# WHP Cruise Summary Information

| | |
|---|---|
| WOCE section designation | A09 |
| Expedition designation (EXPOCODE) | 06MT15_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<br>0˚19.60'W 9˚31.70''E<br>23˚40.00''S |
| Floats and drifters deployed | 30 Drifters |
| Moorings deployed or recovered | 13 |
| Contributing Authors<br>(In order of appearance) | K. Speer<br>K. Schultz Tokos<br>W. Erasmi<br>T.J. Müller<br>J. Holfort<br>N. Zangenberg<br>R. Onken<br>B. Brügge<br>A. Putzka<br>P. Beining<br>K. Bulsiewicz<br>W. Plep<br>C. Goedicke<br>L. Brink<br>K. Heidland<br>T. Bickert<br>G. Meinecke<br>S. Mulitza<br>J. Pätzold<br>H.G. Andres<br>H.-Ch. John<br>C. Zelck<br>L. Veiga<br>D. Wallace<br>K.M. Johnson<br>R.J. Wilke<br>D.L. Bos<br>J.C. Jennings<br>D. Nehring<br>B. Wachs |

## WHP Cruise and Data Information

Instructions: Click on items below to locate primary reference(s) or use navigation tools above.

**Table of Contents**

Abstract

Summary

3 Scientific Programs

3.1 WOCE Programs

3.1.1 Marine Physics

3.1.2 Tracers

3.2 Marine Geology

3.3 Biological Oceanography and Marine Taxonomy

3.4 $CO_2$ Observations

3.5 Air Chemistry

4 Course of the journey

4.1 Leg one

4.2 Leg two

4.3 Leg three

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)

5.1.2 Data acquisition and processing onboard during M15/3 (T.J. Müller, J. Holfort, N. Zangenberg)

5.1.3 On the hydrography of the Brazil Current and the Deep Basin Experiment (K. Speer)

5.1.4 The WHP section (G. Siedler, J. Holfort, T.J. Müller, R. Onken)

5.1.5 Surface drifters (B. Brügge)

5.2 Tracer Measurements and Sampling on M15/2-3 (A. Putzka, P. Beining, K. Bulsiewicz, W. Plep)

5.3 Marine Geosciences

5.3.1 Profiling Shipborne Measurements

5.3.1.1 Sediment Echosounder Parasound
(C. Goedicke, L. Brink, K. Heidland)
5.3.1.2 Bathymetric measurements with HYDROSWEEP (K. Heidland)
5.3.1.3 Navigation and Positioning
5.3.1.4 HYDROSWEEP Postprocessing
5.3.2 Equipment operation and sample collection
(T. Bickert, G. Meinecke, S. Mulitza, J. Pätzold)
5.3.2.1 On-station geological work
5.3.2.2 Sample Collection
5.3.2.3 Multicorer Sampling
5.3.2.4 Gravity core processing
5.3.3 Water samples for $^{13}C$ analysis (T. Bickert)
5.3.4 Testing the Data storage - CTD (T. Bickert)
5.4 Biological Oceanography and marine Taxonomy
(H.G. Andres, H.-Ch. John, C. Zelck)
5.4.1 Introduction
5.4.2 Taxonomy and Vertical Distributions
5.4.3 Zoogeography and Ecology
5.4.4 Conclusions
5.4.5 Some Notes about the Tarball Pollution at the Water Surface
(L. Veiga, C. Zelck)
5.5 $CO_2$ Observations (D. Wallace, K.M. Johnson, R.J. Wilke)
5.5.1 Activities
5.5.2 Methods
5.5.3 Preliminary Results
5.6 Air chemistry
5.7 Nutrient Chemistry (D.L. Bos, J.C. Jennings)
5.8 Observations of dissolved oxygen (D. Nehring, B. Wachs)
6 Lists
6.1 XBT Drops
6.2 CTD Stations
6.3 XCP Drops (M15/3)
6.4 Surface drifters
6.5 Moorings
6.6 List of geoscientific observations (M15/2)
6.6.1 Station list Geosciences Bremen

6.6.2 List of water samples from Multicorers for $^{13}C$ determinations
6.6.3 List of water samples from the IfM Kiel Rosette for $^{13}C$ determinations
6.7 List of plankton samples (M15/1 and M15/2)
7 Concluding remarks
8 References
9 Figures
DQE Reports:
CTD
Nutrients
CFCs

Data History

**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, ichtyoplankton sampling in the western South Atlantic, $CO_2$ 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 $CO_2$ 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 $CO_2$ 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, Letiçia | Biologie | PETROBRAS |
| Flechsenhar, 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., Fahrtleiter | 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, Letiçia | Biologie | PETROBRAS |
| Flechsenhar, 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<br>Postfach 12 01 61<br>W-2850 Bremerhaven 12<br>Germany |
| BAH | Bundesforschungsanstalt Helgoland<br>c/o Zoologisches Institut und Museum<br>Martin-Luther-King-Platz 3<br>W-2000 Hamburg 13<br>Germany |
| DWD | Deutscher Wetterdienst - Seewetteramt -<br>Bernhard-Nocht-Str. 76<br>W-2000 Hamburg 36<br>Germany |
| IfMK | Institut für Meereskunde an der Universität Kiel<br>Düsternbrooker Weg 20<br>W-2300 Kiel 1<br>Germany |
| IfMW | Institut für Meereskunde<br>Seestr. 15<br>O-2530 Rostock-Warnemünde<br>Germany |
| IOUSP | Universidade de Sao Paulo<br>Instituto Oceanográfico Cidade Universitária<br>CEP 055 08<br>Sao Paulo<br>Brazil |
| IUP | Institut für Umweltphysik der Universität Heidelberg<br>Im Neuenheimer Feld 366<br>W-6900 Heidelberg<br>Germany |
| MPI | Max-Planck-Institut für Chemie<br>Postfach 30 60<br>W-6500 Mainz<br>Germany |

**Tab. 3:** Beteiligte Institutionen
Participating institutions

| | |
|---|---|
| OSU | Oregon State University<br>Department of Oceanography<br>Corvallis, Oregon 97331<br>U.S.A. |
| PETROBRAS | Petrobrás / CENPES<br>(Research and Development Center)<br>Cidade Universitária Q7<br>Ilha do Fundao<br>21910 Rio de Janeiro-RJ<br>Brazil |
| SIO | Scripps Institution of Oceanography<br>University of California, San Diego<br>P.O. Box 109,<br>La Jolla, California 92037<br>U.S.A. |
| UBG | Universität Bremen Fachbereich Geowissenschaften<br>Postfach 33 04 40<br>W-2800 Bremen 33<br>Germany |
| UBT | Universität Bremen Fachbereich Tracer-Ozeanographie<br>Postfach 33 04 40<br>W-2800 Bremen 33<br>Germany |
| UNY | State University of New York , Stony Brook<br>Stony Brook, NY 11794-5000<br>U.S.A. |
| WHOI | Woods Hole Oceanographic Institution<br>Woods Hole, MA 02543<br>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 $^3$He 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. $^3$He 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. $^3$He 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 Quarternary which will be achieved using a combination of oxygen-isotope-, bio- and magneto-stratigraphy.

### 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, plantonic 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 $CO_2$ 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 ($CO_2$) 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 $CO_2$ 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 $CO_2$ balance.

The scientific basis of the activities of the American $CO_2$ 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 $CO_2$ content (TC $O_2$), $CO_2$ partial pressure ($pCO_2$) 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. Brügge 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 howls. 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 remainding 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 ($DBK_1$). 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 ($DBK_2$) 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, $DBK_2$) 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 extention 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 then 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 profil (PARASOUND, multicorer, gravity corer) east of the Rio Grande Rise (Stat. 98 - 105). In the CTD data we detected a northward bottom current labelled 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 $CO_2$. The complete series included sampling of the following properties: Freons, $CCl_4$, He, $O_2$, $CO_2$, Tritium, DMS, nutrients, and salinity. The minimum sampling included $O_2$, 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°40S, 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°04.5E. 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°30S, 90°00E 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 l-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 Autosal 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 overto 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:

$$Pcor = A*PCTD + B,$$

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 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 electrial 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):

$$O2 = A*(OC + B\ dOC/dt + c)* Osat(T,S) * exp(D*T + E*(OT-T) + F*P)$$

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 dependend 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 undoubtably 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 nm 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 MKIIIB 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 reqirements 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 sepererate 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 reformated 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 formationregions 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 then 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 easternside 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 $CCl_4$, F113 and $CO_2$ 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 $O_2$ 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 $^{3}$He and changes the $^{3}$He /$^{4}$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 comparision 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 inalienable 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 harddisks 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 (Vp), water content, porosity, corbon 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 carbonrich sediment. Some sediment basins with good reflecting layers could be filled with turbidites form 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 hemispelagic 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 measurment 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 empoyed at 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 empolyed 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 realiable 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 retrival 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 $cm^2$ surface sediment for magnetic investigation
- 20 $cm^2$ surface sediment for clay-mineral analysis
- 10 $cm^2$ surface sediment for Be/Th analysis
- 1 syringe sample (10 $cm^3$) surface sample for faunal analysis (0-1 cm)
- 240 $cm^2$ for investigation of the distribution of bethic foraminifera, preserving with ethanol and dying with Rose Bengal (in 1 cm layers from 0-10 cm, 12 - 13 cm and 15 - 16 cm.
- 80 - 160 $cm^2$ for radiolarian investigations (0 - 1 cm) preserving with methanol

25 $cm^2$ for diatom investigation (0 - 1 cm)

2 series of syringe samples of 10 $cm^3$ 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 $^{13}C$ 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 $^{13}C/^{12}C$ 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 $HgCl_2$ solution, and the screw-on tops sealed airtight with liquid wax. Until further work on the samples in the laboratory - extraction and cleaning the $CO_2$ 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, occured 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 $m^2$) coincided with the subtropical high-pressure-zone.

*Holofaunistic*

From an overall spectrum of 71 fish taxa and 3 Gammaridea, new or some conspiuous taxa have already been mentioned. The two other Gammaridea belong to the family Pardaliscidae 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 Alepisauroidei) 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, Dactylopterus volitans,<br>Balistidae, Makaira nigricans,<br>Coryphaena hippurus |
| Distant-neritic complex: | Clupeoidei, Maurolicus muelleri,<br>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: | Exoceotus volitans, E. obtusirostris, Lepidophanes spp. |
| Subtropical convergence: | Gonichthys barnesi, H. hanseni, 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 $m^2$ (NEU) or 2.0 - 95.3 specimens/1 $m^2$ (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 $m^2$. 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 $m^2$ (NEU) or 5.0 - 12.9 spec./1 $m^2$ (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 $m^2$ and only 40.9% Myctophidae, MCN sta. 100 showed 38.0 fish/1 $m^2$ 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 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 neritical 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 $CO_2$ 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 $CO_2$ 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-$CO_2$ group. The primary goal during this cruise was to collect a high quality data set for the parameters Ct (total dissolved inorganic carbon) and $pCO_2$ (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 $CO_2$ 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 $pCO_2$, 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

*$CO_2$*

The Ct analyses were performed using an automated, dynamic headspace, coulometric $CO_2$ 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 $pCO_2$ 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 $CO_2$ program, Secchi disk readings were performed in order to provide an estimate of depth-integrated biomass.

*Tracers*

In conjunction with the $CO_2$ program, our group made exploratory measurements of a suite of transient halocarbon tracers: notably F113 ($CCl_2FCClF2$) and $CCl_4$. 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

*$CO_2$*

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 $pCO_2$ data were collected from approximately 18 depths per $CO_2$ 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 $pCO_2$ 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) $CCl_4$/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) $CCl_4$/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. CH3I).

## 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 dimethylsufilde (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 $cm^{-3}$ in the east. Carbon values were usually as low as 1 - 5 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 μm. 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 μm 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 $CO_2$ 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, incontrast, 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 | $MO_2/cm^3dm^{-3}$ | 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 sporadicly 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) andVII (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 Breite | Position Länge | Tiefe 1500 m/s | Arbeiten Bemerkungen | | |
|---|---|---|---|---|---|---|---|---|---|
| 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 Breite | Position Länge | Tiefe 1500 m/s | Arbeiten 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 | | 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 Breite | Position Länge | Tiefe 1500 m/s | Arbeiten Bemerkungen | | |
|---|---|---|---|---|---|---|---|---|---|
| 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 Breite | Position Länge | Tiefe 1500 m/s | Arbeiten Bemerkungen | |
|---|---|---|---|---|---|---|---|---|
| 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 |

| EXPOCODE | 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 |

| EXPOCODE | 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 |

| EXPOCODE | 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 |

| EXPOCODE | WHP -ID | STN NBR | CAST NO | TYPE | DATE | TIME | CODE | LATIUDE | LONGITUDE | 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.<br>XCP# | Datum<br>Date | Zeit<br>Time UTC | Breite<br>Latitude | Länge<br>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<br>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<br>6 ACM | 15172 | 27030 |
| 16 | DB1 | WHOI 906 | 4.Jan. | 11.57 | 28S28,00 | 44W27,80 | 3633 | 5 VACM<br>1 XP | 5365 | 26995 |
| 20 | DB2 | WHOI 907 | 5.Jan. | 12.05 | 29S02,60 | 43W29,00 | 3953 | 5 VACM<br>1 XP | 5362 | 26995 |
| 24 | DB3 | WHOI 908 | 6.Jan. | 10.25 | 29S32,00 | 42W42,15 | 4017 | 2 VACM<br>1 XP | - | 26995 |
| 28 | DB4 | WHOI 909 | 7.Jan. | 11.45 | 30S05,20 | 41W44,20 | 3798 | 5 VACM<br>1 XP | 5360 | 26995 |
| 32 | DB5 | WHOI 910 | 8.Jan. | 9.26 | 30S35,30 | 40W47,30 | 3720 | 2 VACM<br>1 XP | - | 26995 |
| 36 | VM | IfM 336 | 9.Jan. | 11.26 | 31S12,30 | 39W46,00 | 3965 | 5 ACM | - | 27040<br>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 Staion list Geosciences University of Bremen

| GeoB-Nr./no. | METEOR Nr./no. | Datum date | Gerät instrument | Zeit time | Breite latitude | Länge longitude | Wasser-tiefe 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 |
| 1302-1 | 68/91 | 21.01. | CTD | 03.55 | 27°55.0'S | 38°50.2'W | 4244 | 2. Probelauf der FS-CTD an der CTD/RO/KIEL |
| 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) |
| 1303-2 | | | SL12 | 12.27 | 30°16.6'S | 35°17.1'W | 1314 | Fehlversuch (umgekippt) |
| 1303-3 | | | SL12 | 13.17 | 30°16.7'S | 35°17.3'W | 1312 | Fehlversuch (umgekippt) |
| 1303-4 | | | SL6 | 14.23 | 30°16.7'S | 35°17.3'W | 1313 | Fehlversuch (umgekippt) |
| 1304-1 | 78/91 | 24.01. | SL6 | 23.28 | 31°00.0'S | 34°00.0'W | 940 | Fehlversuch (umgekippt) |
| 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) |
| 1306-2 | | | SL12 | 12.28 | 35°12.4'S | 26°45.8'W | 4058 | 6,97 m Kerngewinn |
| 1306-2 | | | RO | 14.15 | 35°12.2'S | 26°45.5'W | 4056 | 20 Wasssrproben à 250 ml für Delta 13C |

| GeoB-Nr./no. | METEOR Nr./no. | Datum date | Gerät instrument | Zeit time | Breite latitude | Länge longitude | Wasser-tiefe 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 |
| 1307-2 | | | MC | 04.36 | 33°36.1'S | 27°39.9'W | 4006 | Gewinn 10/10 Rohren (Kerngewinn 33 cm) |
| 1307-3 | | | RO | 05.50 | 33°36.2'S | 27°40.0'W | 4051 | 20 Wasserproben à 250 ml für Delta 13C |
| 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) |
| 1308-2 | | | SL12 | 16.40 | 32°47.1'S | 27°45.0'W | 3613 | Kerngewinn 3,44 m |
| 1309-1 | 98/91 | 31.01. | RO | 03.25 | 31°40.0'S | 28°40.0'W | 3961 | 20 Wasserproben à 250 ml für Dslta 13C |
| 1309-2 | | | SL12 | 07.45 | 31°40.0'S | 28°40.0'W | 3963 | Kerngewinn 9,48 m |
| 1309-3 | | | MC | 09.57 | 31°40.0'S | 28°39.9'W | 3963 | Gewinn 9/10 Rohren (Kerngewinn 27 cm) |
| 1310-1 | 100/91 | 31.01. | MC | 17.06 | 31°35.3'S | 28°54.2'W | 3346 | Gawinn 8/10 Rohren (Kerngewinn 14 cm) |
| 1310-2 | | | SL12 | 19.32 | 31°35.3'S | 28°54.1'W | 3348 | Kerngewinn 5,35 m |
| 1311-1 | 101/91 | 01.02. | SL12 | 01.04 | 31°30.7'S | 29°05.9'W | 2901 | Kerngewinn 7,42 m |
| 1311-2 | | | MC | 03.14 | 31°30.8'S | 29°05.9'W | 2899 | Gewinn 10/10 (Kerngewinn 15cm) |
| 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) |
| 1312-2 | | | SL12 | 13.30 | 31°39.7'S | 29°39.4'W | 3436 | Kerngewinn 4,13 m |
| 1312-3 | | | MC | 15.30 | 31°39.7'S | 29°39.4'W | 3436 | Gewinn 5/10 Rohren (Kerngewinn 7 cm) |

| GeoB-Nr./no. | METEOR Nr./no. | Datum date | Gerät instrument | Zeit time | Breite latitude | Länge longitude | Wasser-tiefe 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 á 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.0. (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 $\delta^{13}C$-Bestimmungen

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

| 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 $\delta^{13}C$ -Bestimmungen

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

| GeoB-Nr./no. | METEOR Nr./no. | Pr. Nr. no. | RO Nr. no. | Druck pressure (db) |
|---|---|---|---|---|
| 1306-2 | 88/91 | 21 | 01 | 4068.5 |
| | | 22 | 03 | 3896.8 |
| | | 23 | 04 | 3700.1 |
| | | 24 | 05 | 3498.8 |
| | | 25 | 07 | 2899.6 |
| | | 26 | 08 | 2599.3 |
| | | 27 | 09 | 2296.9 |
| | | 28 | 10 | 2102.3 |
| | | 29 | 11 | 1904.0 |
| | | 30 | 12 | 1704.9 |
| | | 31 | 13 | 1499.9 |
| | | 32 | 15 | 1202.9 |
| | | 33 | 17 | 902.1 |
| | | 34 | 18 | 750.7 |
| | | 35 | 19 | 600.4 |
| | | 36 | 20 | 436.3 |
| | | 37 | 21 | 301.6 |
| | | 38 | 22 | 202.6 |
| | | 39 | 23 | 101.0 |
| | | 40 | 24 | 29.8 |
| 1309-1 | 98/91 | 61 | 01 | 4020.4 |
| | | 62 | 03 | 3694.0 |
| | | 63 | 04 | 3495.9 |
| | | 64 | 05 | 3202.3 |
| | | 65 | 06 | 2901.9 |
| | | 66 | 07 | 2588.3 |
| | | 67 | 08 | 2293.1 |
| | | 68 | 09 | 2101.0 |
| | | 69 | 10 | 1897.9 |
| | | 70 | 11 | 1699.5 |
| | | 71 | 12 | 1499.8 |
| | | 72 | 13 | 1352.3 |
| | | 73 | 14 | 1199.3 |
| | | 74 | 15 | 1049.8 |
| | | 75 | 16 | 900.1 |
| | | 76 | 18 | 599.4 |
| | | 77 | 20 | 299.7 |
| | | 78 | 21 | 199.7 |
| | | 79 | 22 | 99.4 |
| | | 80 | 23 | 24.8 |

| GeoB-Nr./no. | METEOR Nr./no. | Pr. Nr. no. | RO Nr. no. | Druck pressure (db) |
|---|---|---|---|---|
| 1307-3 | 95/91 | 41 | 01 | 4053.0 |
| | | 42 | 02 | 3932.0 |
| | | 43 | 03 | 3698.0 |
| | | 44 | 05 | 3498.0 |
| | | 45 | 06 | 3199.0 |
| | | 46 | 07 | 2996.0 |
| | | 47 | - | |
| | | 48 | 10 | 2099.8 |
| | | 49 | 11 | 1890.0 |
| | | 50 | 12 | 1699.8 |
| | | 51 | 13 | 1499.6 |
| | | 52 | 15 | 1199.9 |
| | | 53 | 17 | 900.6 |
| | | 54 | 18 | 749.0 |
| | | 55 | - | |
| | | 56 | 20 | 449.9 |
| | | 57 | 21 | 300.1 |
| | | 58 | 22 | 199.4 |
| | | 59 | 23 | 99.6 |
| | | 60 | 24 | 33.0 |
| 1314-3 | 105/91 | 81 | 01 | 4088.9 |
| | | 82 | 03 | 3900.0 |
| | | 83 | 04 | 3648.3 |
| | | 84 | 05 | 3403.2 |
| | | 85 | 06 | 3150.6 |
| | | 86 | 07 | 2897.6 |
| | | 87 | 08 | 2600.4 |
| | | 88 | 09 | 2298.5 |
| | | 89 | 10 | 1998.7 |
| | | 90 | 12 | 1649.0 |
| | | 91 | 14 | 1247.4 |
| | | 92 | 15 | 1001.3 |
| | | 93 | 17 | 729.5 |
| | | 94 | 18 | 648.0 |
| | | 95 | 19 | 550.8 |
| | | 96 | 20 | 400.0 |
| | | 97 | 21 | 198.4 |
| | | 98 | 22 | 148.5 |
| | | 99 | 23 | 79.9 |
| | | 100 | 24 | 29.4 |

| GeoB-<br>Nr./no. | METEOR<br>Nr./no. | Pr.<br>Nr.<br>no. | RO<br>Nr.<br>no. | Druck<br>pressure<br>(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

The project was funded by the Deutsche Forschungsgemeinschaft (DFG) and the Federal Ministry of Science and Technology (BMFT) in Germany. It was part of a cooperative research program of scientific groups in Germany, the U.S.A. and Brazil. The support of the funding agencies and the assistance of the Brazilian government is hereby acknowledged.

## 8 References

ANDRES, H.-G. and H.-Ch. JOHN (1984): Results of some neuston net catches in the warmer Central North Atlantic-Fish larvae and selected invertebrates. Meeresforsch. **30**(3), 144-154.

BACKUS, R.H., J.E. CRADDOCK, R.L. HAEDRICH and B.H. ROBISON (1977): Atlantic mesopelagic zoogeography. In: Fishes of the Western North Atlantic. Mem. Sears. Fdn. Mar. Res. **1**(7), 266-287.

BARNARD, J.L. and J.D. THOMAS (1989): Four species of Synopiidae from the Caribbean region (Crustacea: Amphipoda). Proc. Biol. Soc. Wash., **102** (2), 362-374.

BÖHNECKE, G. (1936): Temperatur, Salzgehalt und Dichte an der Oberfläche des Atlantischen Ozeans. Wiss. Ergebn. dt. atlant. Exped. "Meteor" 1925-1927, **5**, 1-249.

CARPENTER, J.H. (1967): New measurements of oxygen solubility in pure and natural water. Limnol. and oceanogr., **11**, 264-277.

CHENG, L. and M. SCHULZ-BALDES (1981): Frequency and population composition of Halobates micans (Heteroptera: Gerridae) from the Central and South Atlantic Ocean. ("Meteor" Forsch.-Ergebn., **D 33**, 17-21.

GERLACH, S.A. (1981): Marine pollution. Springer Verlag, Berlin, Heidelberg, New York, 218 pp.

GRASSHOFF, K. (1976): Methods of Seawater Analysis. Verlag Chemie Weinheim, New York, 317 pp.

HENTSCHEL, E. (1933): Allgemeine Biologie des südatlantischen Ozeans. I. Das Pelagial der obersten Wasserschicht. Wiss. Ergebn. dt. atlant. Exped. "Meteor" 1925-1927, **11**, 1-168.

HENTSCHEL, E. (1944): Das Leben im atlantischen Ozean. In: SCHOTT, G.: Geographie des atlantischen Ozeans. Boysen Verlag, Hamburg, 332-361.

HOGG, N.G., P. BISCAYE, W. GARDNER and W.J. SCHMITZ, Jr. (1982):On the transport and modification of Antarctic Bottom Water in the Vema Channel. Jour. Mar. Res., **40**, 231-263.

HULLEY, P.A. (1981): Results of the research cruises of FRV "Walther Herwig" to South America. LVIII. Family Myctophidae (Osteichthyes, Myctophiformes). Arch. Fisch. Wiss., **31** (1), 1-300.

JOHN, H.-Ch. (1975): Untersuchungen am oberflächennahen Ichthyoplankton des mittleren und südlichen Atlantischen Ozeans. Diss. Fachber. Math.- Naturwiss., Kiel; 186 S.

