	Neu MSN	64	Neu MSN
16	Neu MSN	67	Neu MSN
17	Neu MSN	68	Neu MSN
18	Neu MSN	69	Neu MSN
19	Neu MSN	74	Neu MSN
20	Neu MSN	77	Neu MSN + Neu MSN
21	Neu MSN	81	Neu MSN
22	Neu MSN	83	Neu MSN
23	Neu MSN	91	Neu MSN
24	Neu MSN	100	Neu MSN
25	Neu MSN	105	Neu MSN + MSN
26	Neu MSN		

Neu n = 49
MSN n = 48

7 Concluding remarks

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9 Figures

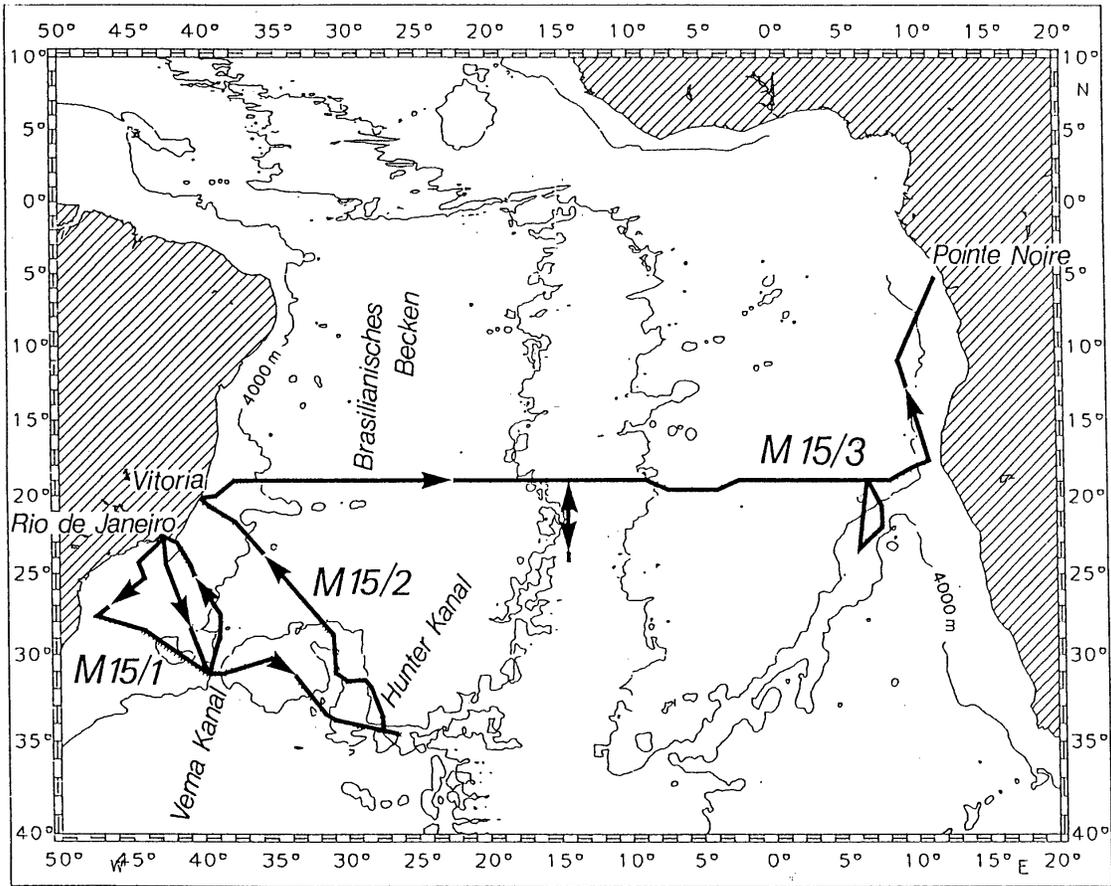


Fig. 1: Track of METEOR Cruise no.15.

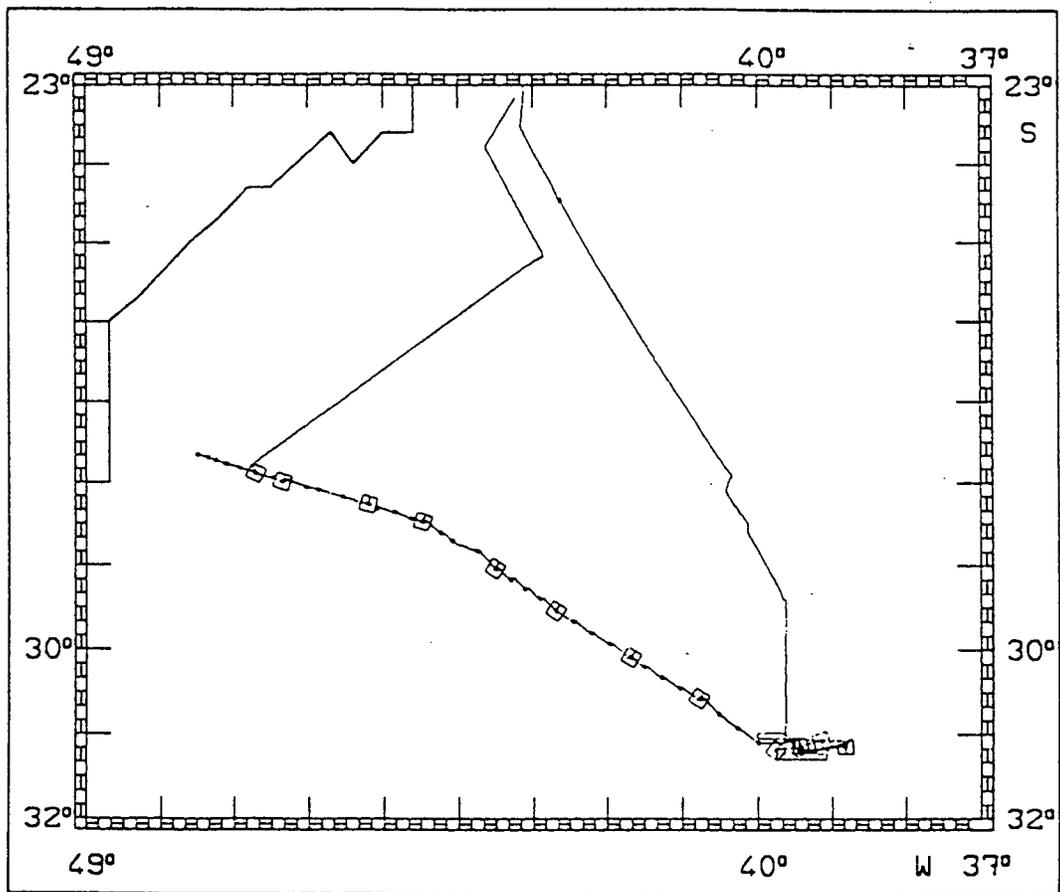


Fig. 2a: M 15/1, CTD stations (.) and mooring positions (□).

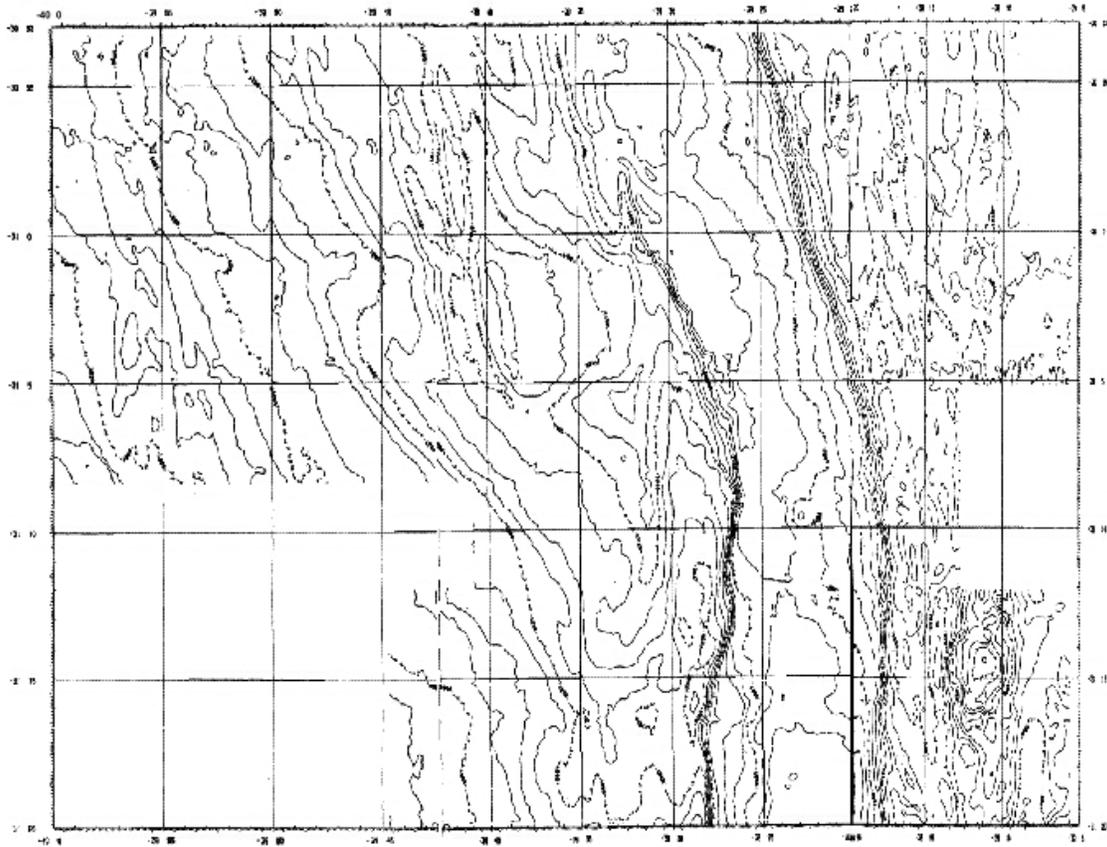


Fig. 2b: Bathymetry of the Vema Channel. Data were analyzed on board.

MERCATOR PROJECTION
Reference -31:07
World Geodetic System 1972
METEOR M15 1/2

ISOPLOT
VEMA-KANAL
IFM-KIEL
HYP1/VEMA91
KAE/HMS1300 3. 2.91

CRUISE M15, Leg 2, GEOLOGY (^) and CTD (•) STATIONS

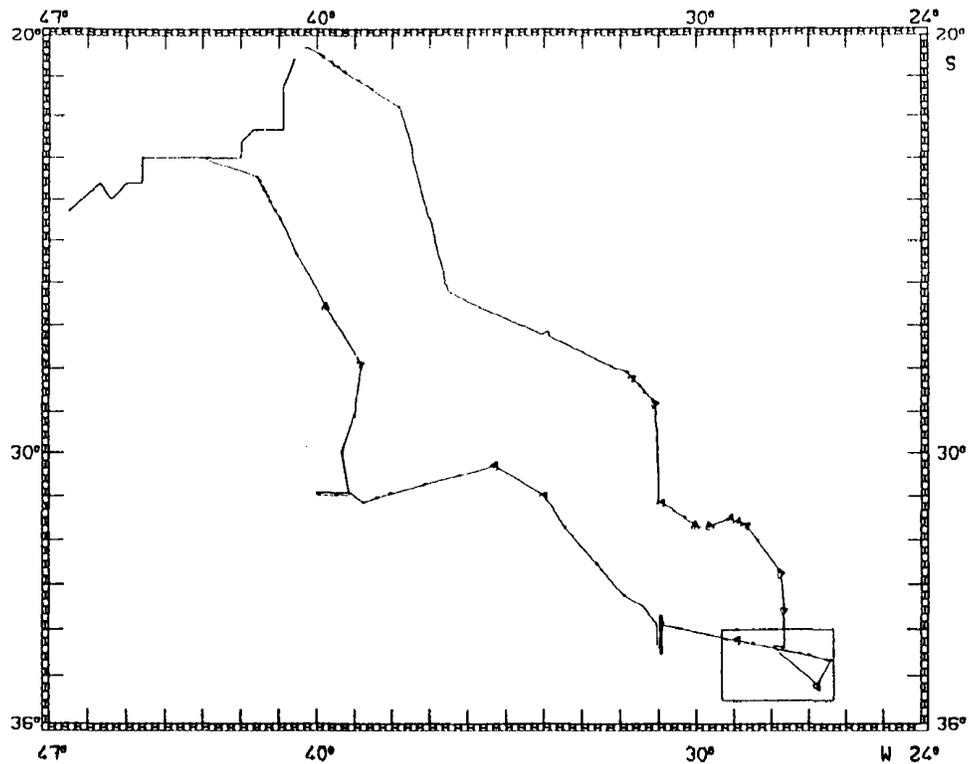


Fig. 3a: M15/2, Geology and CTD stations.

CRUISE M15, LEG 2: GEOLOGY (>) and CTD (•) STATIONS IN HUNTER GAP

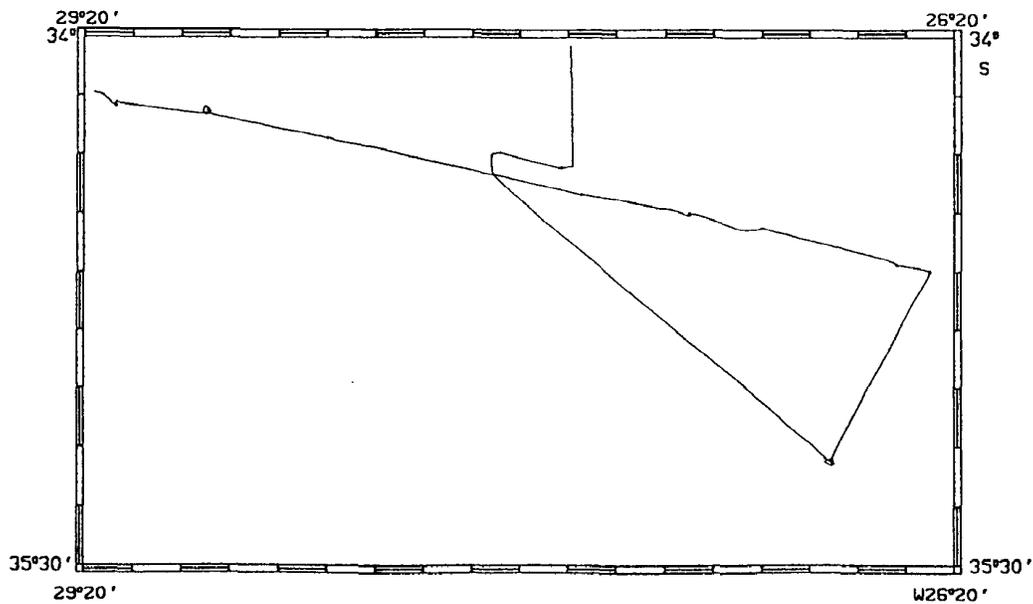


Fig. 3b: M15/2, Geology and CTD stations in Hunter Gap.

METEOR 15/3 + = XBT o = CTD

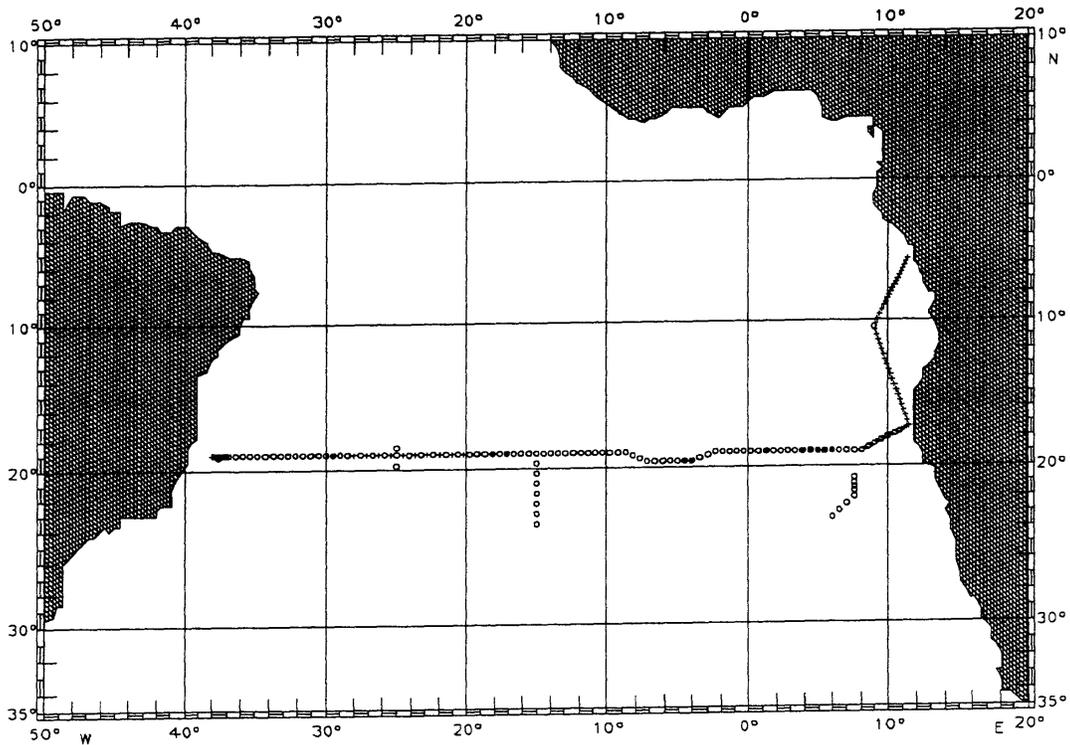


Fig. 4: Stations during leg M 15/3.

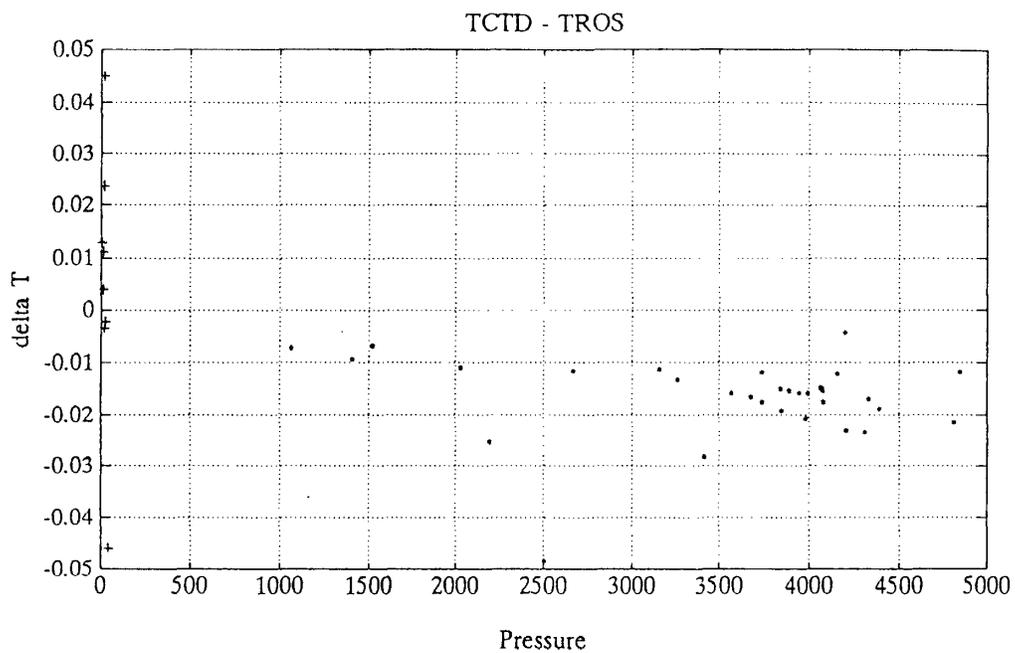


Fig. 5: Temperature difference between CTD and reversing thermometers as a function of pressure (all available samples).

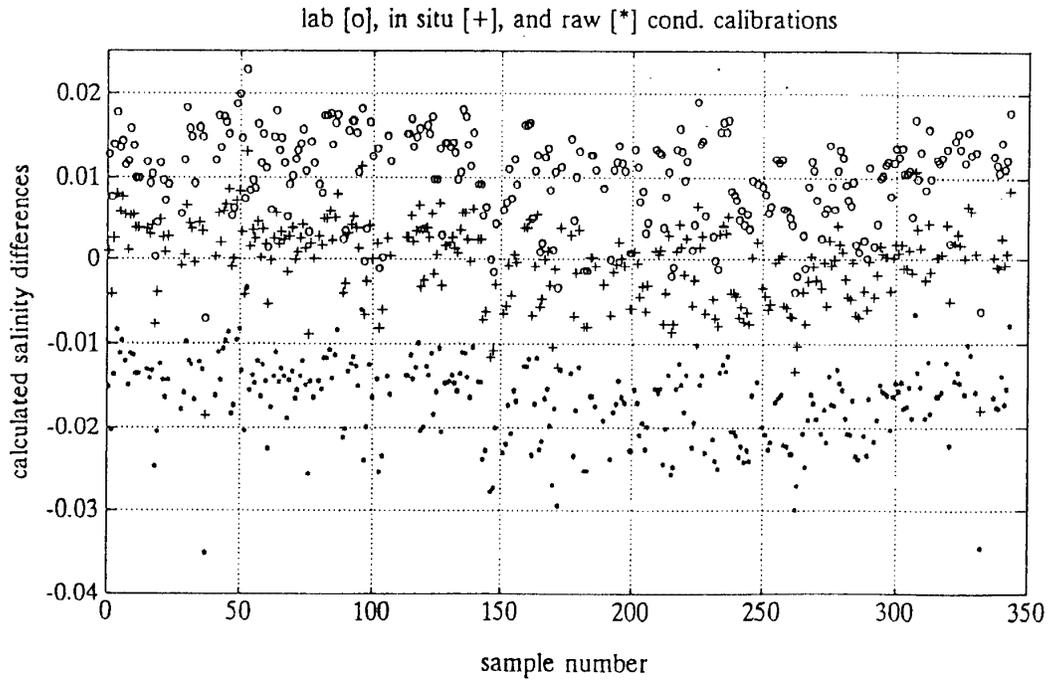


Fig. 6: Salinity differences between rosette and CTD for different conductivity calibrations. “Raw” means no calibration applied, “lab” is laboratory calibration, and “in situ” is the calibration obtained from rosette values.

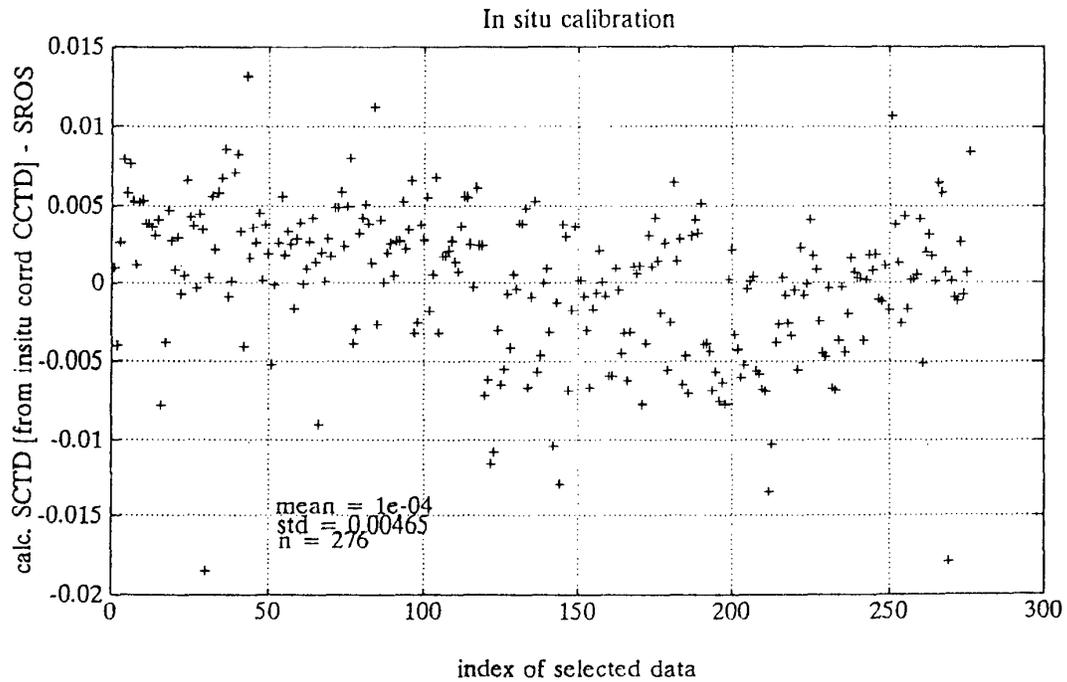


Fig. 7: Same as “in situ” calibration in Figure 6, but after rejecting some data according to the procedure described in the text.

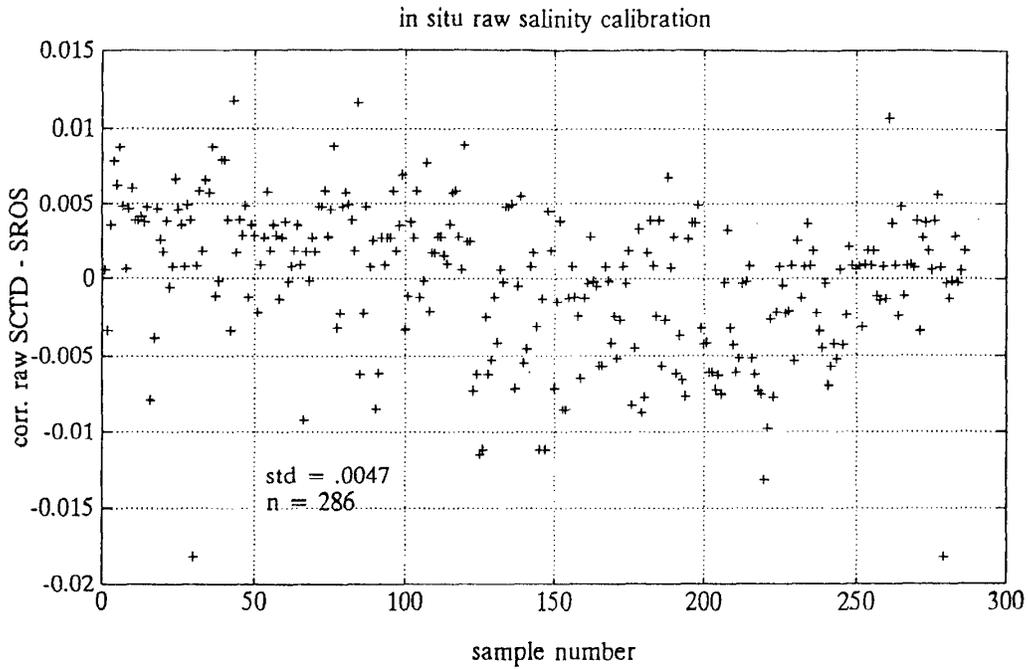


Fig. 8: Salinity differences after calibrating the CTD salinity (not conductivity).

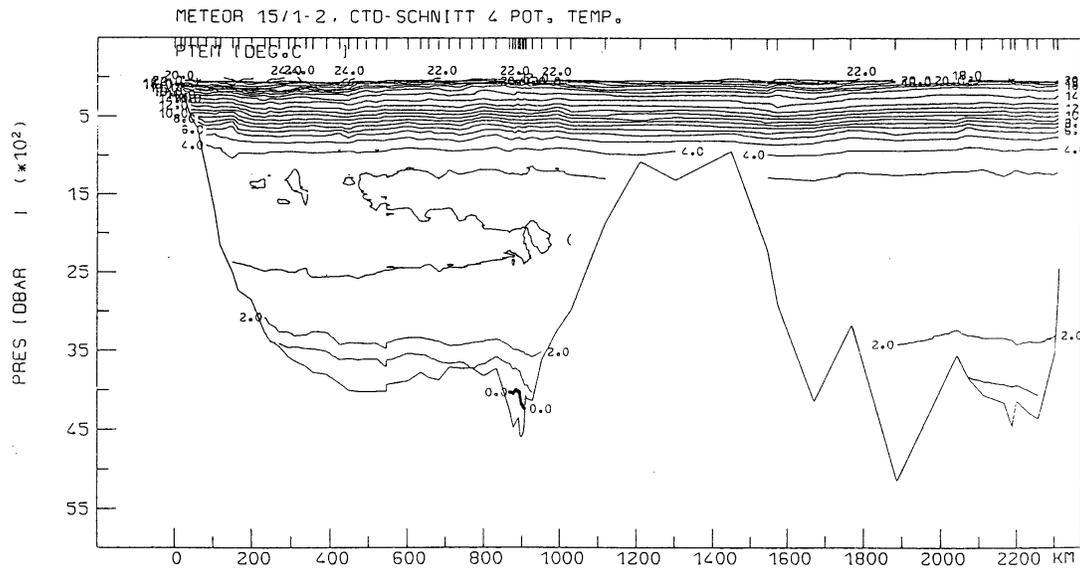


Fig. 9a: Profile of potential temperature ($^{\circ}\text{C}$) near 30°S across the Sao Paulo Plateau, Vema Channel, and Hunter Channel.

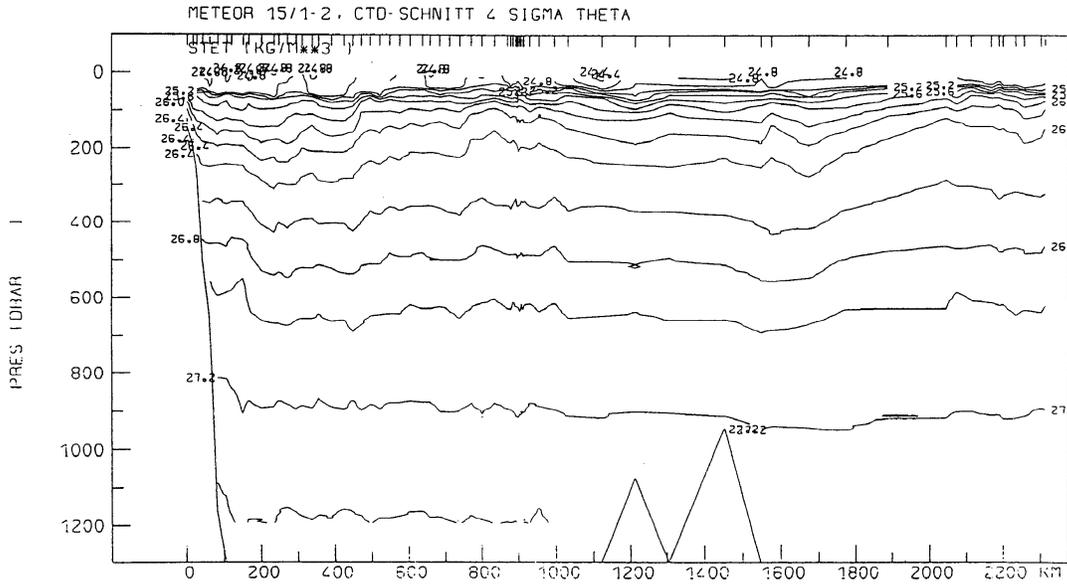


Fig. 9b: Potential density anomaly (kg m^{-3}) for the upper 1200 m of the water column. Some isopycnal tilt associated with the Brazil Current is visible at the shallowest stations.