JOHN, H.-Ch. (1983): Quantitative distribution of fry of beloniform fishes in the Atlantic Ocean. - "Meteor"-Forsch.-Ergebn., **D 36**, 21-33.

LOEB, V.J. (1979): Larval fishes in the zooplankton community of the North Pacific Central gyre. Mar. Biol., **53**, 173-191.

LOPES, P.C. and H.-Ch. JOHN (1986): Ichthyoplankton at the surfaceof the Equatorial Atlantic. - Bol. Soc. Port. Cienc. Nat., **23**, 83-111.

OWENS W. B. and R.C. MILLARD (1985): A New Algorithm for CTD Oxygen Calibration. Jour. of Phys. Oceanography, **15** (5), 621-631.

PARIN, N.V. (1970): Ichthyofauna of the epipelagic zone. Israel Program for Scientific Translations, Keter Press, Jerusalem, 205 pp.

PETERSON, R.G. and L. STRAMMA (1991): Upper-level circulation in the south Atlantic Ocean. Progr. Oceanogr., **26**, 1-73.

SAVILOV, A.I. (1967): Oceanic insects of the genus Halobates (Hemiptera, Gerridae) in the Pacific. Oceanology, **7**, 252-260.

THEOBALD, N., W. LANGE und E. GRÜN (1987): Erdölkohlenwasserstoffe. In: T.J. Müller, G. Siedler und W. Zenk: Fahrtberichte METEOR Reise Nr. 6, 49-55.

WINKLER, L. W. (1888): Ber. Dtsch. Chem. Ges., **21**, 2843-2855.

# 9 Figures

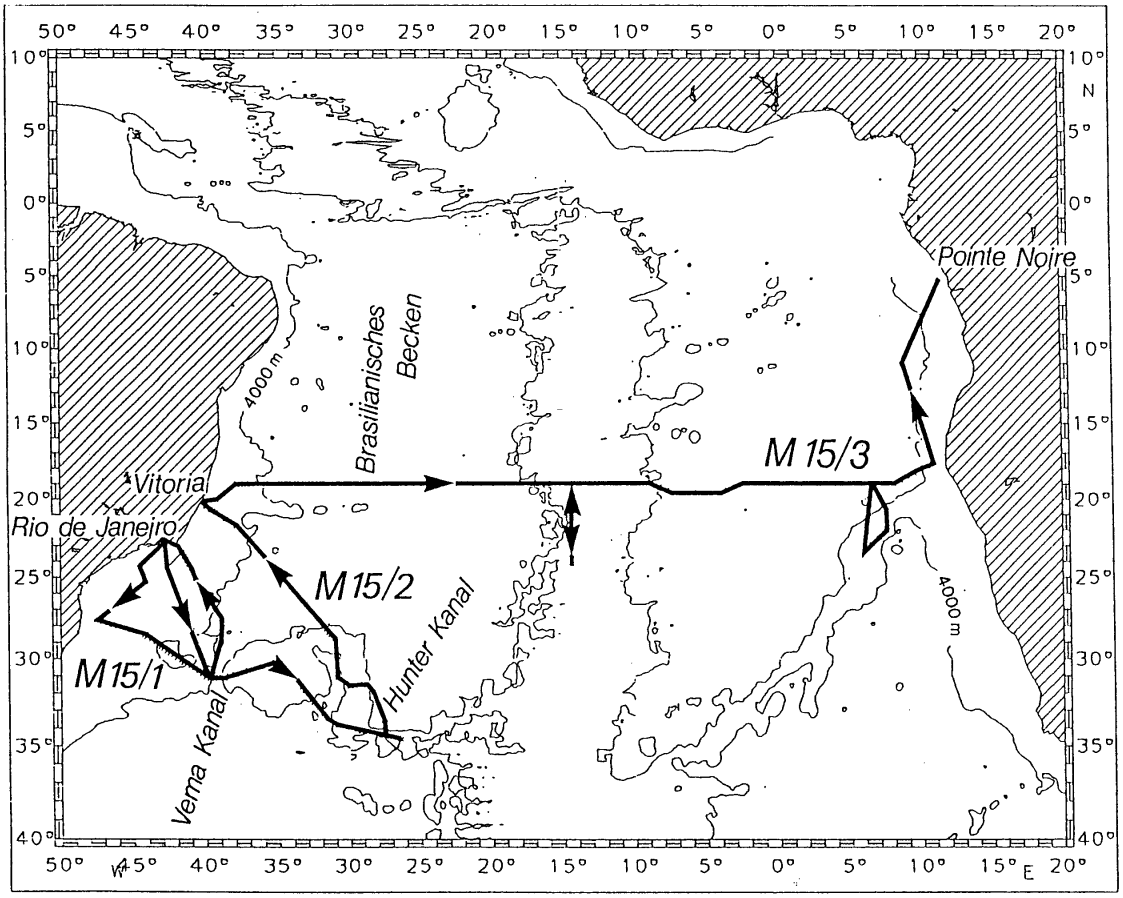



Fig. 1: Track of METEOR Cruise no.15.

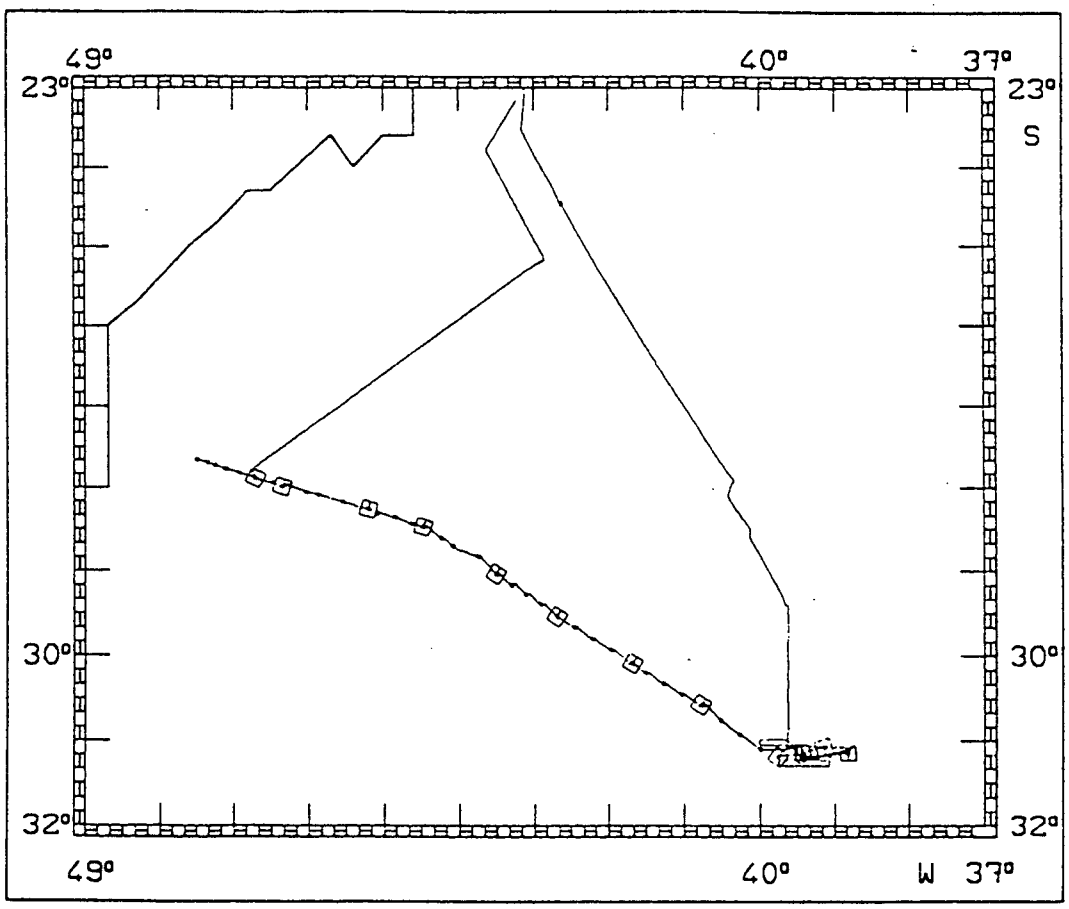



Fig. 2a: M 15/1, CTD stations (.) and mooring positions (□).

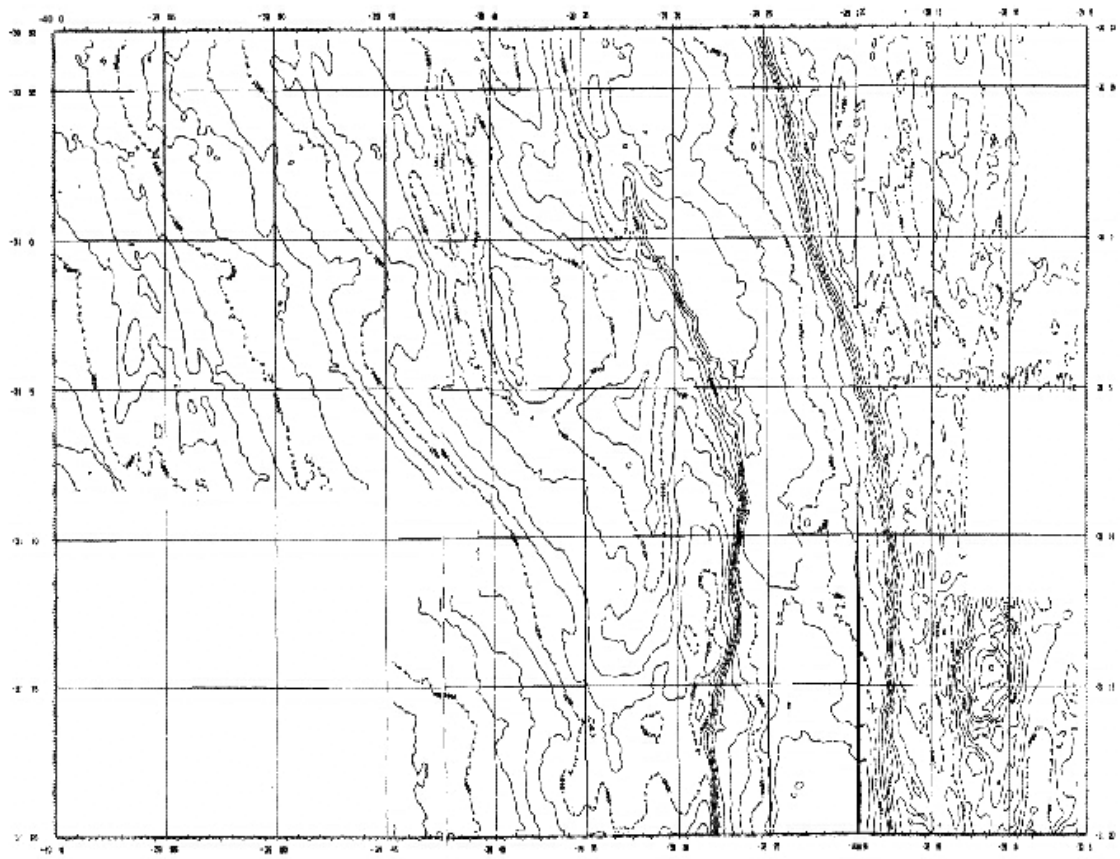


Fig. 2b: Bathymetry of the Vema Channel. Data were analyzed on board.

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**

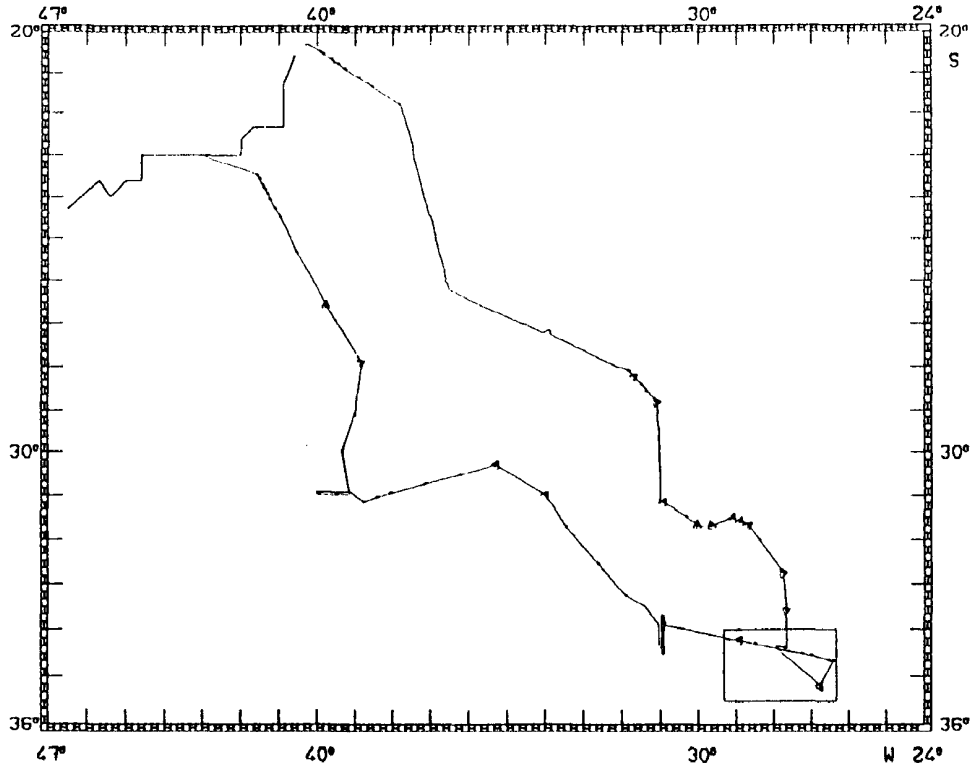



Fig. 3a:M 15/2, Geology and CTD stations.

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

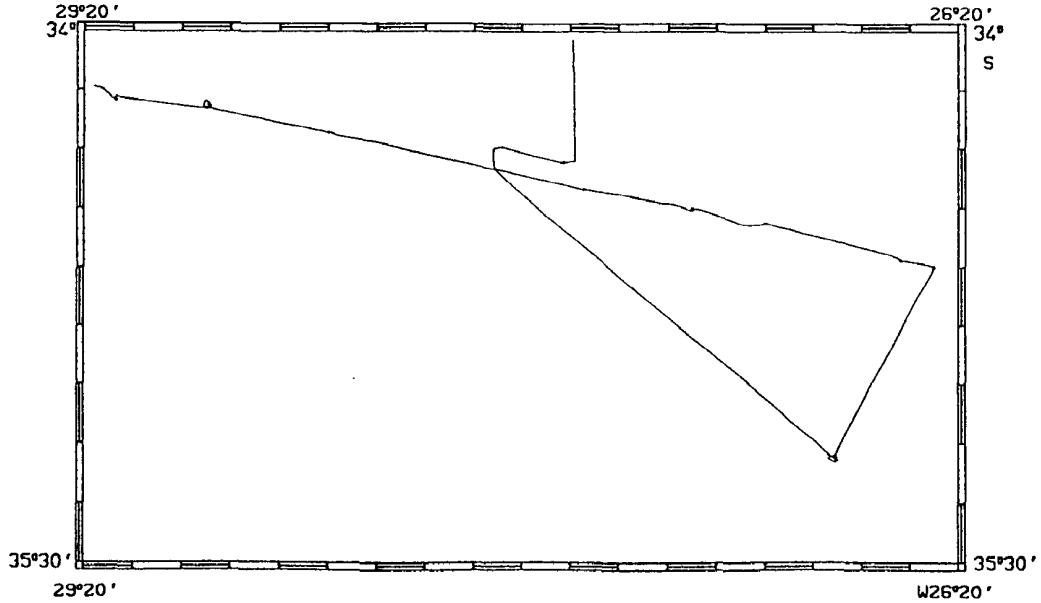



Fig. 3b: M15/2, Geology and CTD stations in Hunter Gap.

METEOR 15/3 + = XBT o = CTD

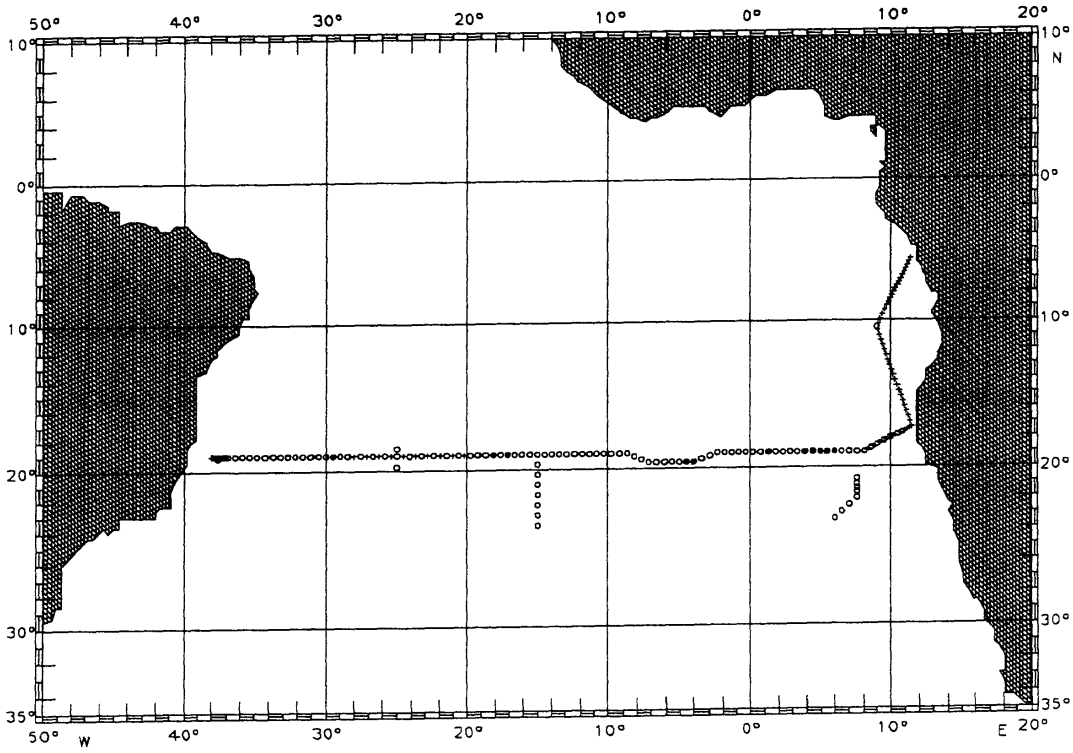



Fig. 4: Stations during leg M 15/3.

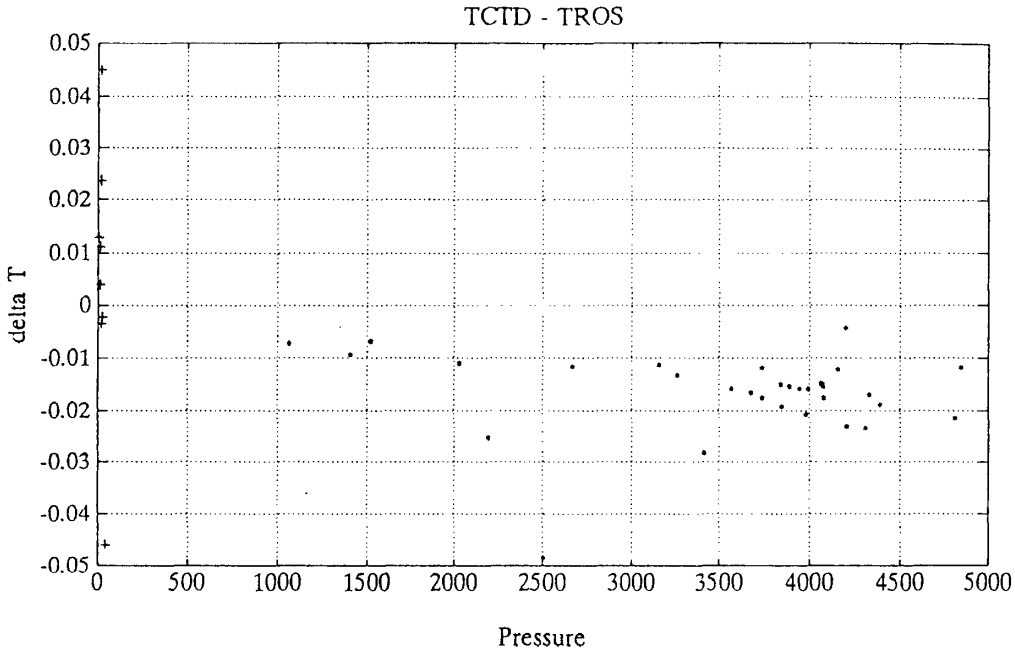



Fig. 5: Temperature difference between CTD and reversing thermometers as a function of pressure (all available samples).

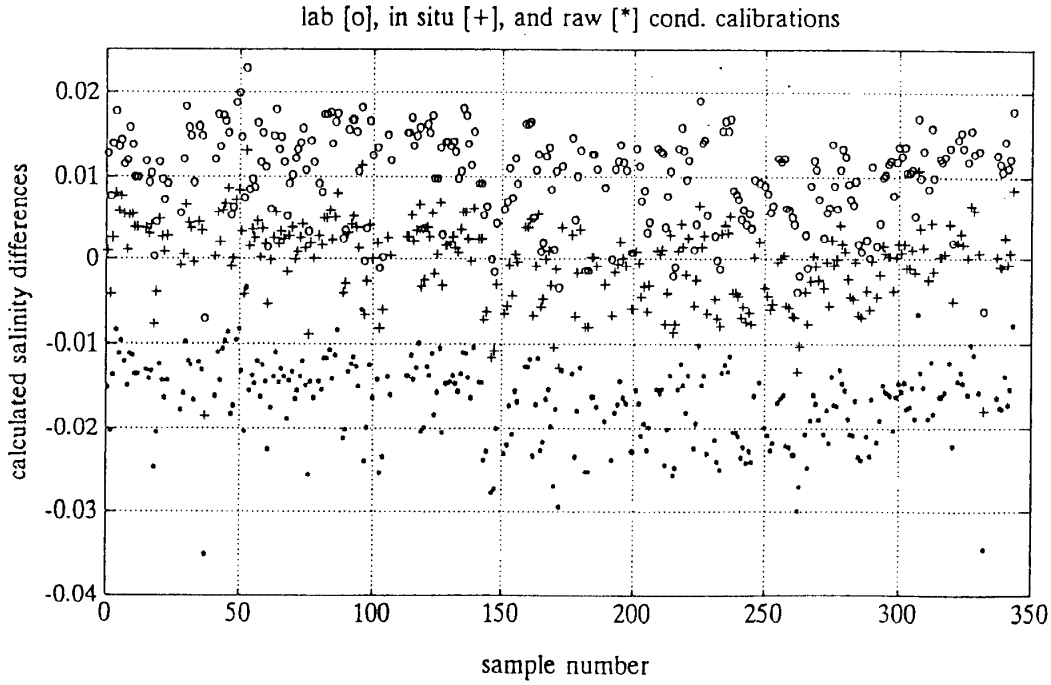



Fig. 6: Salinity differences between rosette and CTD for different conductivity calibrations. "Raw" means no calibration applied, "lab" is laboratory calibration, and "in situ" is the calibration obtained from rosette values.

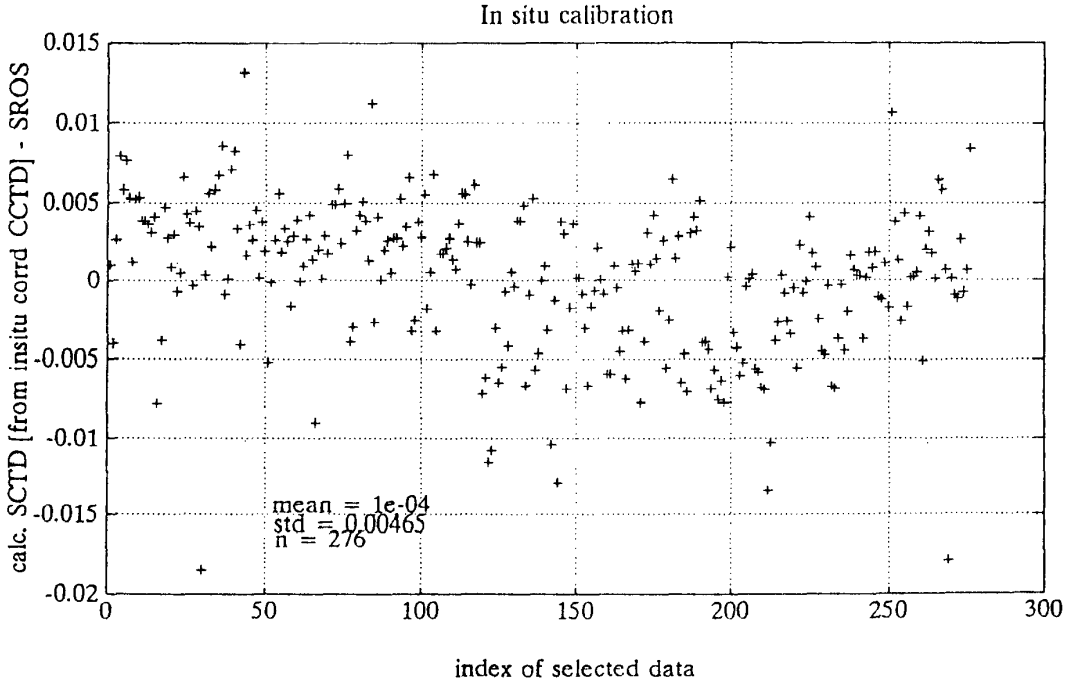



Fig. 7: Same as "in situ" calibration in Figure 6, but after rejecting some data according to the procedure described in the text.