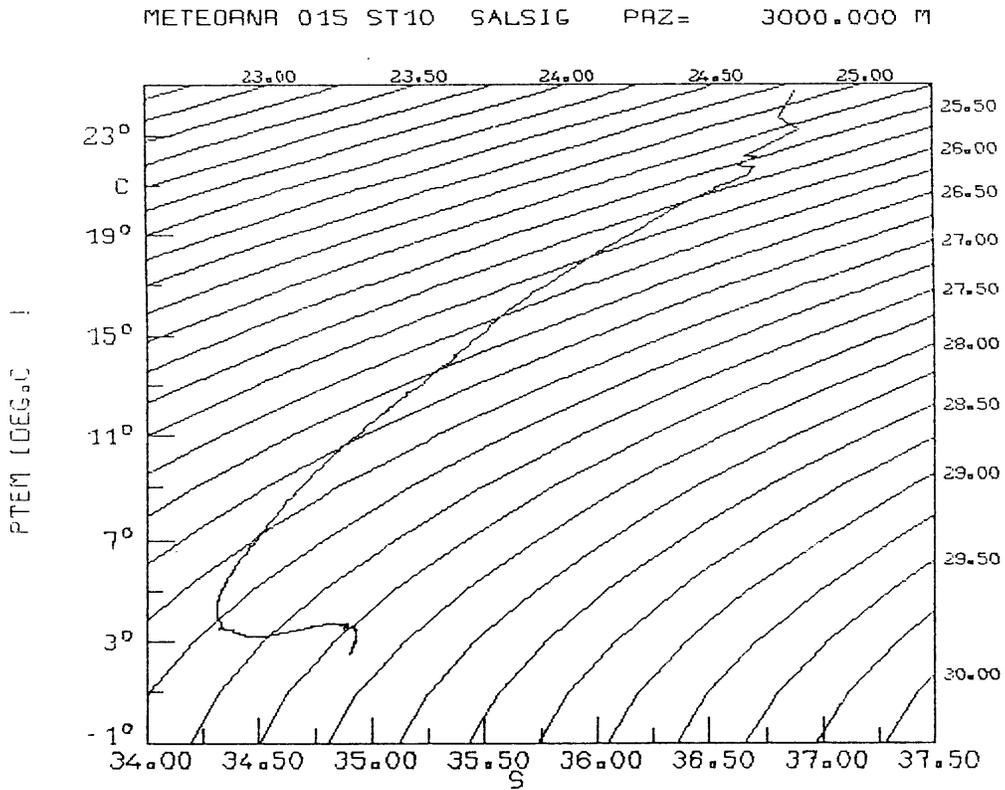


Fig. 10: Potential temperature ($^{\circ}\text{C}$) plotted against salinity (psu) for station 10, with potential density anomaly (kg m^{-3}) overlain.

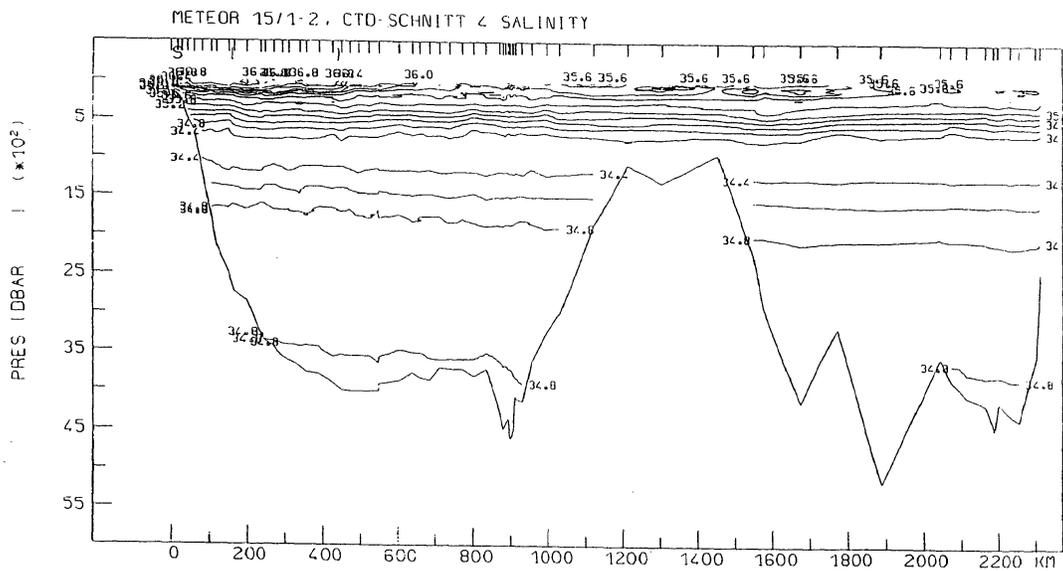


Fig. 11: Profile of salinity (psu), as in Figure 9a. Sub-surface maxima occur especially in the eastern part of the profile near 100m depth and again near 2500 m depth. Intermediate water salinity minimum occurs near 1000 m depth.

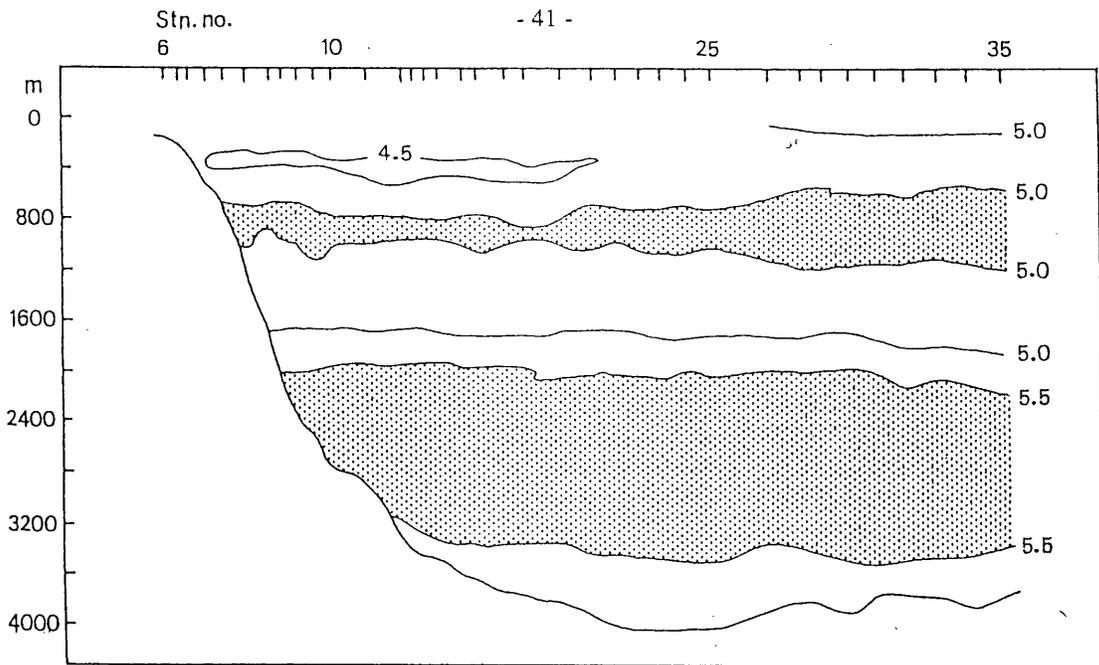


Fig. 12: Profile of oxygen (ml l^{-1}), partially calibrated CTD values in the western part of the region (leg 1).

METEORNR 015 ST97 EXTRAC PRZ= 2092.500 M

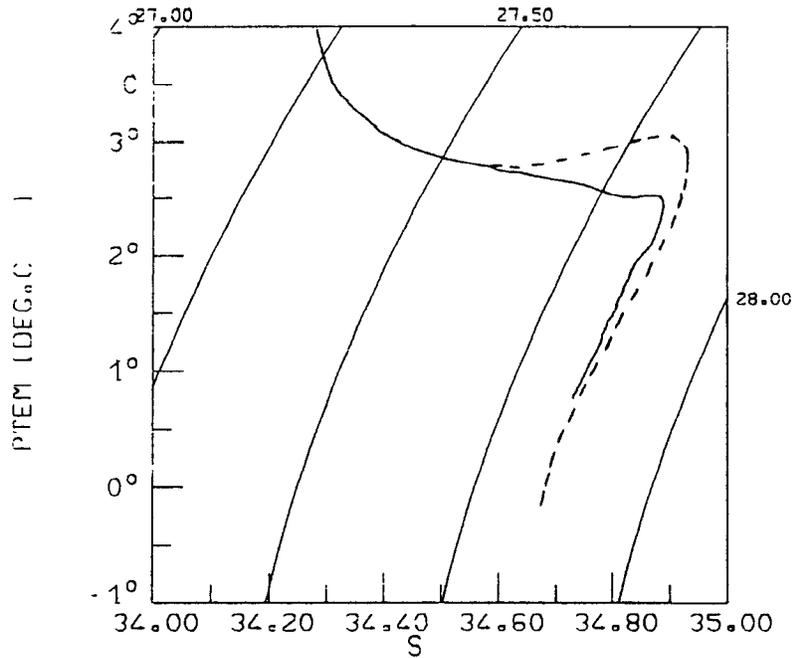


Fig. 13: Potential temperature ($^{\circ}\text{C}$) plotted against salinity (psu) for deep water colder than 4°C . Station 42 in the Vema Channel is shown for comparison (dashed).

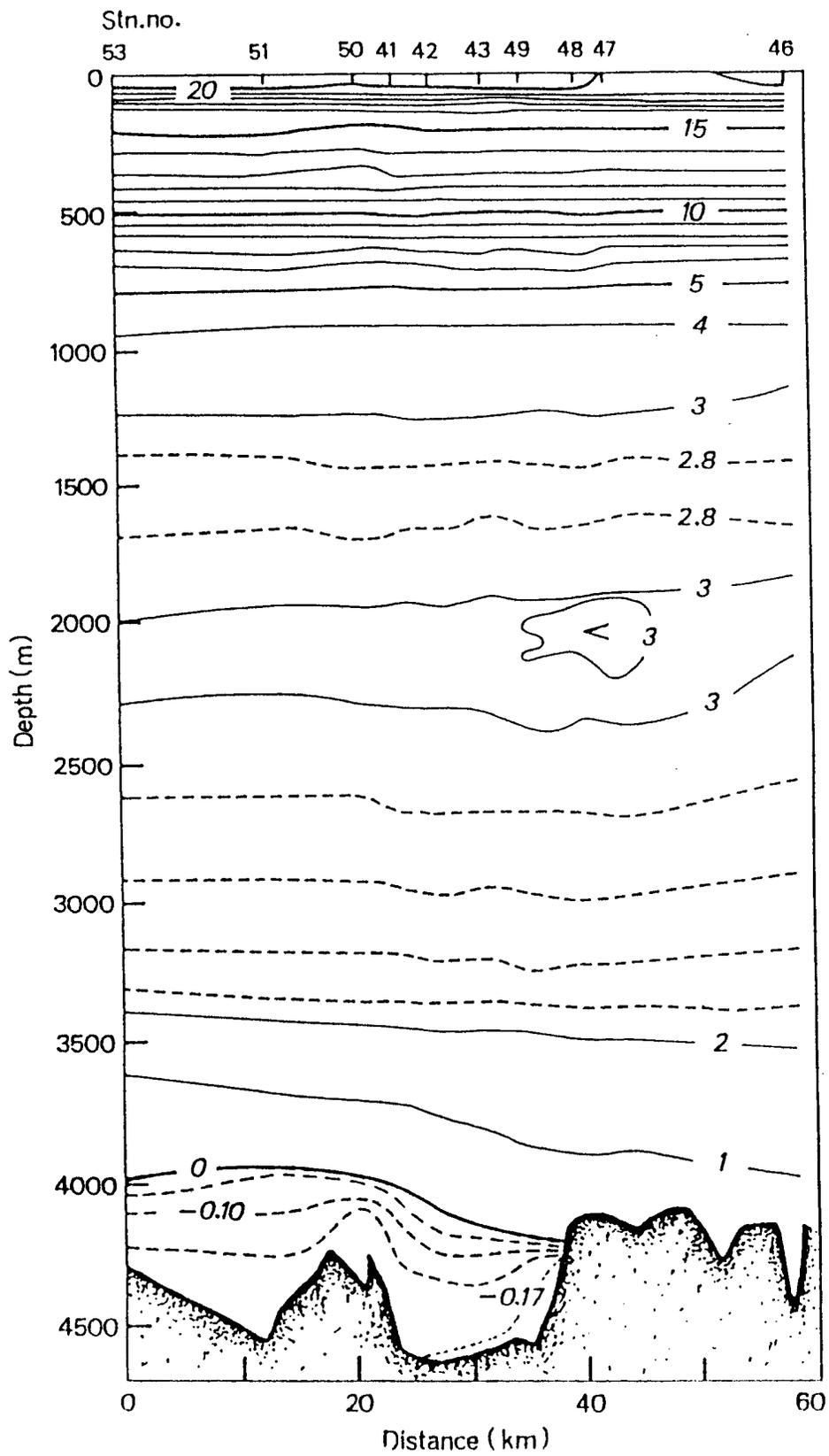


Fig. 14: Profile of potential temperature ($^{\circ}\text{C}$) across the Vema Channel.

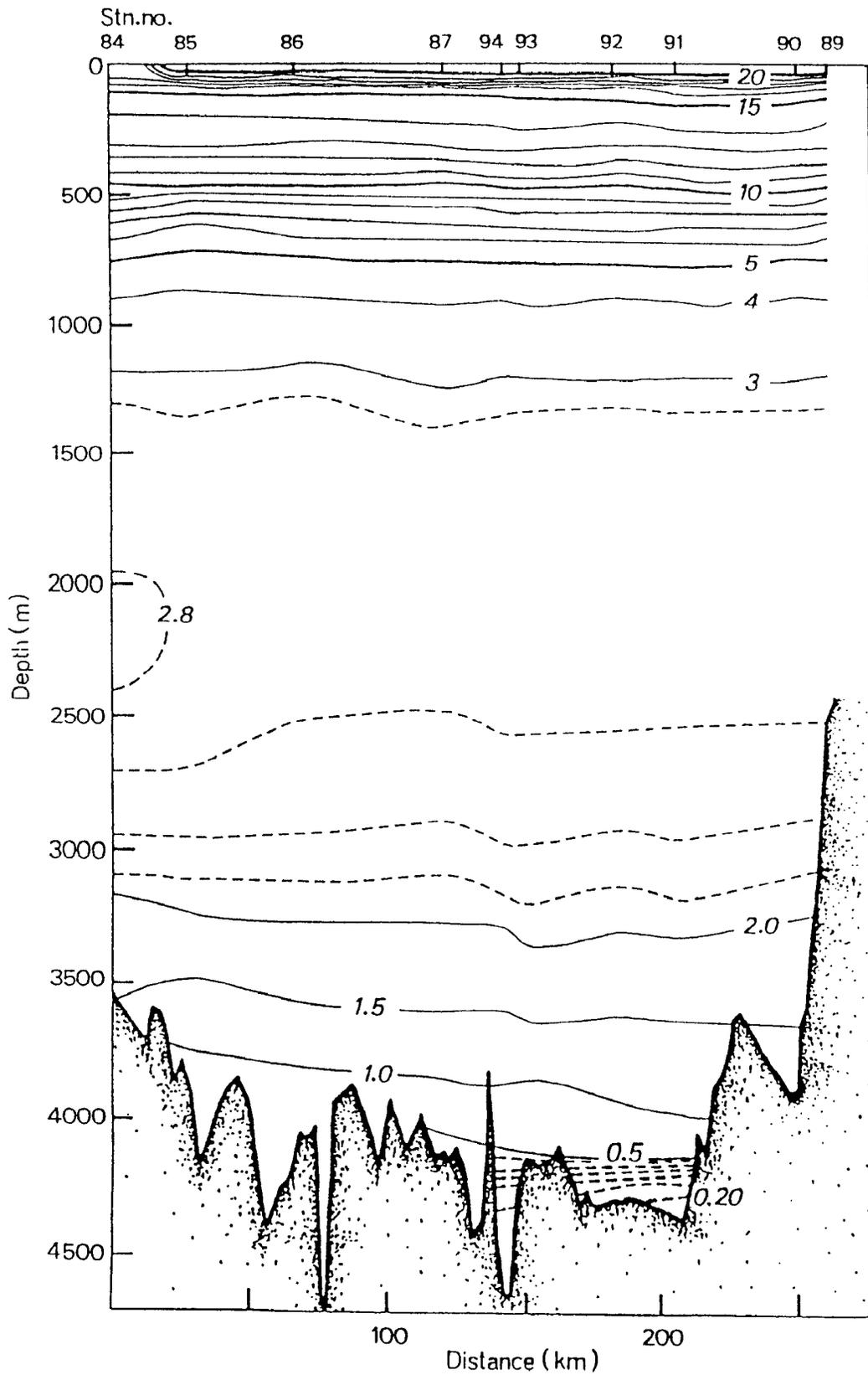


Fig. 15: Profile of potential temperature ($^{\circ}\text{C}$) across the Hunter Channel