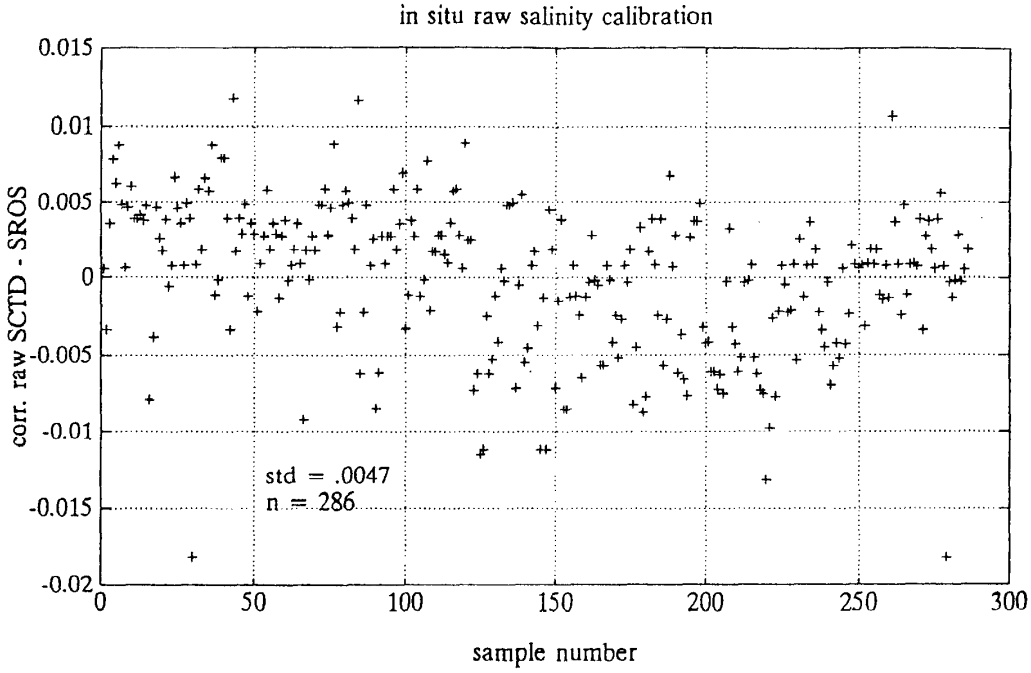



Fig. 8: Salinity differences after calibrating the CTD salinity (not conductivity).

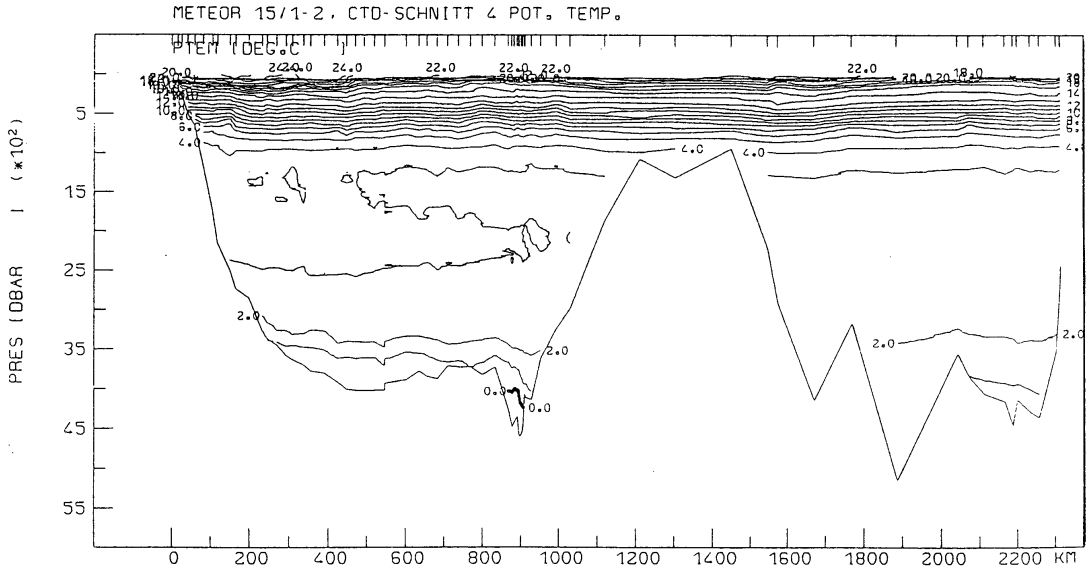



Fig. 9a: Profile of potential temperature (˚C) near 30˚S across the Sao Paulo Plateau, Vema Channel, and Hunter Channel.

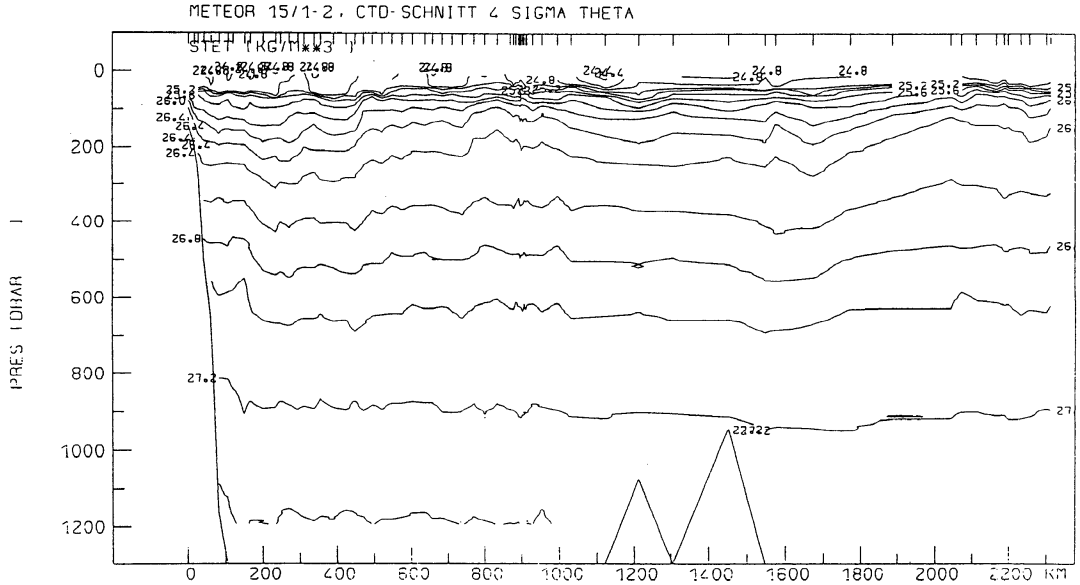



Fig. 9b: Potential density anomaly (kg $m^{-3}$) for the upper 1200 m of the water column. Some isopycnal tilt associated with the Brazil Current is visible at the shallowest stations.

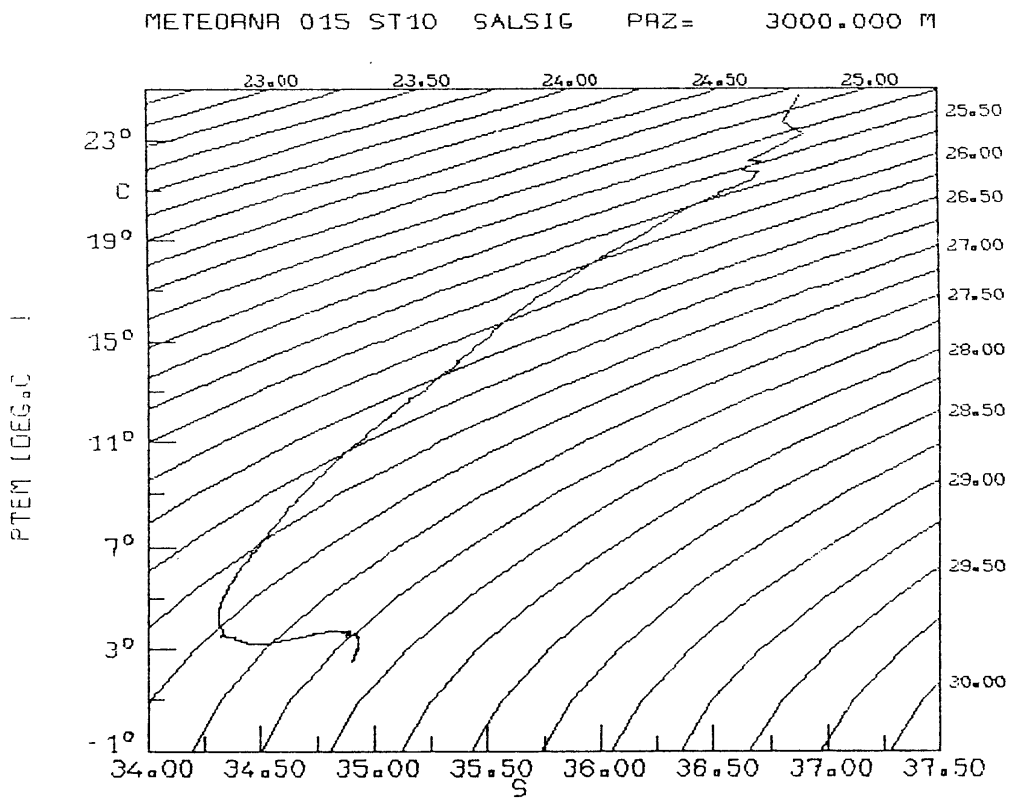



Fig. 10: Potential temperature (˚C) plotted against salinity (psu) for station 10, with potential density anomaly (kg $m^{-3}$) overlain.

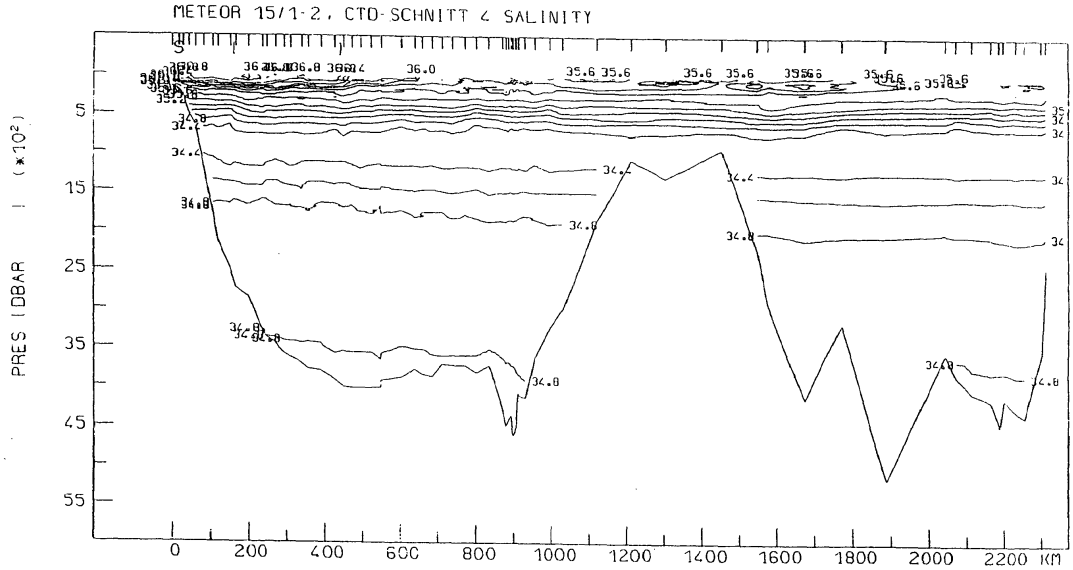



Fig. 11: Profile of salinity (psu), as in Figure 9a. Sub-surface maxima occur especially in the eastern part of the profile near 100m depth and again near 2500 m depth. Intermediate water salinity minimum occurs near 1000 m depth.



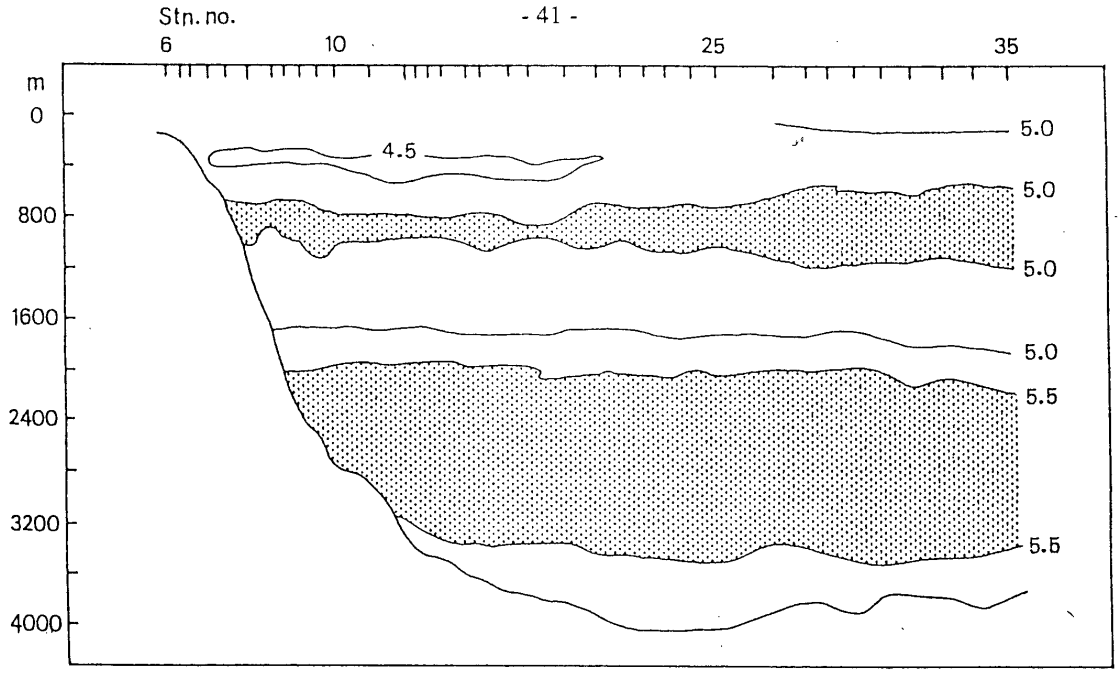



Fig. 12: Profile of oxygen (ml $l^{-1}$), partially calibrated CTD values in the western part of the region (leg 1).

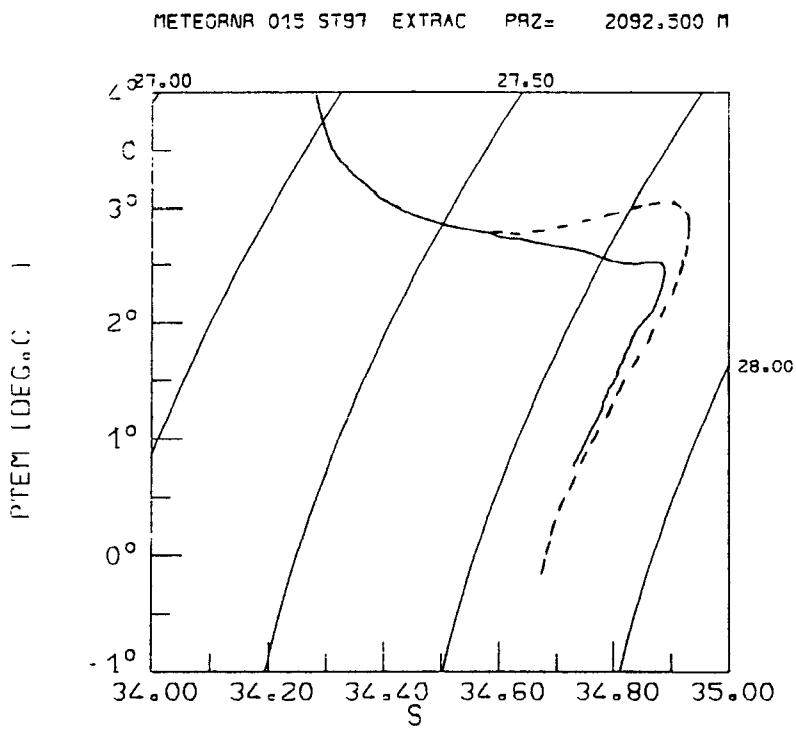



Fig. 13: Potential temperature (˚C) plotted against salinity (psu) for deep water colder than 4˚C. Station 42 in the Vema Channel is shown for comparison (dashed).

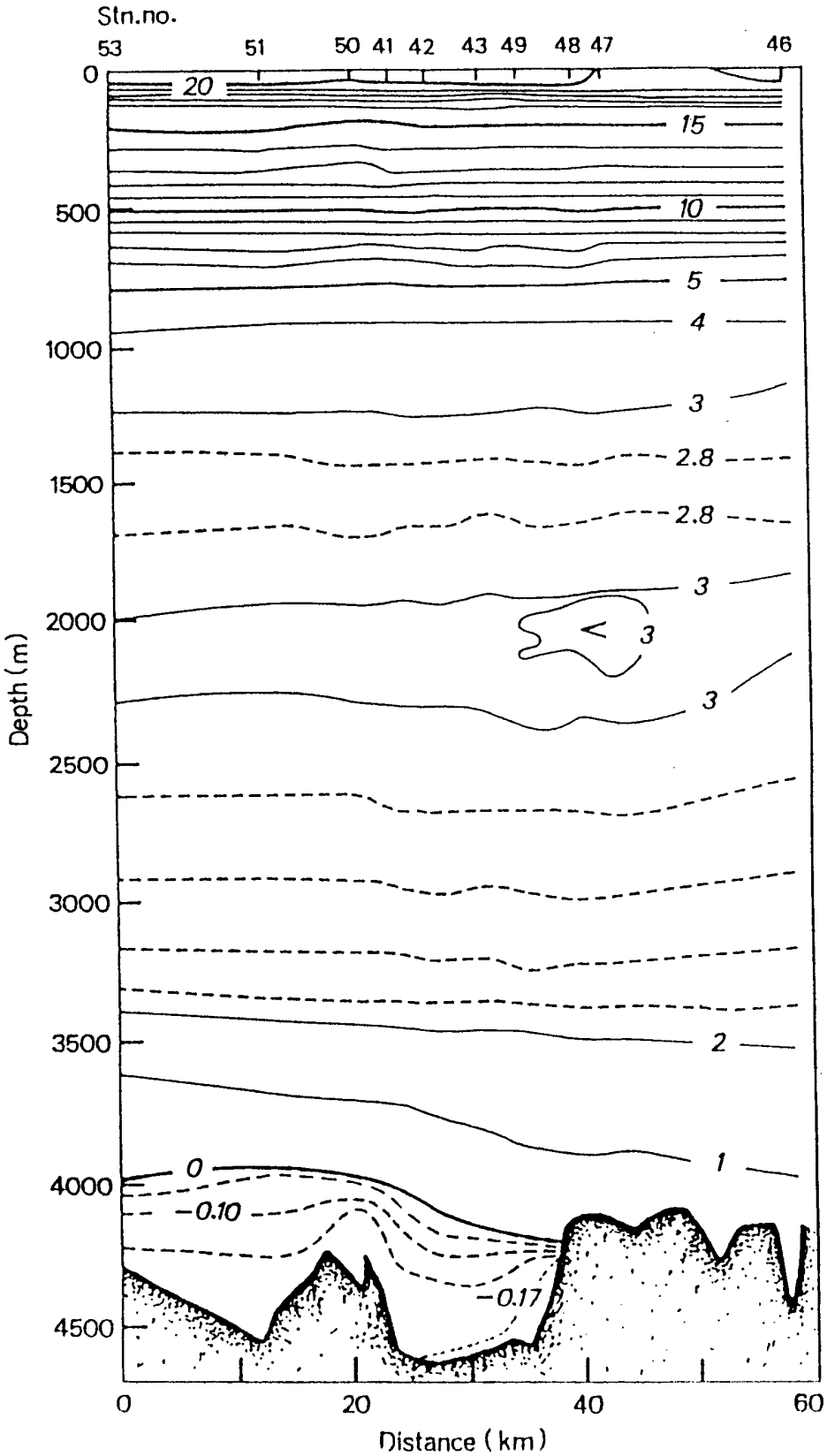



Fig. 14: Profile of potential temperature (˚C) across the Vema Channel.