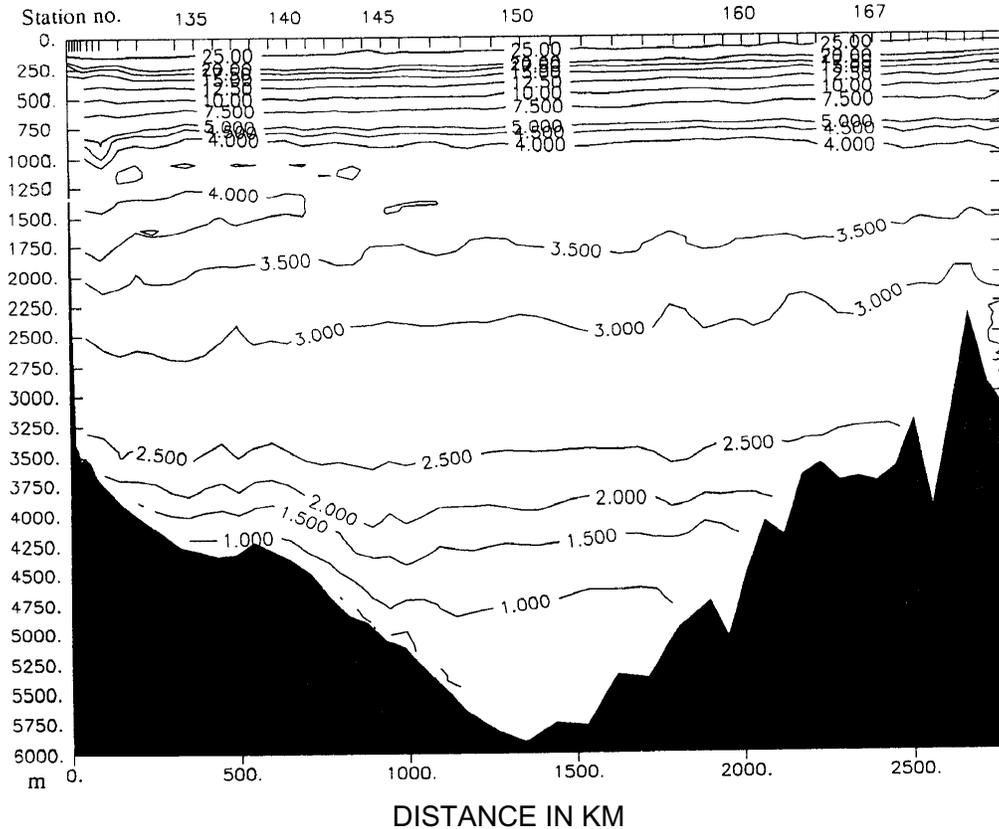


Fig. 16: Potential temperature/ °C at 19°S in the Brazil Basin

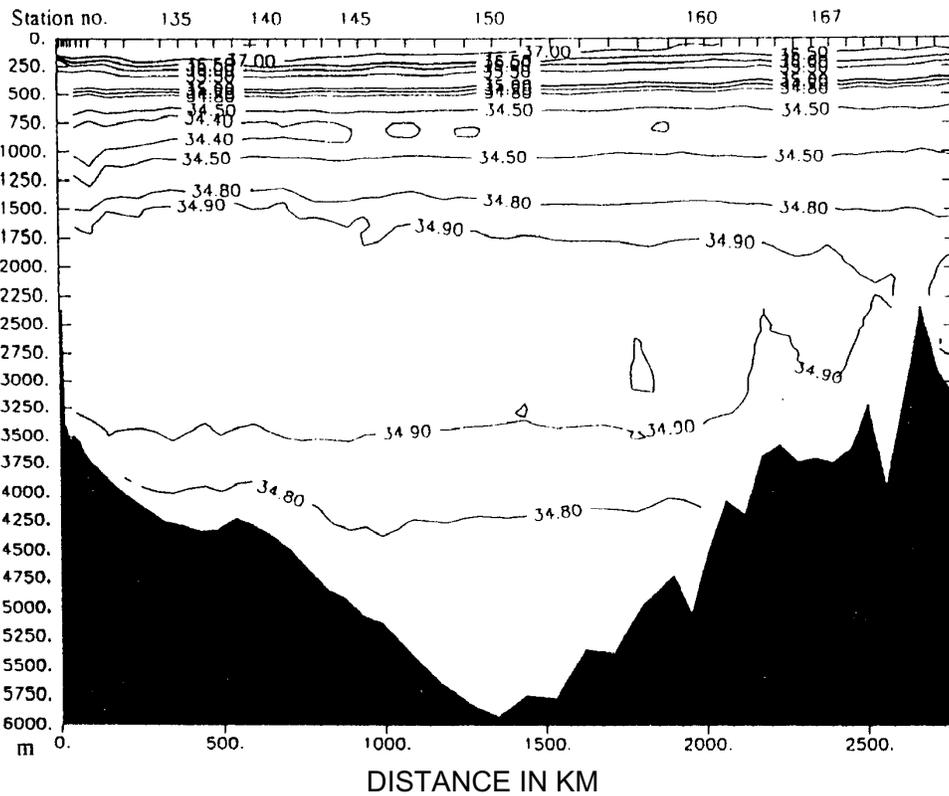


Fig. 17: Salinity/ psu at 19°S in the Brazil Basin

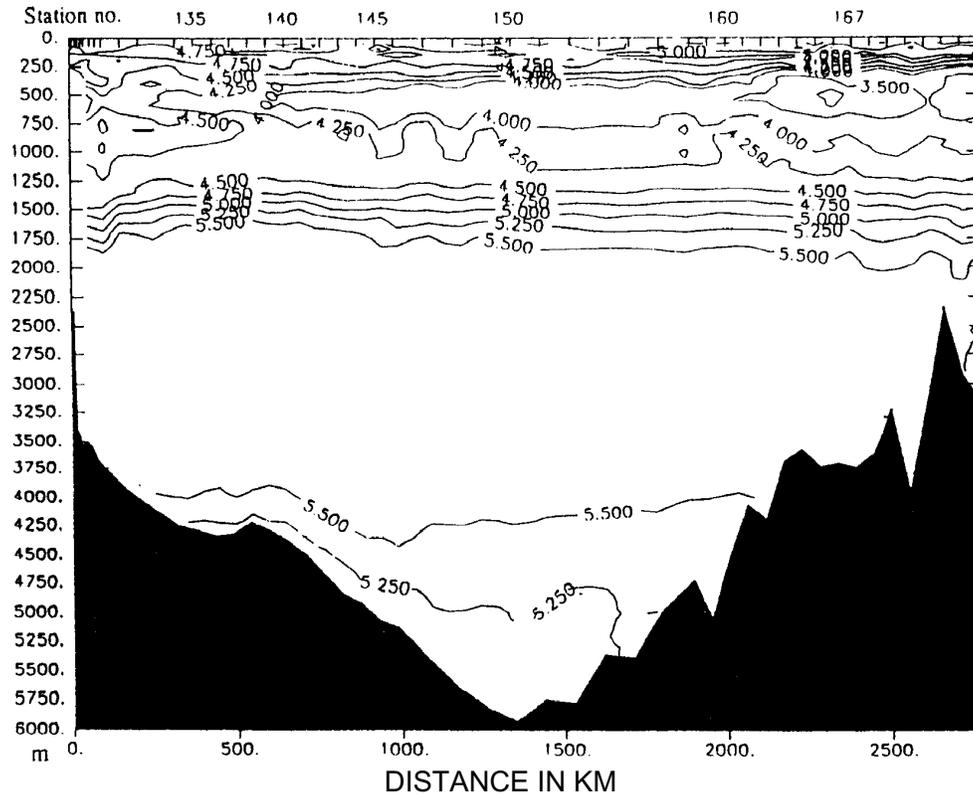


Fig. 18: Oxygen/ ml l⁻¹ at 19°S in the Brazil Basin

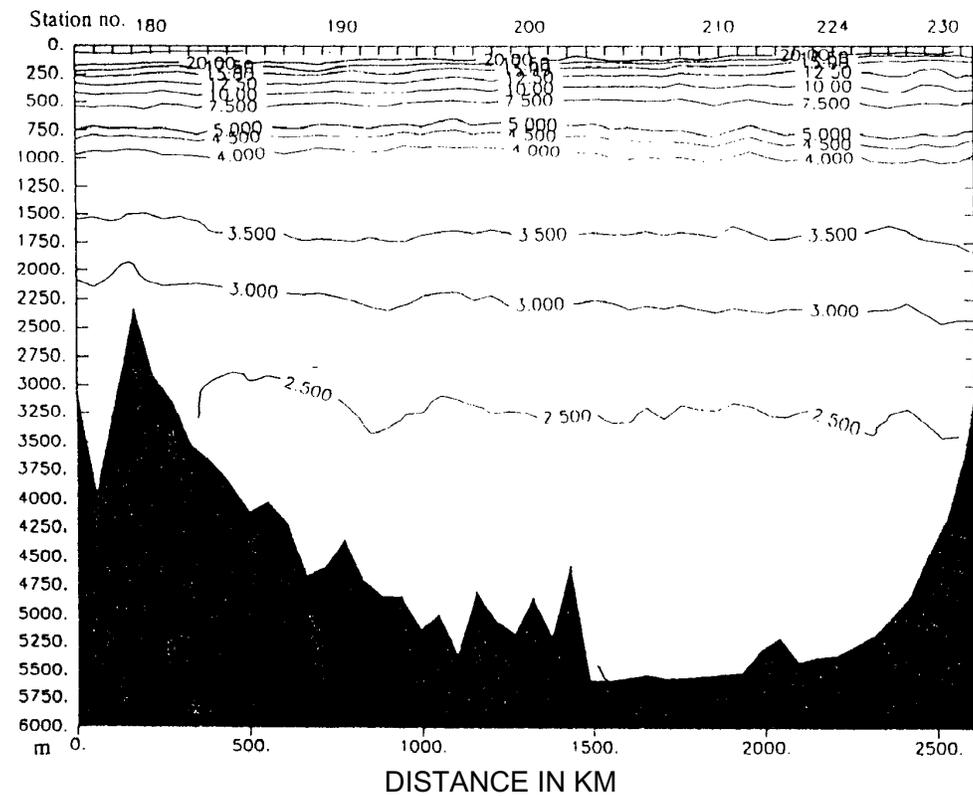


Fig. 19: Potential temperature/ °C at 19°S in the Angola Basin

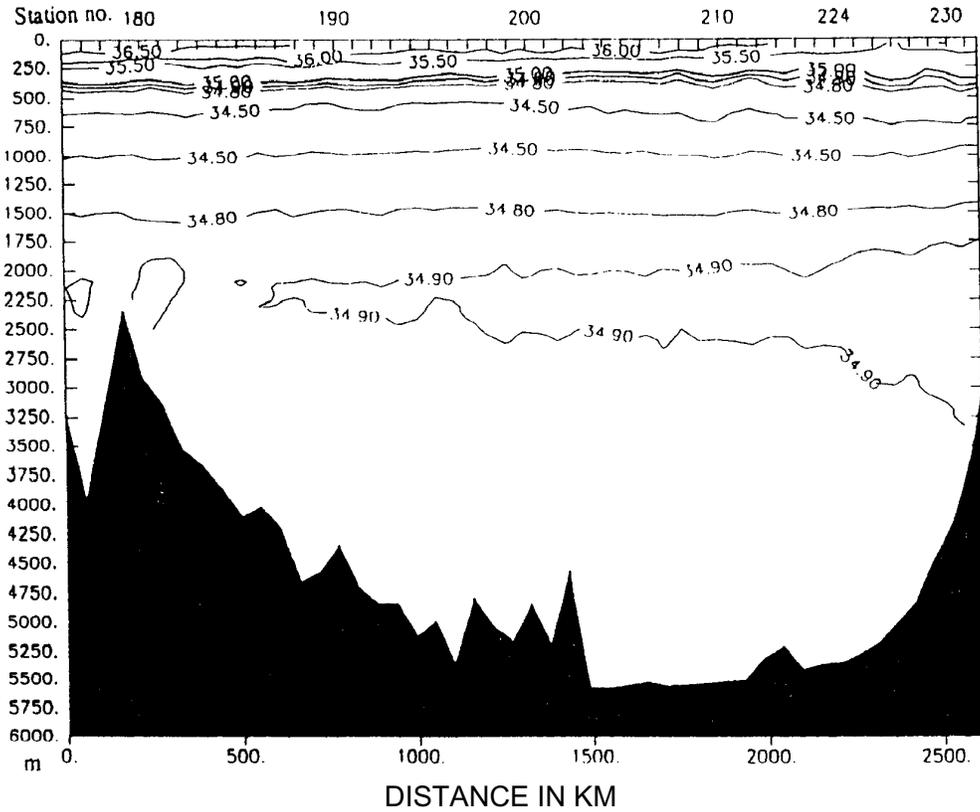


Fig. 20: Salinity/ psu at 19°S in the Angola Basin

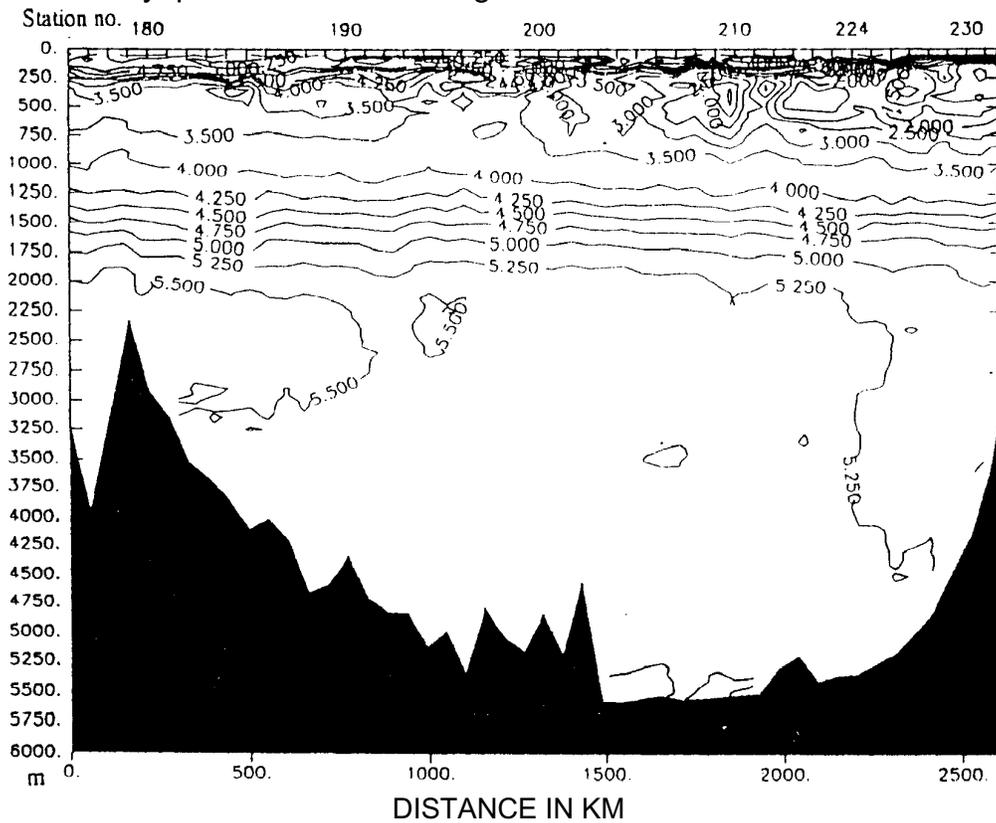


Fig. 21: Oxygen/ ml l⁻¹ at 19°S in the Angola Basin

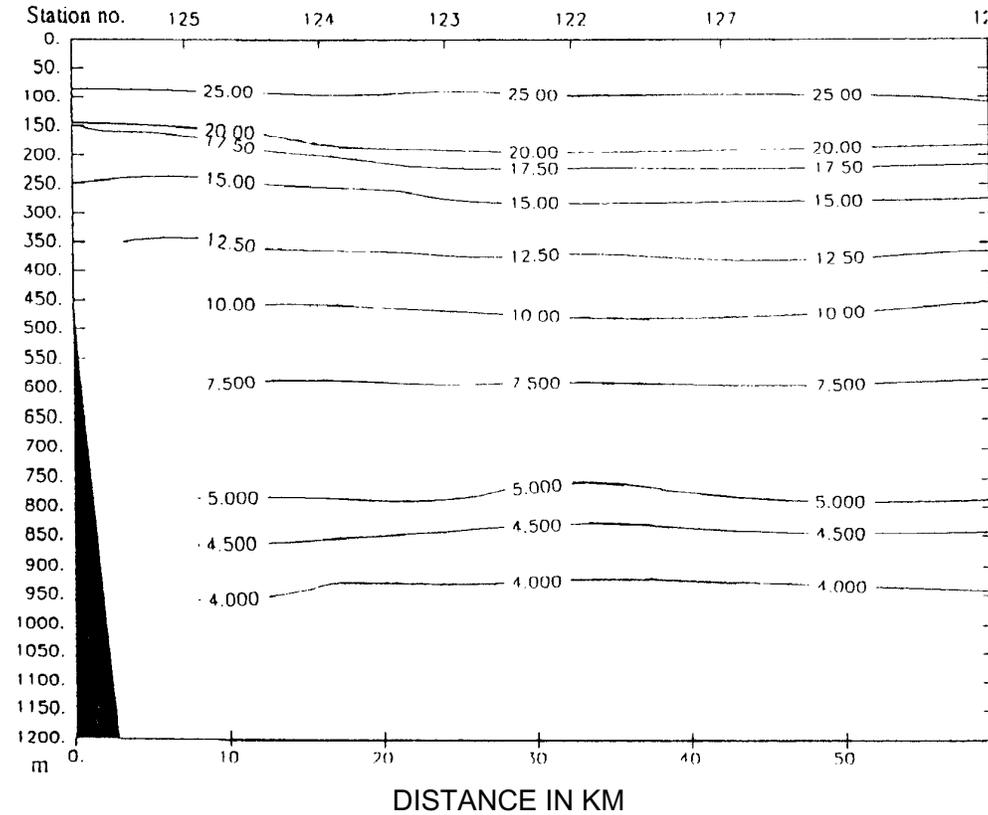


Fig. 22: Potential temperature/ °C at 19°S in the region of the Brazil Current

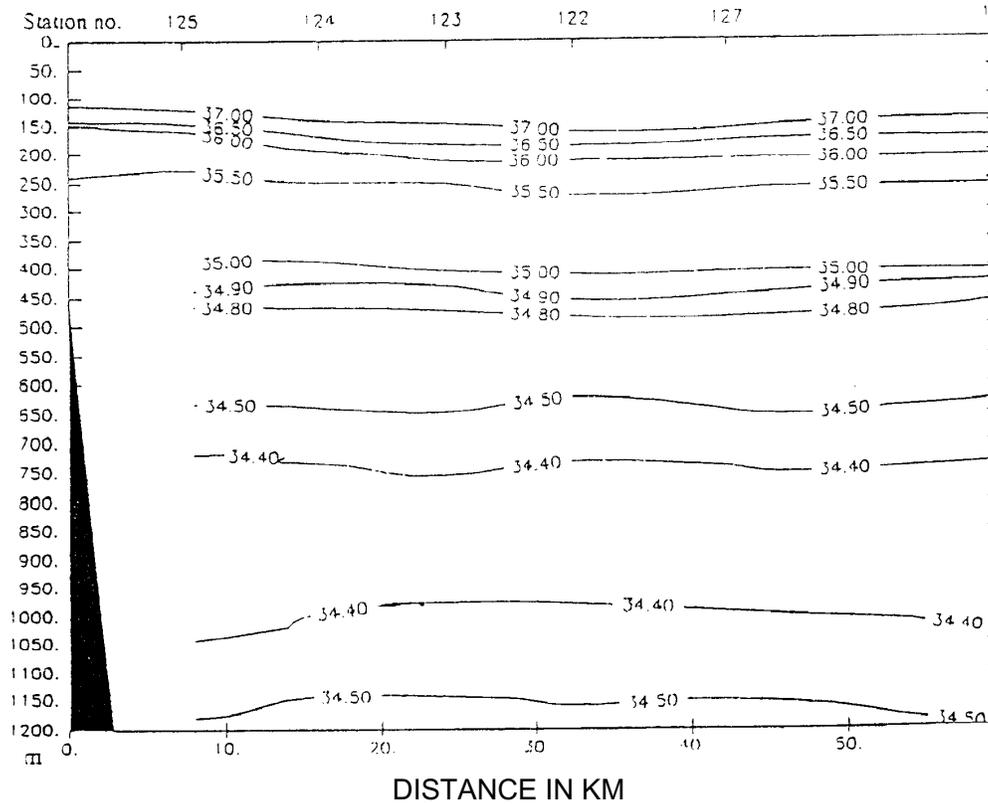


Fig. 23: Salinity/ psu at 19°S in the region of the Brazil Current

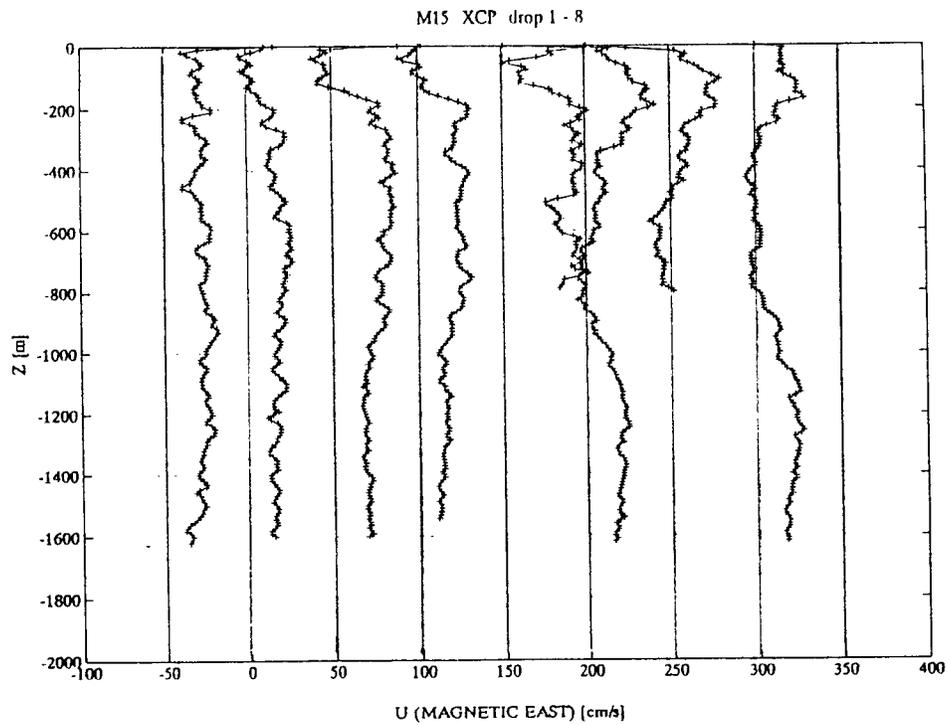


Fig. 24: North-South component (positive: north) of currents in the region of the Brazil Current with unknown offset of the calibration

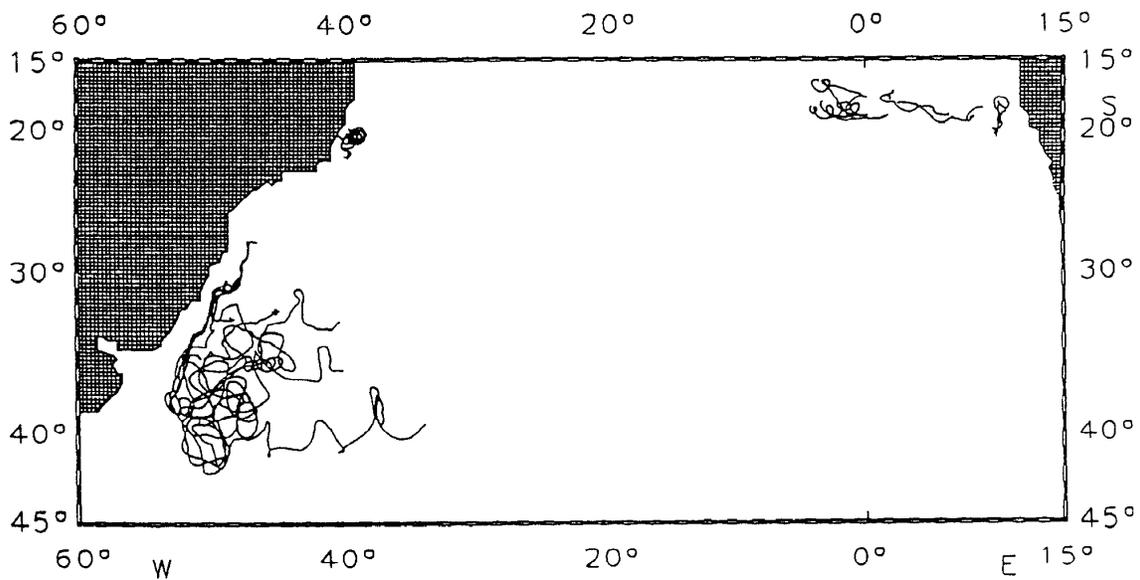


Fig. 25: Trajectories of all surface drifters launched during M 15: December '90 – September '91, drague depth 100m (survey)

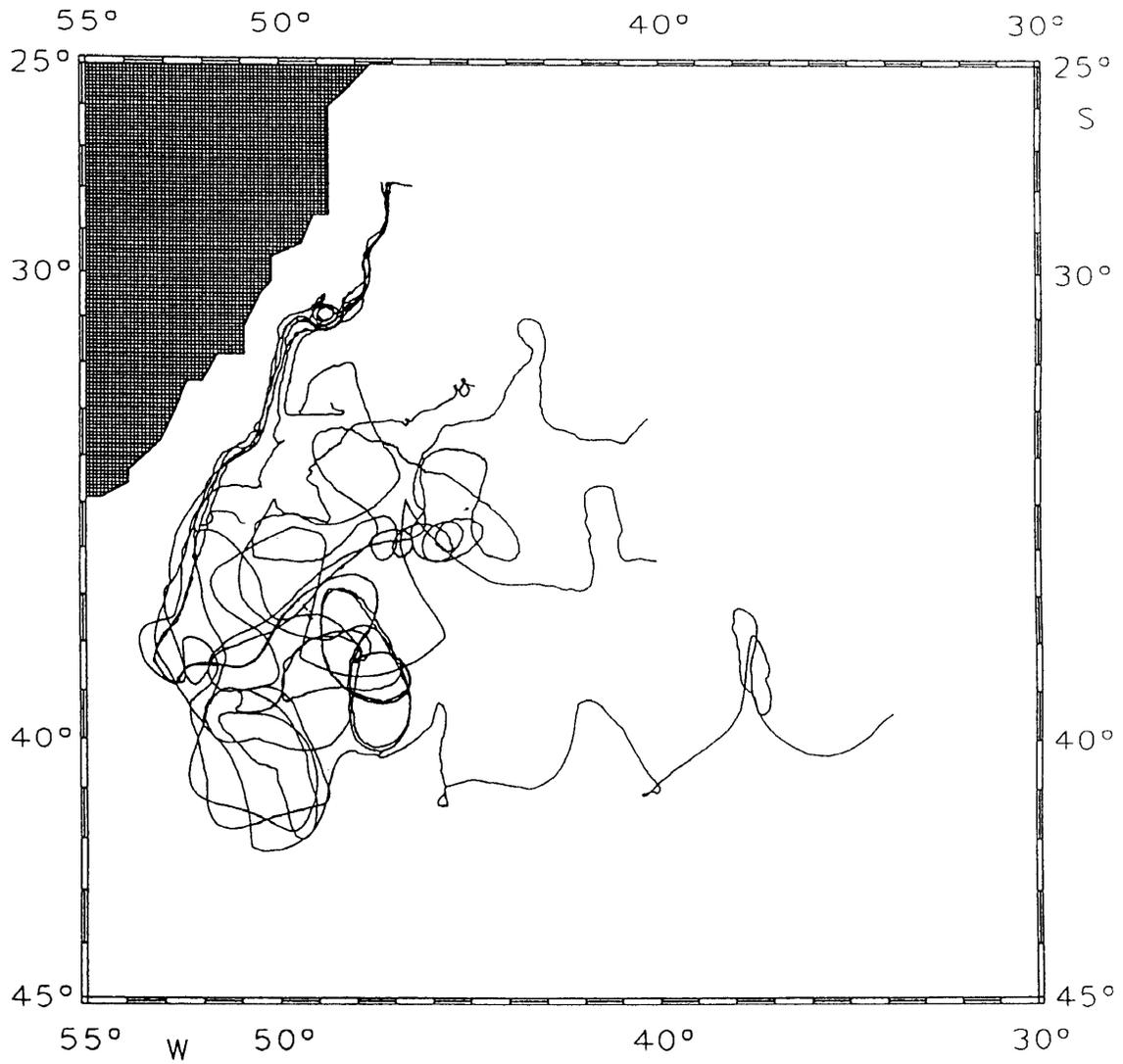


Fig. 26: Trajectories of surface drifters launched during the first leg

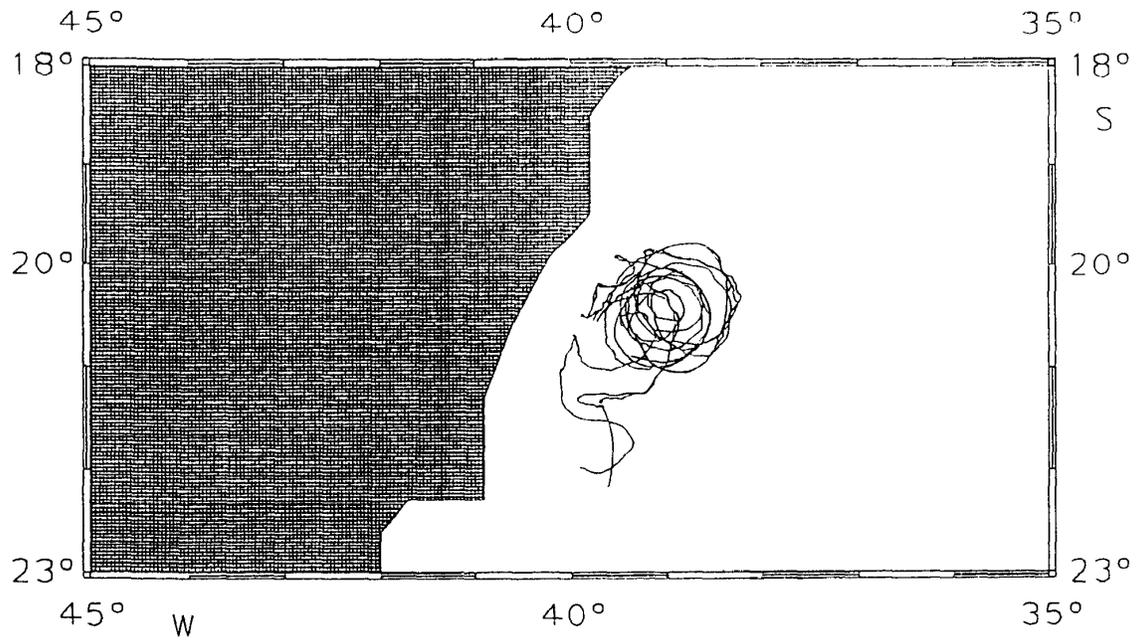


Fig. 27: Trajectories of surface drifters launched during the second leg

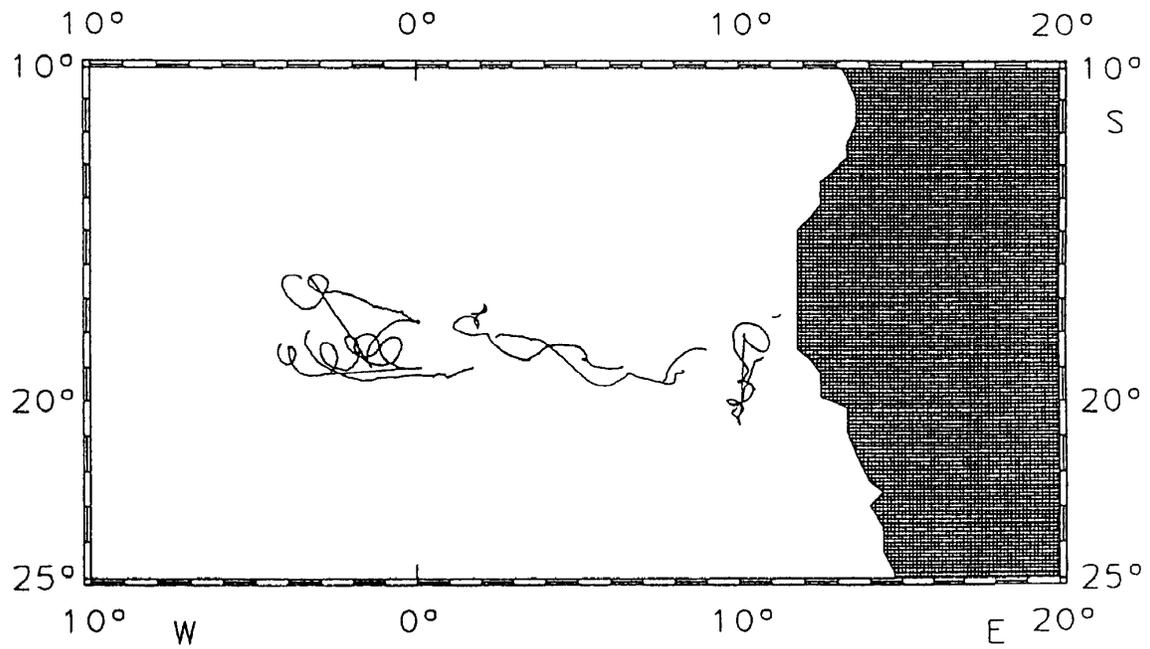


Fig. 28: Trajectories of surface drifters launched during the third leg

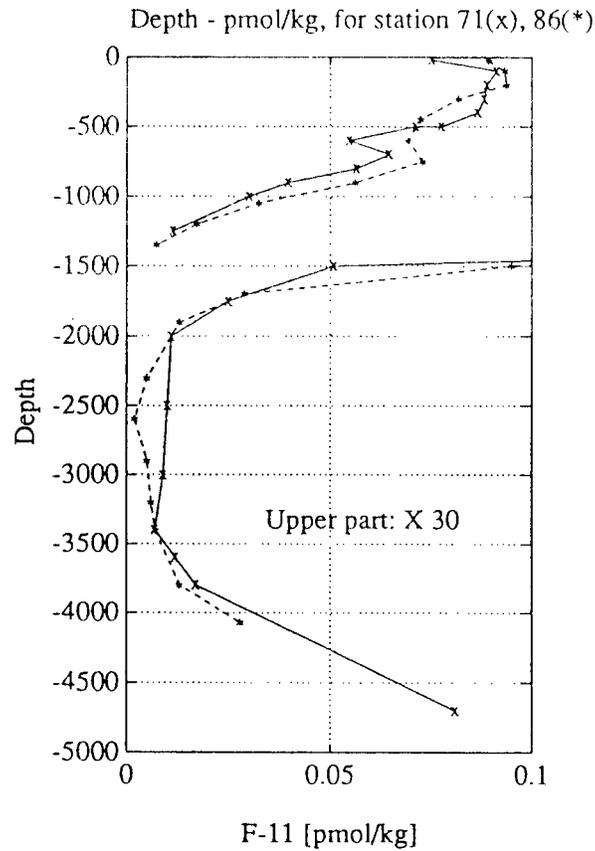


Fig. 29: F11 profiles, stations 71 (solid line) and 86 (dashed line), M 15/2 (preliminary results)

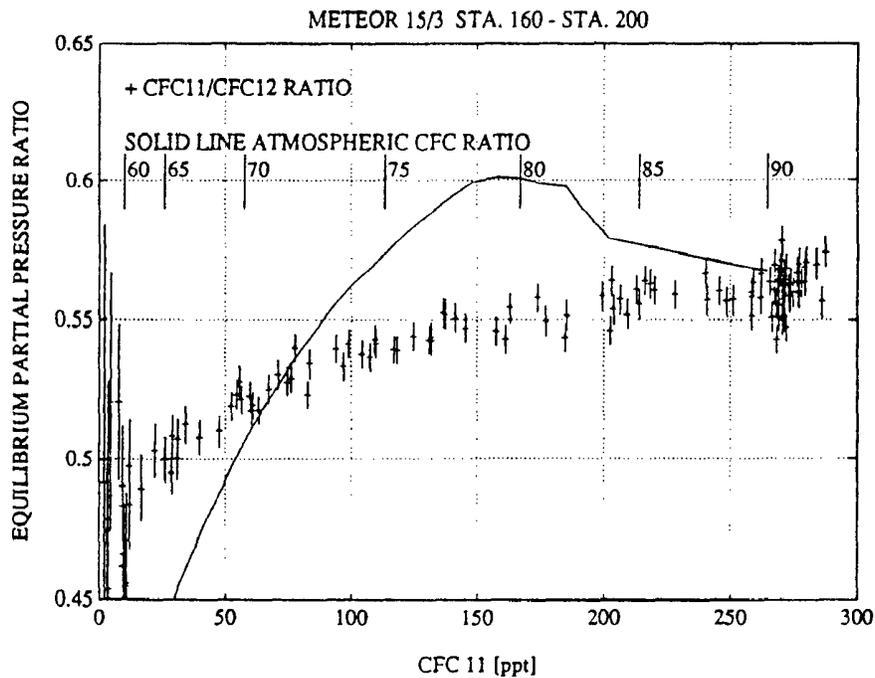


Fig. 30: Partial pressure of F11/F12 versus partial pressure concentration F11 for stations 160 to 200, M 15/3

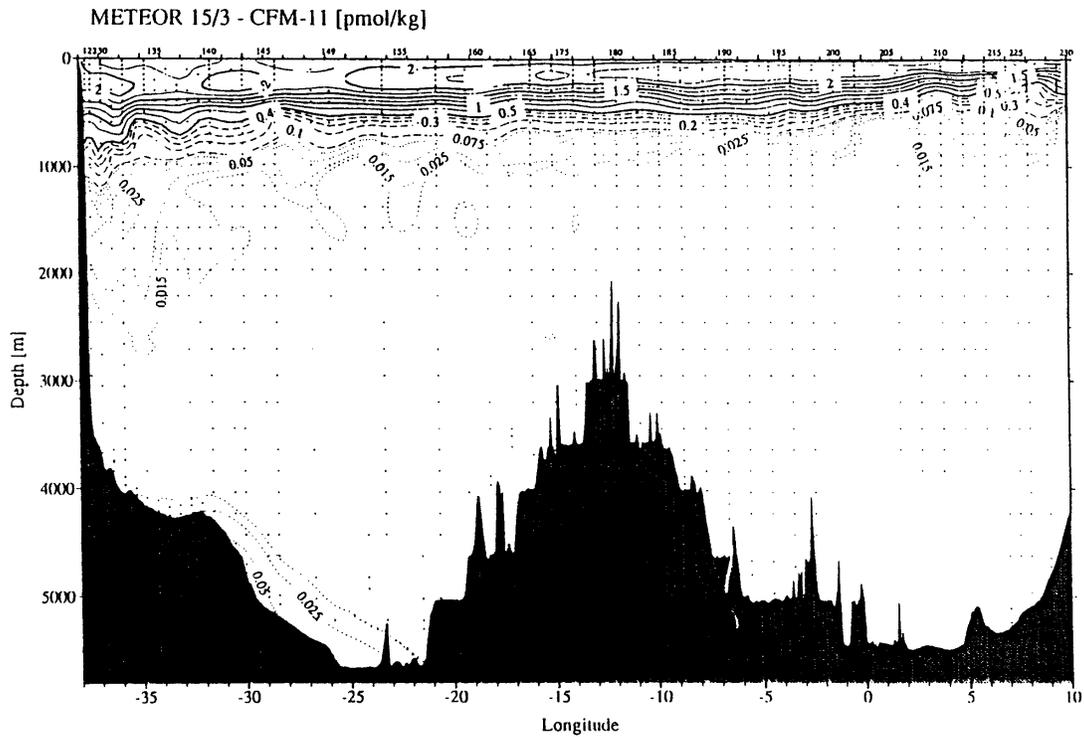


Fig. 31: CFC F11 19°S section, M 15/3

Station 105
GeoB 1314

31°10 W
30°55 S

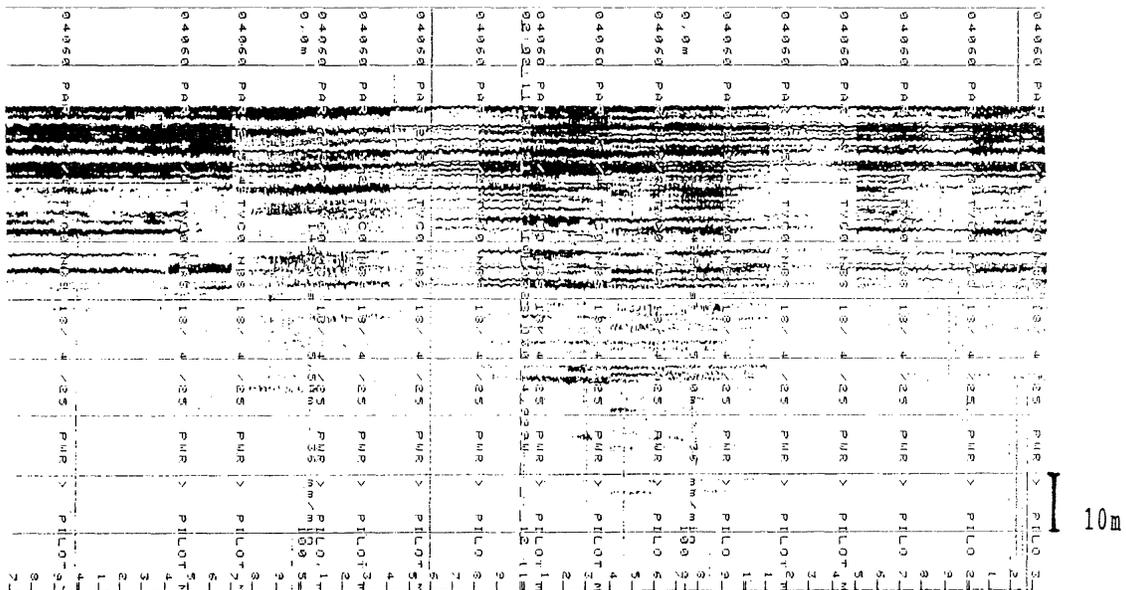


Fig. 32: Sample of the PARASOUND analogue record of a frequency test of the sediment core station GeoB 1314 (station 105)

28°12,3 S
38°52,3 W

28°18,8 S
38°53,2 W

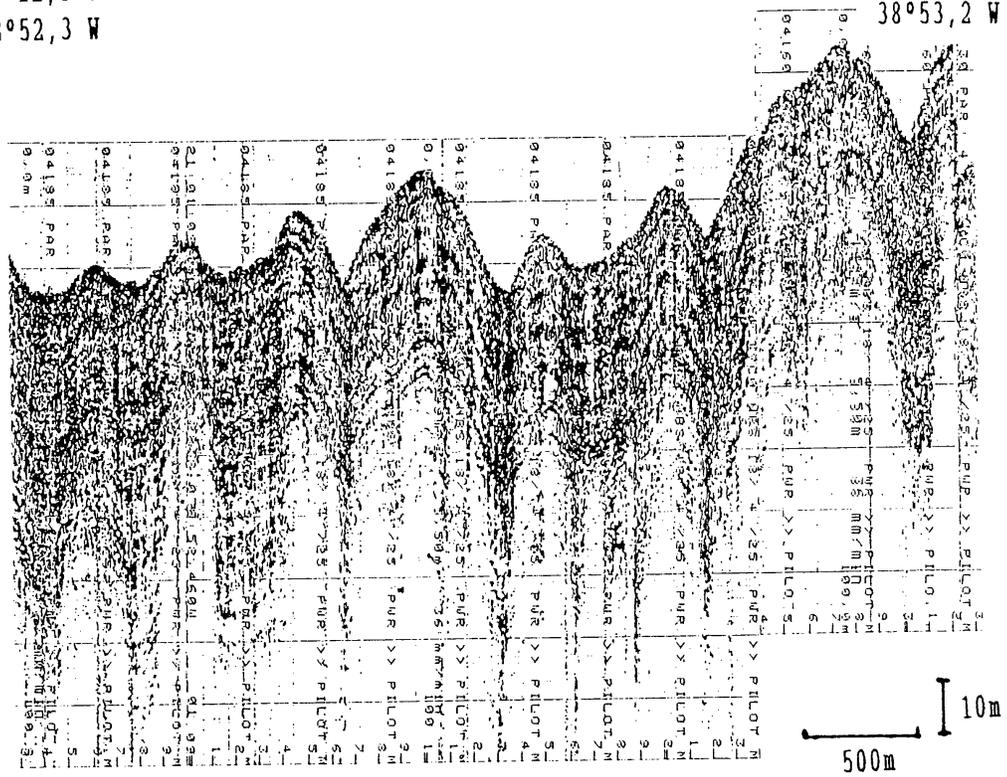


Fig. 33: Sediment waves north of the Vema Channel. Different wave lengths and amplitudes show sediment transport by bottom water current.

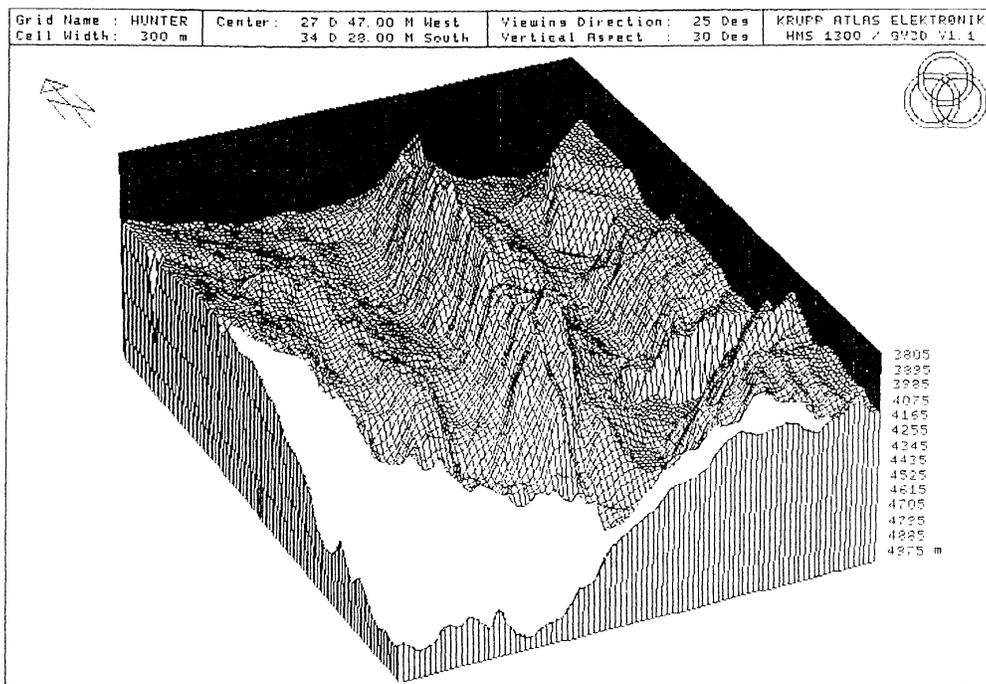
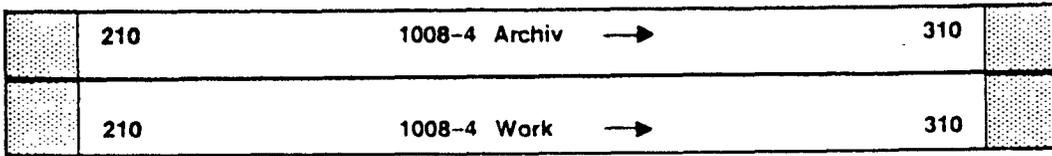
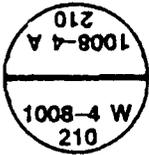


Fig. 34: HYDROMAP 3D presentation of the detailed bathymetry in the western region of the Hunter Channel. The forward region was not covered during the measurement.