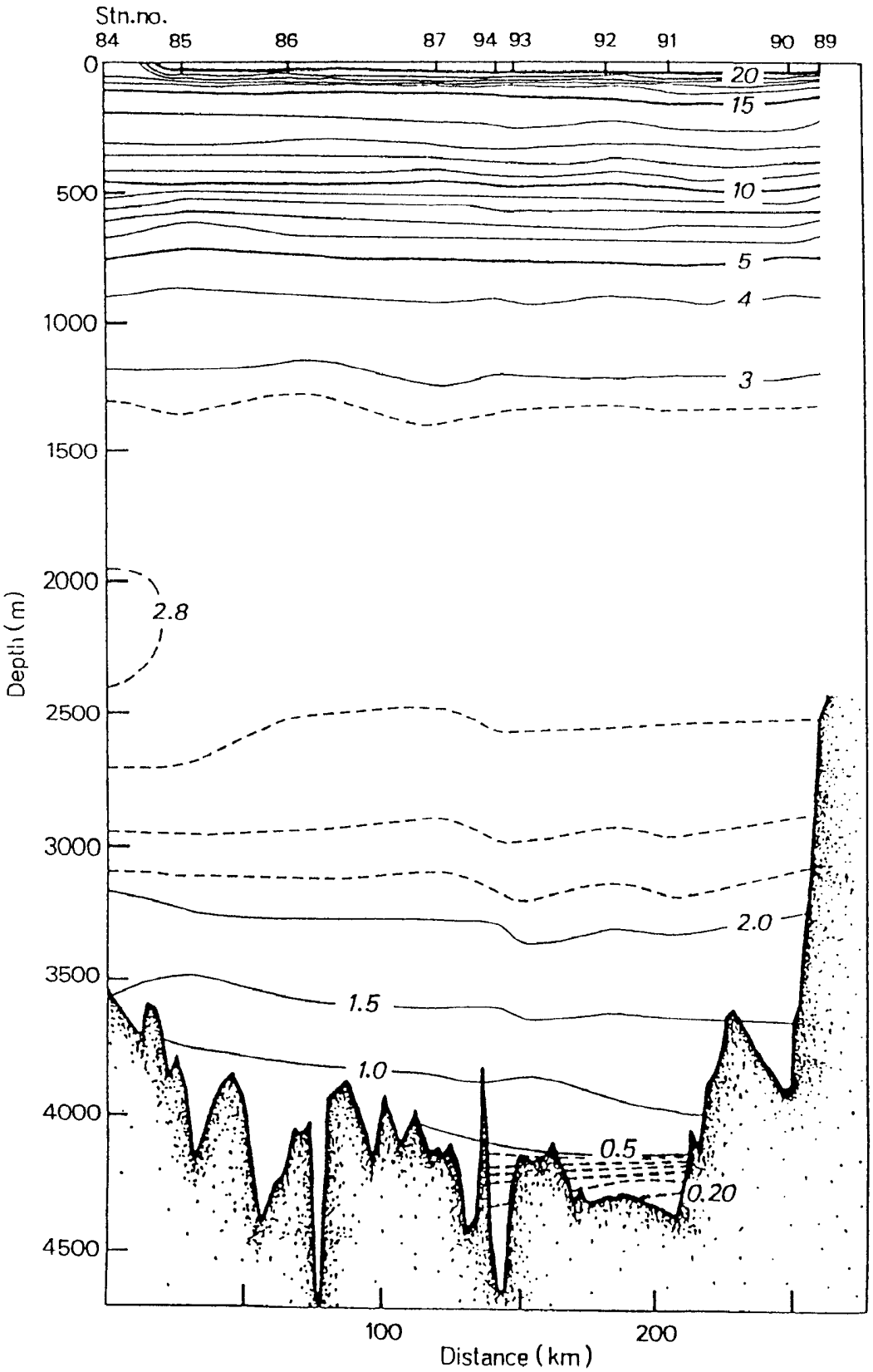



Fig. 15: Profile of potential temperature (˚C) across the Hunter Channel

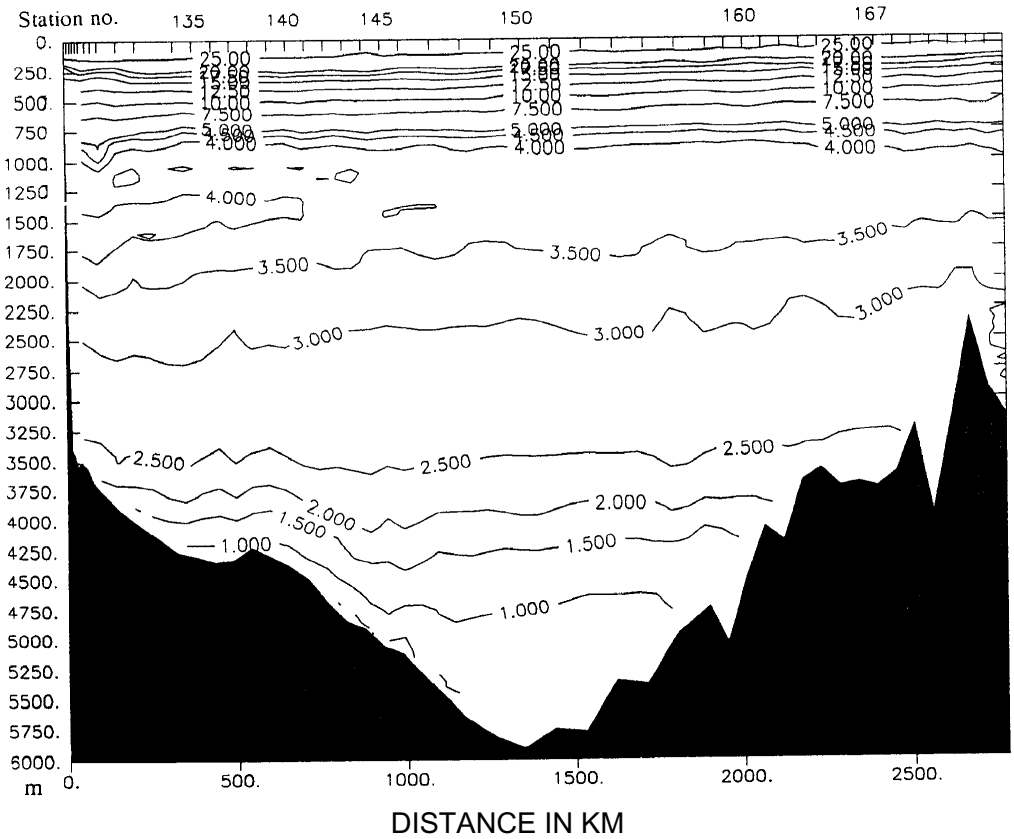



Fig. 16: Potential temperature/ ˚C at 19˚S in the Brazil Basin

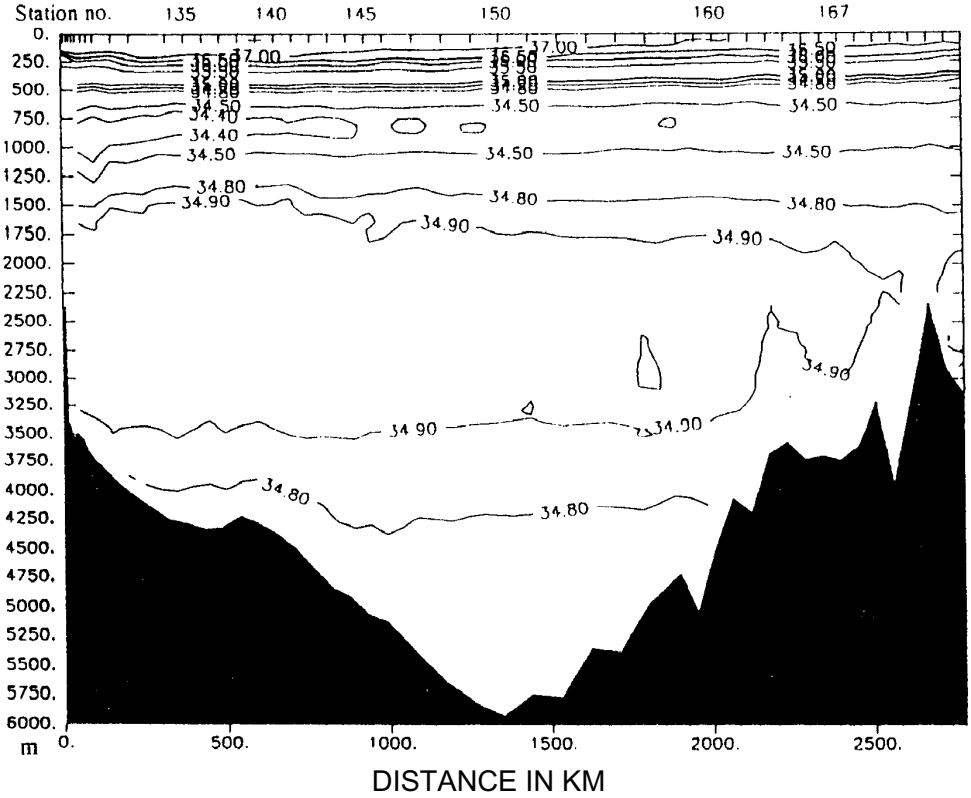



Fig. 17: Salinity/ psu at 19˚S in the Brazil Basin

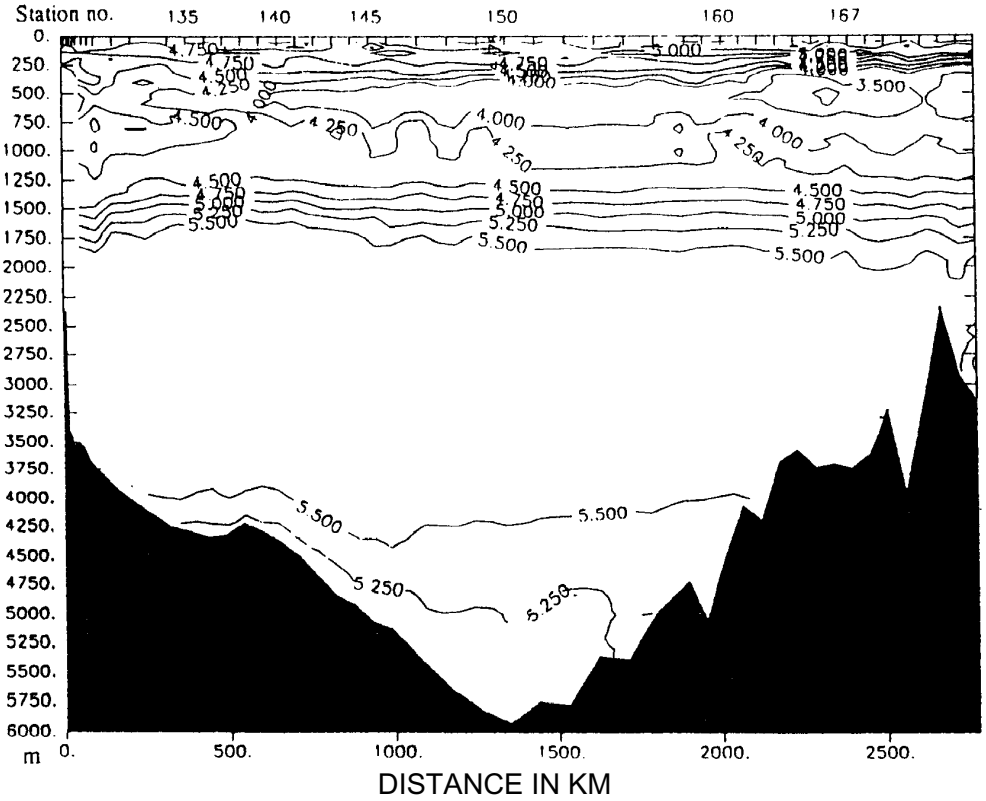



Fig. 18: Oxygen/ ml $l^{-1}$ at 19˚S in the Brazil Basin

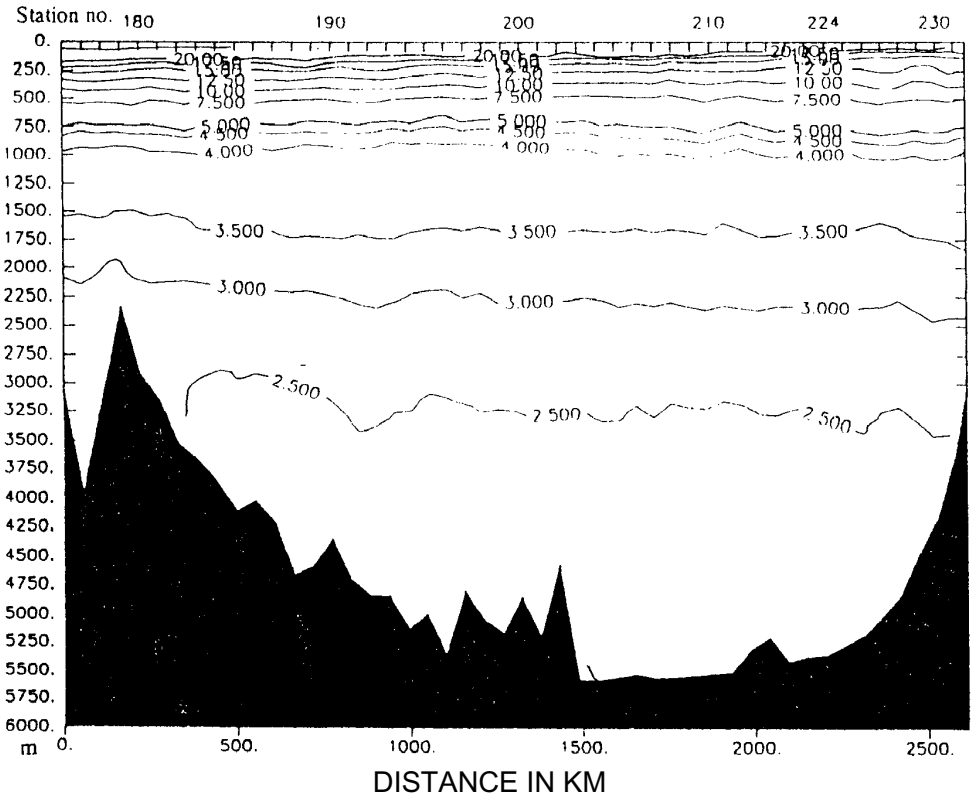



Fig. 19: Potential temperature/ ˚C at 19˚S in the Angola Basin

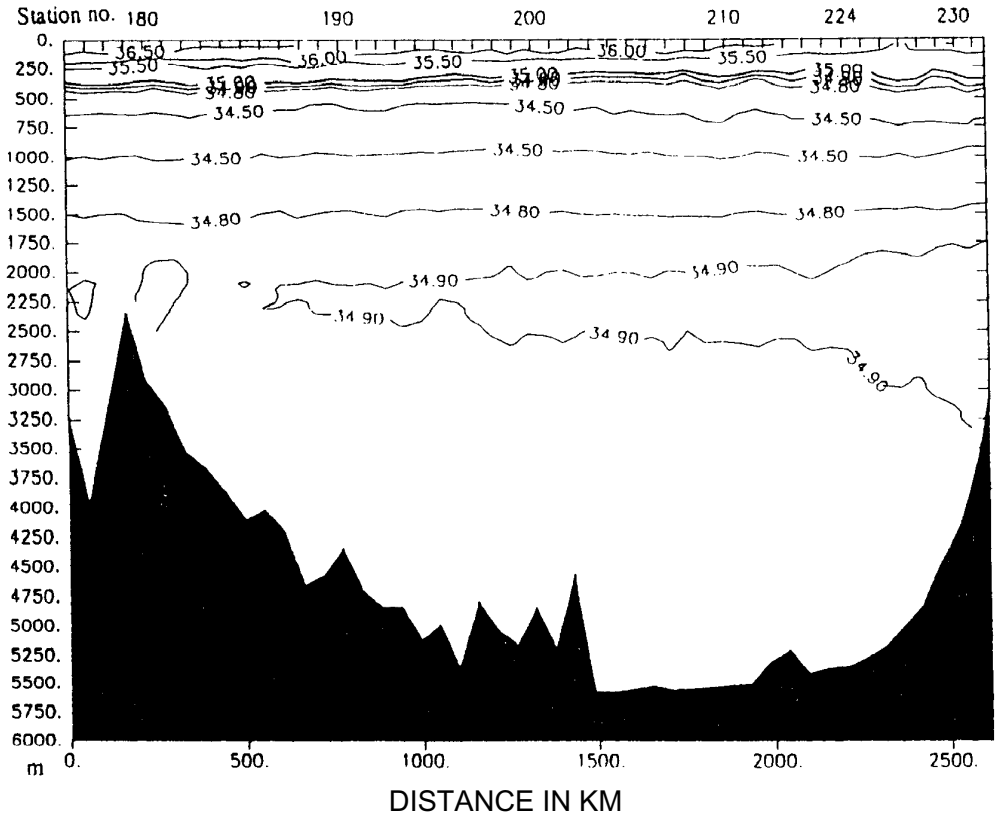



Fig. 20: Salinity/ psu at 19˚S in the Angola Basin

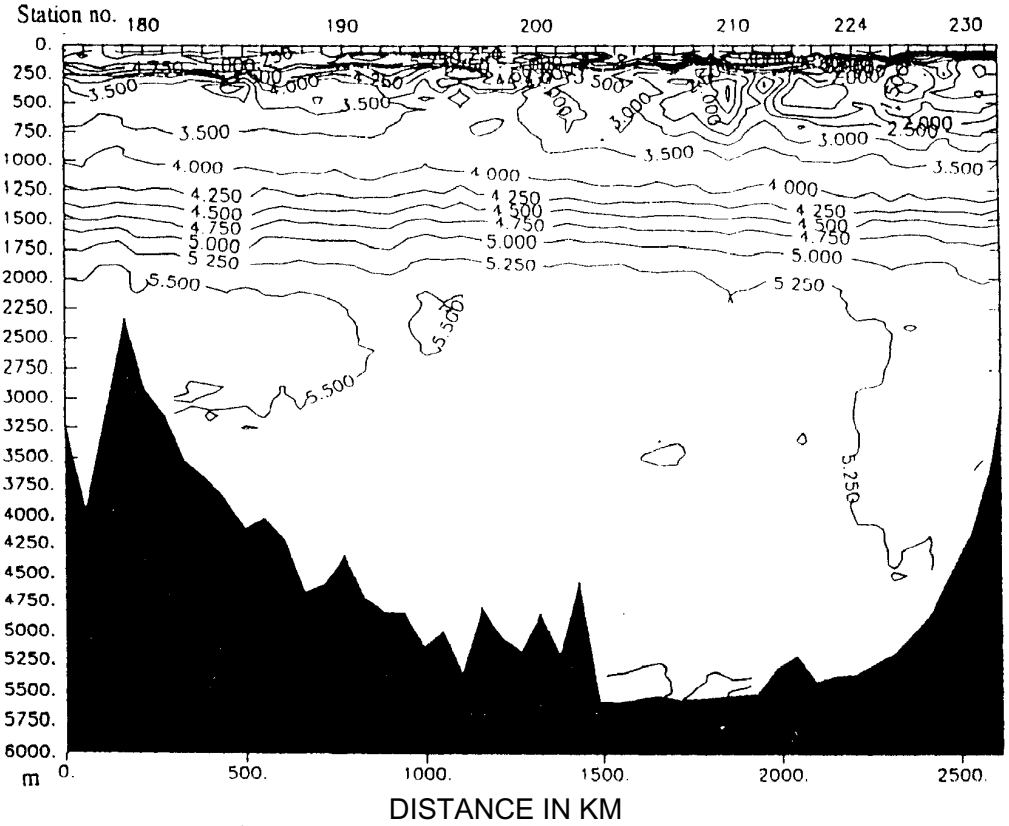



Fig. 21: Oxygen/ ml $l^{-1}$ at 19˚S in the Angola Basin

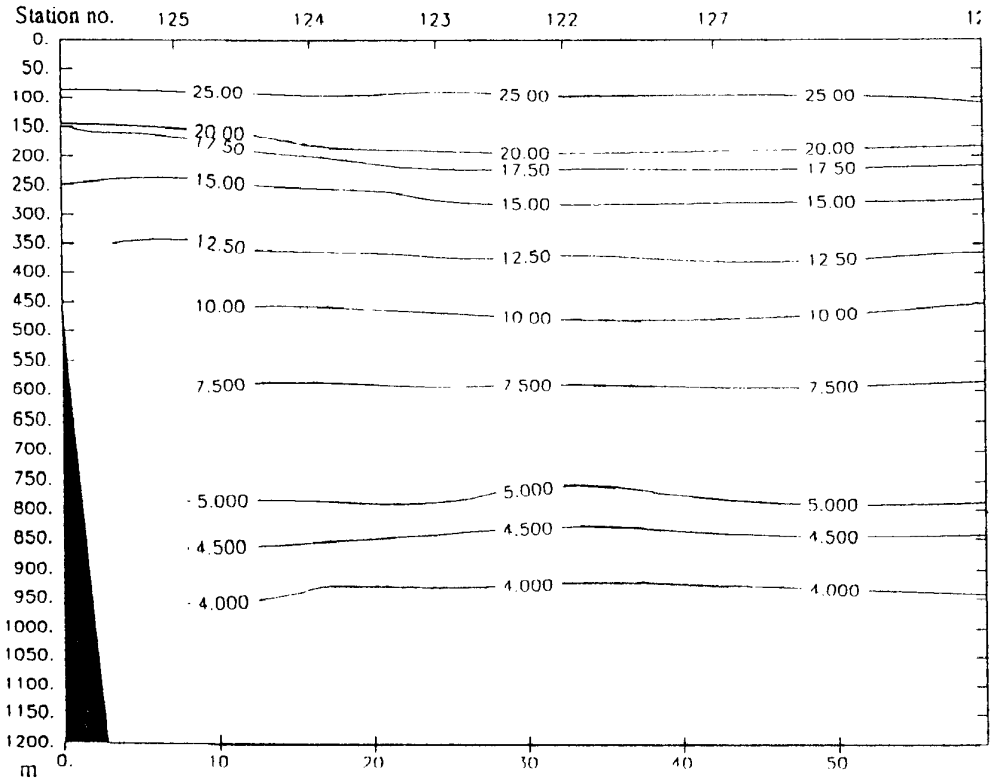



Fig. 22: Potential temperature/ ˚C at 19˚S in the region of the Brazil Current

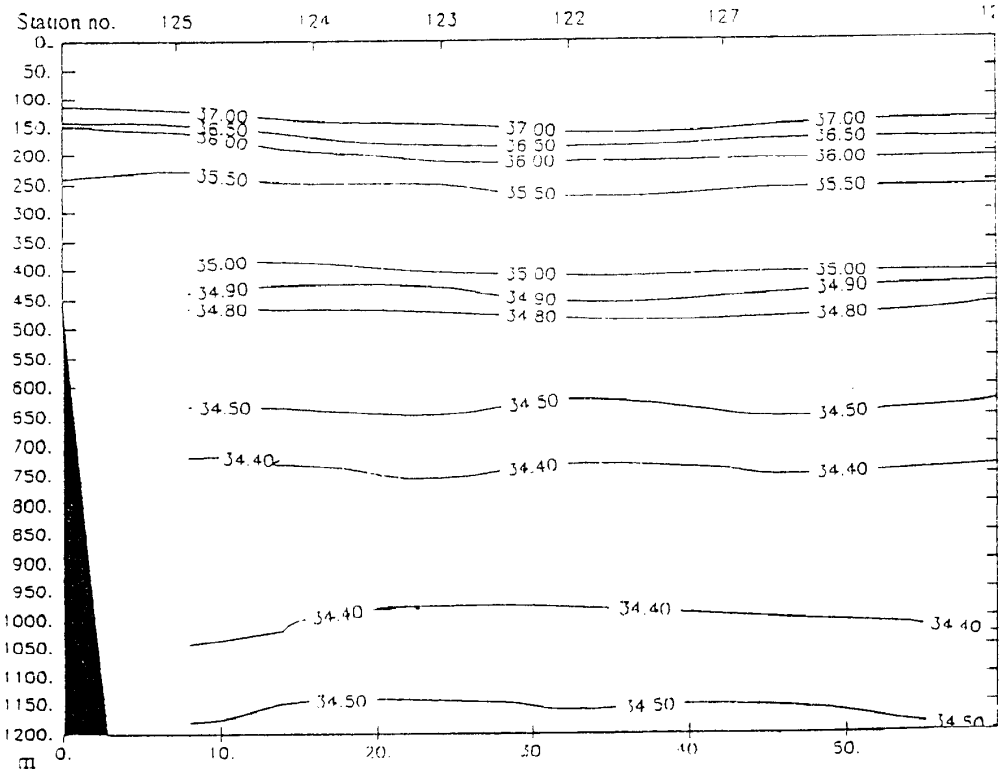



Fig. 23: Salinity/ psu at 19˚S in the region of the Brazil Current

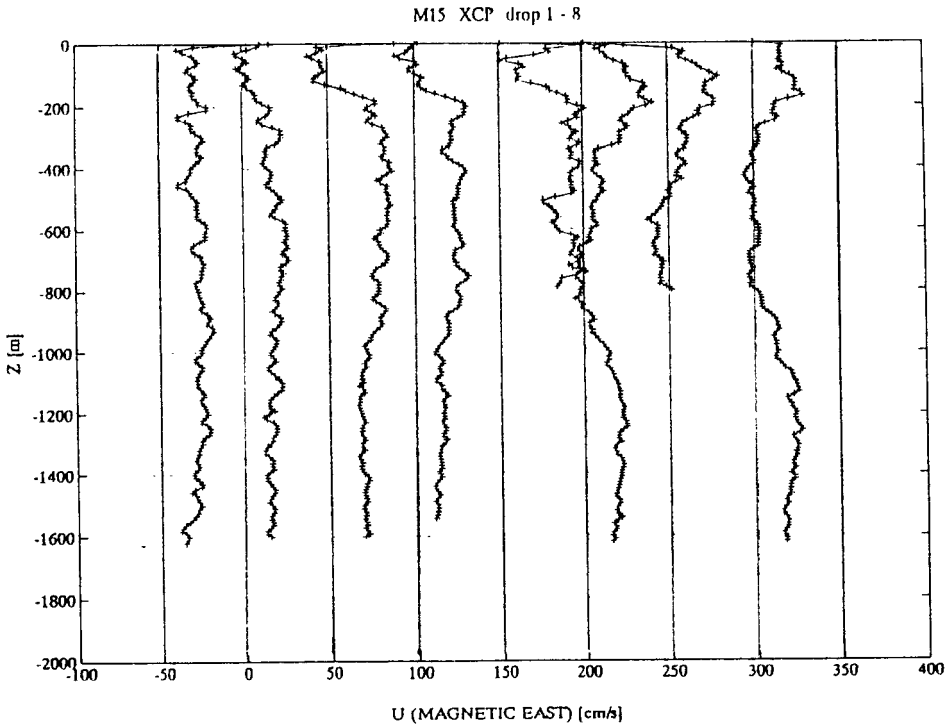



Fig. 24: North-South component (positive: north) of currents in the region of the Brazil Current with unknown offset of the calibration

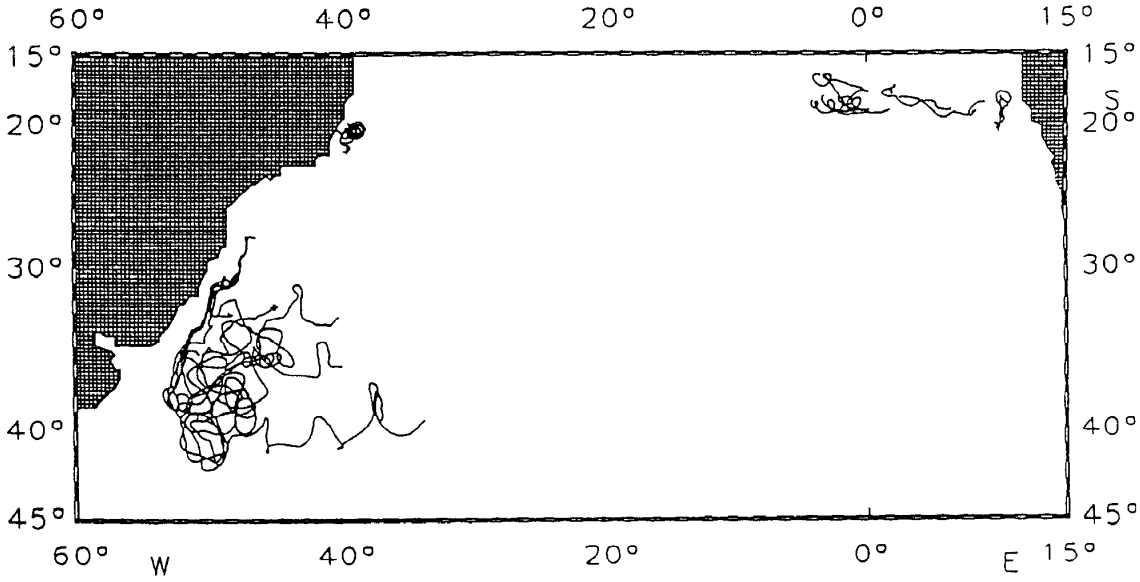



Fig. 25: Trajectories of all surface drifters launched during M 15: December '90 – September '91, drague depth 100m (survey)