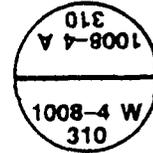
Beschriften:



Liner



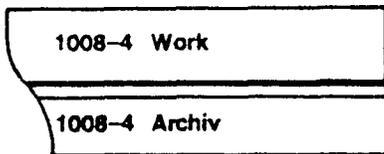
Stationsnummer 1008-4
 Kerntiefe 210 - 310cm
 Markierung für Paläomagnetik —



Graue Bereiche nicht beschriften!

Kappen

Aufsagen:



Röntgenpräparate:
 1 cm - Scheibe aus der
 Archiv! - Hälfte

Fig. 35: Labeling for the plastic liners of the gravity core

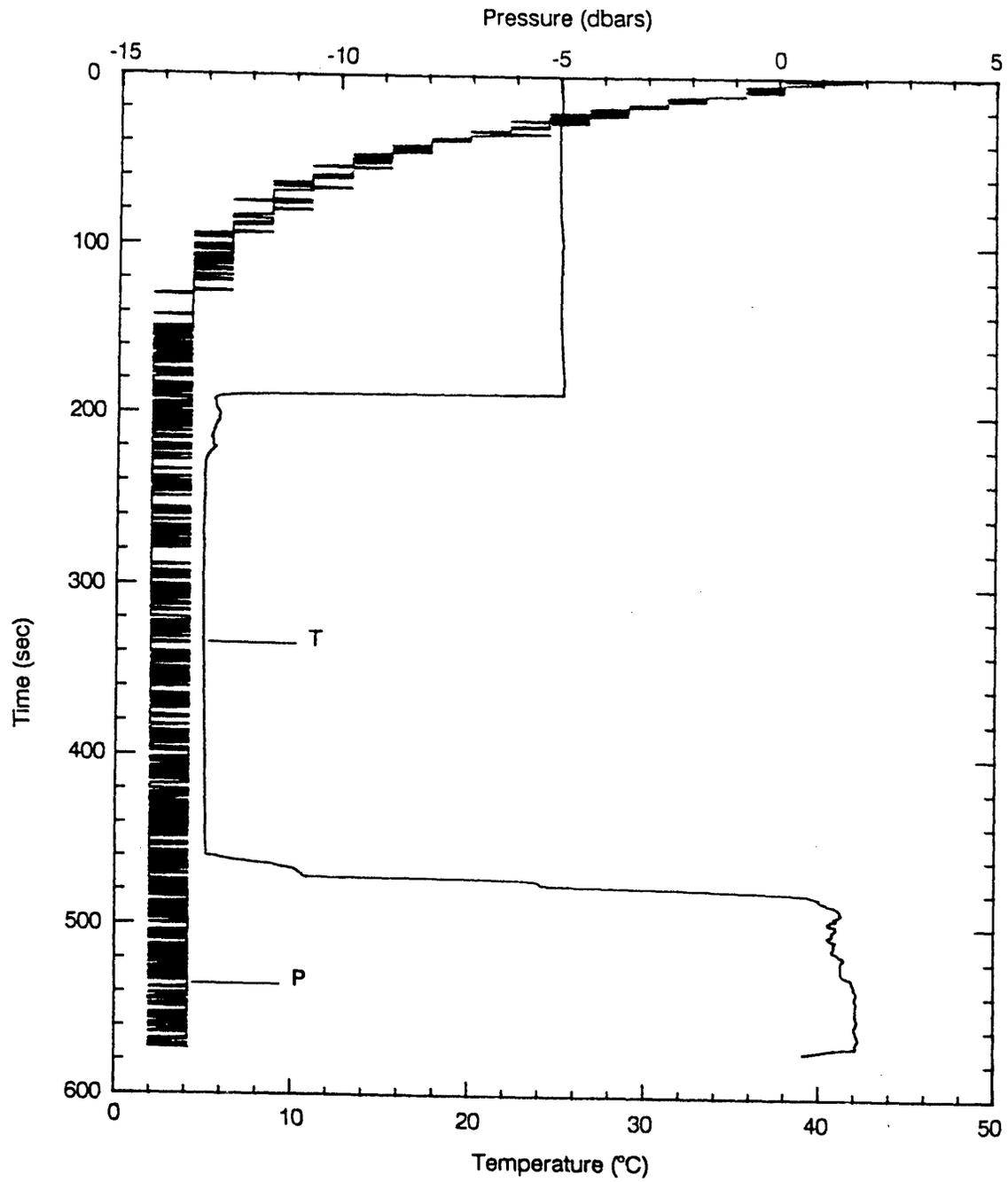


Fig. 36: Test of the temperature dependence of the SBE 19-2 pressure sensor

GeoB 1305

CTD - Vergleich

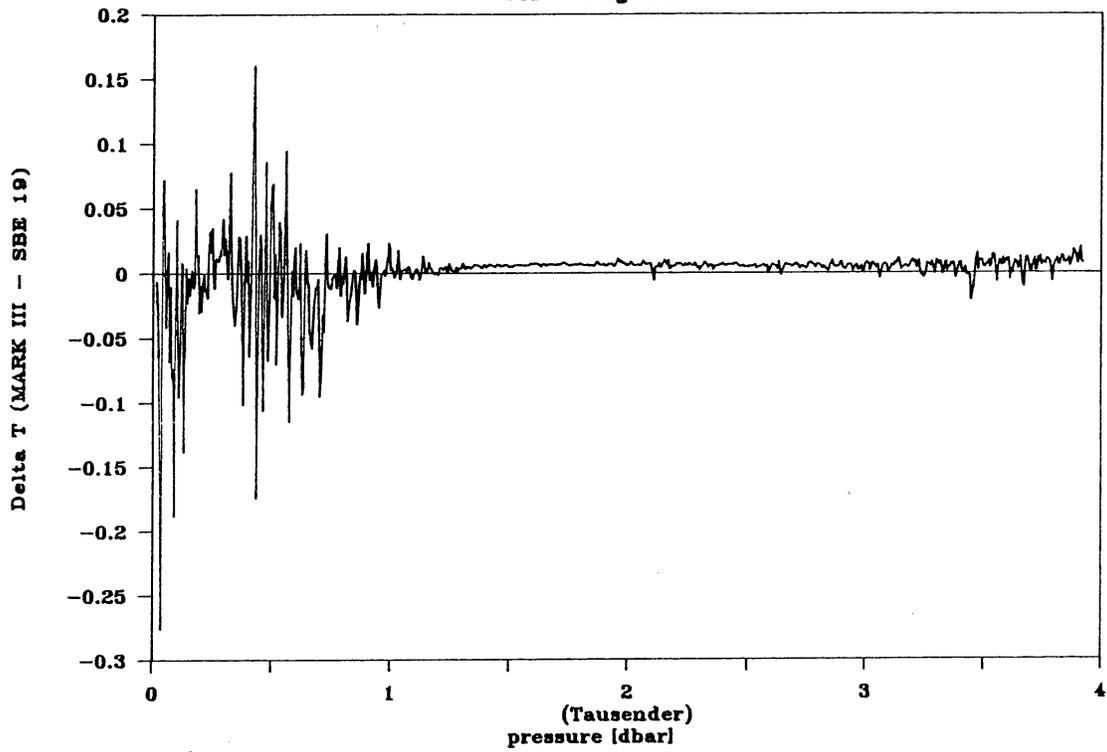


Fig. 37: Comparison of the temperature profiles of the Mark III and SBE 19-2 at station GeoB 1305 (station 85)

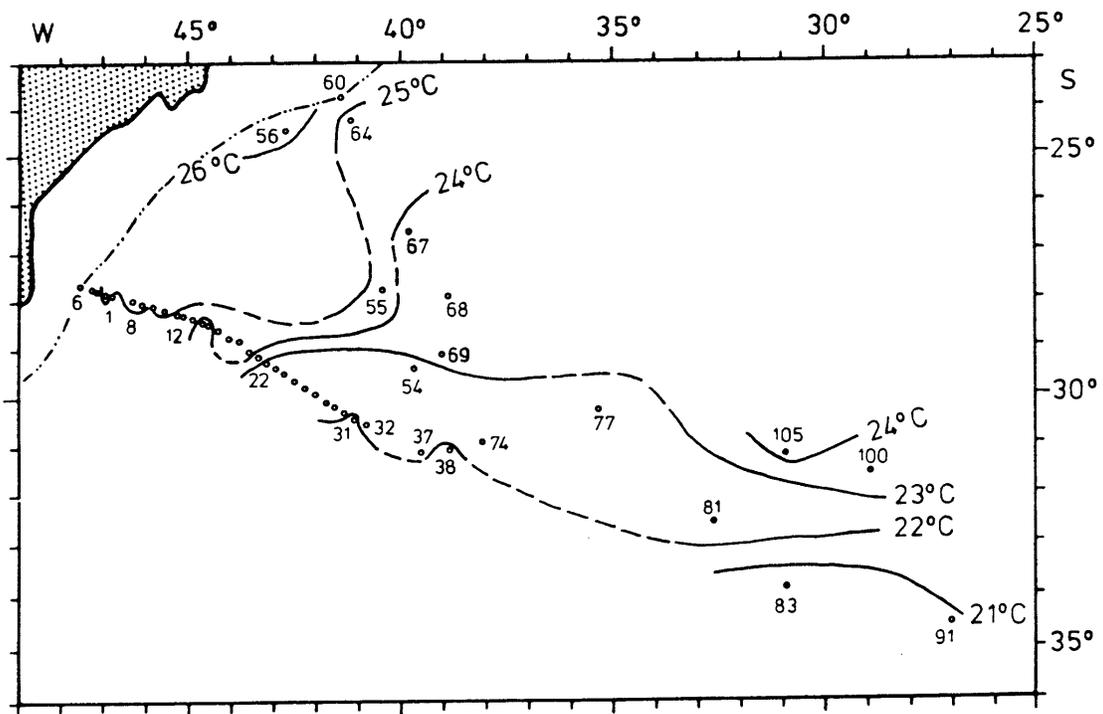


Fig. 38: Positions of the biological stations and the surface temperature distribution

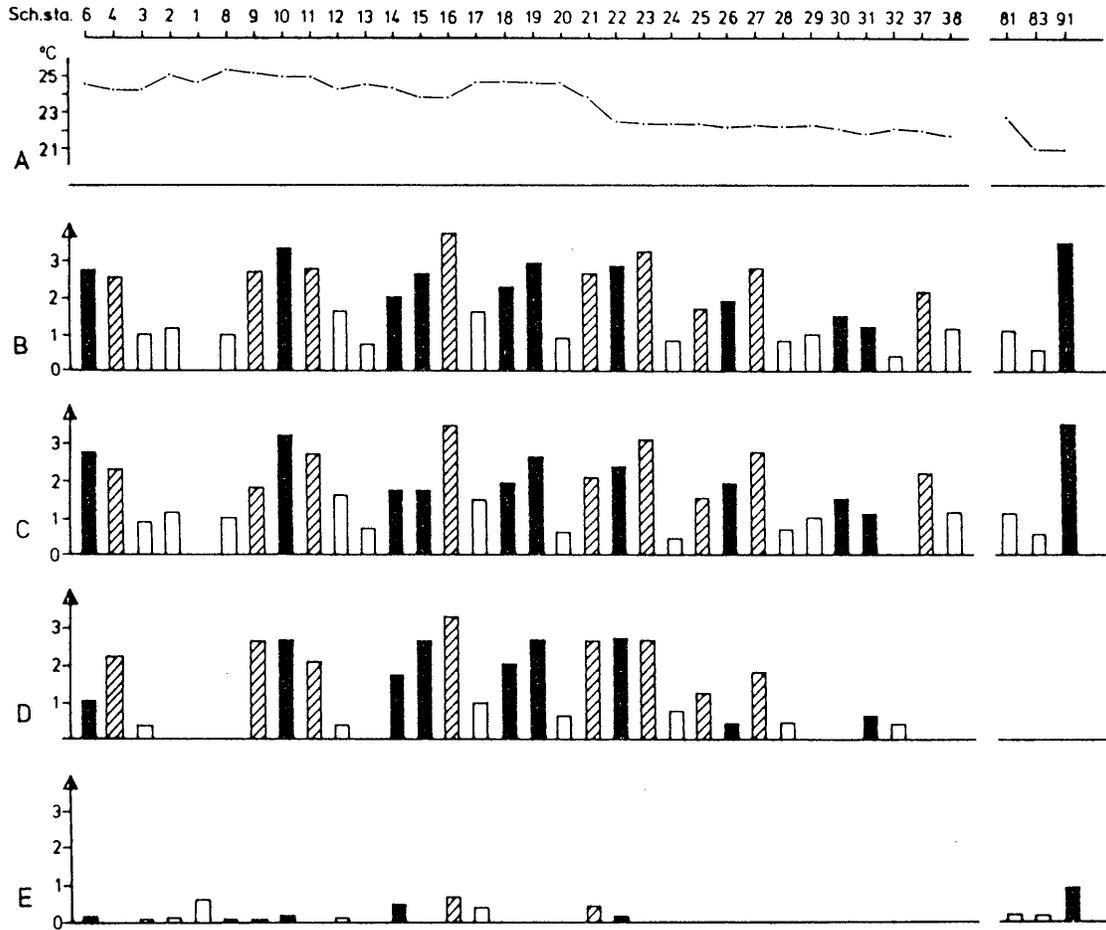


Fig. 39: Surface temperature (A), abundance of the Amphipoda (B), Hyperiidea (C), Synopia sp.m. (D), and Halobates micans (E) of the Neuston tows along the section. Abundances are expressed as $\log(N+1)/1000m^2$. White columns represent daily catches, hatched columns dawn and dusk and shaded columns night catches. The horizontal scale of the figure does not represent the actual distances between stations.

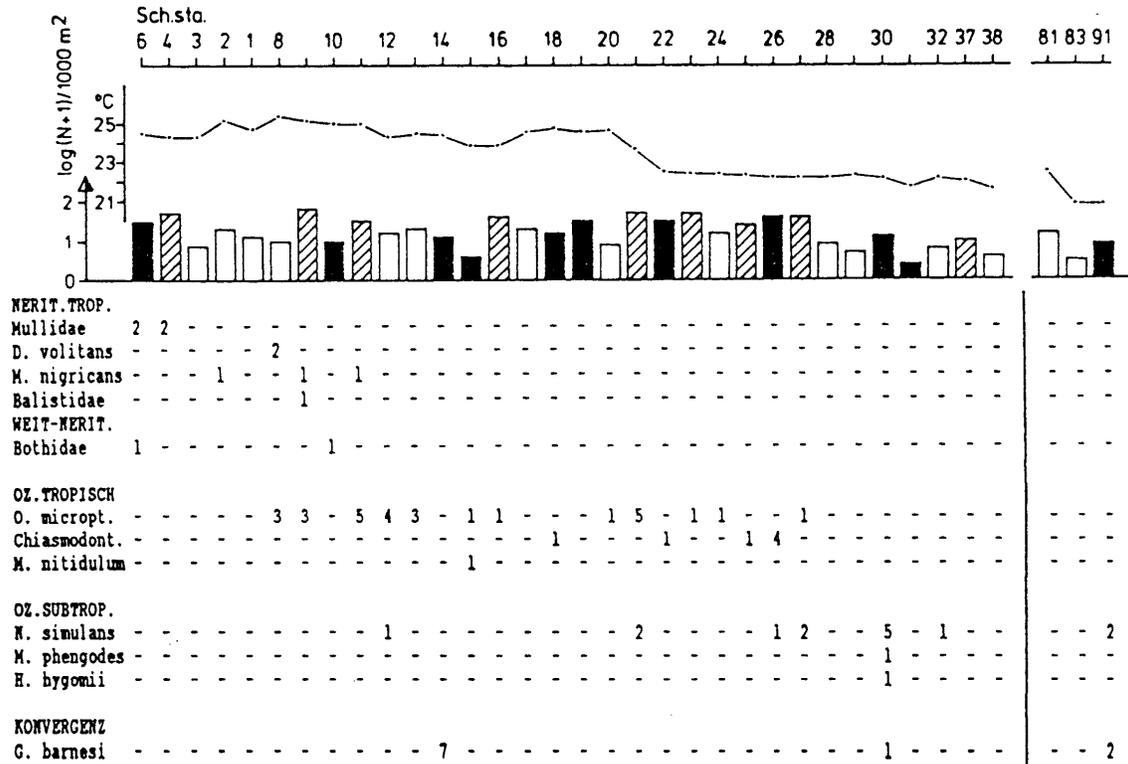


Fig. 40: The surface temperature and the distributions of the Ichthyoplanktons of the Neuston tows along the section. The key is as in figure 37. Beneath this figure the distribution of chosen indicators are tabulated (total per station, uncorrected). Nerit. = neritical, trop. = tropical, oz. = oceanical

Schiff-Sta. 6 - 3 - 1 - - 10 - - - 14 - - - 18 - - - 22 - - - 25 - 27 - 29 - - 32 - 38 | 81 83 91

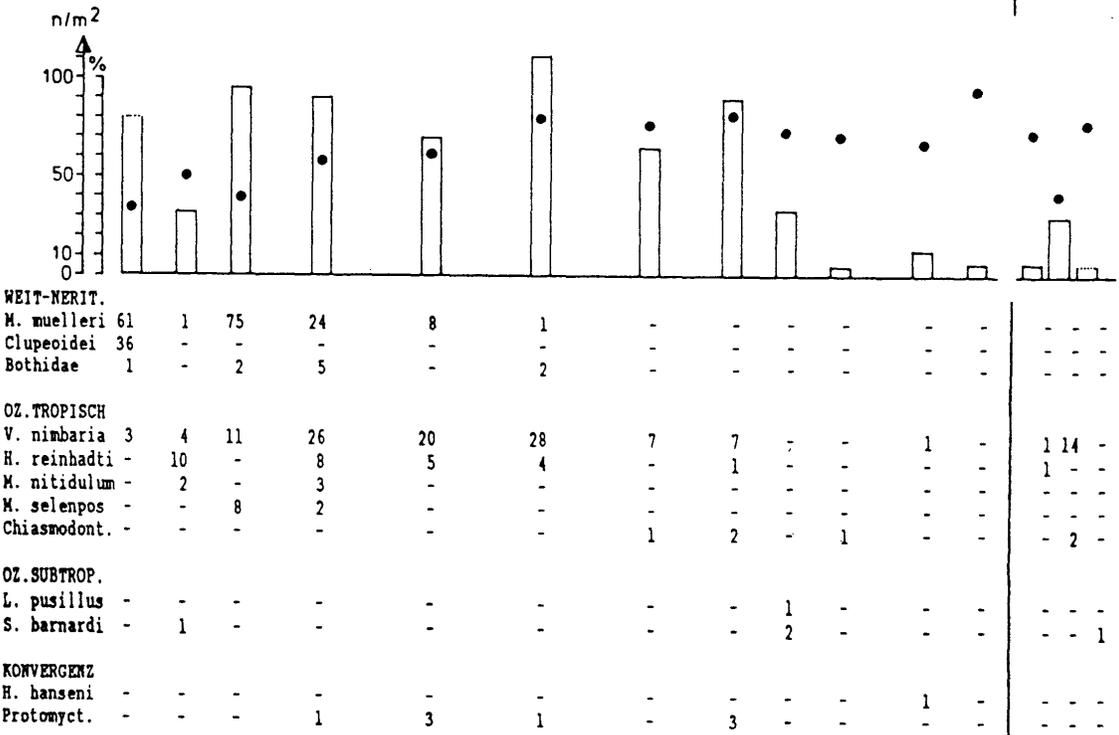


Fig. 41: The abundance of the Ichthyoplankton 0-200m (columns) and the percentage of the total catch (%) of the family Myctophidae (dots). The horizontal scale of the figure does not represent the actual distances between the stations. Beneath this figure the distribution of chosen indicators are tabulated (total per station, uncorrected).

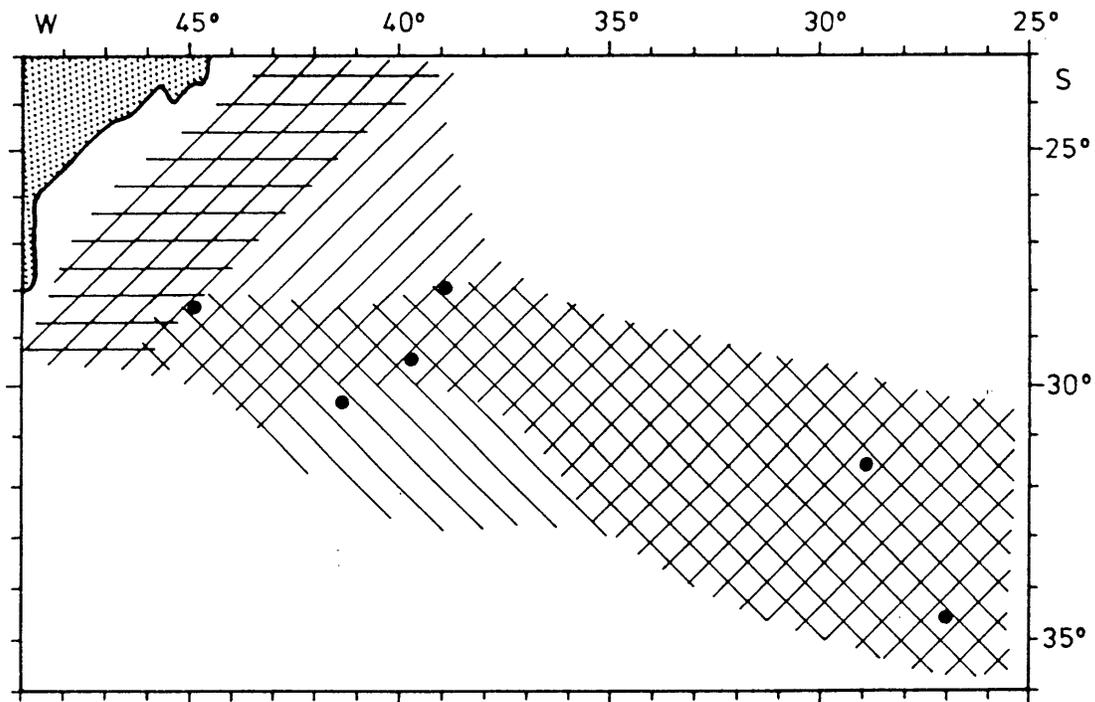


Fig. 42: A representation of the horizontal distribution of the fauna complexes in the Neuston tows.

Horizontal hatching: Both neritic complexes
 From SW to NE: Tropical oceanic complex
 From NW to SE: Subtropical oceanic complex
 Dots: Location sites of Endemisms of the Subtropical Convergence

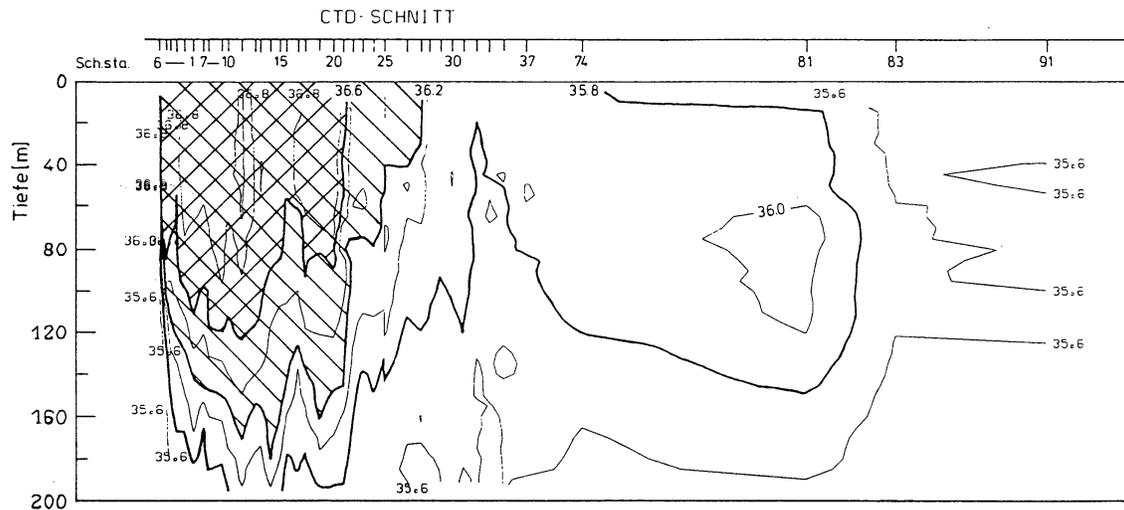
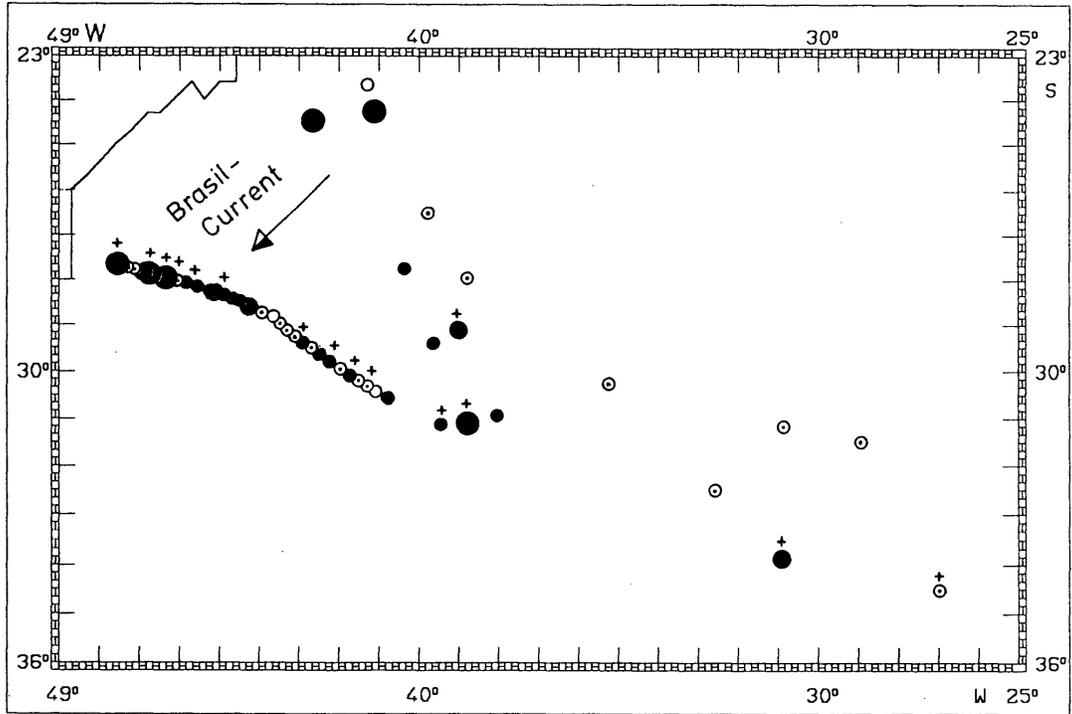


Fig. 43: The salinity distribution from 0-200m along the plancton section.

Hatching from NW to SE: > 36.2 salinity;
 from SW to NE: > 36.6 salinity
 Data IfM Kiel from B.Brügge. Only the stations discussed in the text are marked.



Tarball-classification and percentage of sample (n = 49): ○ none (8.2 %), ⊙ little (38.8 %), ● several (30.6 %), ● many (10.2 %), ● a lot (12.2 %), + organism on tarball

Fig. 44: Distribution and the relative amount of tarball in the biological surface water sample (Neuston sampler upper layer).

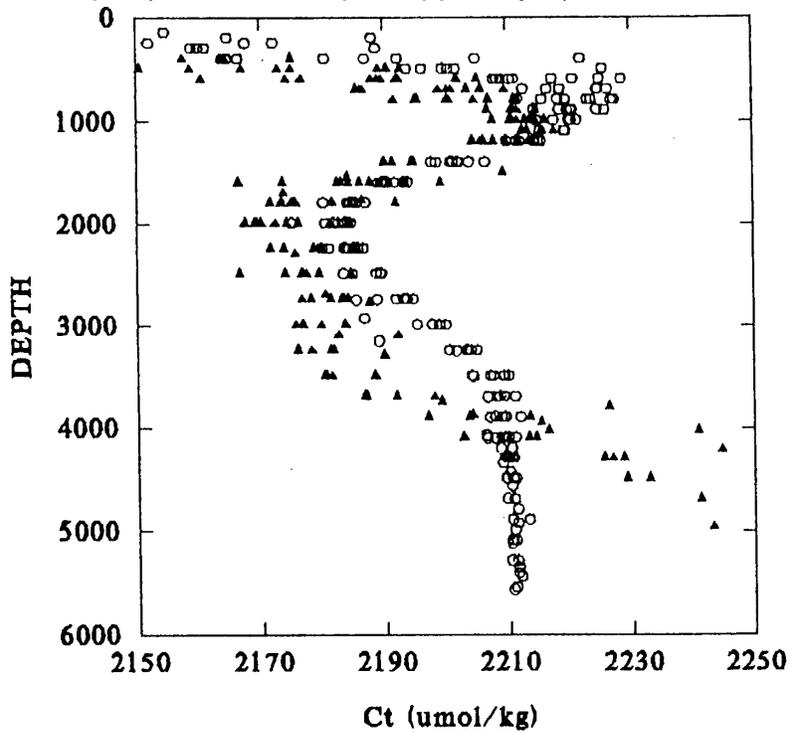


Fig. 45: CO₂ observations in the Brazil Basin (triangles) and the Angola Basin (circles)

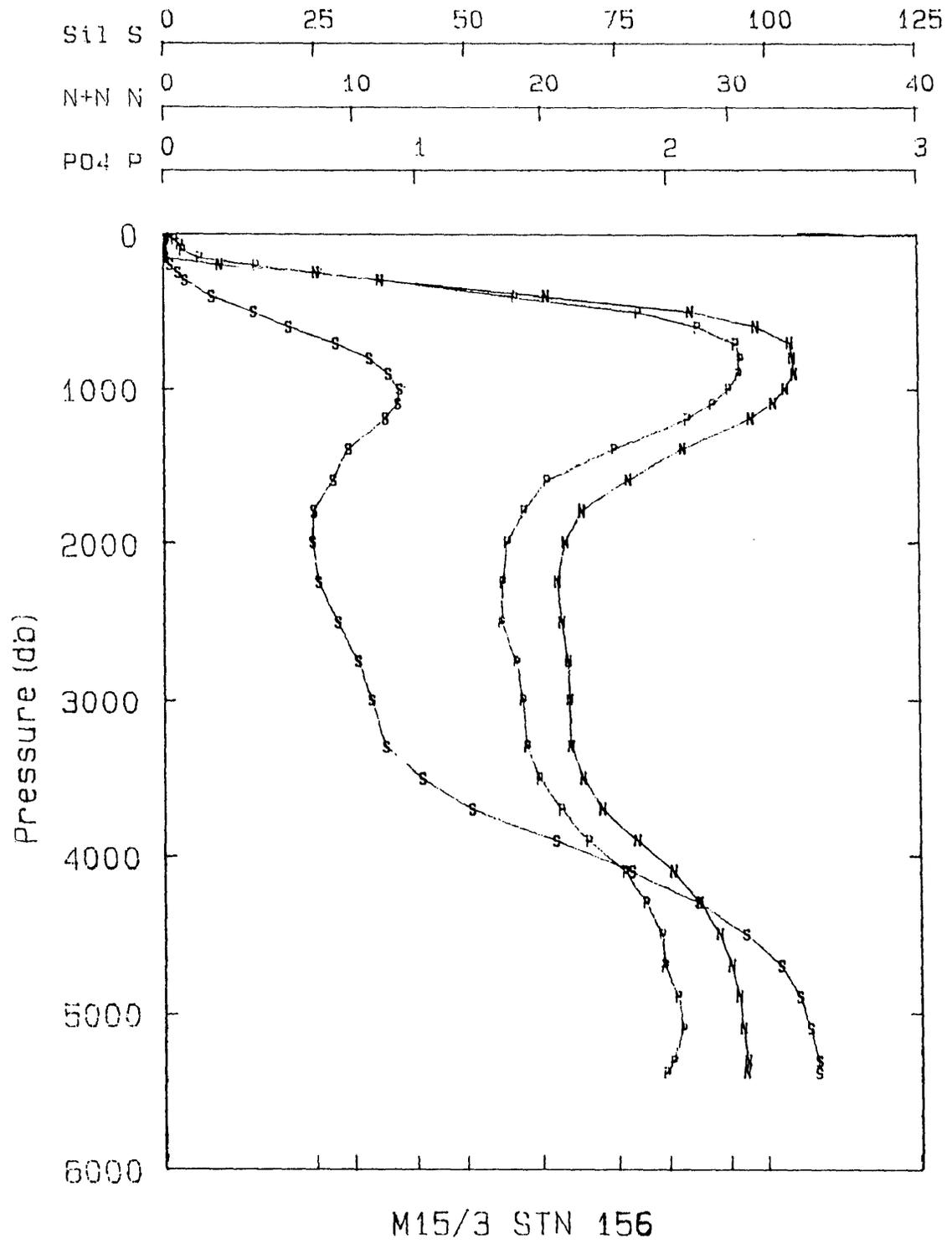


Fig. 46: Nutrients in the Brazil Basin

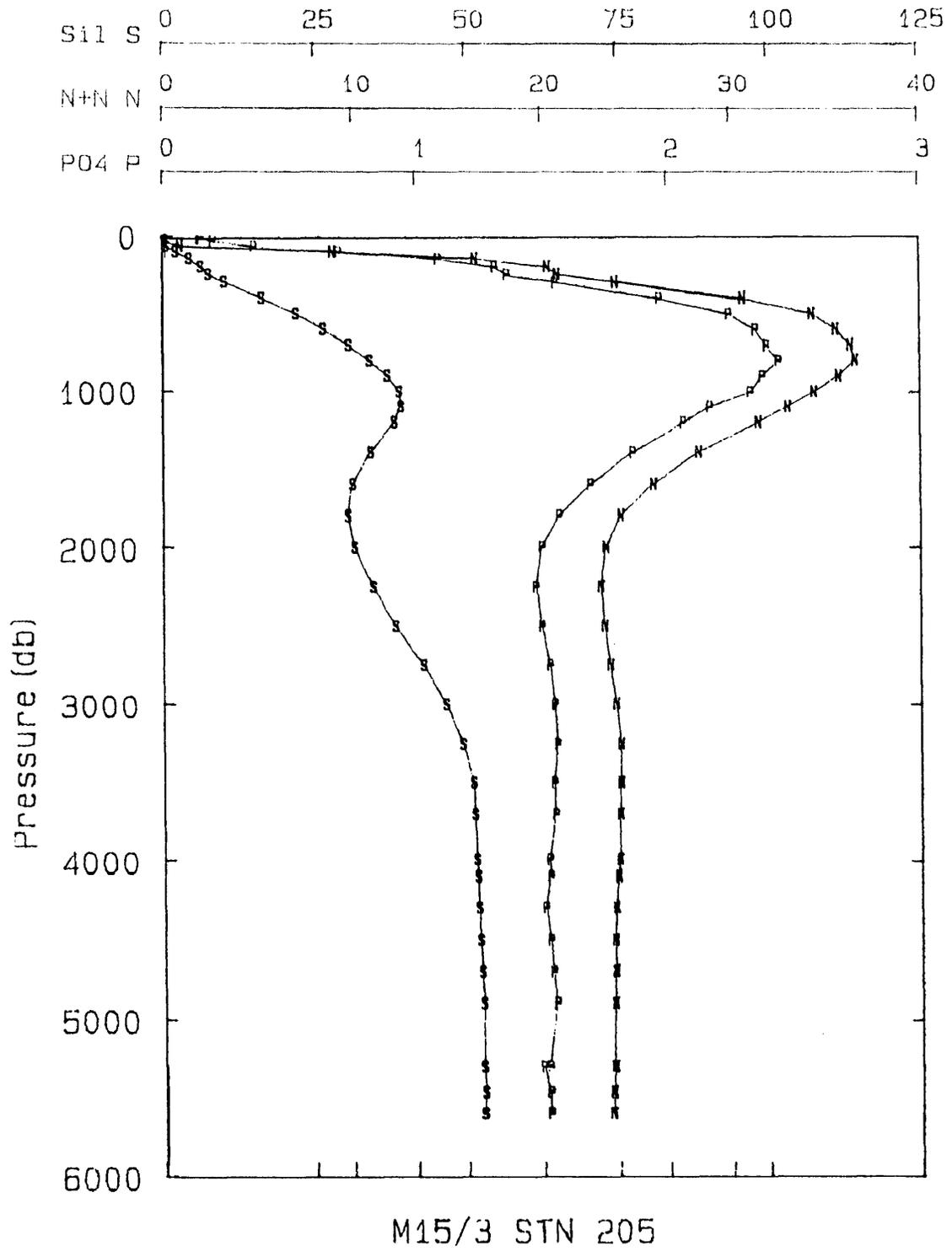


Fig. 47: Nutrients in the Angola Basin

DQE Report on CTD Data for R/V METEOR Cruise 15 (WHP A9)

Michel Arhan, IFREMER
December 10, 1992

For this expertise work we had at our disposal the WHP data files (*.WCT, *.HY2, *.SUM) and a brief internal report from IFM Kiel on the CTD processing (by J. Holfort, IFM ; March 1992). Although the cruise data report was received afterwards, this document provides but a few additional information on the calibration of the CTD data of leg 3 of the cruise (Meteor 15). A more complete document with the basic calibration plots would have been of great help. Some of these plots were produced for the purpose of the examination, and provide the basis for the following discussion. [Figure 1](#) shows the geographic distribution of the stations.

1 The water sample data

We only considered the salinity and dissolved oxygen data which were used to calibrate the CTD sensors (NB3 probe), normally taken at 24 levels per cast. The total number of 2000 samples for salinity calibration is quoted in the data report, but because of salinometer problems, the number of "rosette" salinity values in the WHP files does not exceed 941, out of which 432 are from pressures lower than 2000 db, and 509 from greater pressures. The number of Winkler oxygen values is 2476 (1192 at $p < 2000$ db and 1284 at $p > 2000$ db).

a) Salinities

The Guildline salinity values at a few selected deep levels were plotted as a function of the station number on [figure 2a](#) for the whole transect and on [figure 2b](#) for the eastern basin stations, with the hope of estimating the station to station noise superposed to the large scale trend. This proved difficult for the salinity due to the sparseness of the data - however the eastern basin points suggest a noise of about 0.003 (see the 4100 db level), a relatively good figure which should be considered as a relative (not absolute) uncertainty.

b) Oxygens

Similar plots are shown for the Winkler data ([Figures 3a,b](#)) which reveal an O (1μ mol/kg) noise, a good figure which again should be regarded as a relative noise. A few erratic values stand out on the curve which must have been eliminated in the calibration procedure.

c) Comparison with other cruises

A few stations from the intersecting transects A16 along 25°W and Ajax along 1°W were chosen for comparison. [Figures 4a, b](#) show the two stations groups used for the comparison.

[Figures 5a,b](#) show the deep ($\theta < 2.5$) θ - S plots of each station group. Data from the A9 and A16 cruises compare excellently in a region of well-defined deep θ - S relationship. The scattering of points is greater, and the comparison more difficult in the eastern basin ([fig. 5b](#)). The A9 values are on the average less saline than the Ajax ones (by about 0.003) but that could be due to the ambient variability, and there is of course no indication as to which cruise is closer to reality.

The oxygen comparison is not so good (figs. 6a,b). The deep A9 values are higher than the A16 and Ajax ones by $\simeq 6 \mu \text{ mol kg}^{-1}$ (or $\simeq 0.15 \text{ ml/l}^{-1}$), a rather large difference. This difference seems to result from the factor used to convert ml/l into $\mu \text{ mol kg}^{-1}$. This factor is abnormally high (44.616) and would rather apply to the conversion from ml l^{-1} into $\mu \text{ mol l}^{-1}$ (not $\mu \text{ mol kg}^{-1}$). Assuming a density of the deep water samples between 27 and 27.5 at the time of the oxygen fixation, this factor would be between 43.442 and 43.421. Using the former value would lower the A9 oxygen concentrations on figure 6 by $6.4 \mu \text{ mol kg}^{-1}$, the observed difference. If the "on-board" temperatures of the water samples are not available, it should perhaps be recommended to use a "typical" density of 27.5 to estimate the correct conversion factor.

2 CTD calibration

a) Temperature and Pressure

The pre- and post-cruise laboratory calibration curves for these parameters would have been useful.

b) Salinity

The differences between the water sample and CTD salinities ($S_{ws} - S_{CTD}$) are reported on figure 7 as a function of pressure. A few erratic water sample values still exist in the files at the upper levels, which cause a rather high rms difference of 0.016 : this figure is clearly not representative. The overall average of ΔS is 0.0017, may be also due to those erratic values. Only considering the differences from pressures greater than 2000 db, the bias is 0.0012 and the rms difference 0.0024. The latter figure fulfills the WOCE requirements. The procedure followed to eliminate the wrong measurements is not clearly described. The persistence of a few of them associated with positive ΔS may be the cause of the observed bias of 0.001 to 0.002.

There are indications in the brief report received with the data of a change in the salinity calibration at stations 184-185. It would be useful to plot ΔS as a function of the station number to get confirmation of the continuity of the calibration at that period.

The deep $\theta - S$ diagrams in the western and eastern basin are reported on figures 8a, b (notice the different scales). The relationship is very tight in the western basin and more scattered in the eastern one more subject to lateral water mass mixing.

c) Oxygen

The oxygen values from the CTD sensor must of course be also corrected for the wrong conversion factor discussed above. This will not modify the differences $\Delta O_2 = O_{2ws} - O_{2BTS}$ which may be discussed on the basis of the present values (fig. 9). The overall bias of the CTD oxygen values is within the measurement uncertainty ($-0.52 \mu \text{ mol kg}^{-1}$) but inspection of figure 9 reveals that it is locally more important in the vertical : it is negative ($\simeq -2 \mu \text{ mol kg}^{-1}$) around 1000 db, positive from $\simeq 1500$ db to 3500 db ($\simeq 2 \mu \text{ mol kg}^{-1}$) and negative again at 5500 db ($\simeq -4 \mu \text{ mol kg}^{-1}$ or $\simeq 0.1 \text{ ml l}^{-1}$). It would perhaps be worth trying to reduce this distortion by fitting a fifth order polynomial (in p) to the residuals.

The overall rms difference is $3.2 \mu \text{ mol kg}^{-1}$. That for $p < 2000 \text{ db}$ is $3.9 \mu \text{ mol kg}^{-1}$ and that for $p > 2000 \text{ db}$ is $.2.1 \mu \text{ mol kg}^{-1}$ ($\simeq 0.05 \text{ ml l}^{-1}$). The latter figure is a relatively good one which would probably be improved after the bias elimination.

The ship roll effect has not been eliminated and is apparent at the upper levels (cf. the example of figure 10a). This effect should perhaps be eliminated before storage in the data centers (?). As an example fig. 10b shows the profile of figure 9a after smoothing by a 11 db width running mean.

The bottom approach is always a problem for these oxygen sensors as the probe is slowed down and eventually stopped, and the sensor response is dependant on the velocity. The deep $\theta - \text{O}_2$ Plots (fig. 11) illustrate the effect visible as a systematic decrease of the oxygen concentration by 6 to $8 \mu \text{ mol kg}^{-1}$ in some cases and the end of each profile. It would perhaps be better to suppress the few last meters of each profiles (?).