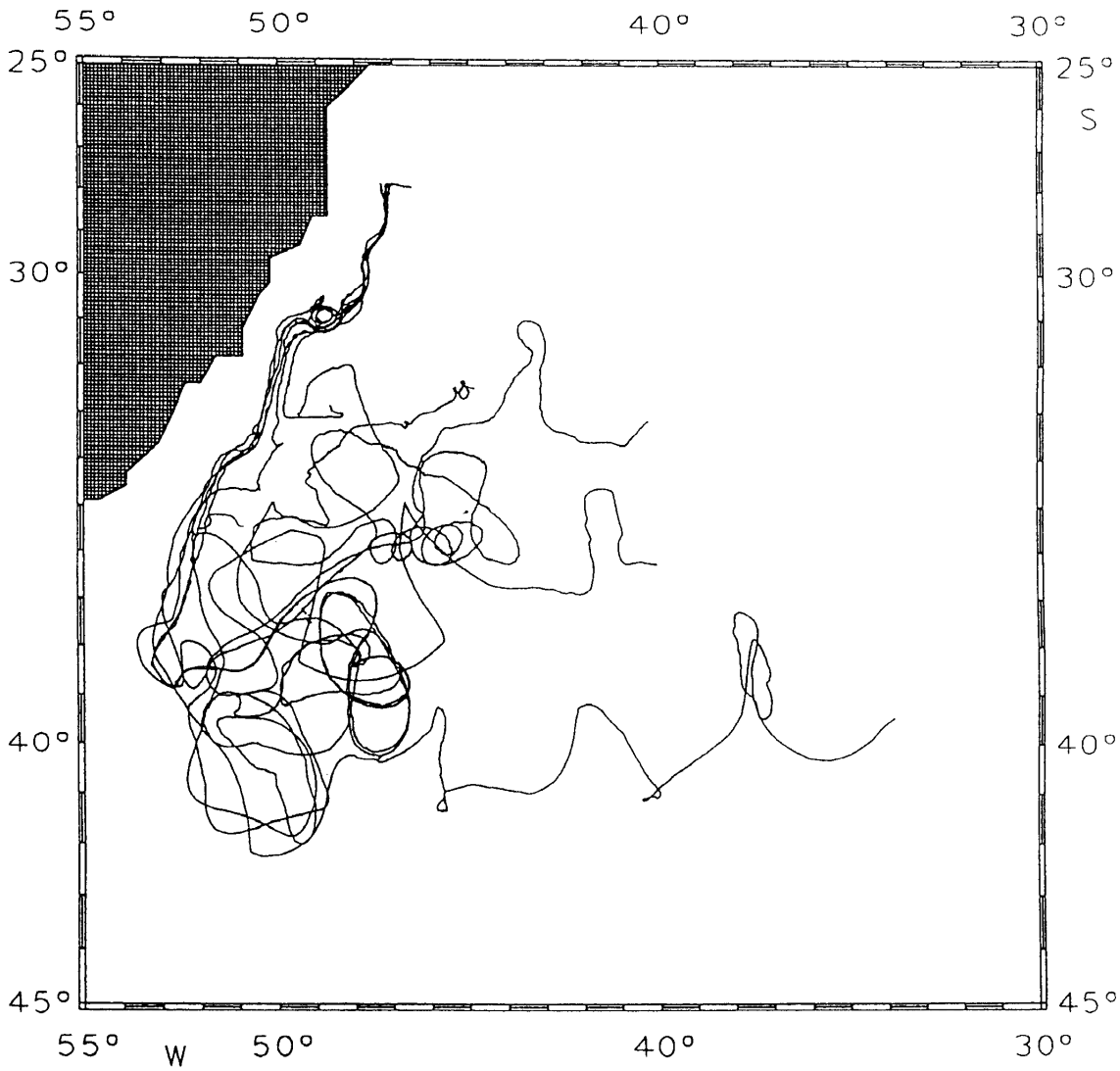


Fig. 26: Trajectories of surface drifters launched during the first leg

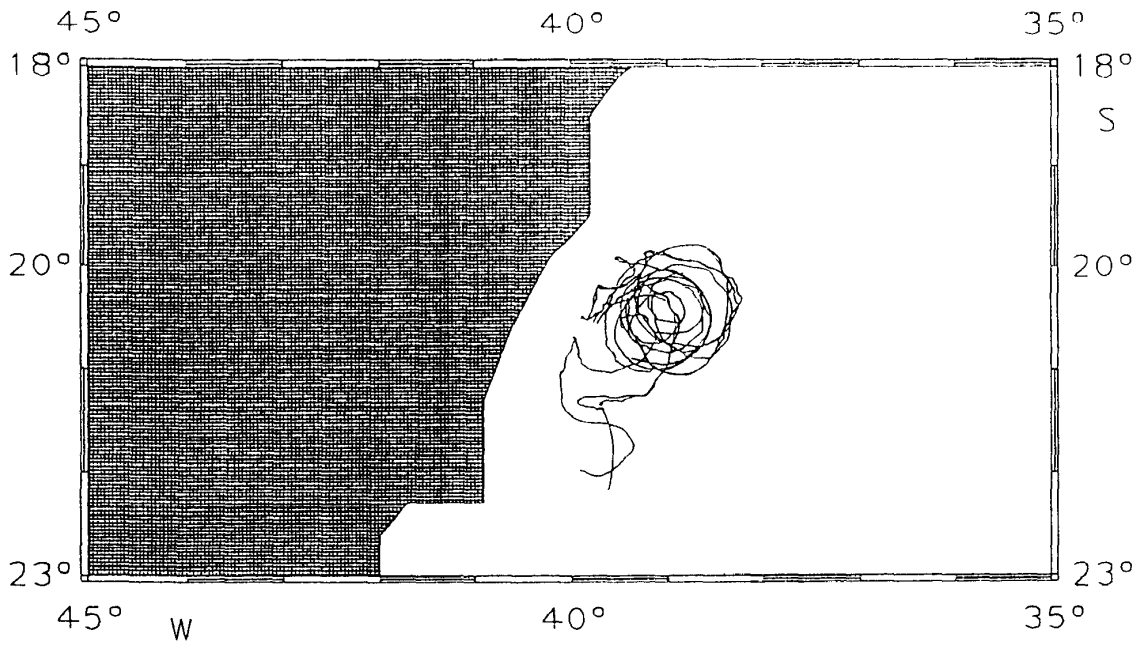



Fig. 27: Trajectories of surface drifters launched during the second leg

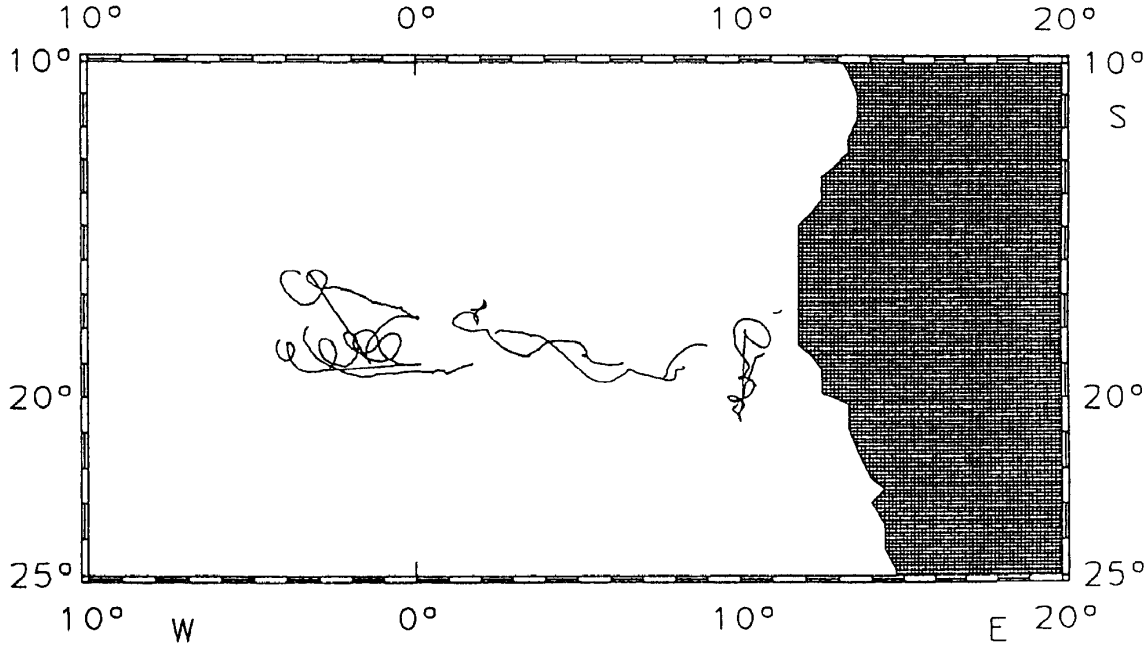



Fig. 28: Trajectories of surface drifters launched during the third leg

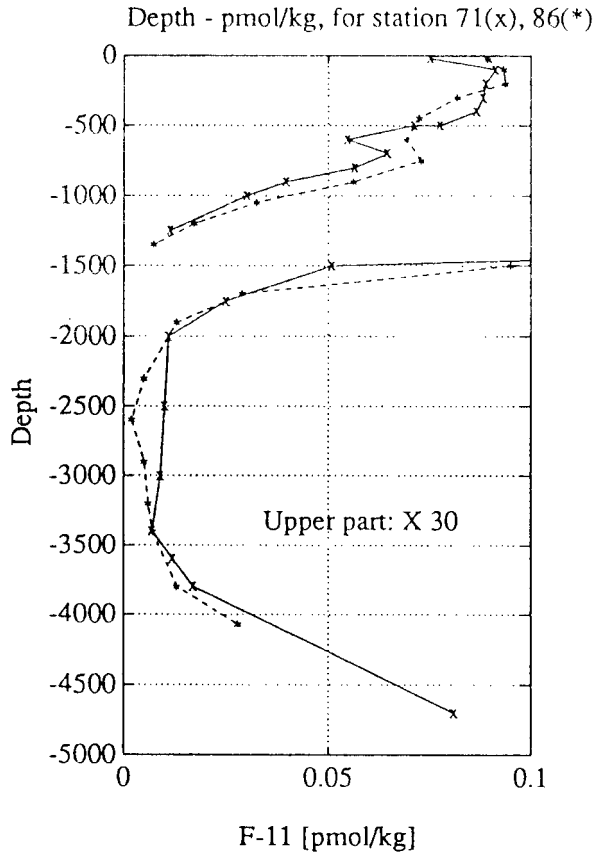



Fig. 29: F11 profiles, stations 71 (solid line) and 86 (dashed line), M 15/2 (preliminary results)

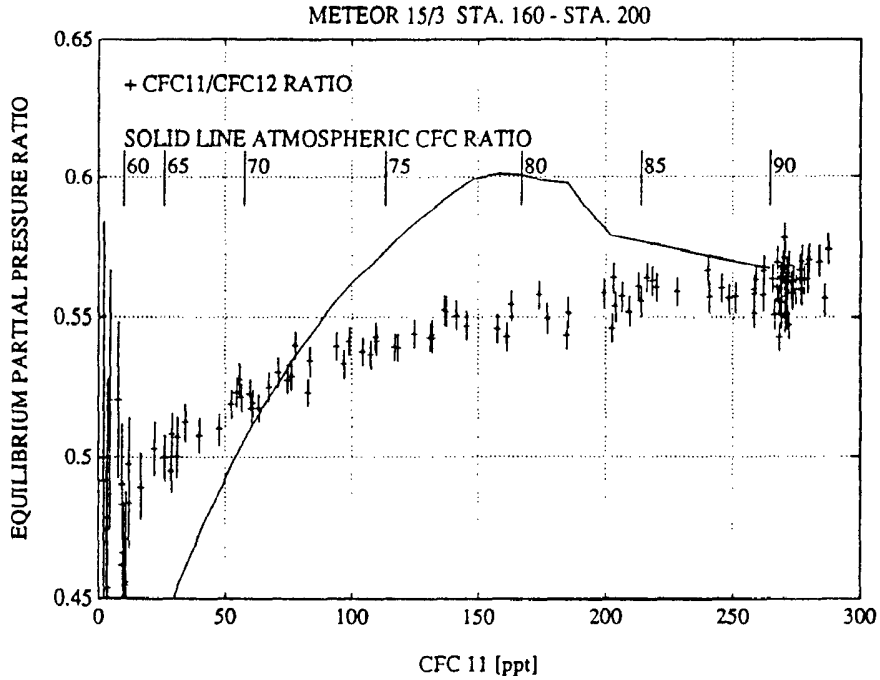



Fig. 30: Partial pressure of F11/F12 versus partial pressure concentration F11 for stations 160 to 200, M 15/3

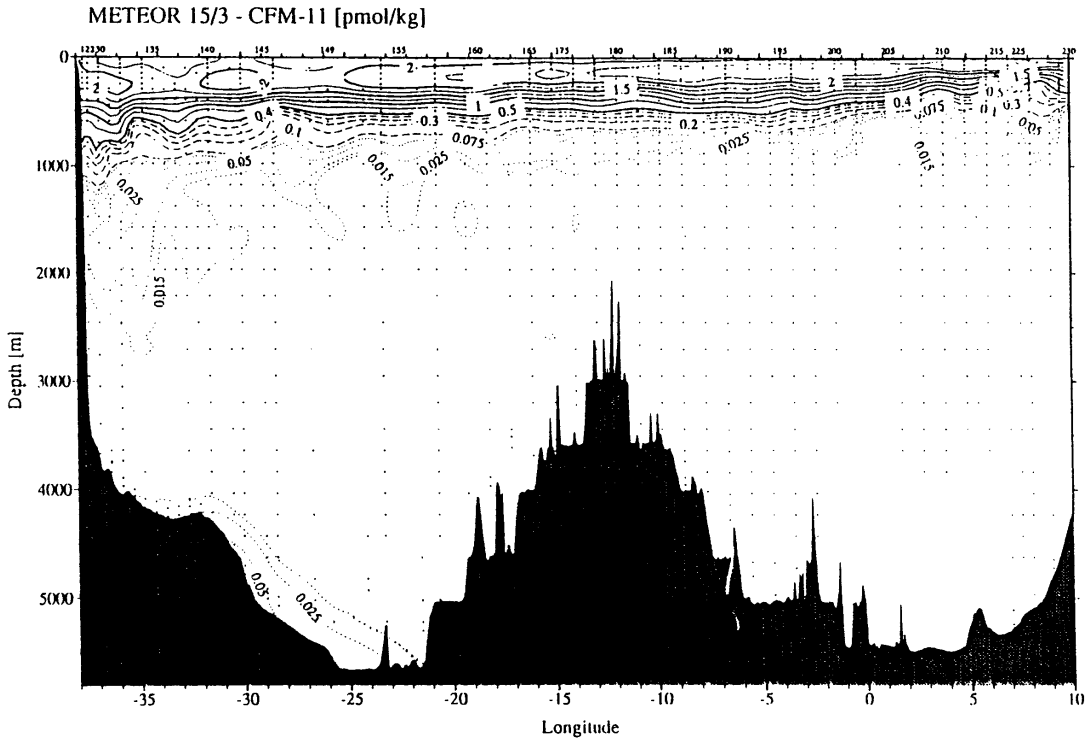



Fig. 31: CFC F11 19°S section, M 15/3

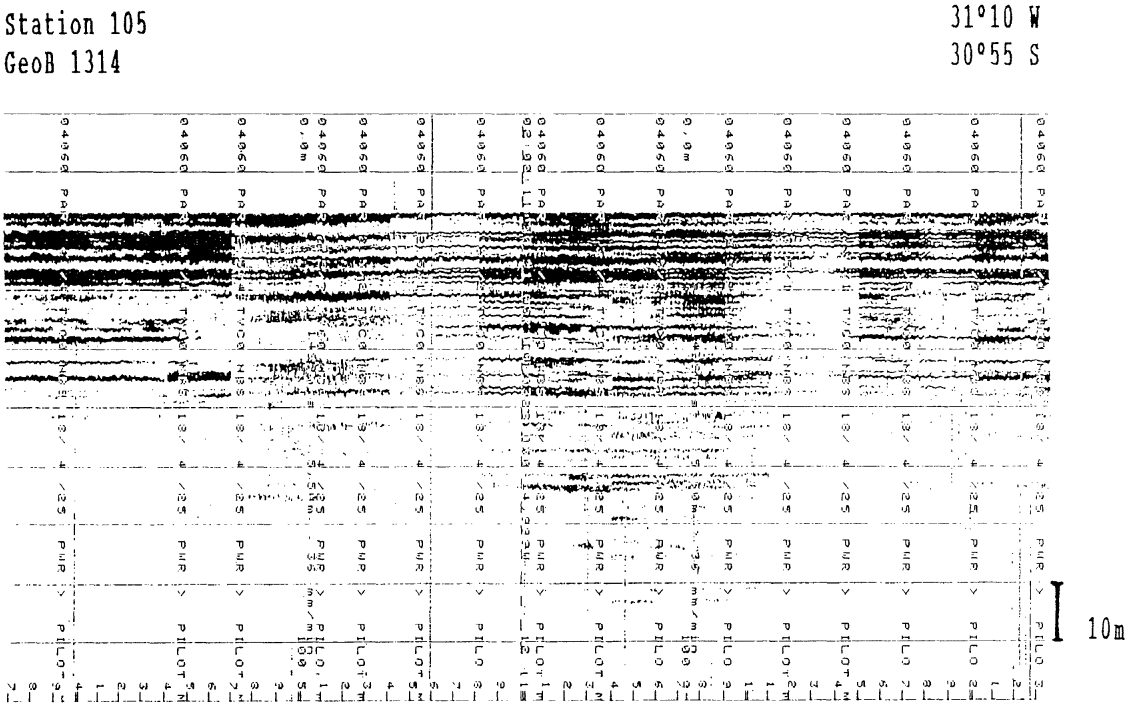



Fig. 32: Sample of the PARASOUND analogue record of a frequency test of the sediment core station GeoB 1314 (station 105)

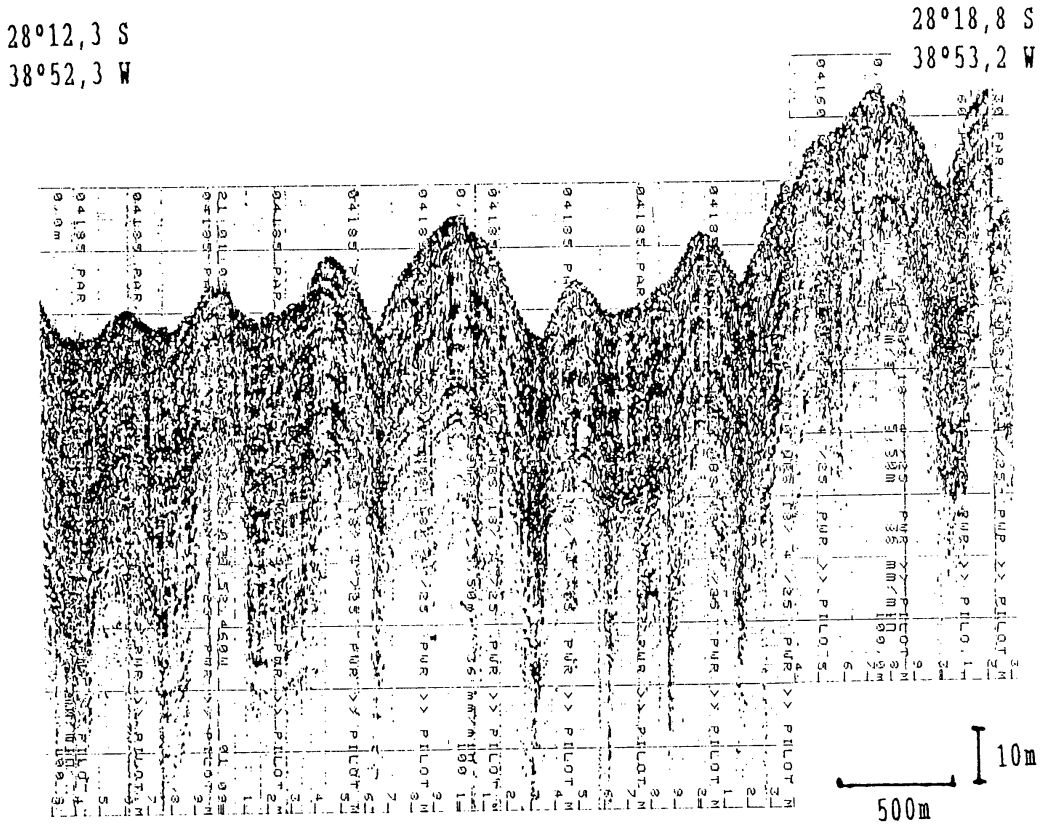



Fig. 33: Sediment waves north of the Vema Channel. Different wave lengths and amplitudes show sediment transport by bottom water current.

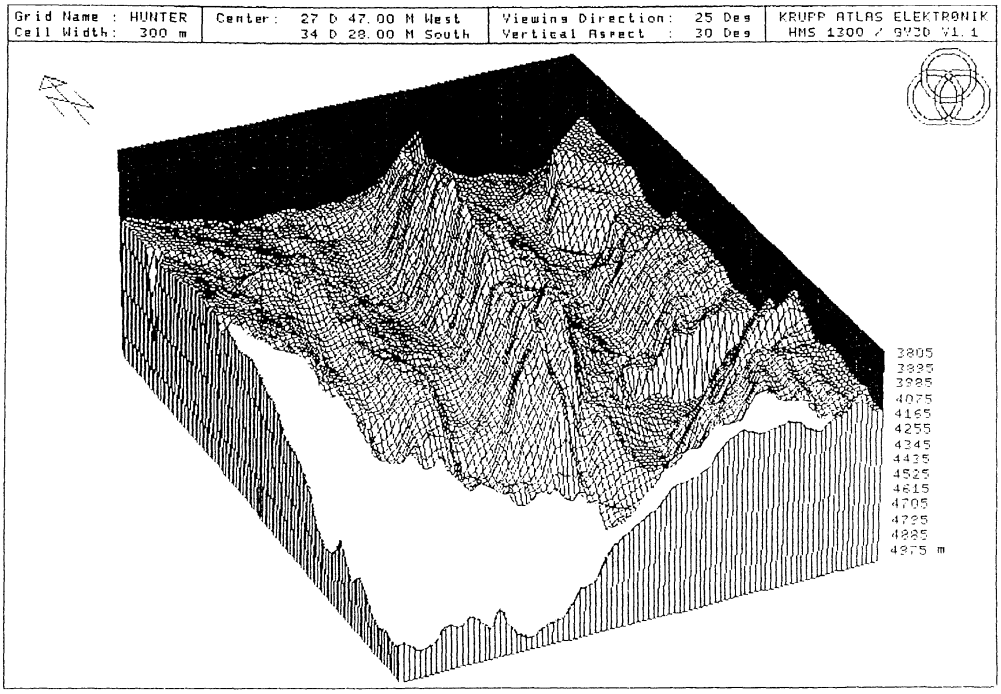



Fig. 34: HYDROMAP 3D presentation of the detailed bathymetry in the western region of the Hunter Channel. The forward region was not covered during the measurement.

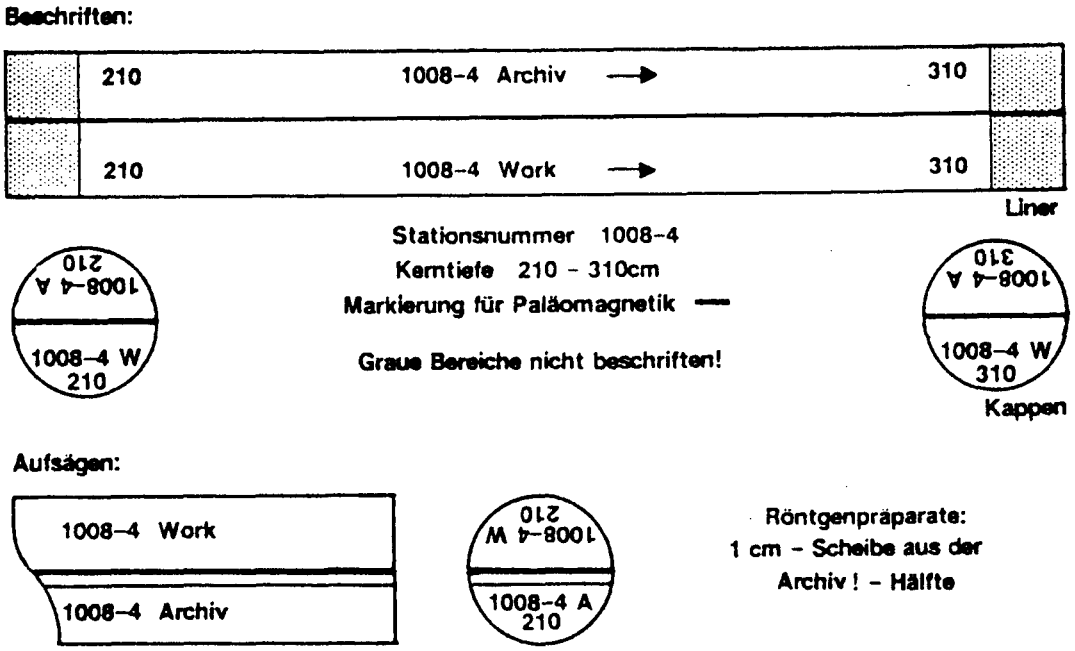



Fig. 35: Labeling for the plastic liners of the gravity core

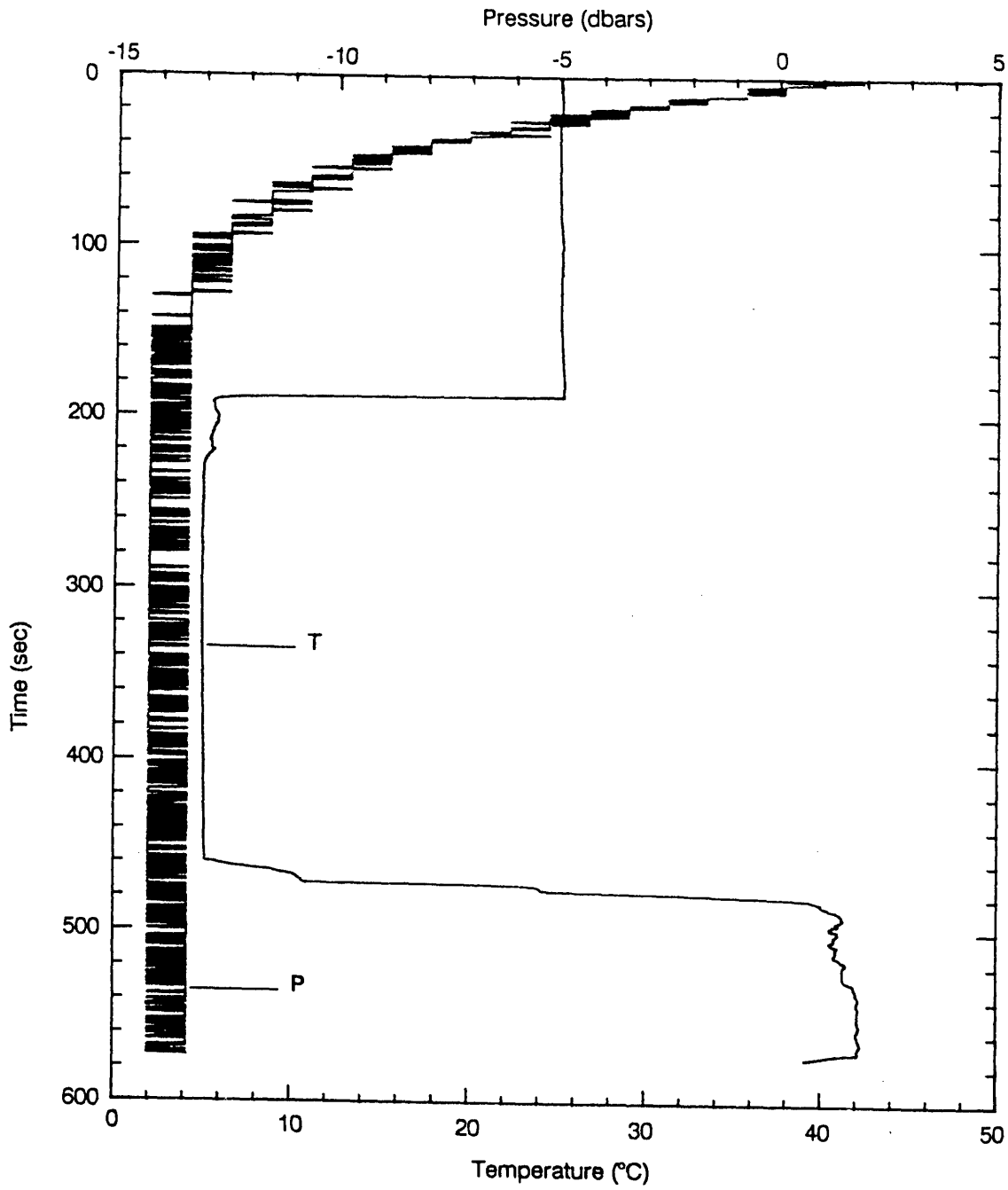



Fig. 36: Test of the temperature dependence of the SBE 19-2 pressure sensor

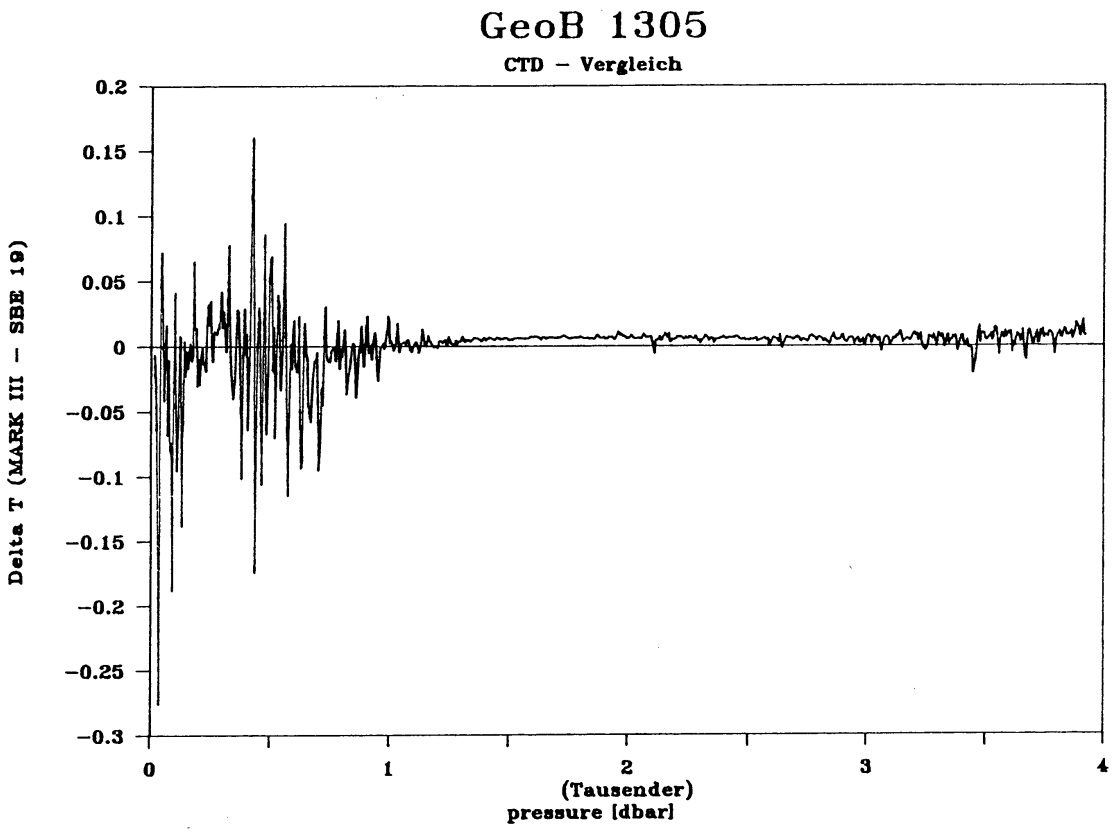



Fig. 37: Comparison of the temperature profiles of the Mark III and SBE 19-2 at station GeoB 1305 (station 85)

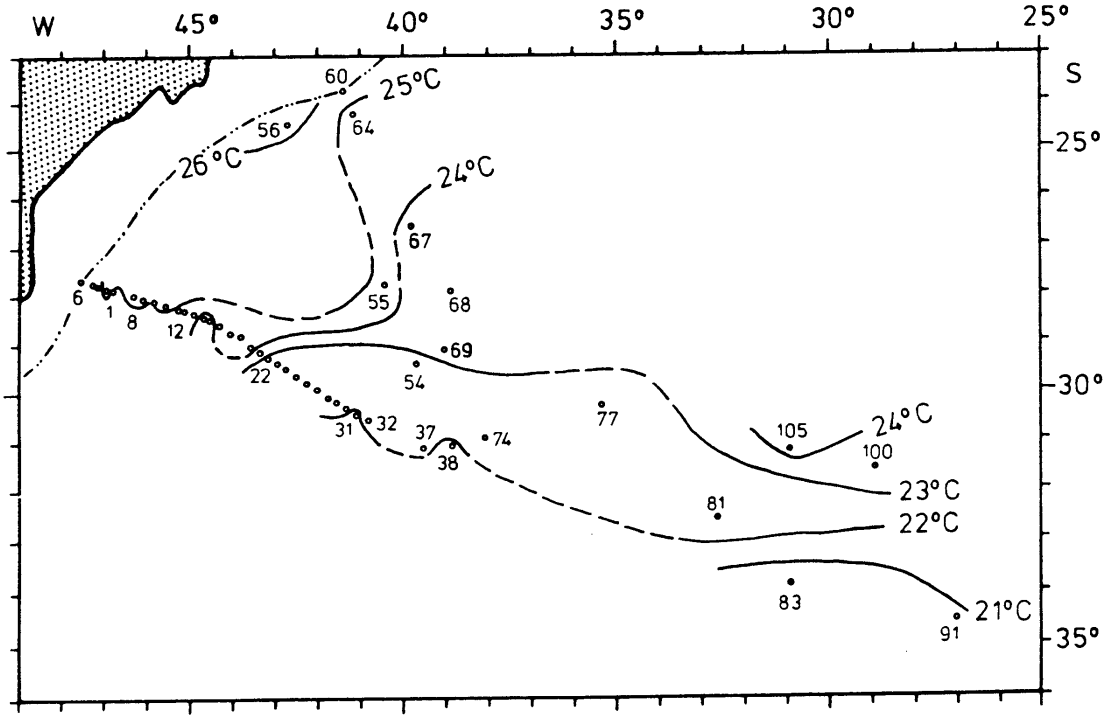



Fig. 38: Positions of the biological stations and the surface temperature distribution

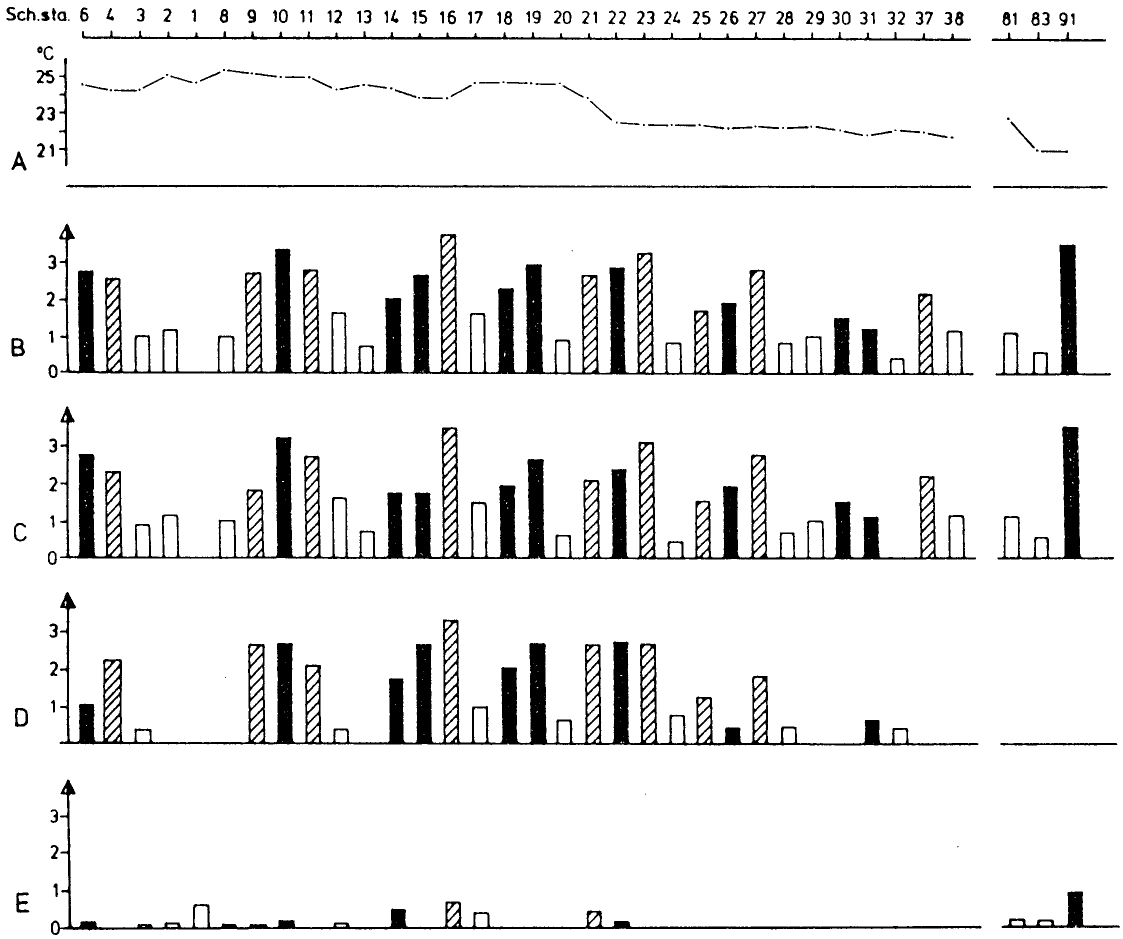
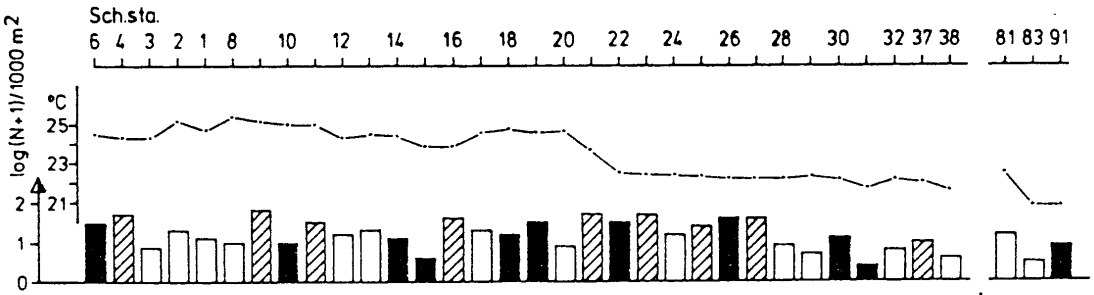


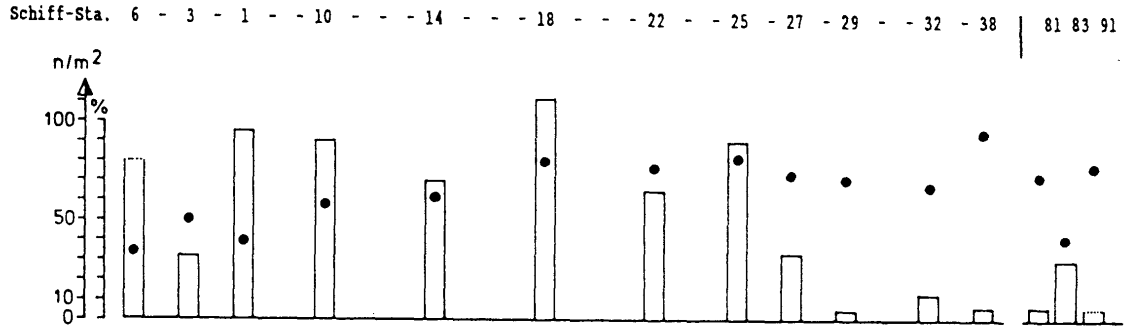

Fig. 39: Surface temperature (A), abundance of the Amphipoda (B), Hyperiidea (C), Synopia sp.m. (D), and Halobates micans (E) of the Neuston tows along the section. Abundances are expressed as log (N+1)/1000m$^2$. White columns represent daily catches, hatched columns dawn and dusk and shaded columns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




| | 6 | 4 | 3 | 2 | 1 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 37 | 38 | 81 | 83 | 91 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NERIT.TROP. | | | | | | | | | | | | | | | | | | | | | | | |
| Mullidae | 2 | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| D. volitans | - | - | - | - | - | 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| M. nigricans | - | - | - | 1 | - | - | 1 | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Balistidae | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| WEIT-NERIT. | | | | | | | | | | | | | | | | | | | | | | | |
| Bothidae | 1 | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| OZ.TROPISCH | | | | | | | | | | | | | | | | | | | | | | | |
| O. micropt. | - | - | - | - | - | 3 | 3 | - | 5 | 4 | 3 | - | 1 | 1 | - | - | - | 1 | 5 | - | 1 | 1 | - |
| Chiasmodont. | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | 1 | - | - | 1 |
| M. nitidulum | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - |
| OZ.SUBTROP. | | | | | | | | | | | | | | | | | | | | | | | |
| N. simulans | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - | 2 | - | - | - | - |
| M. phengodes | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| H. bygomii | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| KONVERGENZ | | | | | | | | | | | | | | | | | | | | | | | |
| G. barnesi | - | - | - | - | - | - | - | - | - | - | 7 | - | - | - | - | - | - | - | - | - | - | - | - |

| | 6 | 4 | 3 | 2 | 1 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 37 | 38 | 81 | 83 | 91 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NERIT.TROP. | | | | | | | | | | | | | | | | | | | | | | | |
| Mullidae | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| D. volitans | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| M. nigricans | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Balistidae | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| WEIT-NERIT. | | | | | | | | | | | | | | | | | | | | | | | |
| Bothidae | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| OZ.TROPISCH | | | | | | | | | | | | | | | | | | | | | | | |
| O. micropt. | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Chiasmodont. | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| M. nitidulum | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| OZ.SUBTROP. | | | | | | | | | | | | | | | | | | | | | | | |
| N. simulans | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | 2 | - | - | 5 | - | 1 | - | - |
| M. phengodes | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - |
| H. bygomii | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - |
| KONVERGENZ | | | | | | | | | | | | | | | | | | | | | | | |
| G. barnesi | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | 2 |

Fig. 40: The surface temperature and the distributions of the Ichthyplanctons 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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WEIT-NERIT.** | | | | | | | | | | | | | | | |
| M. muelleri | 61 | 1 | 75 | 24 | 8 | 1 | - | - | - | - | - | - | - | - | - |
| Clupeoidei | 36 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Bothidae | 1 | - | 2 | 5 | - | 2 | - | - | - | - | - | - | - | - | - |
| **OZ.TROPISCH** | | | | | | | | | | | | | | | |
| V. nimbaria | 3 | 4 | 11 | 26 | 20 | 28 | 7 | 7 | - | - | 1 | - | 1 | 14 | - |
| H. reinhadti | - | 10 | - | 8 | 5 | 4 | - | 1 | - | - | - | - | 1 | - | - |
| M. nitidulum | - | 2 | - | 3 | - | - | - | - | - | - | - | - | - | - | - |
| M. selenpos | - | - | 8 | 2 | - | - | - | - | - | - | - | - | - | - | - |
| Chiasmodont. | - | - | - | - | - | - | 1 | 2 | - | 1 | - | - | - | 2 | - |
| **OZ.SUBTROP.** | | | | | | | | | | | | | | | |
| L. pusillus | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - | - |
| S. barnardi | - | 1 | - | - | - | - | - | - | 2 | - | - | - | - | - | 1 |
| **KONVERGENZ** | | | | | | | | | | | | | | | |
| H. hanseni | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - |
| Protomyct. | - | - | - | 1 | 3 | 1 | - | 3 | - | - | - | - | - | - | - |

Fig. 41: The abundance of the Ichthyoplancton 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).

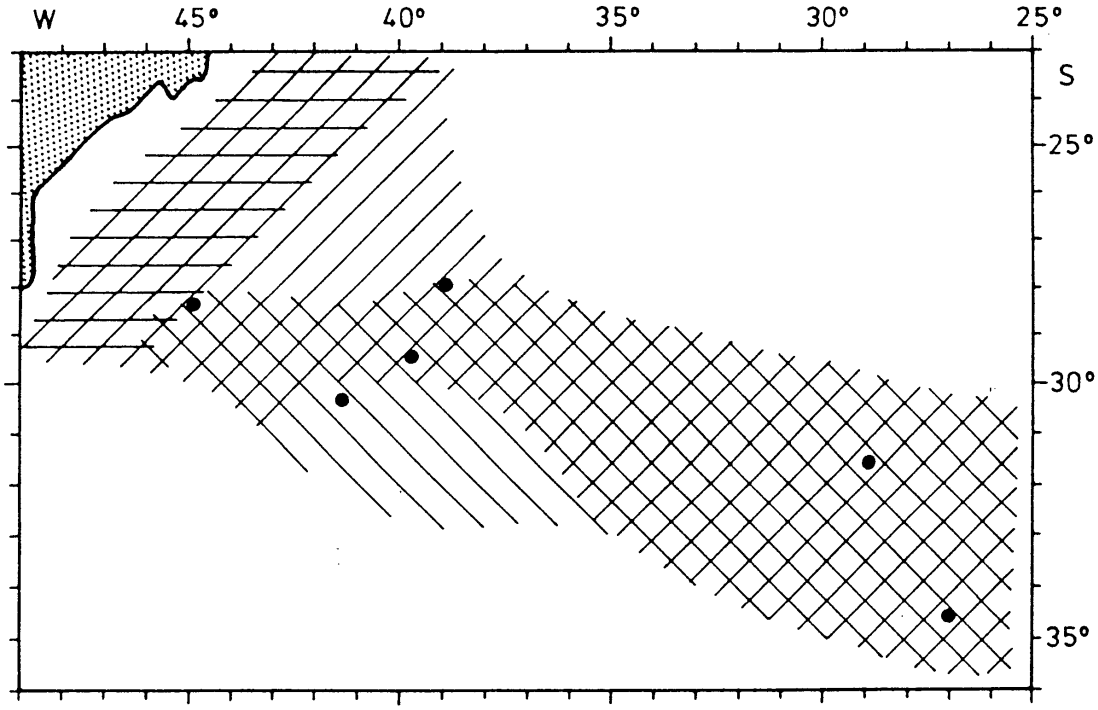



Fig. 42: A representation of the horizontal distribution of the fauna complexes in the Neuston tows.
Horizontal hatching: Both neritic complexes
From SW to NE: Tropical oceanic complex
From NW to SE: Subtropical oceanic complex
Dots: Location sites of Endemisms of the Subtropical Convergence

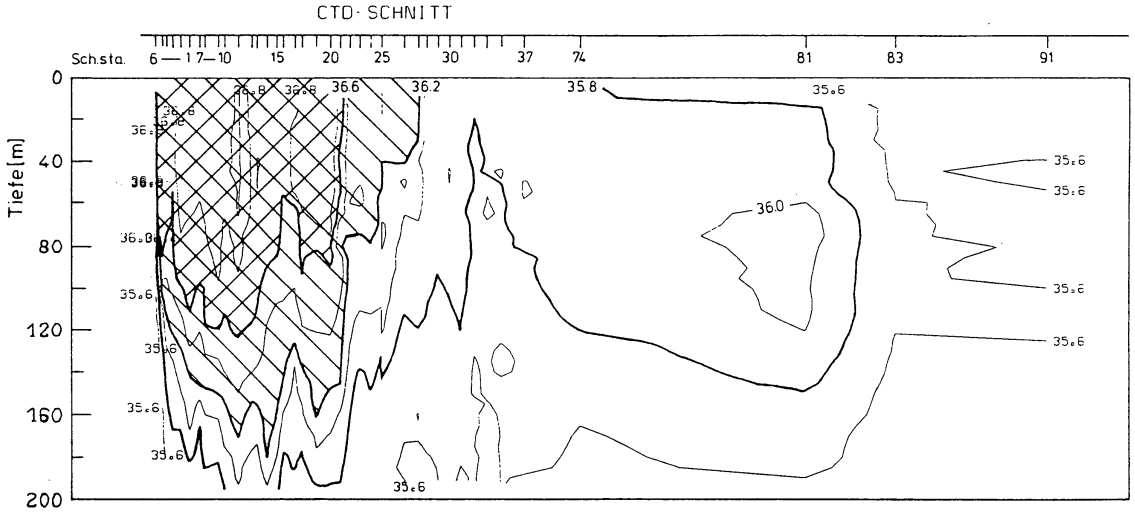
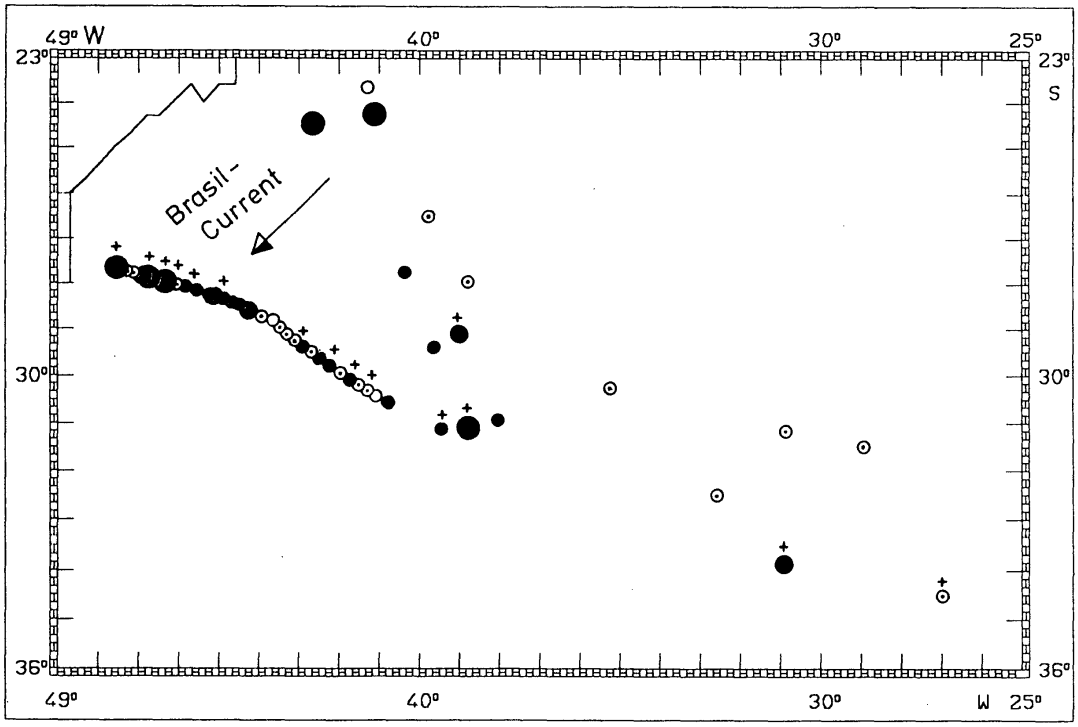



Fig. 43: The salinity distribution from 0-200m along the plancton section.
Hatching from NW to SE: > 36.2 salinity;
from SW to NE: > 36.6 salinity
Data IfM Kiel from B.Brügge. Only the stations discussed in the text are marked.