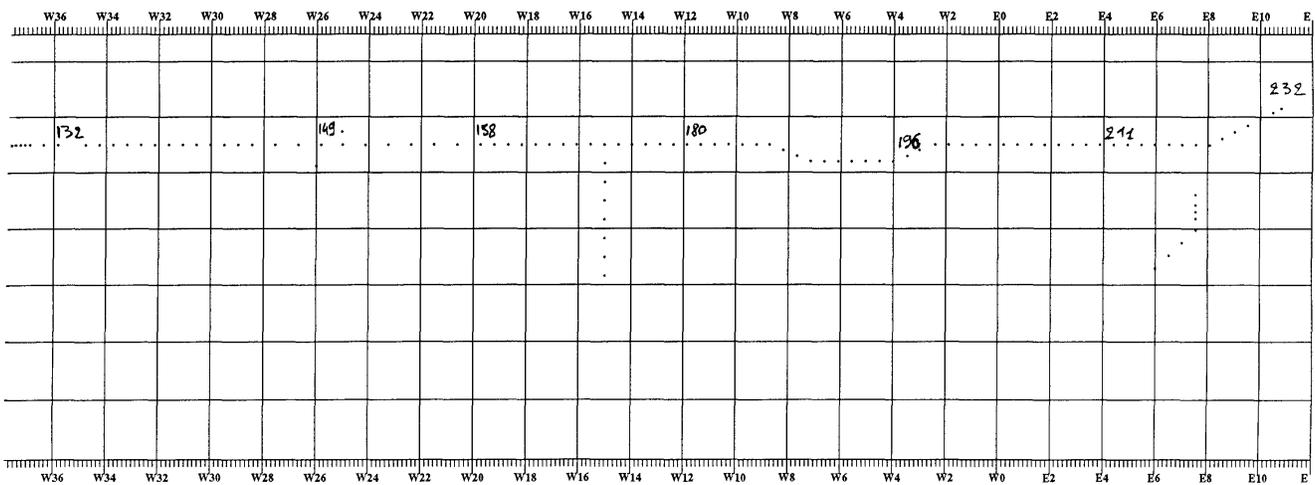


Fig. 1

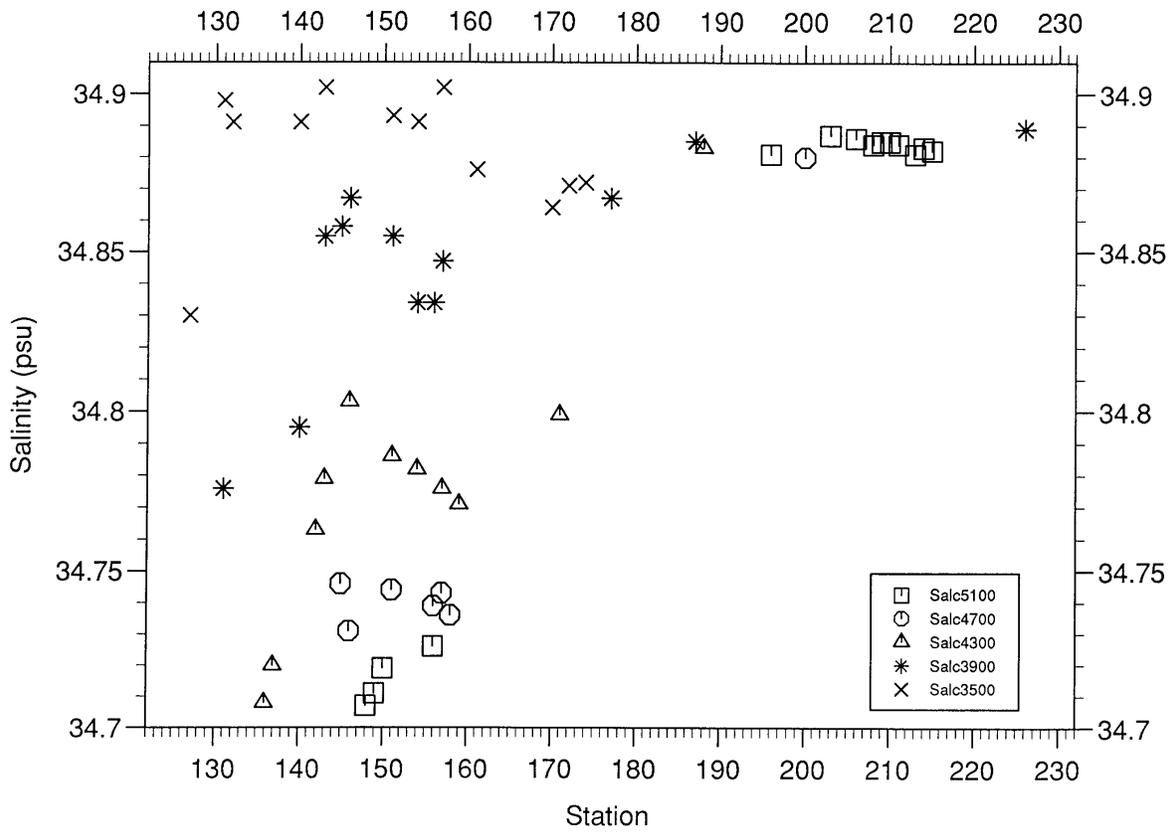


Fig. 2a

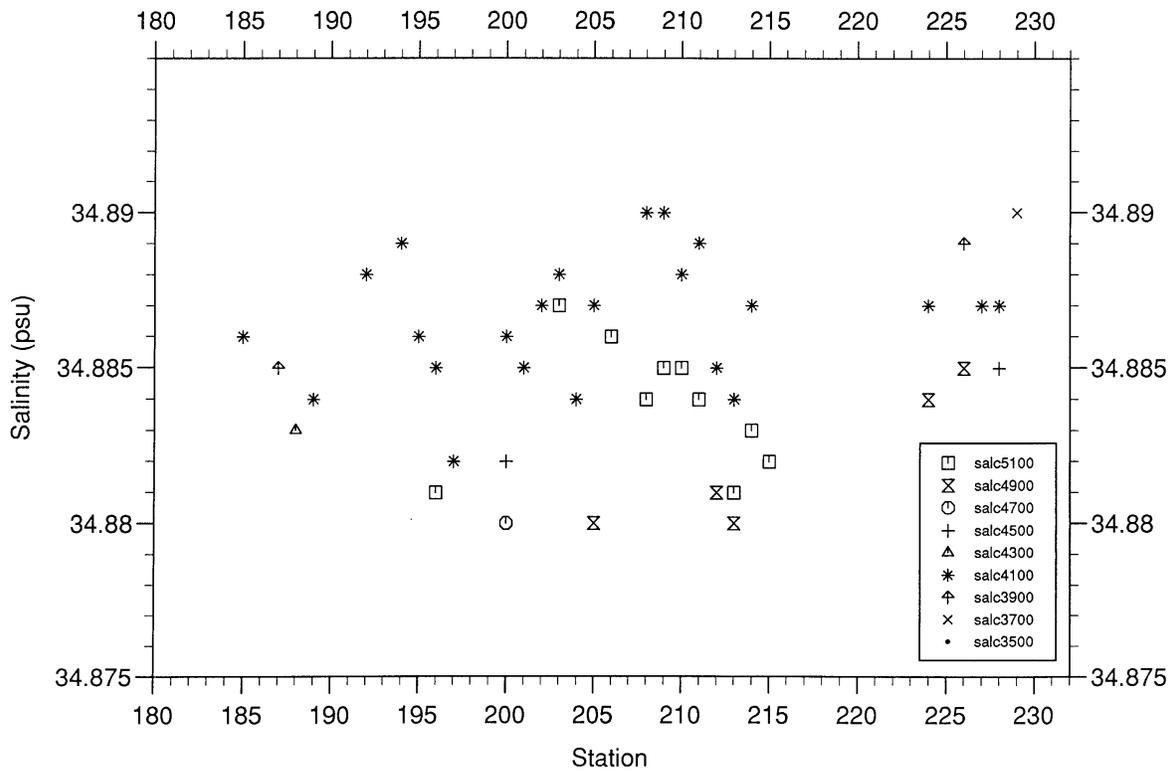


Fig. 2b

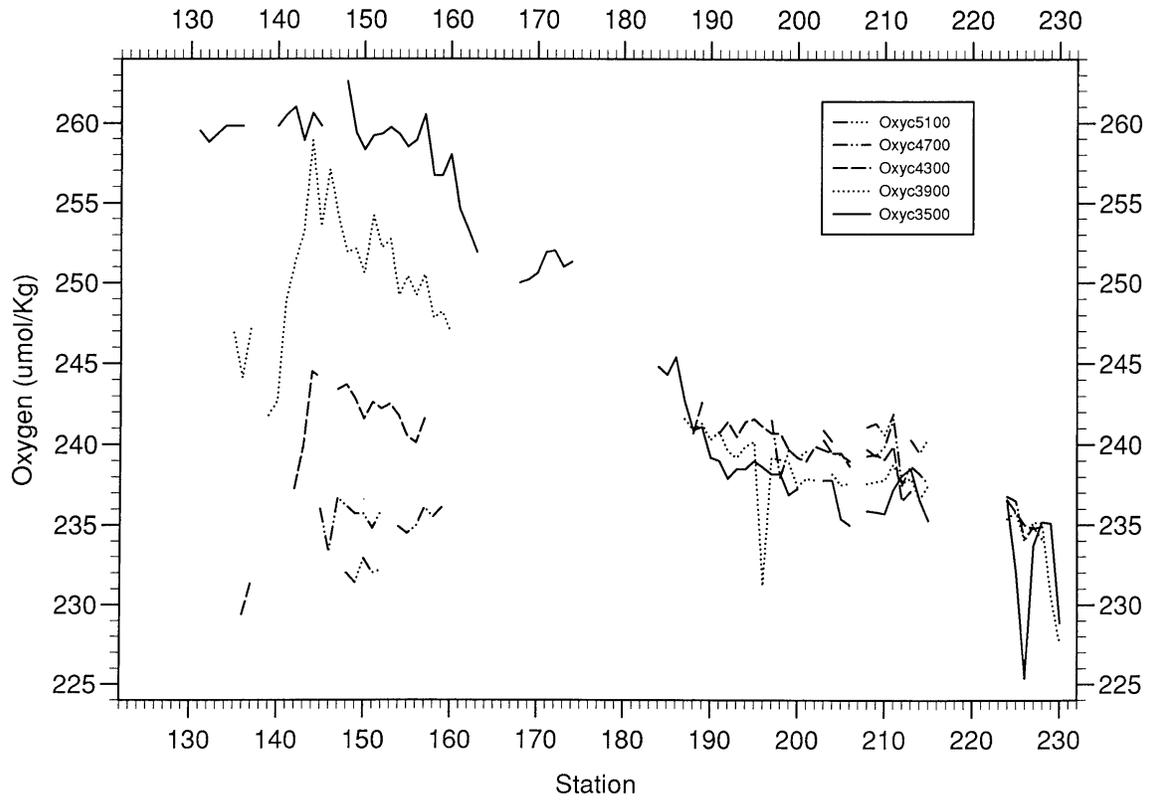


Fig. 3a

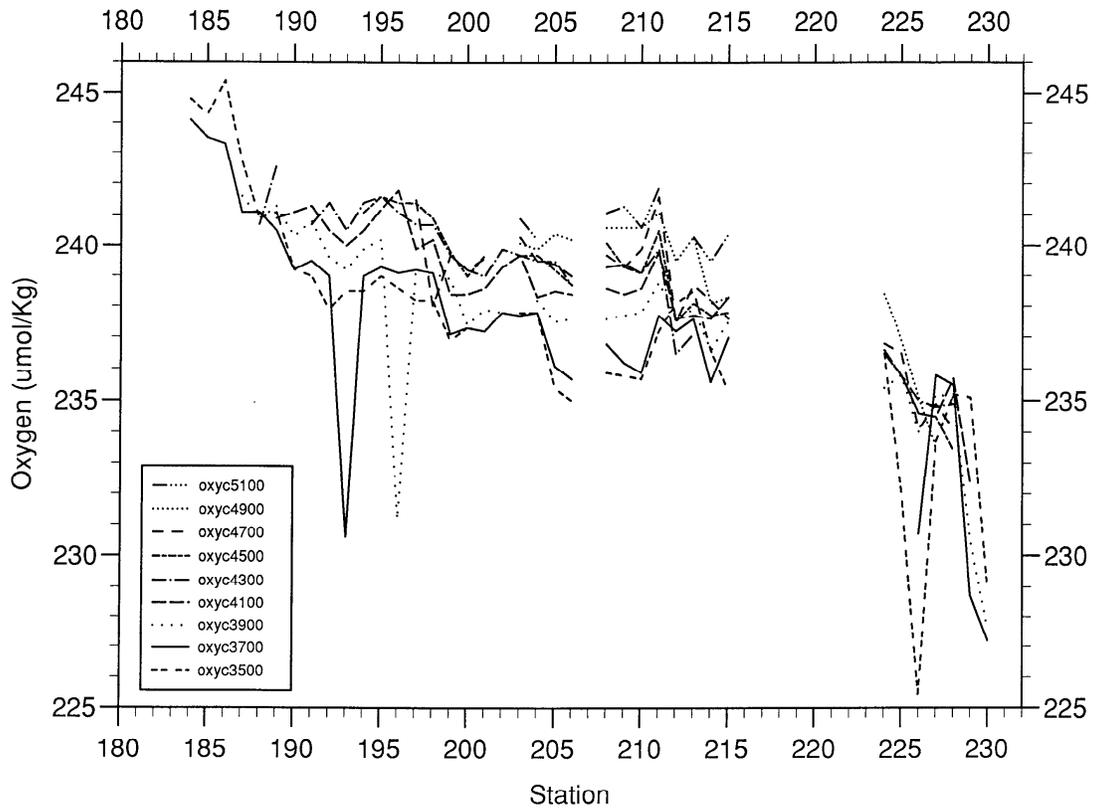


Fig. 3b

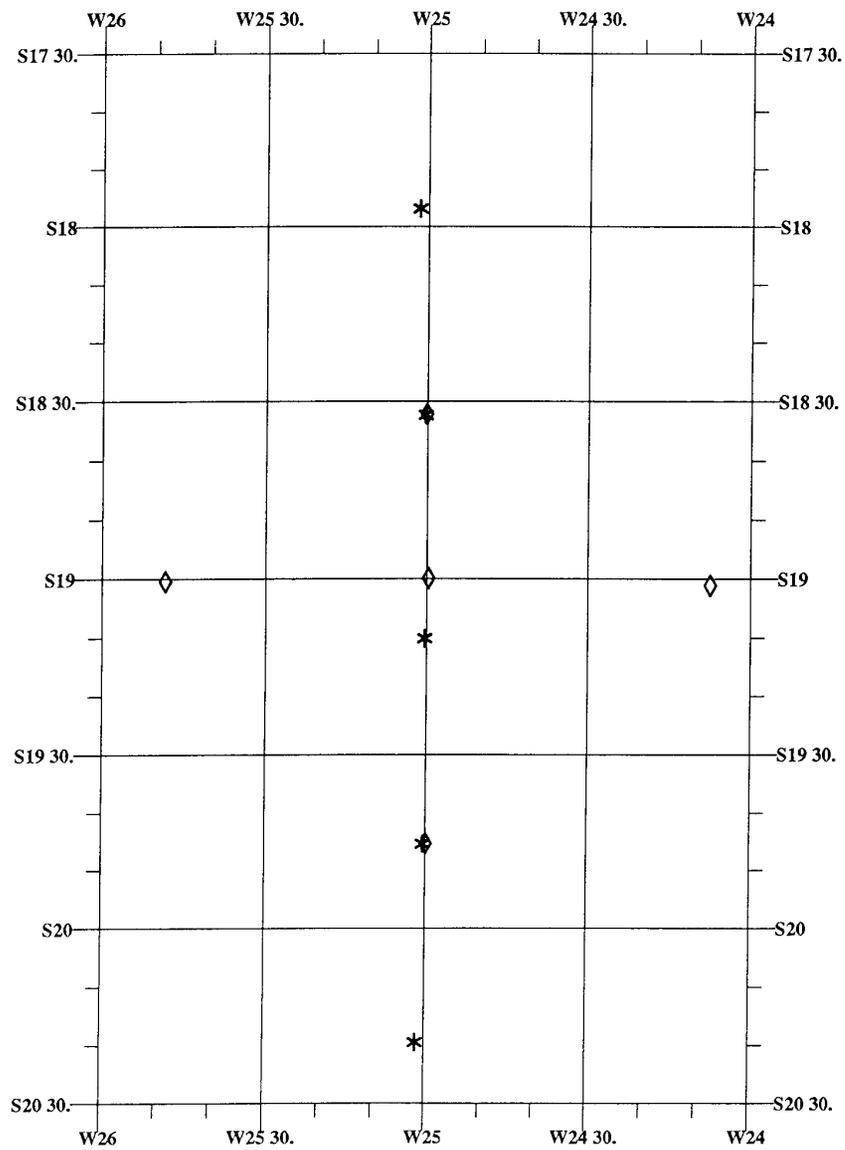


Fig. 4a

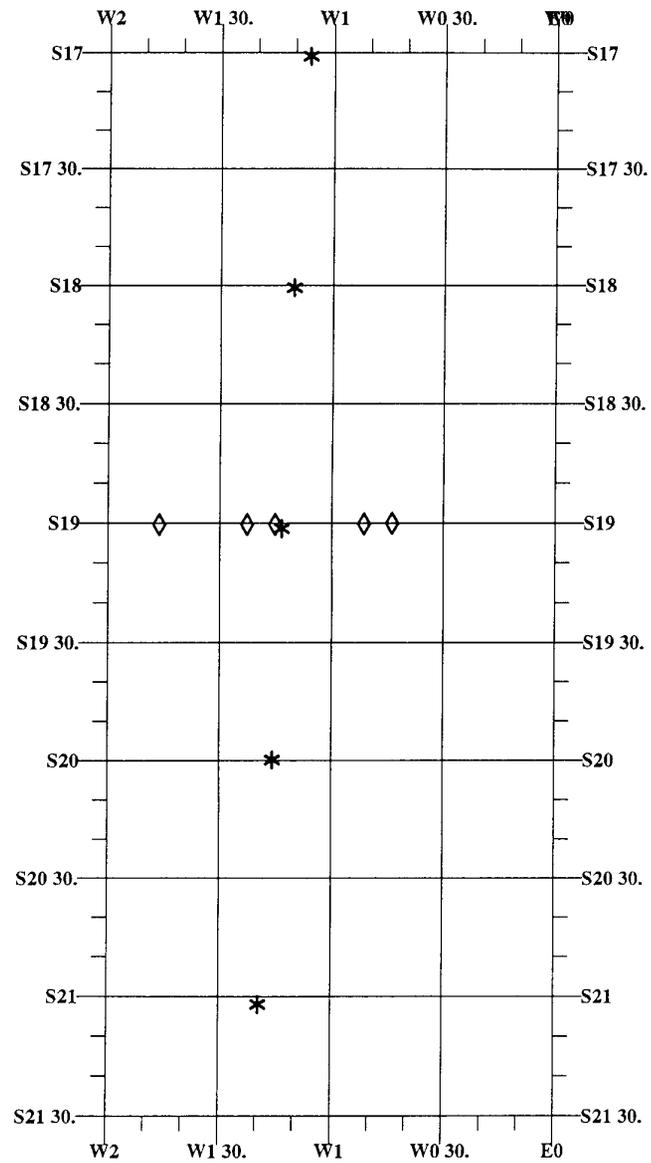


Fig. 4b

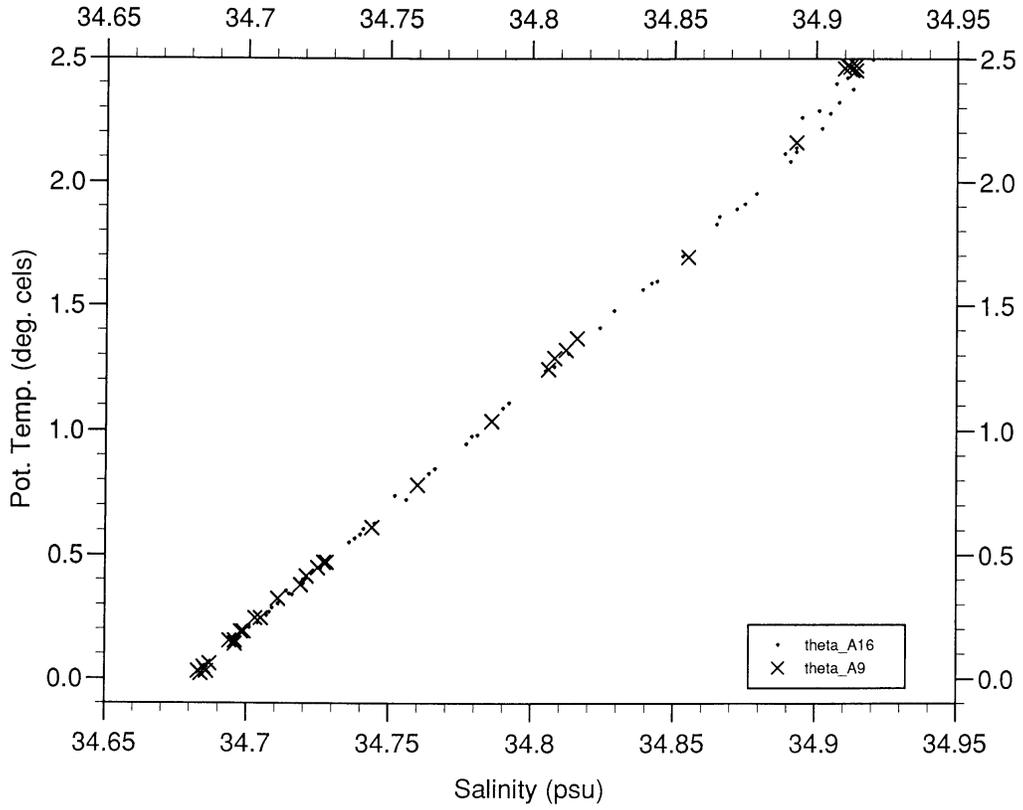


Fig. 5a

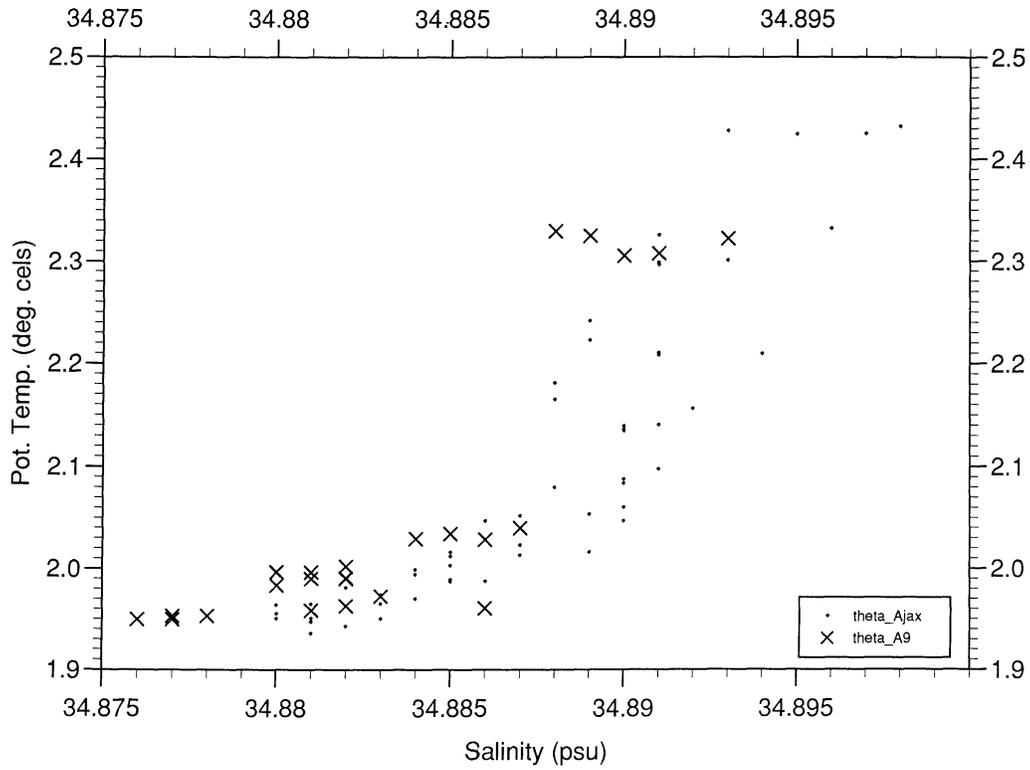


Fig. 5b

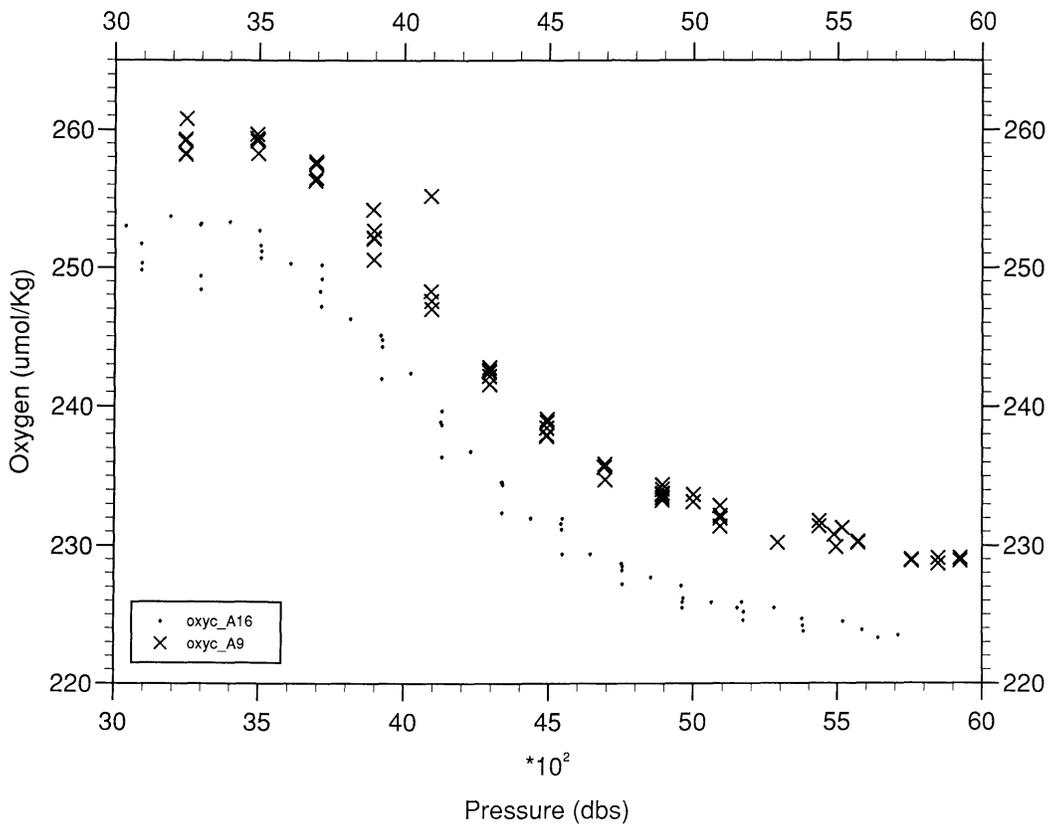


Fig. 6a

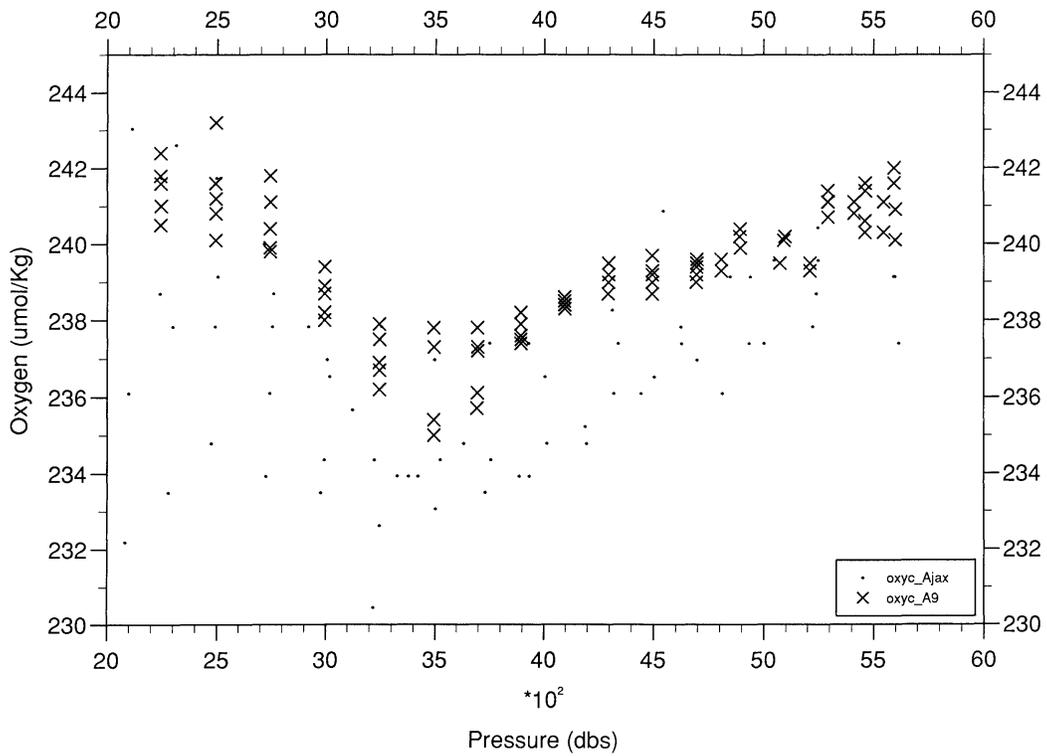


Fig. 6b

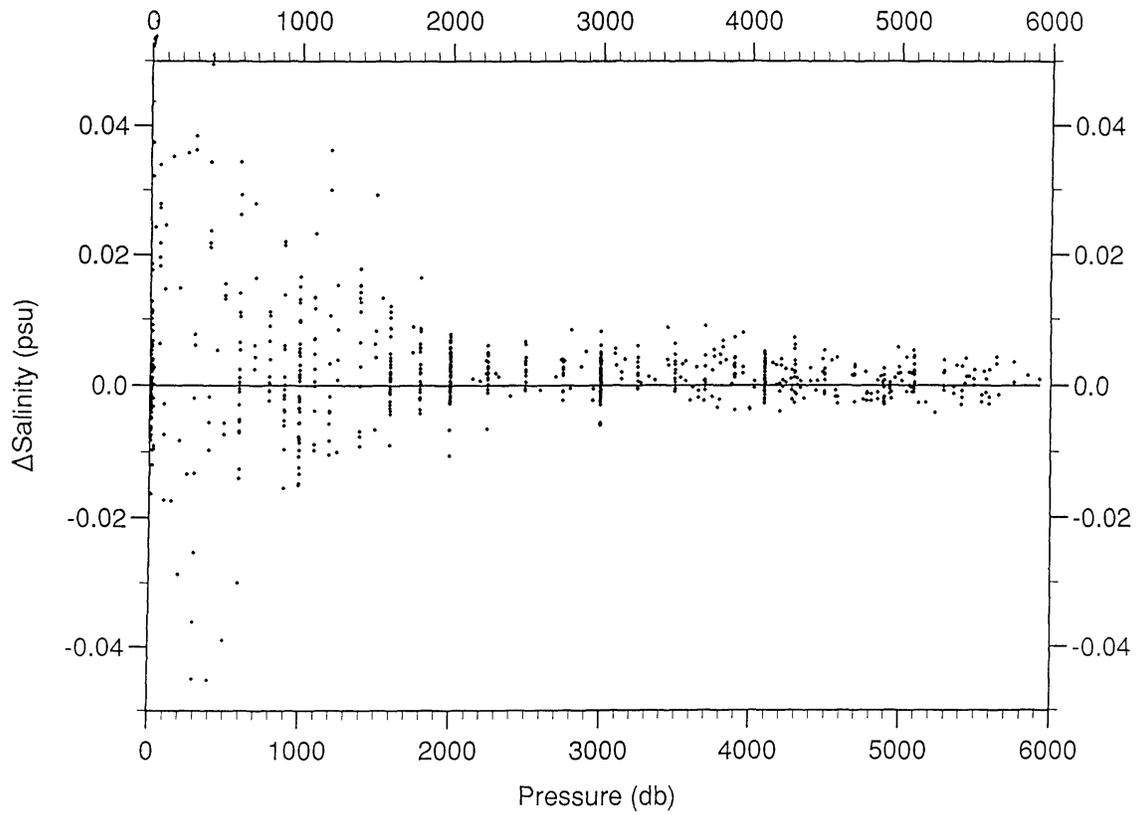


Fig. 7

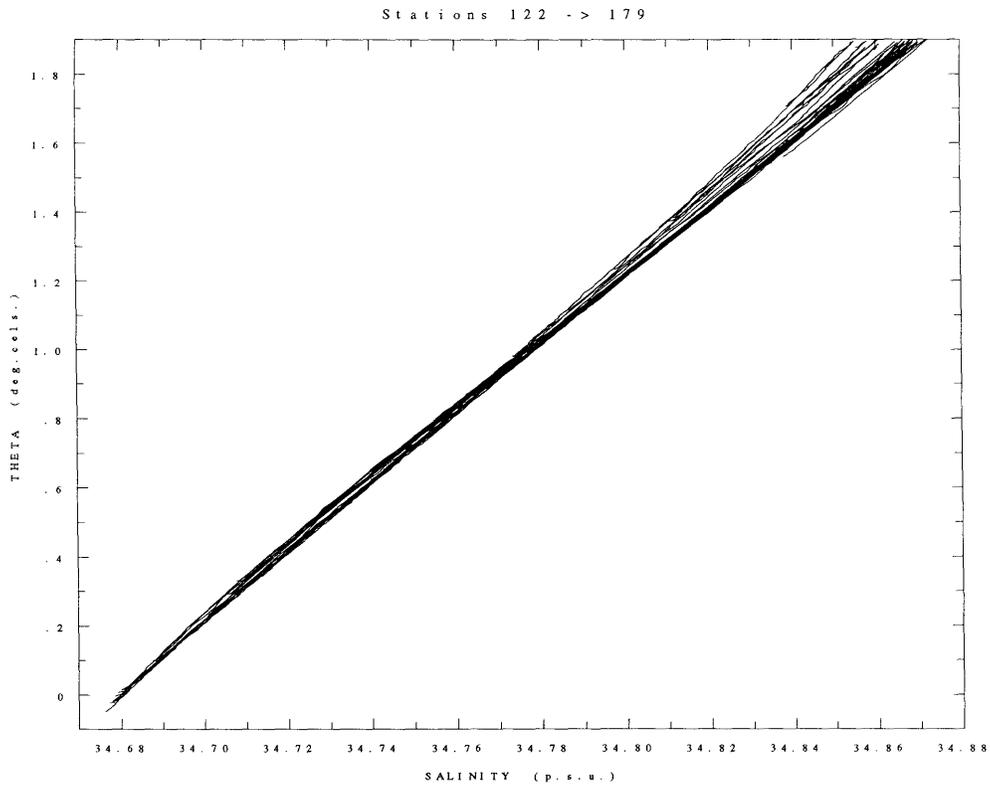


Fig. 8a

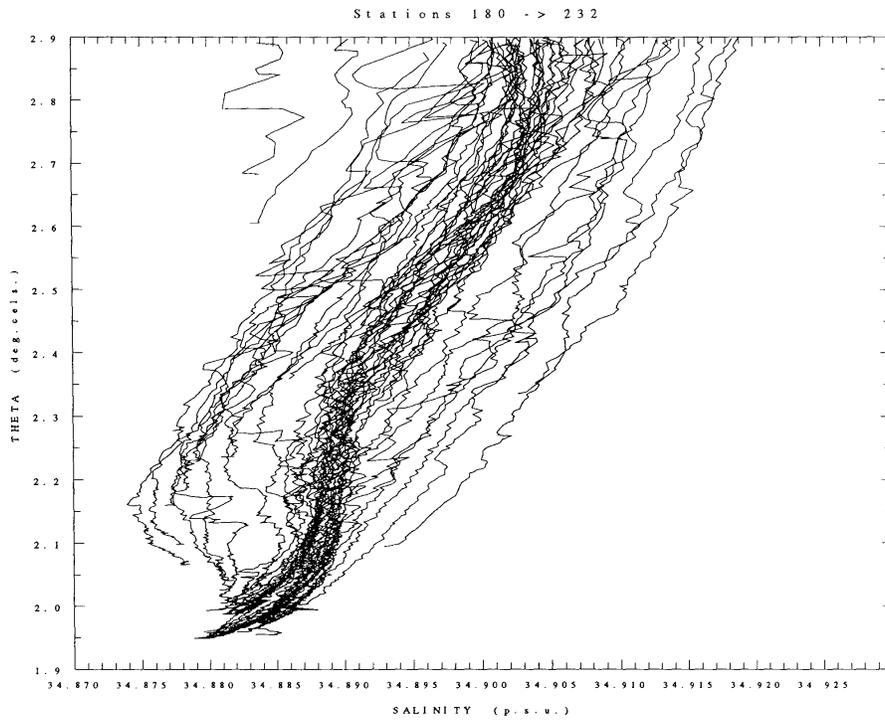


Fig. 8b

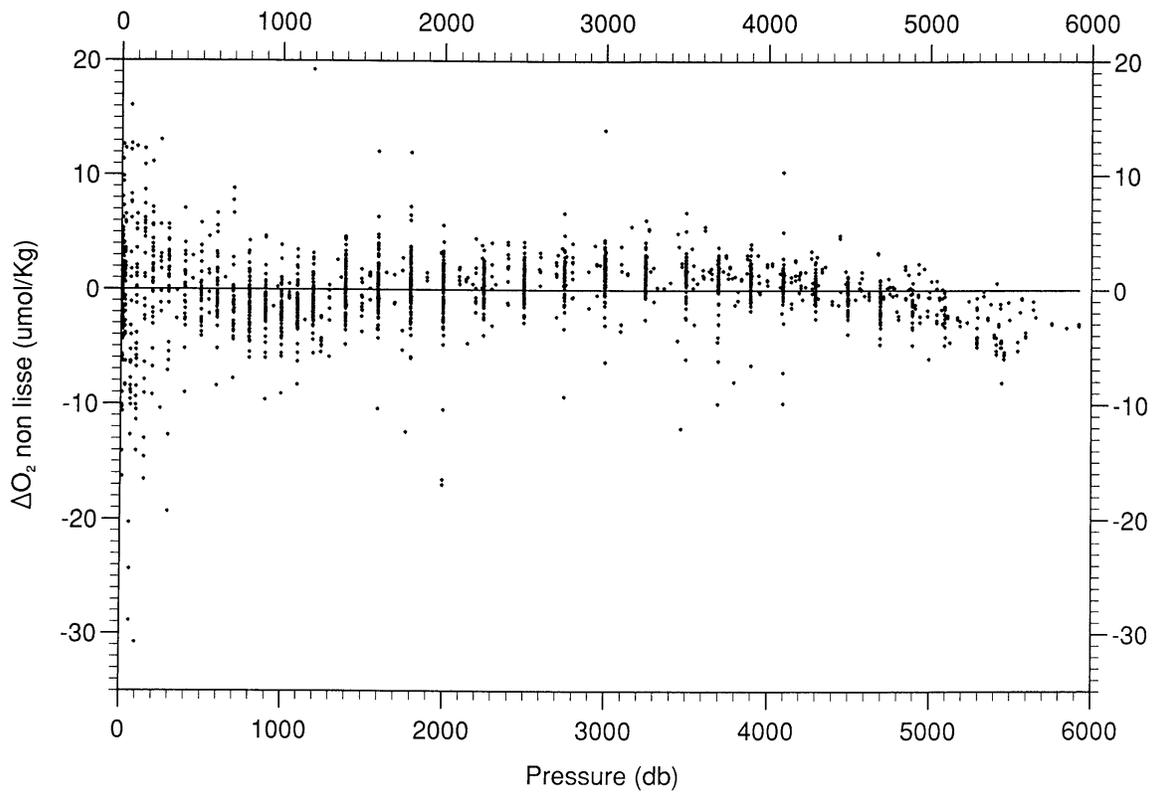


Fig. 9

whpA9-20s Lat:S 19 0.10
ST: 0154 Lon:W 023 14.90

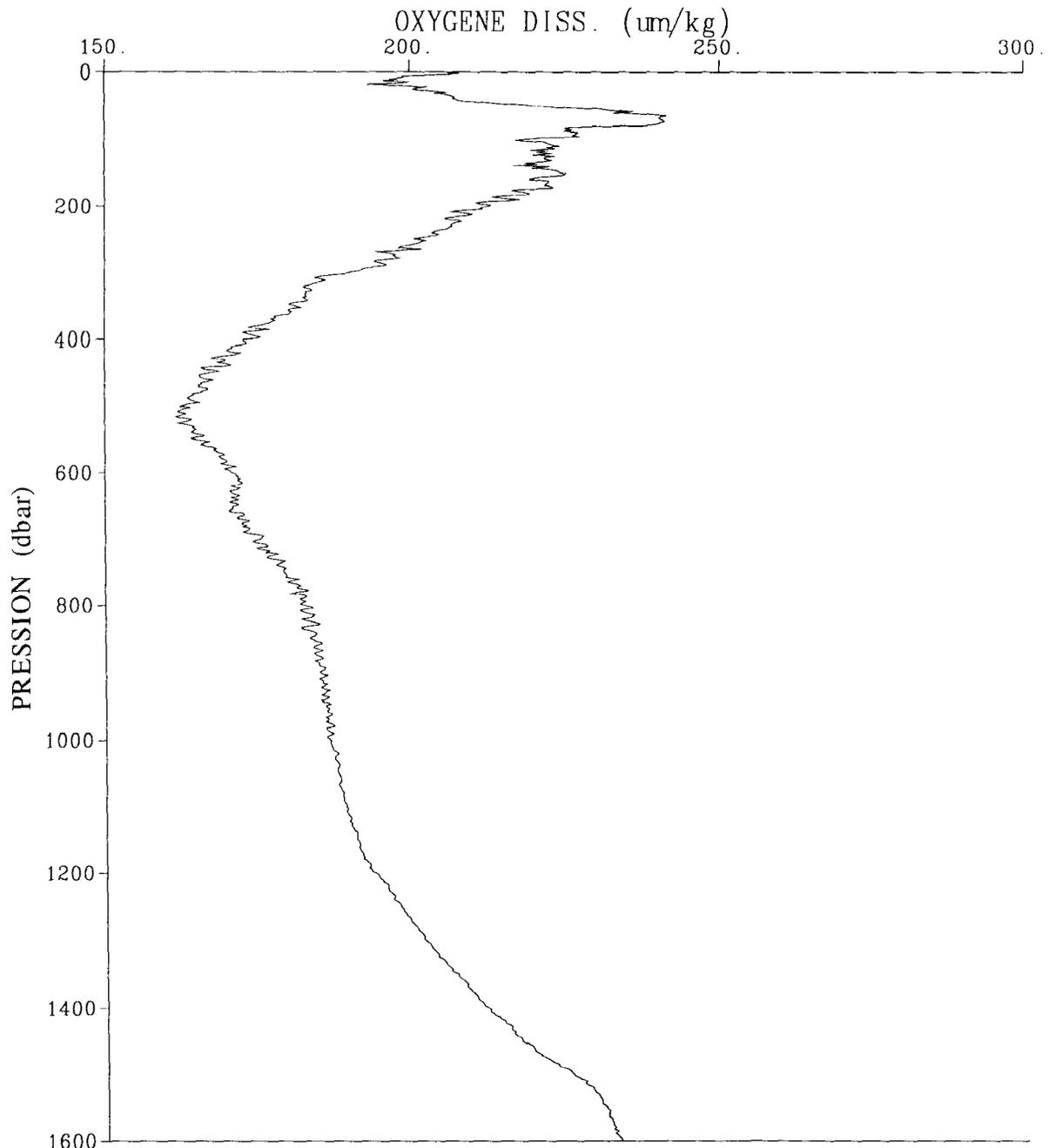


Fig. 10a

whpA9-20s Lat:S 19 0.10
ST: 0154 Lon:W 023 14.90

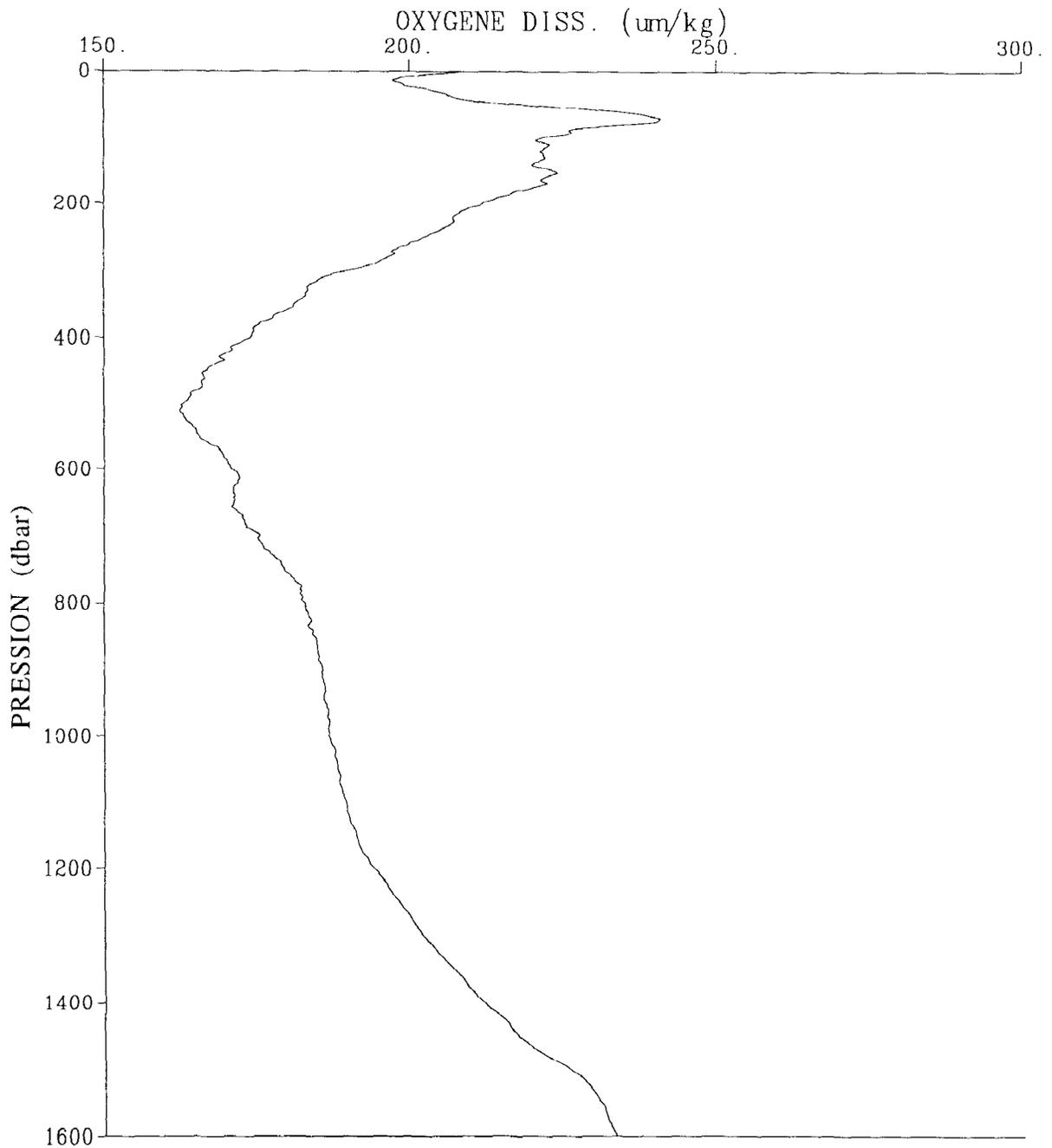


Fig. 10b

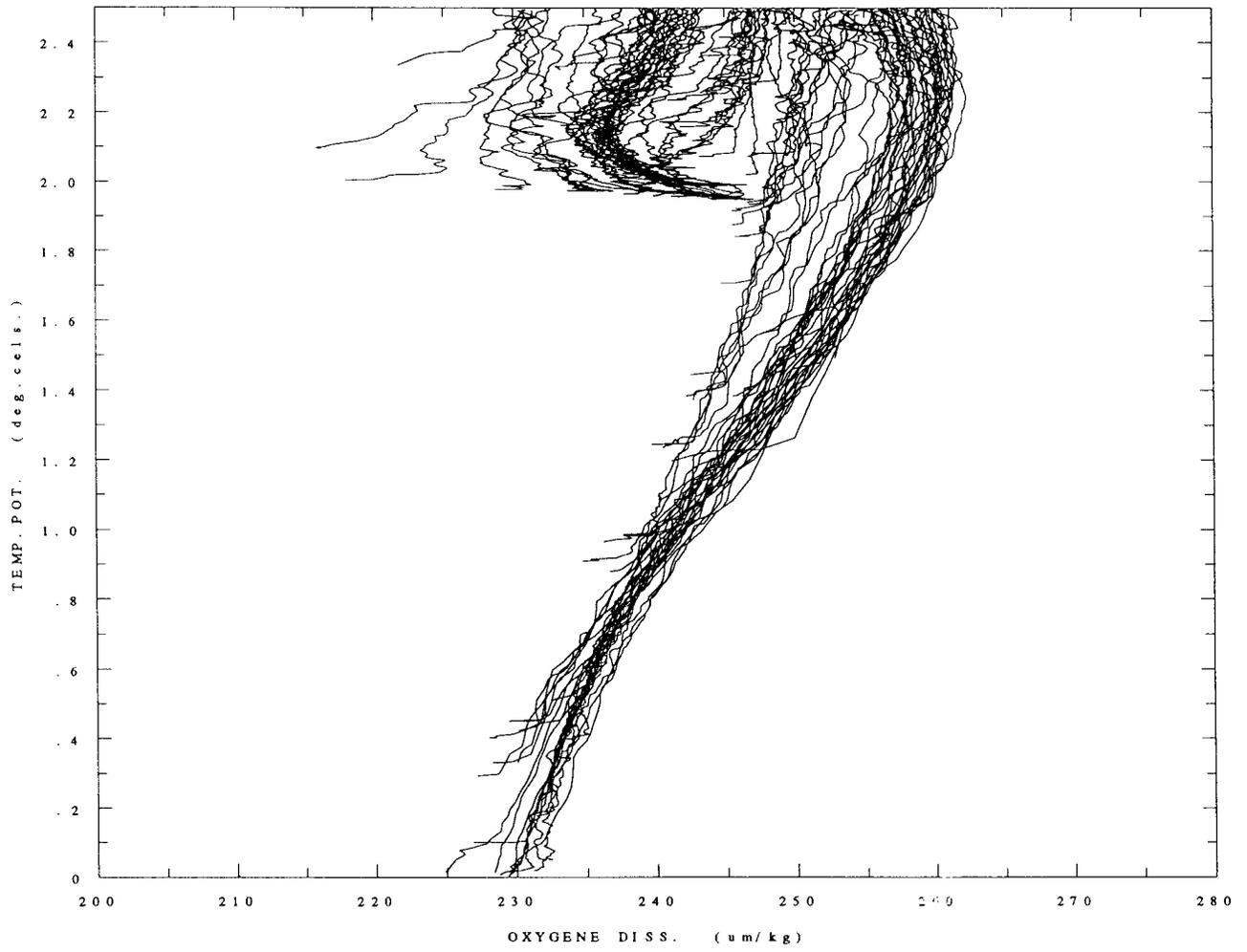


Fig. 11

Nutrient DQE comments on the WOCE A9 data set: 3/02/93.

J. C. Jennings, Jr.

Comments on the overall data set:

The nutrient analyses on this cruise were carried out by personnel from Scripps Institution's Oceanographic Data Facility and Oregon State University's College of Oceanography. Despite sincere attempts to blend the procedures normally used by these two different groups into a single consistent procedure for each analysis, there are shifts in nutrient concentration between and sometimes within stations which almost certainly result from the fact that the two analysts involved were used to different methods. The stations nearest the start of the cruise are the ones most affected by the in situ development of consistent procedures. For the most part, the silicate, nitrate, and nitrite data appear to be of good quality and precision. There are exceptions and these have been flagged as questionable. The phosphate data has much greater scatter than that for the other nutrients, with entire stations which are anomalous relative to adjacent stations.

Specific problems:

Between stations 160 and 161 there is a large shift in phosphate values, with stations 147 - 160 having phosphate concentrations consistently lower than stations from 161 on. According to lab notes made during the cruise, this may be due to a new determination of the "refraction correction" for phosphate which was made at this time. Comparison with the HYDROS data (see note below) and the higher phosphate values determined for the rest of the cruise make it seem likely that the values reported for stations 147 - 160 are too low. Station 149 was anomalous and had very high phosphate values. Log notes indicate that instrumental drift was a problem when samples from station 149 were run and most of these data were flagged.

There was apparently a file merging error in the data for station 225. Nutrient data for one of the three casts are listed twice, causing the appearance of severe scatter in what were to have been replicate samples. When the correct nutrient data for Cast 1 were entered into the file, the resulting plots looked reasonable.

Comparison with historical data:

AJAX stns 26-28 vs A9 stns 203-206. Location approx. 19°S 1°E.

The silicate/theta and silicate/pressure relationships show the AJAX stations as consistently higher in silicate throughout most of the intermediate and deep region of the water column. The best agreement between the two data sets is around the shallow silicate maximum at approximately 1000m and in the underlying silicate minimum. Below about 2500m the A9 silicates are from 1.0 - 1.5 μM less than the AJAX values.

The nitrate comparison shows that the A9 nitrate data is slightly lower than, but within about 2 % of the AJAX data throughout the water column. The nitrate data appear to agree to within 0.3-0.5 μM with average deep water values of about 24 μM .

Phosphate data from the A9 stations is lower than that of the AJAX stations by 0.1 μM on average. A number of phosphate values at A9 station 206 (one of the stations in proximity to the AJAX stations) were unusually high and were flagged as suspicious.

HYDROS 4 stns 335-338 vs A9 stns 146-153. Location approx. 19°S 25°W.

HYDROS silicate values are higher than those of the A9 cruise from about 3500 to 5000 meters, then lower in the bottom water layer. A9 stations 146-149 are closer to the HYDROS silicate values. The best agreement between the two data sets is in the depth range of 1000 to 3000 m. *n.b.* THIS IS TRUE OF THETA ALSO. THERE MAY BE A PROBLEM WITH THE A9 TEMPERATURE OR SALINITY DATA WHICH CAUSES THIS, OR THE WATER COLUMN MAY HAVE REALLY BEEN DIFFERENT WHEN THE A9 STATIONS WERE OCCUPIED. When A9 stations 146-149 were compared with HYDROS stations 335-338, the A9 theta values are somewhat higher in the deep water and definitely lower in the bottom water than are the HYDROS values.

The nitrate values agree better, with overlap of the data points of the two cruises at the nutrient maximum and minimum, and somewhat higher nitrate in the deep waters of the HYDROS stns.

Phosphate values on the A9 cruise have a wider range than those from the HYDROS stations closest to the A9 cruise track. The values for stations 149, 151-152 bracket the HYDROS P04/theta data. Station 150 had very high deep P04 data, which was flagged. These stations were occupied at the end of the first week of the cruise and there were many problems with the A9 phosphate analysis.

INPUT FILE: A9.JCJ
 THE DATE TODAY IS: 11-MAR-93

STNNBR CASTNO SAMPNO CTDPRS SILCAT NITRAT NITRIT PHSPHT QUALT1 QUALT2

STNNBR	CASTNO	SAMPNO	CTDPRS	SILCAT	NITRAT	NITRIT	PHSPHT	QUALT1	QUALT2
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122	1	12	2998.0				1.15	~~~2	~~~3
122	1	12	2998.0				1.13	~~~2	~~~3
122	1	12	2998.0				1.17	~~~2	~~~3
122	1	12	2998.0				1.16	~~~2	~~~3
122	1	12	2998.0				1.19	~~~2	~~~3
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125	1	12	6.0			0.65		~~2~	~~3~
125	1	12	25.0			0.53		~~2~	~~3~
125	1	12	60.0			0.62		~~2~	~~3~
125	1	12	96.0			0.62		~~2~	~~3~
125	1	12	196.0			0.77		~~2~	~~3~
125	1	12	246.0			0.69		~~2~	~~3~
125	1	12	293.0			0.69		~~2~	~~3~
125	1	12	345.0			0.62		~~2~	~~3~
125	1	12	397.0			0.54		~~2~	~~3~
125	1	12	494.0			0.49		~~2~	~~3~
125	1	12	593.0			0.56		~~2~	~~3~
125	1	12	794.0			0.31		~~2~	~~3~
125	1	12	894.0			0.39		~~2~	~~3~
125	1	12	994.0			0.35		~~2~	~~3~
125	1	12	1193.0			0.40		~~2~	~~3~
125	1	12	1392.0			0.27		~~2~	~~3~
125	1	12	1592.0			0.24		~~2~	~~3~
125	1	12	1793.0			0.21		~~2~	~~3~
125	1	12	1995.0			0.25		~~2~	~~3~
125	1	12	2194.0			0.18		~~2~	~~3~
125	1	12	2316.0			0.18		~~2~	~~3~
126	1	12	144.0				0.47	~~~2	~~~3
126	1	12	194.0				0.51	~~~2	~~~3
126	1	12	244.0				0.59	~~~2	~~~3
126	1	12	290.0				0.64	~~~2	~~~3
128	1	12	1995.0		21.89			~2~~	~3~~
132	1	13	9.1			0.63		~~2~	~~3~
132	1	13	9.1			0.40		~~2~	~~3~
132	1	13	9.1			0.32		~~2~	~~3~
132	1	13	9.1			0.75		~~2~	~~3~
132	1	13	9.1			0.99		~~2~	~~3~
132	1	13	9.1			0.78		~~2~	~~3~
132	1	13	9.0			0.66		~~2~	~~3~
132	1	13	9.0			0.44		~~2~	~~3~

STNNBR CASTNO SAMPNO CTDPRS SILCAT NITRAT NITRIT PHSPHT QUALT1 QUALT2

STNNBR	CASTNO	SAMPNO	CTDPRS	SILCAT	NITRAT	NITRIT	PHSPHT	QUALT1	QUALT2
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132	1	13	99.0			0.45		~2~	~3~
132	1	13	197.0			0.79		~2~	~3~
132	1	13	248.0			0.39		~2~	~3~
132	1	13	298.0			0.29		~2~	~3~
132	1	13	398.0			0.30		~2~	~3~
132	1	13	497.0			0.22		~2~	~3~
132	1	13	600.0			0.15		~2~	~3~
132	1	13	700.0			0.08		~2~	~3~
132	2	13	1695.0				1.33	~~2	~~3
132	2	13	1995.0				1.24	~~2	~~3
132	2	13	2144.0				1.24	~~2	~~3
132	2	13	2295.0				1.24	~~2	~~3
132	2	13	2495.0				1.27	~~2	~~3
132	2	13	2695.0				1.30	~~2	~~3
132	2	13	2896.0				1.32	~~2	~~3
132	2	13	3095.0				1.31	~~2	~~3
132	2	13	3296.0				1.31	~~2	~~3
132	2	13	3492.0		19.20		1.41	~2~2	~3~3
133	1	13	9.0			0.41		~2~	~3~
133	1	13	28.0			0.30		~2~	~3~
133	1	13	64.0			0.24		~2~	~3~
133	1	13	148.0			0.90		~2~	~3~
133	1	13	198.0			0.25		~2~	~3~
133	1	13	248.0			0.27		~2~	~3~
133	1	13	298.0			0.18		~2~	~3~
133	1	13	397.0			0.09		~2~	~3~
133	1	13	498.0		27.14	0.12		~22~	~33~
133	2	13	594.0		31.97			~2~	~3~
133	2	13	694.0		32.96			~2~	~3~
135	1	13	297.0		12.76			~2~	~3~
135	1	13	396.0		20.23			~2~	~3~
135	2	13	4269.0		27.75			~2~	~3~
139	2	13	1592.0		20.86			~2~	~3~
139	2	13	1793.0		19.75			~2~	~3~
139	2	13	1994.0		19.23			~2~	~3~
139	2	13	2493.0		19.67			~2~	~3~
139	2	13	2742.0		19.79			~2~	~3~
139	2	13	3243.0		19.73			~2~	~3~
142	1	14	397.0	12.24				2~	3~
143	2	14	1593.0		20.34			~2~	~3~
143	2	14	1792.0		19.19			~2~	~3~
143	2	14	1992.0		19.05			~2~	~3~

STNNBR CASTNO SAMPNO CTDPRS SILCAT NITRAT NITRIT PHSPHT QUALT1 QUALT2

STNNBR	CASTNO	SAMPNO	CTDPRS	SILCAT	NITRAT	NITRIT	PHSPHT	QUALT1	QUALT2
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143	2	14	2494.0		19.90			~2~	~3~
143	2	14	2742.0		19.76			~2~	~3~
143	2	14	2995.0		19.92			~2~	~3~
143	2	14	3244.0		19.63			~2~	~3~
143	2	14	3494.0		19.86			~2~	~3~
143	2	14	3694.0		20.54			~2~	~3~
143	2	14	3894.0		21.84			~2~	~3~
143	2	14	4094.0		24.04			~2~	~3~
143	2	14	4293.0		25.81			~2~	~3~
143	2	14	4494.0		27.77			~2~	~3~
143	2	14	4769.0		30.07			~2~	~3~
143	2	14	4769.0		30.06			~2~	~3~
143	2	14	4849.0		30.04			~2~	~3~
143	2	14	4849.0		29.94			~2~	~3~
146	1	14	398.0				1.57	~~~2	~~~3
146	1	14	497.0				1.99	~~~2	~~~3
146	1	14	597.0				2.30	~~~2	~~~3
146	1	14	695.0				2.48	~~~2	~~~3
146	1	14	796.0				2.55	~~~2	~~~3
146	1	14	897.0				2.54	~~~2	~~~3
146	2	14	994.0				2.49	~~~2	~~~3
146	2	14	1094.0				2.41	~~~2	~~~3
146	2	14	1193.0				2.27	~~~2	~~~3
146	2	14	1394.0				1.94	~~~2	~~~3
146	2	14	1593.0				1.81	~~~2	~~~3
146	2	14	1793.0				1.69	~~~2	~~~3
146	2	14	1994.0		19.95		1.64	~2~2	~3~3
146	2	14	2244.0		19.45		1.64	~2~2	~3~3
146	2	14	2494.0		19.83		1.63	~2~2	~3~3
146	2	14	2744.0		19.81		1.66	~2~2	~3~3
146	2	14	2993.0		19.74		1.67	~2~2	~3~3
146	2	14	3245.0		19.89		1.68	~2~2	~3~3
146	2	14	3694.0		20.45		1.73	~2~2	~3~3
146	2	14	3895.0		21.10		1.81	~2~2	~3~3
146	2	14	4094.0		22.56		1.96	~2~2	~3~3
146	2	14	4293.0		24.26		2.12	~2~2	~3~3
146	2	14	4493.0		25.90		2.20	~2~2	~3~3
146	2	14	4692.0		27.67		2.37	~2~2	~3~3
146	2	14	5061.0		29.78			~2~	~3~
146	2	14	5061.0		29.85		2.38	~2~2	~3~3
146	2	14	5144.0		30.07		2.39	~2~2	~3~3
146	2	14	5144.0		29.96		2.25	~2~2	~3~3
147	1	14	198.0			0.14		~~2~	~~3~

STNNBR CASTNO SAMPNO CTDPRS SILCAT NITRAT NITRIT PHSPHT QUALT1 QUALT2

STNNBR	CASTNO	SAMPNO	CTDPRS	SILCAT	NITRAT	NITRIT	PHSPHT	QUALT1	QUALT2
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148	1	14	147.0		1.19			~2~	~3~
148	1	14	197.0		4.13			~2~	~3~
148	1	14	247.0		8.89			~2~	~3~
148	1	14	298.0		15.05			~2~	~3~
148	1	14	497.0		28.98			~2~	~3~
148	1	14	597.0		33.21			~2~	~3~
148	1	14	696.0		34.65			~2~	~3~
148	1	14	897.0		35.13			~2~	~3~
148	2	14	2243.0		23.06			~2~	~3~
148	2	14	2493.0		22.98			~2~	~3~
148	2	14	2993.0		24.40			~2~	~3~
148	2	14	3244.0		23.90			~2~	~3~
148	2	14	3494.0		23.95			~2~	~3~
148	2	14	3695.0		24.75			~2~	~3~
148	2	14	3896.0		27.07			~2~	~3~
148	2	14	4494.0		30.48			~2~	~3~
148	2	14	4692.0		30.94			~2~	~3~
148	2	14	5093.0		32.55			~2~	~3~
149	1	14	148.0				0.46	~~~2	~~~3
149	1	14	197.0				0.66	~~~2	~~~3
149	1	14	247.0				1.01	~~~2	~~~3
149	1	14	298.0				1.34	~~~2	~~~3
149	1	14	398.0				1.71	~~~2	~~~3
149	1	14	497.0				2.08	~~~2	~~~3
149	1	14	597.0				2.30	~~~2	~~~3
149	1	14	697.0				2.42	~~~2	~~~3
149	1	14	796.0				2.48	~~~2	~~~3
149	1	14	897.0				2.41	~~~2	~~~3
149	1	14	996.0				2.37	~~~2	~~~3
149	2	14	7.0				0.34	~~~2	~~~3
149	2	14	1794.0				1.46	~~~2	~~~3
149	2	14	1994.0				1.44	~~~2	~~~3
149	2	14	2244.0				1.45	~~~2	~~~3
149	2	14	2494.0				1.47	~~~2	~~~3
149	2	14	2745.0				1.50	~~~2	~~~3
149	2	14	2995.0				1.52	~~~2	~~~3
149	2	14	3244.0				1.51	~~~2	~~~3
149	2	14	3492.0				1.58	~~~2	~~~3
149	2	14	3693.0				1.67	~~~2	~~~3
149	2	14	3895.0				1.79	~~~2	~~~3
149	2	14	4094.0				1.91	~~~2	~~~3
149	2	14	4294.0				2.00	~~~2	~~~3
149	2	14	4494.0				2.10	~~~2	~~~3

STNNBR CASTNO SAMPNO CTDPRS SILCAT NITRAT NITRIT PHSPHT QUALT1 QUALT2

STNNBR	CASTNO	SAMPNO	CTDPRS	SILCAT	NITRAT	NITRIT	PHSPHT	QUALT1	QUALT2
149	2	14	4691.0				2.17	~~~2	~~~3
149	2	14	4893.0				2.24	~~~2	~~~3
149	2	14	5093.0				2.25	~~~2	~~~3
149	2	14	5291.0				2.26	~~~2	~~~3
149	2	14	5756.0				2.28	~~~2	~~~3
149	2	14	5849.0				2.23	~~~2	~~~3
149	2	14	5849.0				2.20	~~~2	~~~3
150	1	15	397.0		27.32			~2~~	~3~~
150	1	15	497.0		25.17			~2~~	~3~~
150	1	15	597.0		28.42			~2~~	~3~~
150	1	15	698.0		30.79			~2~~	~3~~
150	1	15	797.0		32.01			~2~~	~3~~
150	2	15	7.0				0.56	~~~2	~~~3
150	2	15	1195.0				2.14	~~~2	~~~3
150	2	15	1394.0				1.87	~~~2	~~~3
150	2	15	1594.0				1.70	~~~2	~~~3
150	2	15	1794.0				1.61	~~~2	~~~3
150	2	15	2244.0				1.60	~~~2	~~~3
150	2	15	2494.0				1.62	~~~2	~~~3
150	2	15	2745.0				1.69	~~~2	~~~3
150	2	15	2993.0				1.72	~~~2	~~~3
150	2	15	3246.0				1.80	~~~2	~~~3
150	2	15	3495.0				1.86	~~~2	~~~3
150	2	15	3695.0				1.94	~~~2	~~~3
150	2	15	3894.0				2.07	~~~2	~~~3
150	2	15	4093.0				2.20	~~~2	~~~3
150	2	15	4294.0				2.32	~~~2	~~~3
150	2	15	4493.0				2.35	~~~2	~~~3
150	2	15	4693.0				2.37	~~~2	~~~3
150	2	15	4892.0				2.34	~~~2	~~~3
150	2	15	5092.0				2.36	~~~2	~~~3
150	2	15	5437.0				2.33	~~~2	~~~3
150	2	15	5437.0				2.26	~~~2	~~~3
150	2	15	5518.0				2.13	~~~2	~~~3
150	2	15	5518.0				2.00	~~~2	~~~3
155	2	15	4294.0				1.95	~~~2	~~~3
155	2	15	4493.0				2.06	~~~2	~~~3
155	2	15	4694.0				2.15	~~~2	~~~3
155	2	15	4892.0				2.17	~~~2	~~~3
155	2	15	5243.0				2.20	~~~2	~~~3
155	2	15	5323.0				2.22	~~~2	~~~3
155	2	15	5323.0				2.16	~~~2	~~~3
157	1	15	197.0			0.08		~~~2~	~~~3~
157	1	15	248.0			0.07		~~~2~	~~~3~

STNNBR CASTNO SAMPNO CTDPRS SILCAT NITRAT NITRIT PHSPHT QUALT1 QUALT2

STNNBR	CASTNO	SAMPNO	CTDPRS	SILCAT	NITRAT	NITRIT	PHSPHT	QUALT1	QUALT2
157	1	15	298.0			0.07		~2~	~3~
157	1	15	497.0			0.14		~2~	~3~
157	2	15	1394.0			0.09		~2~	~3~
157	2	15	1593.0	29.38				2~~	3~~
157	2	15	2244.0	33.97	22.10			22~~	33~~
157	2	15	2494.0	36.58	22.18			22~~	33~~
157	2	15	2744.0	39.22	22.28			22~~	33~~
157	2	15	2994.0	39.79	22.08			22~~	33~~
159	2	15	1994.0		21.90			~2~	~3~
159	2	15	2244.0		21.97			~2~	~3~
160	2	16	795.0		32.52			~2~	~3~
161	2	16	247.9	0.29	0.04		0.21	22~2	33~3
161	2	16	297.7	0.59	0.00		0.25	22~2	33~3
161	2	16	397.5	0.73	0.22		0.29	22~2	33~3
161	2	16	497.3	8.19	14.97		1.12	22~2	33~3
162	1	16	600.0		31.58			~2~	~3~
162	2	16	694.0		32.51			~2~	~3~
165	2	16	1765.0		24.82			~2~	~3~
173	1	17	1394.0	41.90				2~~	3~~
173	1	17	1594.0	40.08				2~~	3~~
174	2	17	1394.0	44.99				2~~	3~~
174	2	17	1594.0	42.73				2~~	3~~
174	2	17	1794.0	39.59				2~~	3~~
175	2	17	395.0				1.48	~~~2	~~~3
175	2	17	495.0				1.80	~~~2	~~~3
175	2	17	594.0				2.05	~~~2	~~~3
175	2	17	694.0				2.10	~~~2	~~~3
175	2	17	793.0				2.14	~~~2	~~~3
175	2	17	893.0				2.11	~~~2	~~~3
175	2	17	994.0				2.01	~~~2	~~~3
175	2	17	1094.0				1.94	~~~2	~~~3
175	2	17	1193.0				1.87	~~~2	~~~3
175	2	17	1393.0				1.56	~~~2	~~~3
175	2	17	1594.0				1.39	~~~2	~~~3
175	2	17	1994.0				1.21	~~~2	~~~3
175	2	17	2193.0				1.19	~~~2	~~~3
175	2	17	2393.0				1.22	~~~2	~~~3
175	2	17	2594.0				1.22	~~~2	~~~3
175	2	17	2794.0				1.22	~~~2	~~~3
175	2	17	2994.0				1.21	~~~2	~~~3
175	2	17	3244.0				1.27	~~~2	~~~3
175	2	17	3530.0				1.27	~~~2	~~~3
175	2	17	3612.0				1.31	~~~2	~~~3
175	2	17	3612.0				1.32	~~~2	~~~3

STNNBR CASTNO SAMPNO CTDPRS SILCAT NITRAT NITRIT PHSPHT QUALT1 QUALT2

STNNBR	CASTNO	SAMPNO	CTDPRS	SILCAT	NITRAT	NITRIT	PHSPHT	QUALT1	QUALT2
184	1	18	297.0		24.14			~2~	~3~
184	2	18	1194.0	34.04	28.31		1.84	22~2	33~3
185	1	18	298.0	13.88	28.13			22~	33~
185	2	18	895.0	29.53	29.38		2.02	22~2	33~3
185	2	18	3997.0	42.50				2~	3~
187	1	18	497.0		33.34			~2~	~3~
187	1	18	599.0		36.94			~2~	~3~
187	2	18	695.0		38.49			~2~	~3~
187	2	18	794.0		38.10			~2~	~3~
187	2	18	894.0		38.18			~2~	~3~
187	2	18	995.0		37.79			~2~	~3~
187	2	18	1095.0		36.75			~2~	~3~
187	2	18	1194.0		35.85			~2~	~3~
187	2	18	1993.0		23.62			~2~	~3~
187	2	18	2244.0		23.91			~2~	~3~
187	2	18	2492.0		23.88			~2~	~3~
188	1	18	498.0		34.74			~2~	~3~
188	1	18	598.0		39.44			~2~	~3~
188	1	18	697.0		41.36			~2~	~3~
188	2	18	794.0		40.78			~2~	~3~
188	2	18	894.0		39.77			~2~	~3~
188	2	18	994.0		38.26			~2~	~3~
188	2	18	1094.0		36.47			~2~	~3~
188	2	18	1393.0		29.85			~2~	~3~
193	2	19	1393.0				1.74	~~~2	~~~3
193	2	19	1593.0				1.62	~~~2	~~~3
193	2	19	1794.0				1.45	~~~2	~~~3
193	2	19	1994.0				1.39	~~~2	~~~3
197	2	19	2994.0				1.49	~~~2	~~~3
197	2	19	3244.0				1.50	~~~2	~~~3
197	2	19	3694.0				1.51	~~~2	~~~3
197	2	19	4776.0				1.47	~~~2	~~~3
201	1	20	98.0	3.95				2~	3~
201	1	20	149.0	6.41				2~	3~
201	1	20	198.0	8.50				2~	3~
201	1	20	248.0	11.08				2~	3~
201	1	20	298.0	14.89				2~	3~
201	1	20	397.0	20.21				2~	3~
201	1	20	498.0	24.55				2~	3~
201	1	20	598.0	29.07				2~	3~
202	2	20	1593.0				1.79	~~~2	~~~3
202	2	20	1793.0				1.76	~~~2	~~~3
202	2	20	1993.0				1.75	~~~2	~~~3
202	2	20	2243.0				1.74	~~~2	~~~3

STNNBR CASTNO SAMPNO CTDPRS SILCAT NITRAT NITRIT PHSPHT QUALT1 QUALT2

STNNBR	CASTNO	SAMPNO	CTDPRS	SILCAT	NITRAT	NITRIT	PHSPHT	QUALT1	QUALT2
202	2	20	2493.0				1.76	~~~2	~~~3
202	2	20	2744.0				1.80	~~~2	~~~3
205	2	20	5462.0				1.40	~~~2	~~~3
206	2	20	3494.0				1.68	~~~2	~~~3
206	2	20	4692.0				1.70	~~~2	~~~3
206	2	20	5291.0				1.68	~~~2	~~~3
206	2	20	5411.0				1.65	~~~2	~~~3
206	2	20	5411.0				1.79	~~~2	~~~3
206	2	20	5546.0				1.64	~~~2	~~~3
207	2	20	5581.0				1.63	~~~2	~~~3
208	2	20	2493.0				1.63	~~~2	~~~3
208	2	20	3695.0				1.63	~~~2	~~~3
213	2	21	1794.0	27.24				2~~~	3~~~
214	1	21	397.0				2.64	~~~2	~~~3
214	1	21	498.0				2.79	~~~2	~~~3
214	1	21	597.0				2.77	~~~2	~~~3
214	1	21	698.0				2.80	~~~2	~~~3
214	1	21	798.0				2.69	~~~2	~~~3
214	1	21	896.0				2.66	~~~2	~~~3
214	1	21	997.0				2.63	~~~2	~~~3
214	1	21	1100.0				2.50	~~~2	~~~3
214	2	21	1193.0				2.41	~~~2	~~~3
214	2	21	1394.0				2.21	~~~2	~~~3
214	2	21	1594.0				2.00	~~~2	~~~3
214	2	21	2994.0				1.73	~~~2	~~~3
214	2	21	3493.0				1.77	~~~2	~~~3
217	1	21	195.0	10.37	28.50		1.82	22~2	33~3
220	1	22	543.0		34.12			~2~~	~3~~
221	1	22	544.0		34.55			~2~~	~3~~
222	1	22	545.0		35.32			~2~~	~3~~
222	1	22	1994.0	28.25	21.62			22~~	33~~
223	1	22	543.0		35.58			~2~~	~3~~
224	2	22	3495.0				1.41	~~~2	~~~3
226	1	22	896.0		40.61			~2~~	~3~~
226	1	22	996.0		38.74			~2~~	~3~~
226	2	22	1094.0		37.72			~2~~	~3~~
226	2	22	1194.0		35.89			~2~~	~3~~
226	2	22	1394.0		31.03			~2~~	~3~~
226	2	22	1593.0		27.85			~2~~	~3~~
226	2	22	1794.0		26.38			~2~~	~3~~
226	2	22	1994.0		25.38			~2~~	~3~~
226	2	22	2243.0		24.91			~2~~	~3~~
226	2	22	2493.0		24.59			~2~~	~3~~
226	2	22	2744.0		24.71			~2~~	~3~~

STNNBR CASTNO SAMPNO CTDPRS SILCAT NITRAT NITRIT PHSPHT QUALT1 QUALT2

STNNBR	CASTNO	SAMPNO	CTDPRS	SILCAT	NITRAT	NITRIT	PHSPHT	QUALT1	QUALT2
226	2	22	2994.0		24.77			~2~	~3~
226	2	22	3243.0		24.79			~2~	~3~
226	2	22	3493.0		24.81			~2~	~3~
226	2	22	3694.0		25.05			~2~	~3~
229	1	22	148.0	9.71				2~	3~
229	1	22	171.0	9.84				2~	3~
229	1	22	199.0	10.10				2~	3~
229	1	22	224.0	11.55				2~	3~
229	1	22	248.0	12.68				2~	3~
229	1	22	273.0	13.92				2~	3~
229	1	22	298.0	14.53				2~	3~
231	2	23	1593.0				1.50	~~2	~~3
231	2	23	1794.0				1.41	~~2	~~3
231	2	23	1993.0				1.35	~~2	~~3
231	2	23	2243.0				1.33	~~2	~~3
231	2	23	2493.0				1.28	~~2	~~3
231	2	23	2745.0				1.41	~~2	~~3

CFC DQE Report: Meteor 15 Leg 3, A9

My technique and reasoning for flagging data was abbreviated due to not having all of the information necessary to do a more thorough job. But with the information that was provided, I generated station listings for the values of CFC11, CFC12, CFC11/CFC12 ratio, percent saturation of O₂, O₂, pressure and density. I then plotted both CFC's concentration vs. depth for each station. The strongest indicator of questionable CFC data is the CFC11/CFC12 concentration ratio that is physically constrained by the solubility of the gases. Ratios that were thus determined to be unlikely indicate that one or possibly both CFCs could be questionable. From the station profiles and comparing to other parameters (such as O₂ saturation for the surface waters) I attempted to judge which of the CFCs was most likely to cause the improbable ratio. In some cases I had to flag both values questionable if the profiles, values from the stations before and/or after or other measured tracers did not provide an indication as to which value to question. If the data generator provides the information that was requested for in the report, particularly for the data points in question, I would be able to reassess those quality control words.

I am not sure that a sampling blank has been applied to the CFC values for A9 since all the values in the files were zero or positive. When a reasonable sampling blank is applied to CFC "free" water you would expect some bottles to have a negative concentration reported. More information on the sampling blank applied for A9 would clarify this concern.