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).

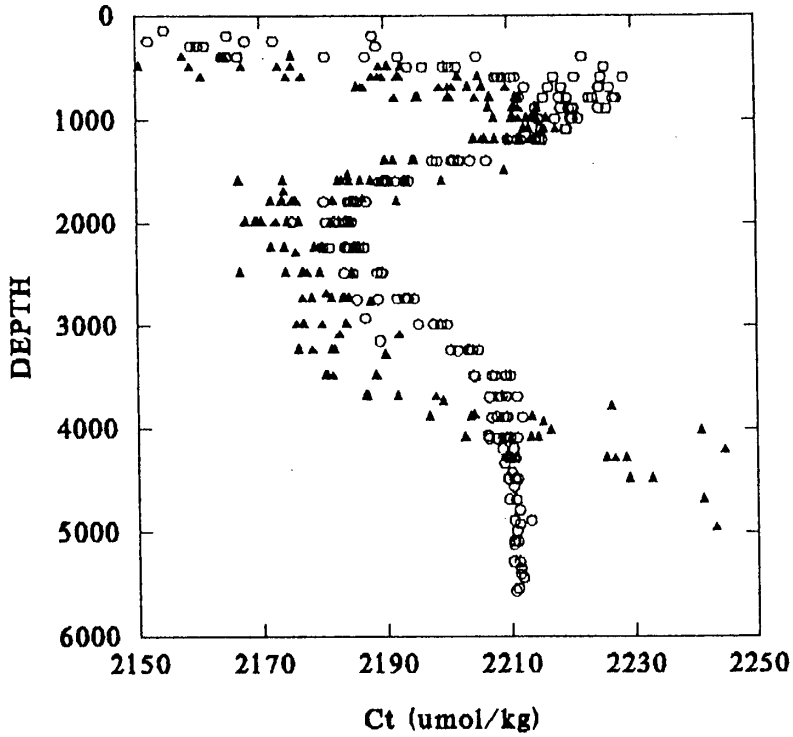



Fig. 45: $CO_2$ observations in the Brazil Basin (triangles) and the Angola Basin (circles)

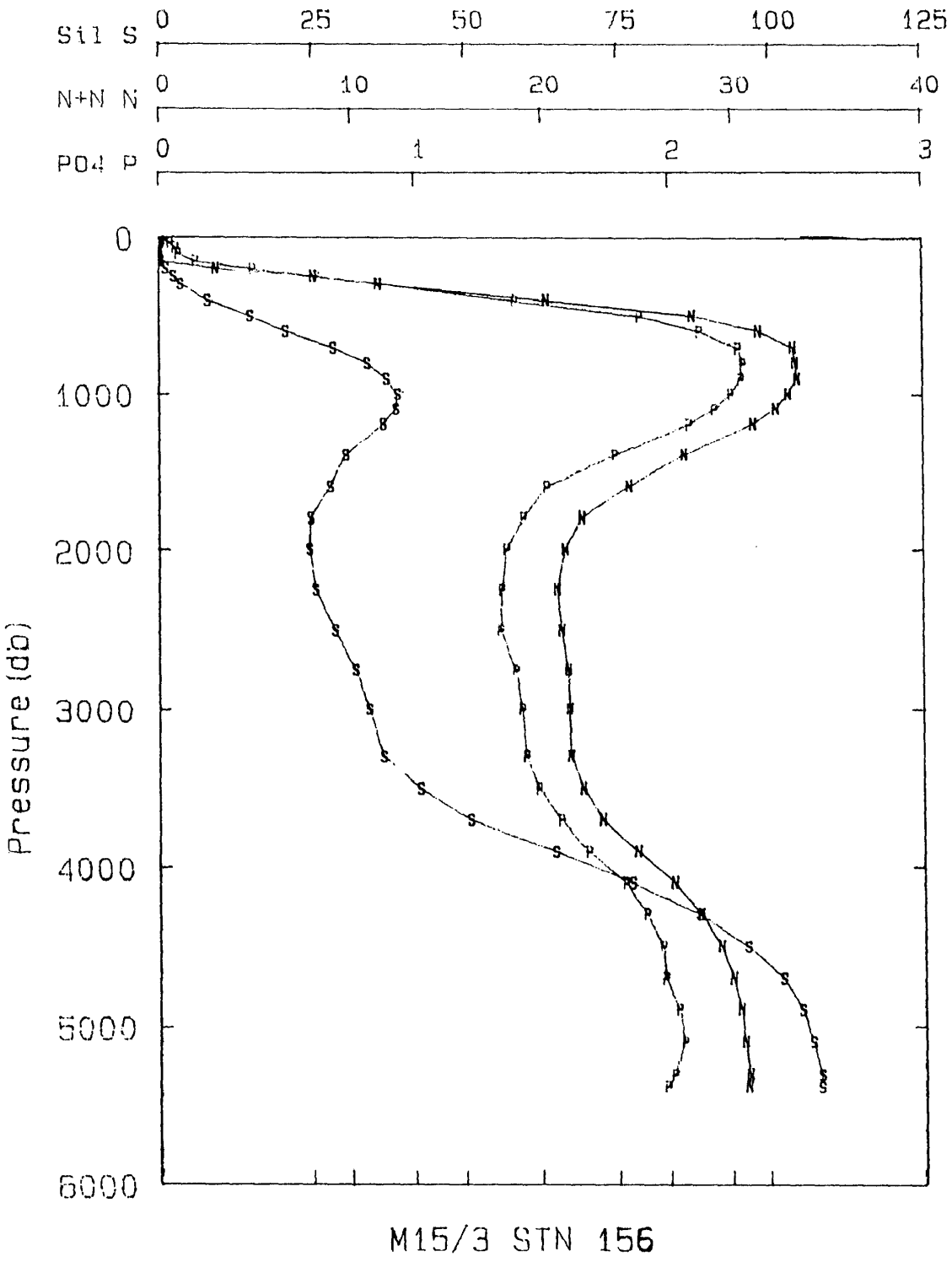



Fig. 46: Nutrients in the Brazil Basin

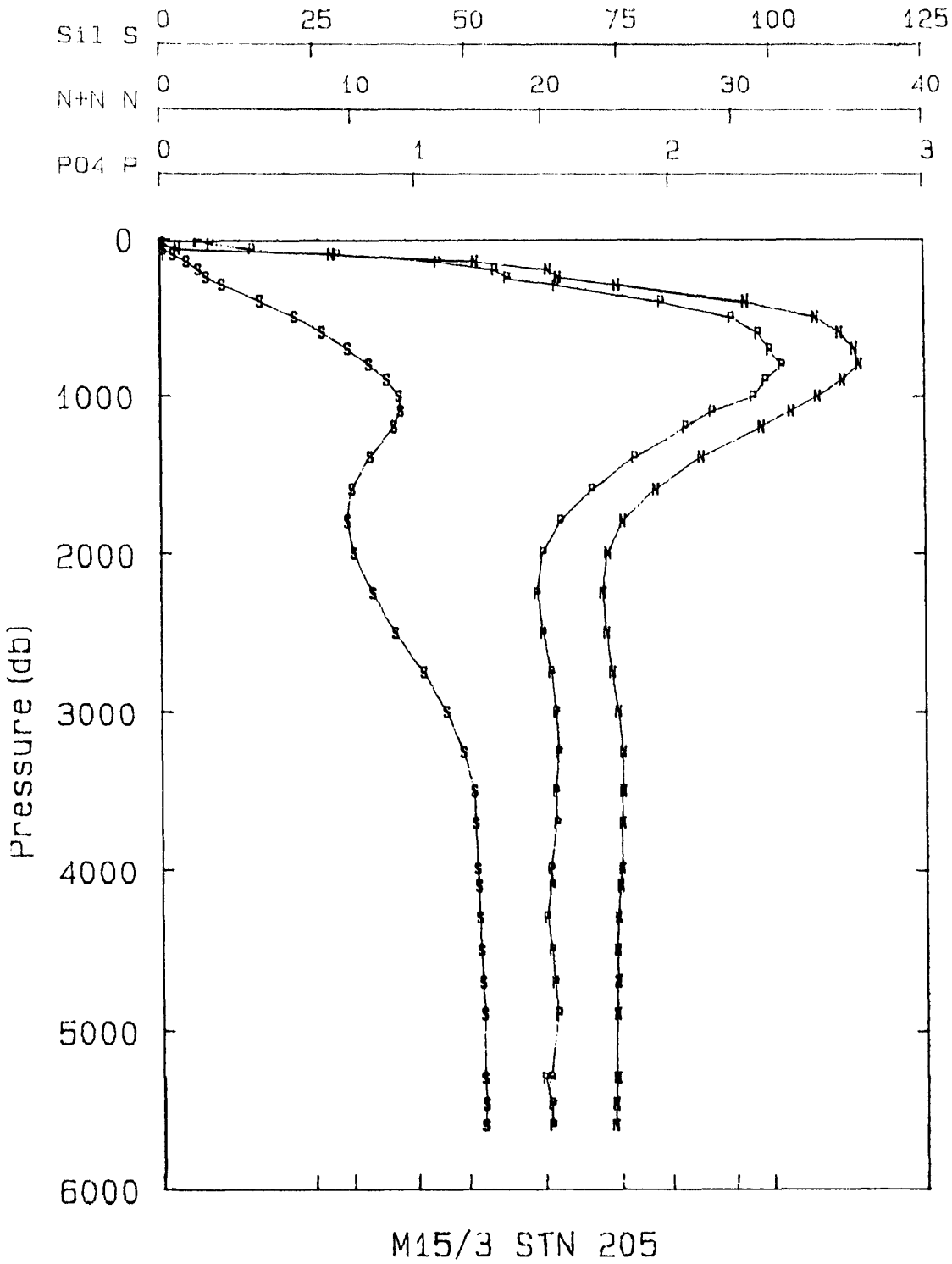



Fig. 47: Nutrients in the Angola Basin

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 (1 $\mu$ 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 25ºW and Ajax along 1ºW 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) $\theta$ - S plots of each station group. Data from the A9 and A16 cruises compare excellently in a region of well-defined deep $\theta$ - 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 ambiant 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 $\mu$ mol kg$^{-1}$ (or $\simeq$ 0.15 ml/l$^{-1}$), a rather large difference. This difference seems to result from the factor used to convert ml/l into $\mu$ mol kg$^{-1}$. This factor is abnormally high (44.616) and would rather apply to the conversion from ml l$^{-1}$ into $\mu$ mol l$^{-1}$ (not $\mu$ 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 $\mu$ 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 $\Delta S$ 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 $\Delta S$ 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 $\Delta S$ 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 (-.52 $\mu$ mol kg$^{-1}$) but inspection of figure 9 reveals that is it locally more important in the vertical : it is negative ($\simeq$ -2 $\mu$ mol kg$^{-1}$) around 1000 db, positive from $\simeq$ 1500 db to 3500 db ($\simeq$ 2 $\mu$ mol kg$^{-1}$) and negative again at 5500 db ($\simeq$ -4 $\mu$ mol kg$^{-1}$ or $\simeq$ 0.1 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 $\mu$ mol kg$^{-1}$. That for $p$ < 2000 db is 3.9 $\mu$ mol kg$^{-1}$ and that for $p$ > 2000 db is .2.1 $\mu$ mol kg$^{-1}$ ($\simeq$ 0.05 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 $\theta$ - $O_2$ Plots (fig. 11) illustrate the effect visible as a systematic decrease of the oxygen concentration by 6 to 8 $\mu$ 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 (?).

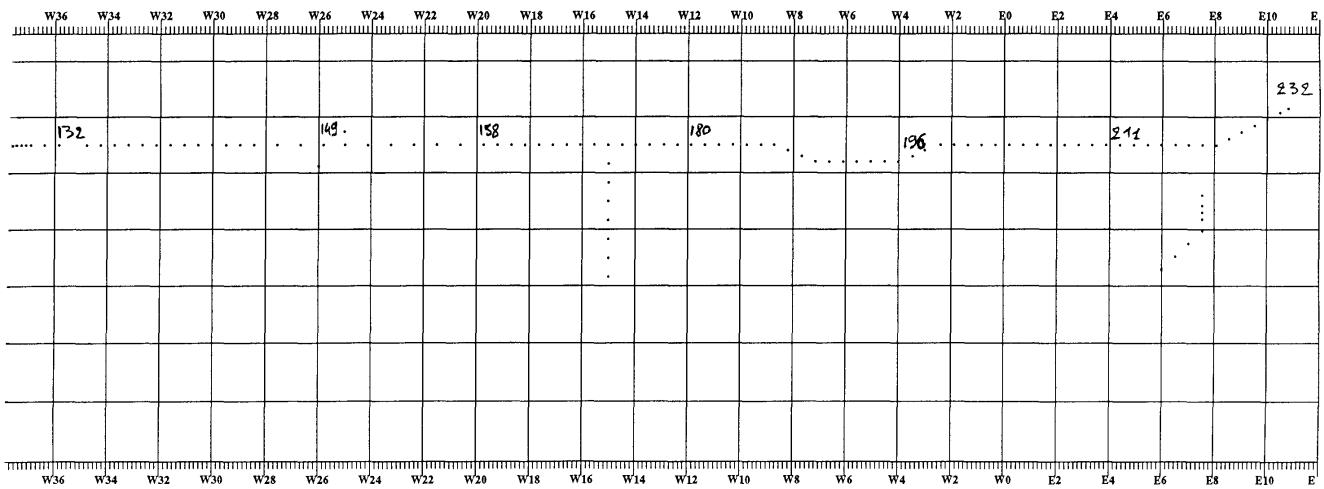



Fig. 1

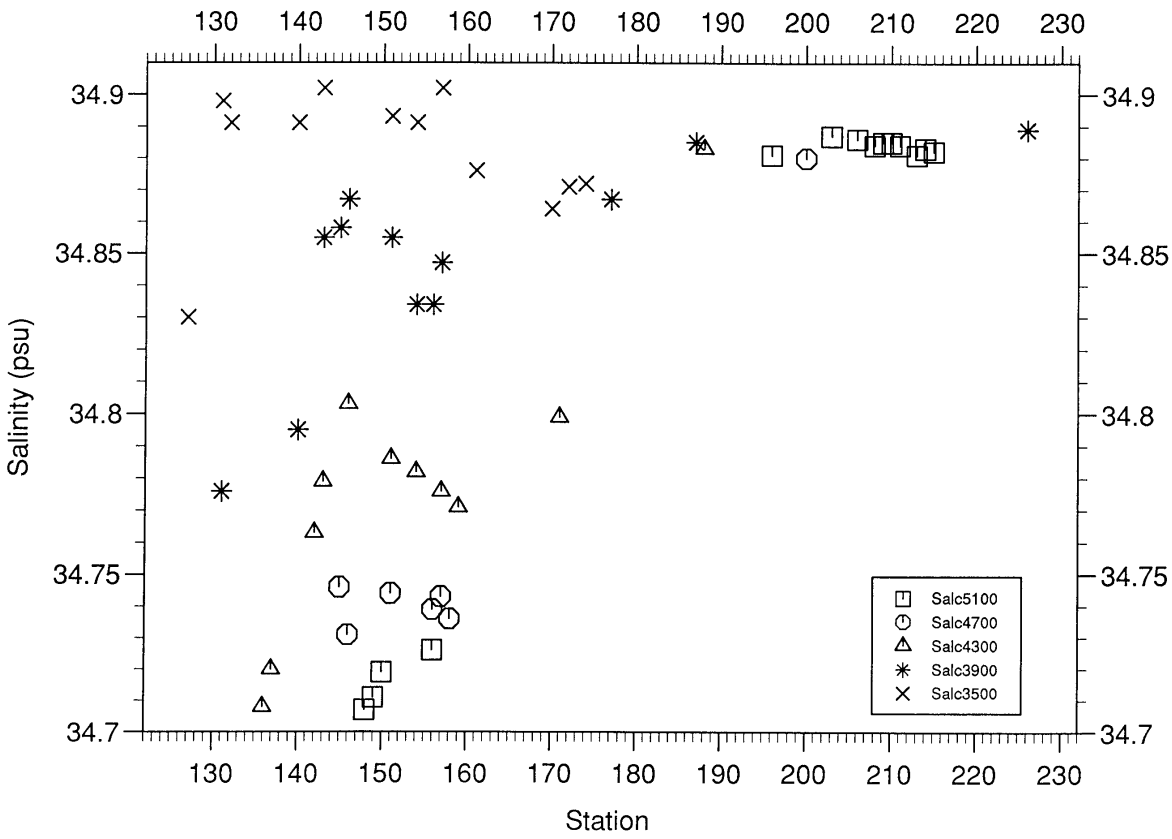

Salinity (psu)
Station
Salc5100
Salc4700
Salc4300
Salc3900
Salc3500

Fig. 2a

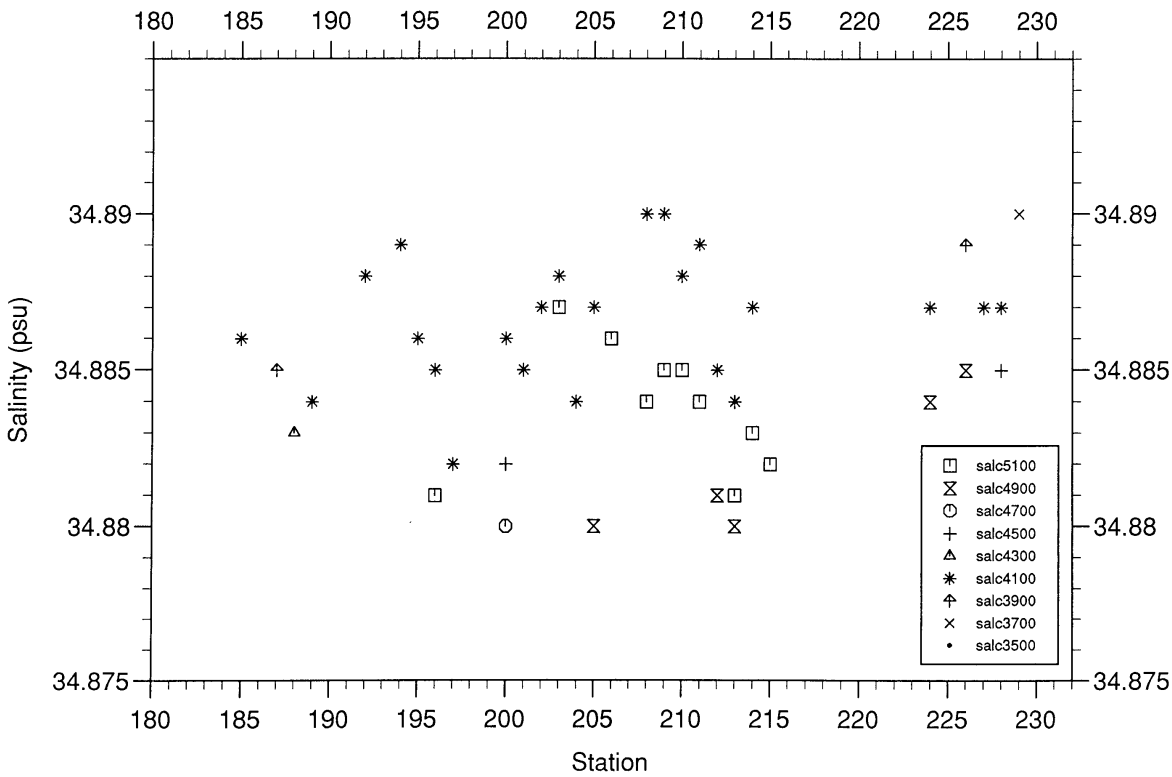

Salinity (psu)
Station
salc5100
salc4900
salc4700
salc4500
salc4300
salc4100
salc3900
salc3700
salc3500