-Rick Van Woy
June 1, 1993

WOCE A-9

#Station cast sample F-11 qual 2 F-12 qual 2

122	1	301	3	3
122	1	302	3	3
122	1	309	3	2
122	1	312	3	2
122	1	315	3	2
122	1	316	3	2
122	1	319	3	2
122	1	322	3	2
122	1	323	3	2
122	1	324	3	2
123	1	319	3	3
123	1	322	3	3
123	1	323	3	3
123	1	324	3	3
127	1	312	3	2
127	1	319	3	2
127	1	320	3	3
130	1	323	3	3
130	1	324	3	3
132	1	211	3	3
132	2	301	3	3
132	2	314	3	3
132	2	320	2	3
134	2	304	2	3
134	2	305	2	3
135	2	313	3	2
136	2	315	2	3
137	2	323	3	3
138	2	315	2	3
140	1	201	3	3
140	1	202	3	3
140	2	315	2	3
143	2	304	3	2
143	2	316	2	3
146	1	202	2	3
146	1	203	2	3
146	1	204	3	3
146	1	205	3	3
146	2	323	3	2
149	2	303	3	2
149	2	321	3	2
151	1	216	3	3

#Station cast sample F-11 qual 2 F-12 qual 2

151	1	207	2	3
151	2	304	2	3
151	2	309	3	3
151	2	315	3	3
151	2	316	2	3
151	2	323	3	2
151	2	324	3	3
152	2	303	2	3
153	1	204	2	3
153	2	301	2	3
153	2	302	2	3
153	2	317	2	3
153	2	318	2	3
157	2	309	2	3
157	2	312	3	2
157	2	317	3	3
165	2	303	9	3
165	2	316	3	3
165	2	317	3	3
165	2	318	2	3
169	1	311	3	3
169	1	313	3	3
170	1	312	2	3
170	1	313	2	3
172	1	306	3	2
174	2	310	3	2
182	1	305	3	2
184	2	305	3	2
186	2	312	2	3
190	2	304	3	2
190	2	322	2	3
192	1	201	2	3
196	2	301	2	3
196	2	306	2	3
196	2	310	2	3
196	2	316	2	3
196	2	317	2	3
196	2	318	2	3
196	2	322	2	3
198	2	317	3	3
202	1	202	2	3
202	1	203	2	3
202	1	204	2	3
208	1	206	3	2

#Station cast sample F-11 qual 2 F-12 qual 2

208	1	208	3	2
208	2	319	3	3
208	2	322	3	3
210	2	323	3	3
212	1	201	2	3
212	1	204	2	3
212	1	205	2	3
214	1	205	3	3
214	1	206	2	3
214	2	319	3	3
219	1	301	3	2
219	1	302	3	3
219	1	303	3	3
219	1	304	3	3
224	1	201	2	3
224	1	202	3	2
225	1	322	9	3
225	1	324	2	3
226	1	203	3	3
226	1	207	2	3
228	2	322	2	3
229	2	306	3	2
229	2	322	3	3
232	2	304	3	2
232	2	309	3	2
232	2	315	2	3
232	2	316	2	3
232	2	317	2	3
232	2	318	2	3
232	2	319	2	3
232	2	320	2	3

INPUT FILE: A9.RVW
THE DATE TODAY IS: 27-MAY-93

STNNBR CASTNO SAMPNO CTDPRS CFC-11 CFC-12 QUALT1 QUALT2

122	1	12	2998.0	0.061	2~	3~
122	1	12	2998.0	0.021	2~	3~
127	1	12	145.0	1.842	2~	3~
127	2	12	3001.0	0.009	2~	9~
130	1	13	6.0	1.731	2~	3~
130	1	13	26.0	1.620	2~	3~
132	1	13	28.0	1.624	2~	3~
132	2	13	1243.0	0.012	2~	3~
132	2	13	2144.0	0.026	2~	3~
132	2	13	4027.0	0.015	2~	3~
134	2	13	3894.0	0.012	2~	3~
134	2	13	4147.0	0.007	2~	3~
136	2	13	1593.0	0.011	2~	3~
137	2	13	595.0	1.515	2~	3~
138	2	13	1593.0	0.025	2~	3~
140	1	14	497.0	0.555	2~	3~
140	1	14	599.0	0.555	2~	3~
140	2	14	1793.0	0.015	2~	3~
142	2	14	1994.0	0.016	2~	9~
143	2	14	1992.0	0.007	2~	3~
145	2	14	2243.0	0.006	2~	9~
146	1	14	497.0	0.270	2~	3~
146	1	14	597.0	0.269	2~	3~
146	1	14	695.0	0.116	2~	3~
146	1	14	796.0	0.077	2~	3~
151	1	15	29.0	1.707	2~	3~
151	1	15	597.0	0.225	2~	3~
151	2	15	7.0	1.912	2~	3~
151	2	15	2994.0	0.001	2~	3~
151	2	15	3244.0	0.011	2~	3~
151	2	15	4493.0	0.031	2~	3~
151	2	15	5495.0	0.027	2~	3~
152	2	15	5489.0	0.016	2~	3~
153	1	15	597.0	0.235	2~	3~
153	2	15	1793.0	0.015	2~	3~
153	2	15	1993.0	0.015	2~	3~
153	2	15	5000.0	0.008	2~	3~
153	2	15	5000.0	0.009	2~	3~
154	2	15	3495.0	0.000	2~	9~
154	2	15	3893.0	0.004	2~	9~
157	2	15	1593.0	0.001	2~	3~

STNNBR CASTNO SAMPNOCTDPRS CFC-11 CFC-12 QUALT1 QUALT2

157	2	15	3494.0	0.004	2~	3~
165	2	16	894.0	0.026	2~	3~
165	2	16	994.0	0.025	2~	3~
165	2	16	1093.0	0.019	2~	3~
169	1	16	893.0	0.078	2~	3~
169	1	16	1194.0	0.041	2~	3~
170	1	17	1094.0	0.010	2~	3~
170	1	17	1194.0	0.008	2~	3~
186	2	18	2244.0	0.001	2~	3~
190	2	19	896.0	0.016	2~	3~
192	1	19	697.0	0.062	2~	3~
196	2	19	993.0	0.013	2~	3~
196	2	19	1594.0	0.003	2~	3~
196	2	19	1793.0	0.004	2~	3~
196	2	19	1995.0	0.004	2~	3~
196	2	19	3495.0	0.000	2~	3~
196	2	19	4293.0	0.006	2~	3~
196	2	19	5360.0	0.002	2~	3~
198	2	19	1993.0	0.014	2~	3~
200	2	20	3244.0	0.000	2~	9~
202	1	20	597.0	0.048	2~	3~
202	1	20	697.0	0.019	2~	3~
202	1	20	797.0	0.017	2~	3~
208	2	20	1593.0	0.011	2~	3~
208	2	20	2242.0	0.009	2~	3~
210	2	21	1394.0	0.012	2~	3~
212	1	21	597.0	0.044	2~	3~
212	1	21	698.0	0.029	2~	3~
212	1	21	999.0	0.011	2~	3~
214	1	21	597.0	0.044	2~	3~
214	1	21	698.0	0.019	2~	3~
214	2	21	1993.0	0.129	2~	3~
219	1	21	2694.0	0.013	2~	3~
219	1	21	2794.0	0.016	2~	3~
219	1	21	2963.0	0.017	2~	3~
224	1	22	999.0	0.020	2~	3~
225	1	22	493.0	0.098	2~	3~
226	1	22	397.0	0.147	2~	3~
226	1	22.	798.0	0.050	2~	3~
228	2	22	994.0	0.009	2~	3~
229	2	22	793.0	0.027	2~	3~
232	2	23	494.0	0.137	2~	3~
232	2	23	594.0	0.031	2~	3~
232	2	23	694.0	0.020	2~	3~

STNNBR CASTNO SAMPNOCTDPRS CFC-11 CFC-12 QUALT1 QUALT2
***** *****

232	2	23	794.0	0.020	2~	3~
232	2	23	893.0	0.010	2~	3~
232	2	23	993.0	0.005	2~	3~

Tracer Oceanography
University of Bremen

from: Peter Beining

Comments on quality flags of the CFC-data from METEOR 15 leg 3 (A9).

Estimated error of the CFC-data:

We estimated for both CFCs an error of 0.8% or 0.005 pmol/kg, whichever is greater, with the exception of stations # 122 to # 151, where we had a problem with a leaking valve. The errors for these stations are 3% for both CFCs.

Sampling blank:

The DQ-Expert mentioned that it seemed to him that there was no sampling blank applied. He argued that if a sampling blank was subtracted from the CFC-data, one would expect negative values. In fact, unfortunately, in the step of connecting the CFC-data with the other hydrographic data the sign of negative values was lost. A corrected file is now made available and we would appreciate a reassessment.

The CFC-data were only stripper-blank corrected (not sampling-blank corrected). [Figure 1](#) compares concentrations obtained on samples for which vanishing values can be expected (Stations # 172 - # 192, >1500m) without any blank corrections applied, with stripper blank measurements (converted to concentrations). The means of the "zero-water" concentrations are 0.009 ± 0.003 pmol/kg (CFC11) and 0.01 ± 0.005 pmol/kg (CFC12), the mean of the stripper blanks are 0.008 ± 0.004 pmol/kg (the errors are standard deviation of individual measurements). The difference is regarded as insignificant. We concluded that a sampling blank can be ignored.

Quality flags:

In most cases we agree with the setting of the quality flag by the DQ-Expert. But we want emphasize that we didn't remove the values because we feel that in some cases the signal may be real or in other cases the signal may be helpful to recognize a wrong sample. Two examples should support this:

1. [Figure 2](#) shows hydrographic profiles from station #229 which includes salinity, oxygen, CFC11 and CFC12. If you consider the data point near 800 m you can recognize an intermediate maximum in the CFC-profiles. The calculated ratio is suspicious but on the other hand you find at the same depth in the oxygen profile also an intermediate maximum. So there might be a real signal from Antarctic Intermediate Water. The use of the CFC-ratio for checking this values makes no sense because the error of the ratio is 60%.
2. [Figure 3](#) shows profiles from station #214. The CFC concentrations near 2000 m is obviously wrong but you can see that the oxygen value at the same depth shows also an

anomalous behaviour. A possible reason is that this bottle did not correctly close. In this case you can use the CFC value and the oxygen value to check the quality.

For this reasons we agree that the values are questionable but they might give helpful information for the user of the data set.

P. Beining

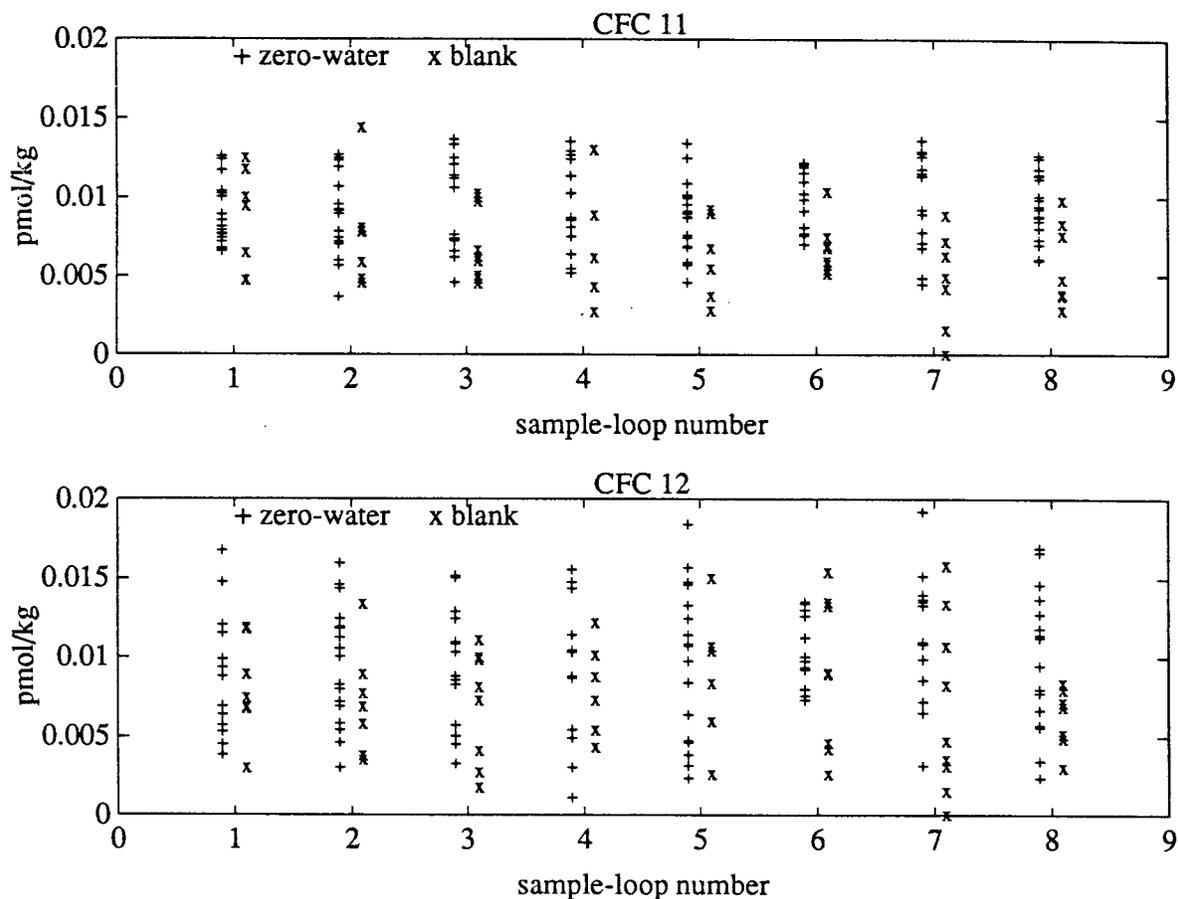


Fig. 1: #172 - #196

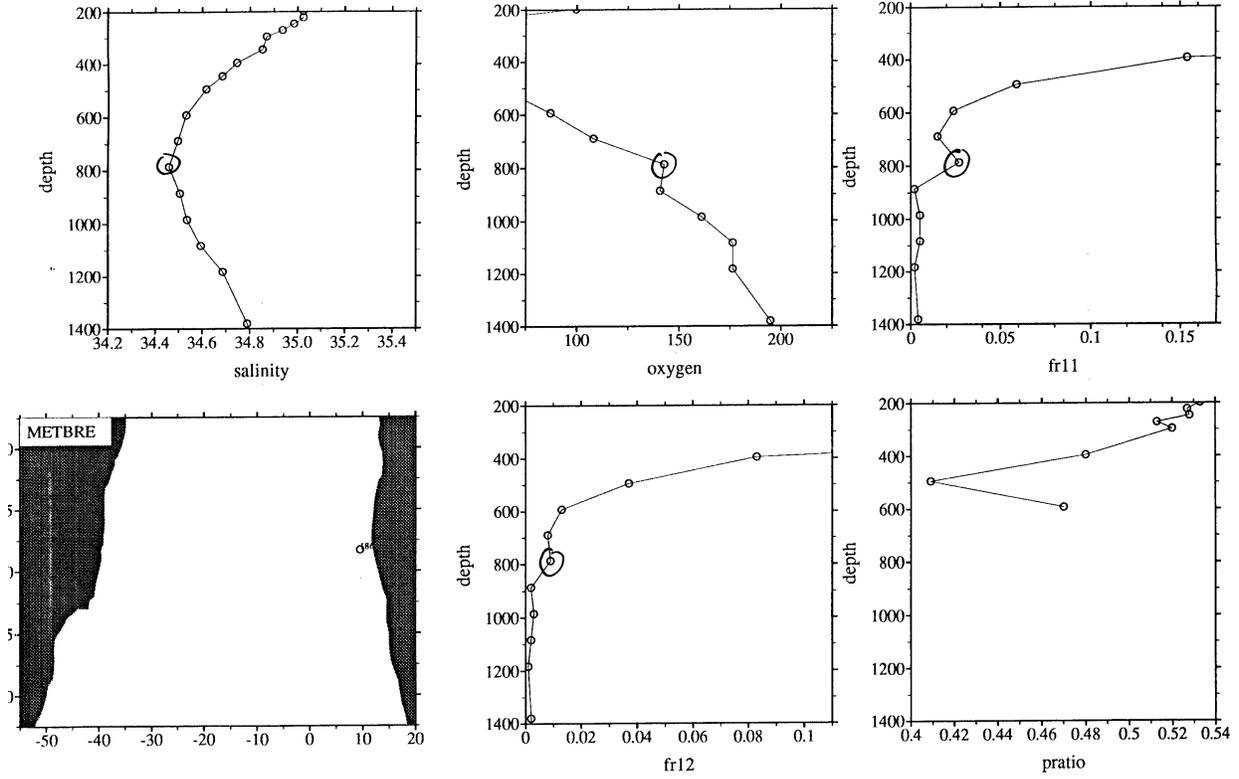


Fig. 2: #229

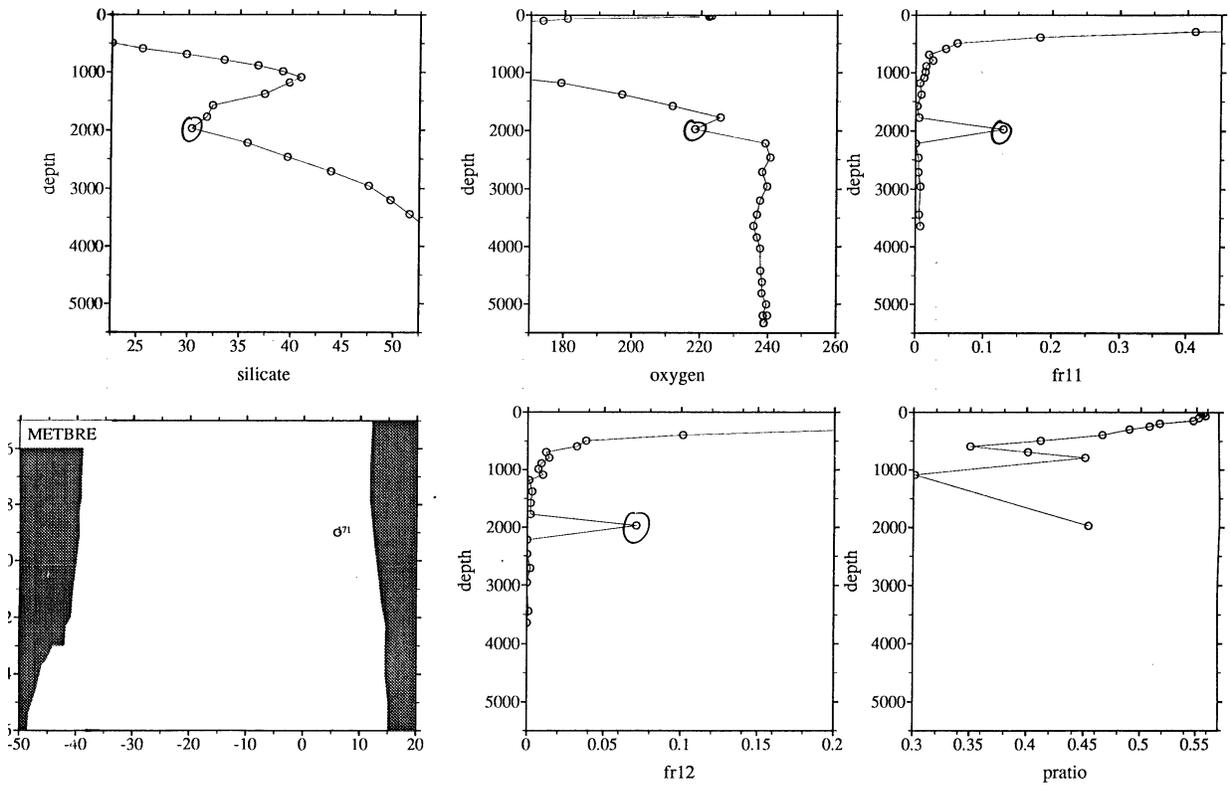


Fig. 3: #214

Data Processing History

Date	Contact	Data Type	Data Status	Summary
8/24/92	Siedler	BTL	Submitted for DQE	
9/11/92	Arhan	CTD/S/O	DQE Contacted	
9/25/92	Van Woy	CFCs	DQE Begun	
9/25/92	Gordon	NUTs	DQE Begun	with Joe Jenings
9/25/92	Arhan	CTD/S/O	DQE Begun	
12/30/92	Arhan	CTD/S/O	DQE Report to WHPO	
1/5/93	Siedler	CTD/S/O	DQE Report sent to PI	
3/2/93	Jennings	NUTs	DQE Report to WHPO	
3/26/93	Siedler	NUTs	DQE Report to PI	
5/11/93	Van Woy	CFCs	DQE Report to WHPO	
6/11/93	Siedler	CFCs	DQE Report to PI	
3/6/95	Siedler	CTC/NUTs/CFCs	Data are Final	
8/21/96	Putzka	Tracer	Data Rcvd @ WHPO	
8/15/97	Siedler	DOC	Submitted	
9/25/97	Klein	HELIUM/DELHE3	Submitted	also Neon
<p>The helium data I submitted for a9 have the following meaning: Helium stands for the isotope helium4 delHe3 stands for delta-He3 and is the deviation of the isotope ratio of helium3/helium4 compared to helium3/helium4 ratio in air (given in percent). Neon stands for the isotope neon20</p> <p>Helier is the individual error assigned to the respective helium measurement. delher is the individual error assigned to the respective delta-He3 value Neoner is the individual error assigned to the respective neon value</p> <p>I submitted today helium measurements for WHP section a8, the file was named WHPA8_he.dat, the corresponding documentation is given in whpa8_he.txt. The helium and neon isotope measurements for this cruise have just been finished and have not been reported yet. The delta-He3 values for this section are not final yet because we need to make a correction for tritium decay during storage time but these corrections are small.</p>				
3/12/99	Diggs	DELC14	Submitted for DQE	not yet merged into btl file
12/9/99	Klein	He/Tr	Final Data Rcvd @ WHPO	Tritium corrected/final
<p>As I understood from the mailing with Jerry Kappa you are unable to locate the tritium and final helium data for a9. I think they have been submitted to WHOI but it is no problem to submit these data again. The data file is called a09trihe.woc and the accompanying meta information is given in file m15tridoc.txt.</p> <p>The delhe3 data are tritium corrected and are therefore final, helium and neon data did not need a correction.</p> <p>All quality flags follow woce standards. All data including the CFCs which are not submitted again can be public.</p>				

12/13/99	Mueller	CTD/SUM	Update Needed	Numbering problems.
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I received the below msg of Robert Key while I'm working in Brazil for a week. It concerns with a problem that arose earlier with A9, and may arise with A8, too. The problem maybe identified as Robert Key suspected:

On all 3 sections A9, A10 and A8, the Kiel CTD group on-board counted casts increasingly, starting with 1 and ending with some high number. All other groups on-board were asked to keep these cast numbers for identification. To my knowledge, and J. Holfort may confirm this, the cast numbers as created on-board have been used in the CTD and SUM files we sent to the WHPO. Later (I do not exactly remember when) I got to know that someone at the WHPO changed the cast numbers in the SUM and CTD files to start with 1 for each station (as it is usual for the rest of the world). However, changing the cast numbers in the CTD and SUM files will cause problems with the rosette file as it will be completed with additional data flowing in. It seems to me that this is the problem the WHPO now is facing. The way out of it would be as recommended by Robert Key:

DO NOT CHANGE CAST NUMBERS BUT KEEP THEM AS THEY ARE SENT IN BY THE PIs (besides obvious mistakes). To solve the problem, you may have to reconstruct the original cast numbers from the original SUM and CTD files as they were sent in by the PIs

Juergen Holfort who has sent the CTD, SUM and part of the HYD files for A8, A9 and A10, and myself will assist if necessary.

Regards
Thomas J. Mueller

2/14/00	Kozyr	TCARBN/ALKI/ PCO2	Final Data Rcvd @ WHPO
2/22/00	Diggs	He/Tr/Neon	Data ready to be merged
2/25/00	Newton	He/Tr/Neon	Data Merged See note:

Notes on modifications made to A09 expocode 06MT15/3
 From file a09_1999.12.09.bklein.he-tr.txt
 merged in HELIUM HELIER NEON NEONER DELHE3 DELHER
 and added TRITUM, TRITER
 File named above had goofy sequential cast numbers that were reconciled to correct numbers before merging.
 In file named above station 139 cast 1 botlnbr 201 is probably really station 139 cast 2 botlnbr 201, but it's moot because all values are missing anyway.
 In file named above station 196 cast 1 btlnbr 213 is probably a stray, but it's moot because values are missing anyway.
 In file named above two DELHE3 values had -9 as value, but had a 2 recorded in Qflag. These were stn 157 cast 1 botlnbr 203 and stn 214 cast 2 botlnbr 320. Left axis Scores of DELHE3 values were -9.00 with Qflag of 4. Left axis.
 In file named above all DELHE3 missing values were -9.00 instead of -999. I fixed this in merged file.
 Rearranged columns into WHPO 90-1 table 4.1 order.
 25Feb2000 David Newton

2/28/00	Diggs	He/Tr/Neon	Website Updated	See note:
	I have placed the updated version of the hydro bottle file online which has the new (1999/12) version of He/Tr/Ne. All tables and files have been updated and the files are now archived.			
3/1/00	Diggs	CFCs	Update Needed	Note to B. Klein:
	<p>Re: Meteor 15 (WHPO # A09 : 06MT15_3)</p> <p>I have run into some issues with the 1997 CFC file that you sent to the WHPO. In that file, some of the CFC values are -8.7796 and -9.1148. While these are clearly out of the range of valid values for CFCs, I think that perhaps your software was writing out numbers approximating -9.0, the NO_DATA values for WOCE.</p> <p>I had also received an updated C14 file from Matthias Arnold (Institut fuer Umweltphysik der Universitaet Heidelberg) on 1998.08.10. In that file he has CFC values, I'm assuming that they are from you. This file has no large negative values except for the usual -9.0 as NO_DATA values. In addition, some of these CFC values for the same CAST, STN and SAMPLE differ from your values in the 1997 file. Did you update the CFC values from A09 after 1997?</p> <p>The question is, which file do I use to merge the CFCs into our bottle file online? I will send you a uuencoded compressed tarfile of these files and you may judge for yourself. Just be aware that the pressures are inverted from one file to another, and the BTLNBRs in one file match the SAMPNOs in the other.</p> <p>The tarfile will be in a separate message.</p>			
5/9/00	Mueller	CTD/BTL/NEON	Data are Public	See note:
	<p>Again, I would like to declare all CTD and all bottle data including the tracer-data of the WHP one-time cruises A9/M15-3, A10/M22-5 and A8/M28-1 as ,public'. This has been done several times earlier, and I hope that by now this information will flow into your files.</p> <p>Also please note, all CTD-data from repeat hydrography cruises / mooring cruises with chief scientists / Pls T.J. Mueller, W. Zenk, and / or O. Boebel / C. Schmid are ,public'.</p> <p>Viel Glueck</p> <p>Thomas J. Muller (speaking also for G. Siedler/M15-3; R. Onken/M22-5 and W. Roether/Tracers)</p>			
5/23/00	Huynh	DOC	Website Updated	pdf, txt versions online

6/8/00

Klein	He/Tr/Ne	Final Data Rcvd @ WHPO	Merging Instructions, see note:
We report final freon, helium isotope, neon and tritium data for the WOCE-WHP A9 (South-Atlantic) section (zonal at about 19 South) METEOR -cruise 15/3 (zonal at about 19 South). The data are stored under the file name 'wocea9.dat'. The bottle data file stored below contains all hydrographic variables although we contribute only tracer data. Freon data and helium data have been submitted earlier but should be replaced by the final values.			
The new and final data which should be included into the water sample file are:			
CFC11	(column 12)		
CFC12	(column 13)		
HELIUM	(column 22)		
DELHE3	(column 24)		
TRITIUM	(column 20)		
NEON	(column 26)		
and their respective errors			
CFC11ER	(column 12)		
CFC12ER	(column 13)		
HELIER	(column 22)		
DELHER	(column 24)		
TRITER	(column 20)		
NEONER.	(column 27)		
The corresponding hydrographic-data are under the responsibility of the Institut fuer Meereskunde University Kiel Prof. Dr. Siedler, Dr. T. Müller =====			
Responsible for the tracer data given here are: Dr. A. Putzka, Prof. Dr. Roether, Dr. B. Klein Institut fuer Umweltphysik Tracer Ozeanographie University Bremen Email: bklein@physik.uni-bremen.de =====			
The data file (Wocea9.dat) contains 38 columns and 3707 lines, variables and units are listed below.			

Column	Parameter-Name	Units
1	STNNBR	
2	CASTNO	
3	SAMPNO	
4	CTDPRS	DBAR
5	CTDTMP	Deg C
6	CTDSAL	PSS-78
7	OXYGEN	UMOL/KG
8	SILCAT	UMOL/KG
9	NITRAT	UMOL/KG
10	NITRIT	UMOL/KG
11	PHSPHT	UMOL/KG
12	CFC-11	PMOL/KG
13	CFC-12	PMOL/KG
14	CFC113	PMOL/KG
15	CCL4	PMOL/KG
16	CFC11ER	PMOL/KG
17	CFC12ER	PMOL/KG
18	CCF113ER	PMOL/KG
19	CCL4ER	PMOL/KG
20	TRITUM	TU
21	TRITER	TU
22	HELIUM	NMOL/KG
23	HELIER	NMOL/KG
24	DELHE3	%
25	DELHER	%
26	NEON	NMOL/KG
27	NEONER	NMOL/KG
28	O18 /O16	PER MILLE
29	TCARBN	UMOL/KG
30	ALKALI	UMOL/KG
31	FCO2	UATM
32	PH	
33	BLN-CFC11	PMOL/KG
34	METHYLJODID	
35	CTD-OXY	UMOL/KG
36	STORAGE TIME OF HELIUM	DAYS
37	QUALITY WORD1	
38	QUALITY WORD2	

invalid or missing data have been indicated by -9.000

The tracer data have each been assigned individual errors. Information about data quality is contained in quality word 1 (column 37) and quality word 2 (column 38).

Quality flag1:	
digit 1:	CTDSAL
digit 2:	OXYGEN
digit 3:	SILCAT
digit 4:	NITRAT
digit 5:	NITRIT
digit 6:	PHSPHT
digit 7:	CFC-11
byte 8:	CFC-12
byte 9:	CFC113
byte 10:	CCI4
byte 11:	TRITIUM
byte 12:	HELIUM
Quality flag2:	
digit 1:	DELHE3
digit 2:	NEON
digit 3:	O18/O16
digit 4:	TCARBN
digit 5:	ALKALI
digit 6:	FCO2
digit 7:	PH
digit 8:	BLN-CFC11
digit 9:	METHYLJODID
digit 10:	CTDOXY
digit 11:	not used
digit 12:	not used
<p>The quality code is defined as follows (Woce standard basically with minor modification):</p> <p>1==sample taken but not measured 2==acceptable measurement 3==questionable measurement 4==bad measurement 5==correction for air contamination 6==mean of replicate measurements 7==slightly questionable measurement 8==sample identification uncertain 9==sample not drawn from this bottle</p> <p>General comments:</p> <p>Helium and Neon measurements</p> <p>The water samples for the analysis of helium isotopes and neon measurements were stored in copper tubes and extracted later on in the laboratory. Storage time is indicated in the data file and amounted between 2 to 3 years. An internal standard filled with regular air has been used for the helium isotope and neon measurements at the laboratory in Bremen to make all measurements internally self-consistent. An external standard does not exist. The helium data reported now have been corrected for tritium decay, this correction is in the order of at maximum 0.6% and effects only the upper waters.</p>	

Tritium measurements

Tritium samples are stored in 1 liter glas bottles and were extracted later on in the laboratory. Tritium concentrations are measured by helium-ingrowth, therefore the same standard procedures apply as for helium. Tritium concentrations have been decay corrected to March 1st 1991.

CFC measurements:

CFC measurements were continously performed during the cruise by gas chromatography. The CFC data reported earlier were based on the SIO86 scale and have now been rescaled to SIO93 using the following corrections:

F11_SIO93=F11_SIO86/1.0251

F12_SIO93=F12_SIO86/0.9874

6/8/00	Diggs	TCARBN	Website Updated	data merged into btl file/online
6/23/00	Newton	CFCs	Data Merged into BTL file	
	had to resolve questionable sequential cast numbers in new file again. > stn139 cast 1 btlnbr 201 could not be merged. but moot because values were missing. > stn196 cast 1 btlnbr 213 is probably a stray. changed it to btlnbr 224. > deleted stn196 cast 1 btlnbr 224 as it contain bogus missing cfc. > corrected bogus missing cfc11s of -8.7796 and bogus missing cfc12s of -9.1148 The cfc's used none of the nonstandard quality flags noted by the originator.			
6/25/00	Diggs	CFCs	Website Updated - merged CFCs now online; See note:	
	Updated values from Birgit Klein merged into on-line bottle file by David Newton. Placed online after checking, associated files and tables updated.			
11/3/00	Bartolacci	SUM	Website Updated	Reformatted SUM file online
	I have replaced the current online sumfile with the newly reformatted file and moved the old file to the "original" subdirectory. Reformatting completed by S. Anderson. Tables and referenced have been updated to reflect this change.			
3/20/01	Diggs	DELC14	Data Ready to be Merged	
3/21/01	Muus	DELC14	Data Merged into BTL file	
3/27/01	Kappa	DOC	PDF, TXT Versions Updated	
	ar15 added, pdf links colored			
3/28/01	Kappa	DOC	PDF, TXT Versions Updated	
	Added PS cruise track/data processing notes to pdf/txt			