Fig. 2b

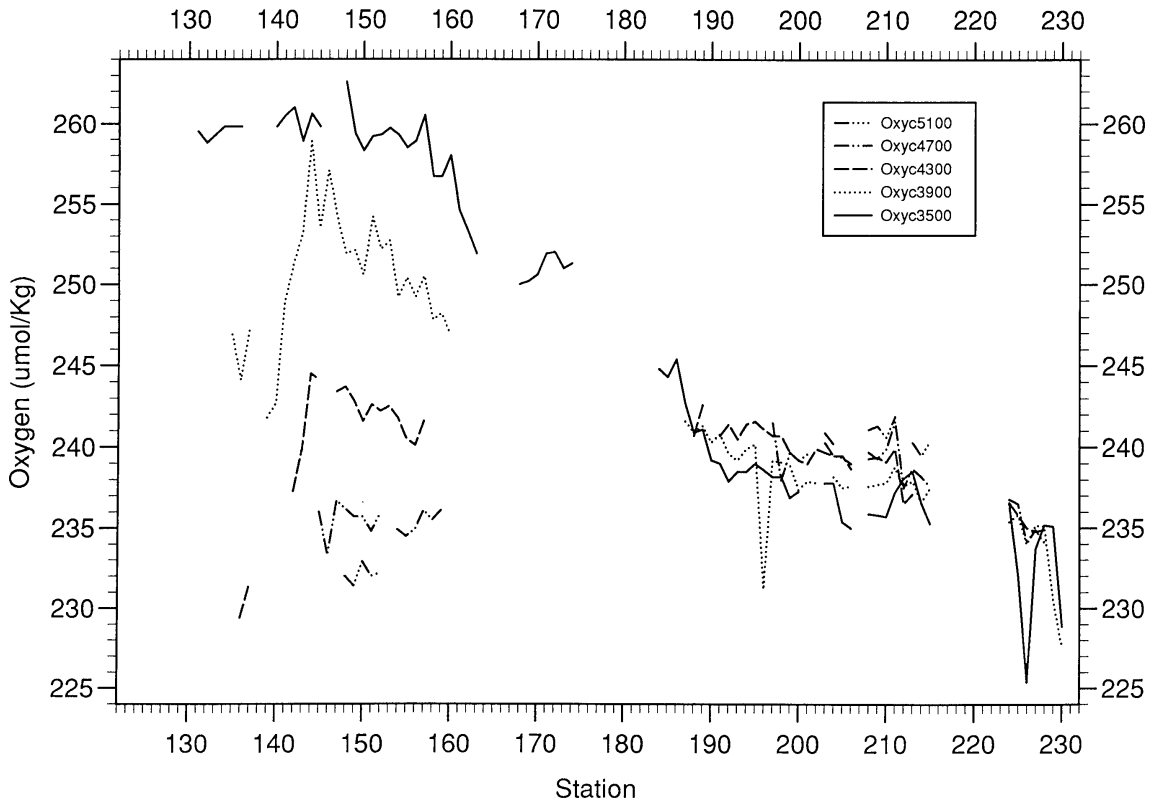

Oxyc5100
Oxyc4700
Oxyc4300
Oxyc3900
Oxyc3500
Oxygen (umol/Kg)
Station

Fig. 3a

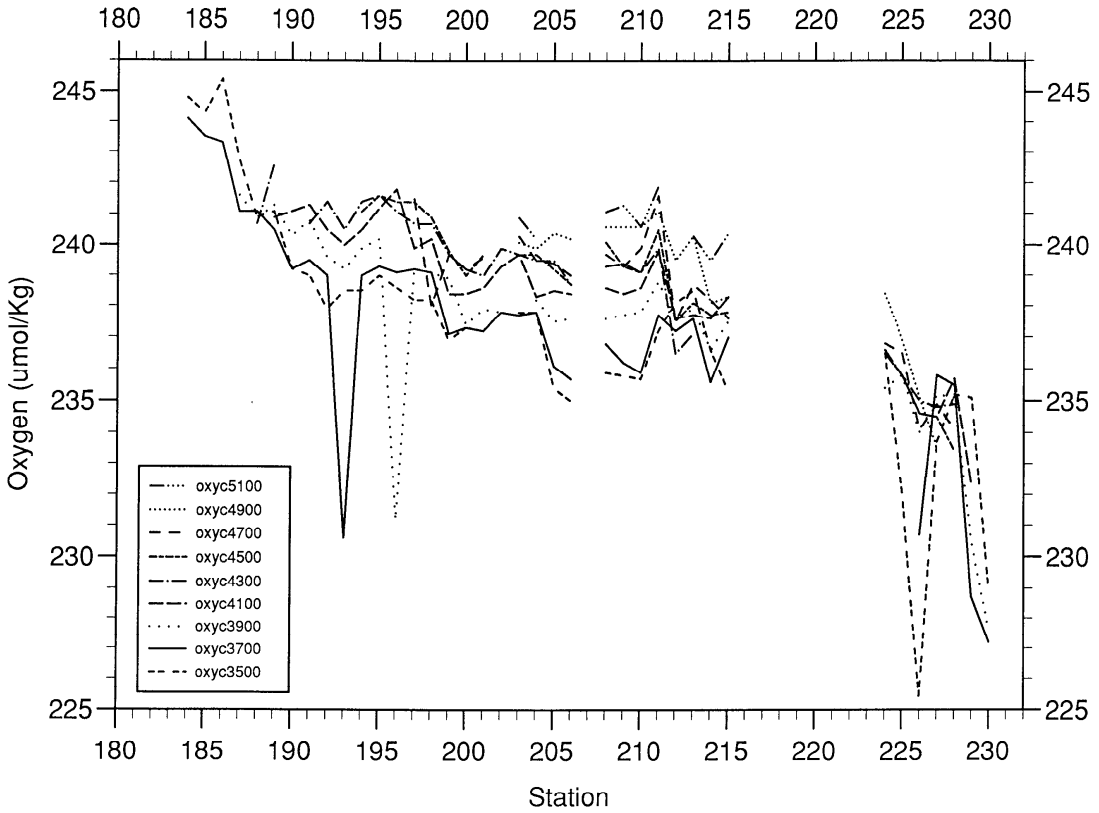

oxyc5100
oxyc4900
oxyc4700
oxyc4500
oxyc4300
oxyc4100
oxyc3900
oxyc3700
oxyc3500
Oxygen (umol/Kg)
Station

Fig. 3b

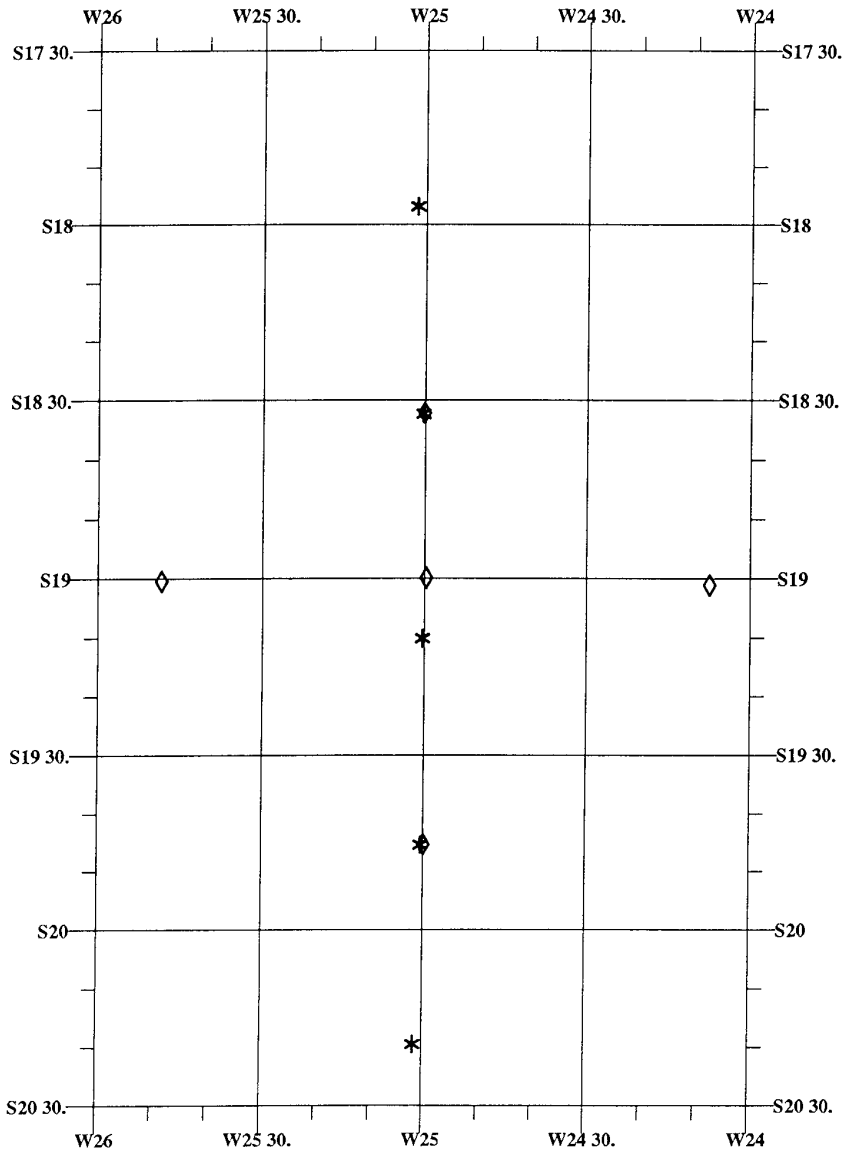

W26
W25 30.
W25
W24 30.
W24
S17 30.
S18
S18 30.
S19
S19 30.
S20
S20 30.

Fig. 4a

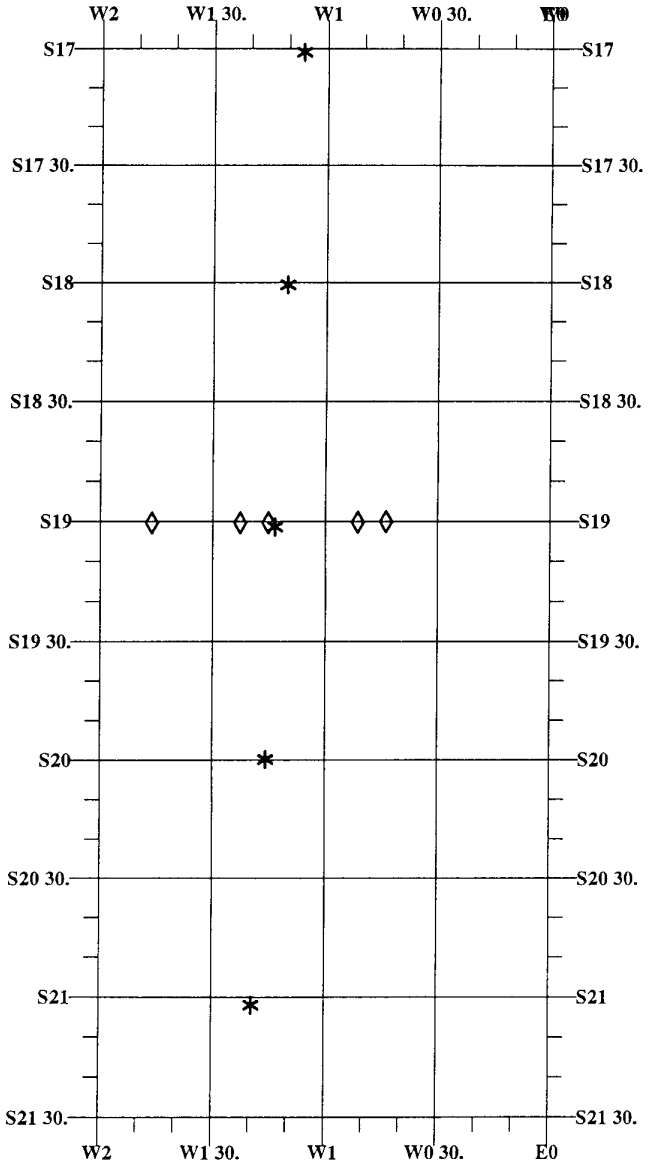

W2
W1 30.
W1
W0 30.
E0
S17
S17 30.
S18
S18 30.
S19
S19 30.
S20
S20 30.
S21
S21 30.

Fig. 4b

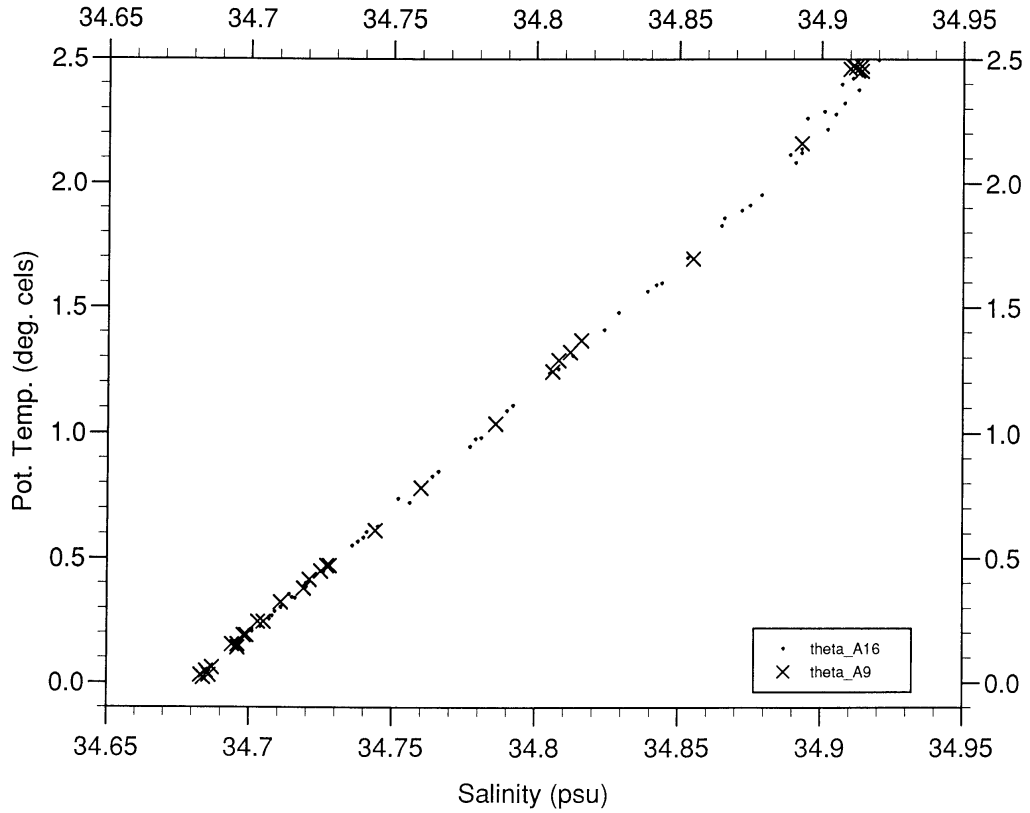

34.65
34.7
34.75
34.8
34.85
34.9
34.95
2.5
2.0
1.5
1.0
0.5
0.0
Pot. Temp. (deg. cels)
Salinity (psu)
theta_A16
theta_A9

Fig. 5a

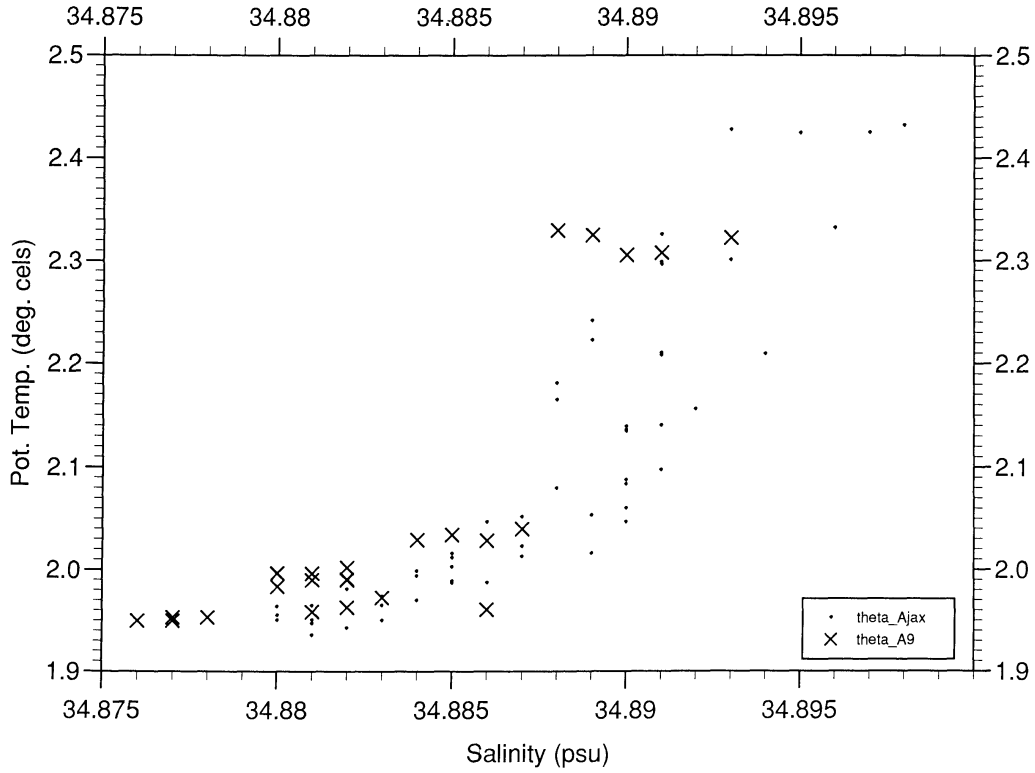

34.875
34.88
34.885
34.89
34.895
2.5
2.4
2.3
2.2
2.1
2.0
1.9
Pot. Temp. (deg. cels)
Salinity (psu)
theta_Ajax
theta_A9

Fig. 5b

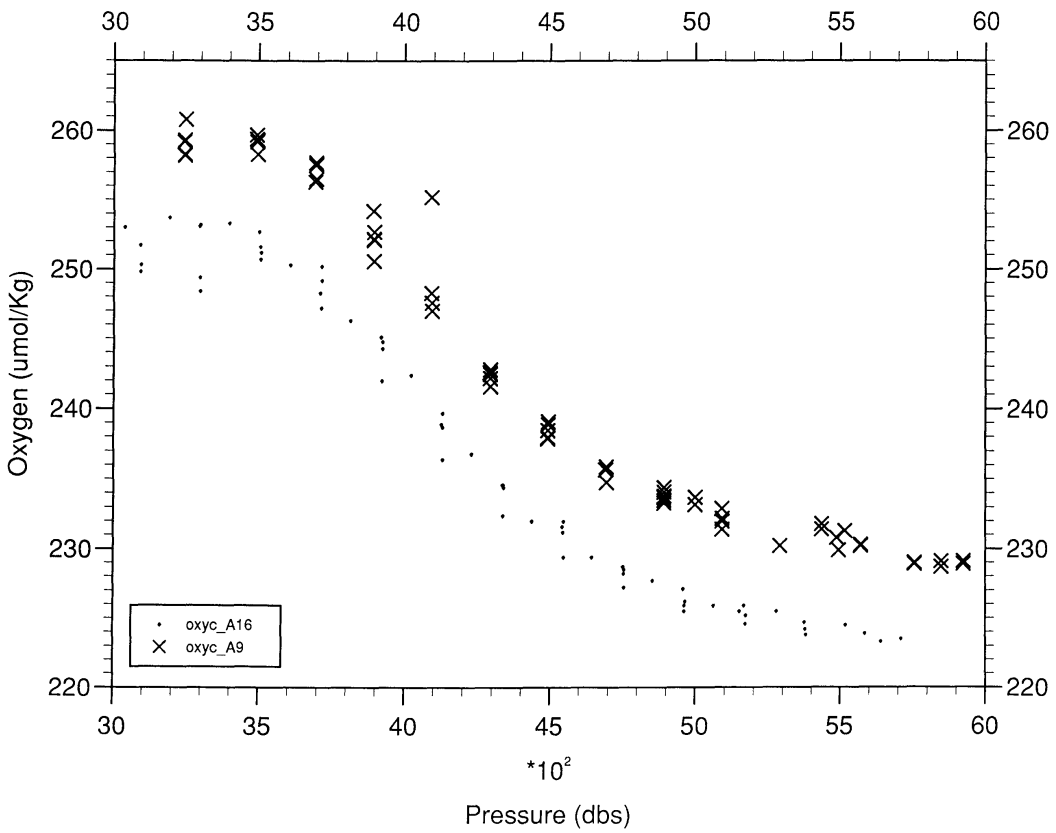

Oxygen (umol/Kg)
Pressure (dbs)
*10^2
oxyc_A16
oxyc_A9

Fig. 6a

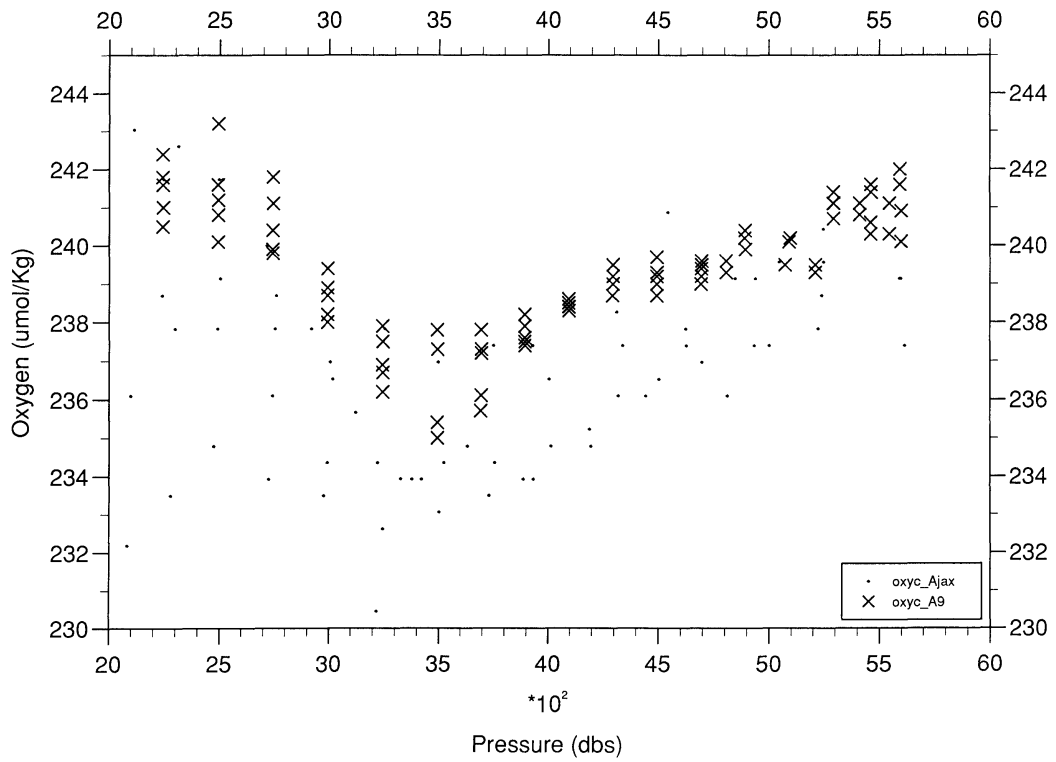

Oxygen (umol/Kg)
Pressure (dbs)
*10^2
oxyc_Ajax
oxyc_A9

Fig. 6b

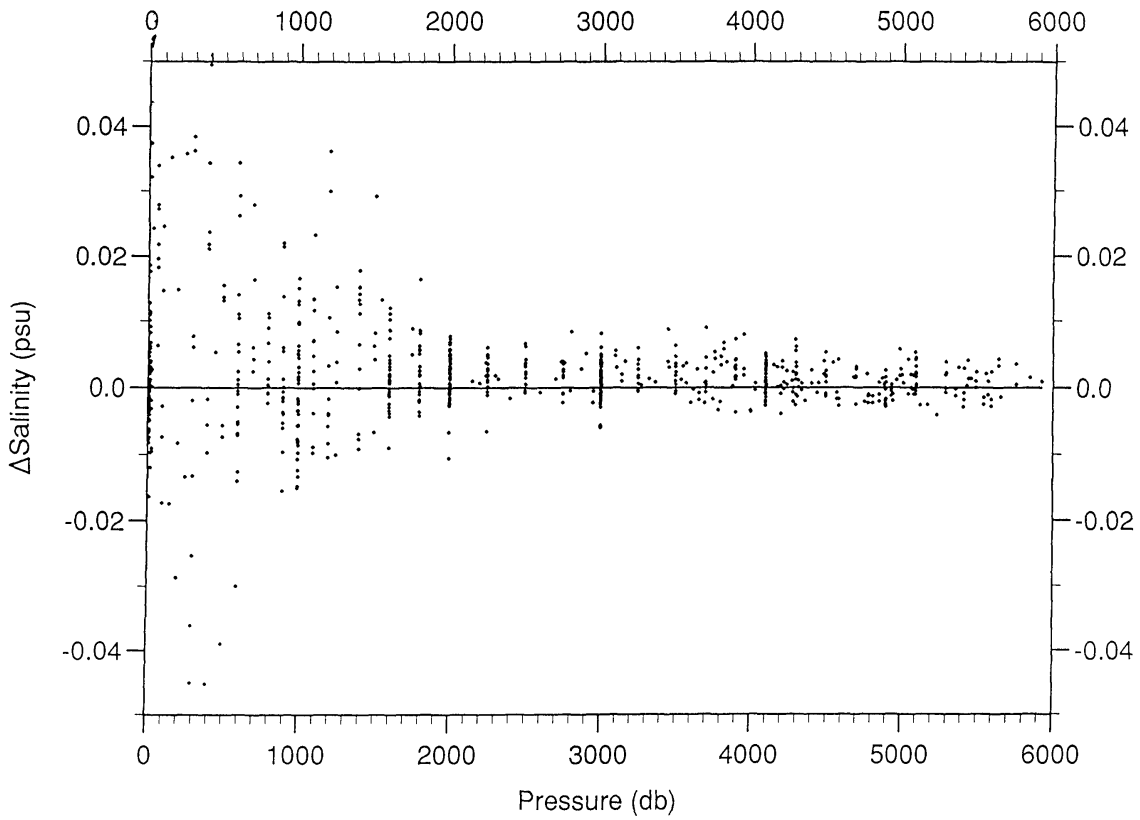

0
1000
2000
3000
4000
5000
6000
0.04
0.02
0.0
-0.02
-0.04
ΔSalinity (psu)
Pressure (db)

Fig. 7

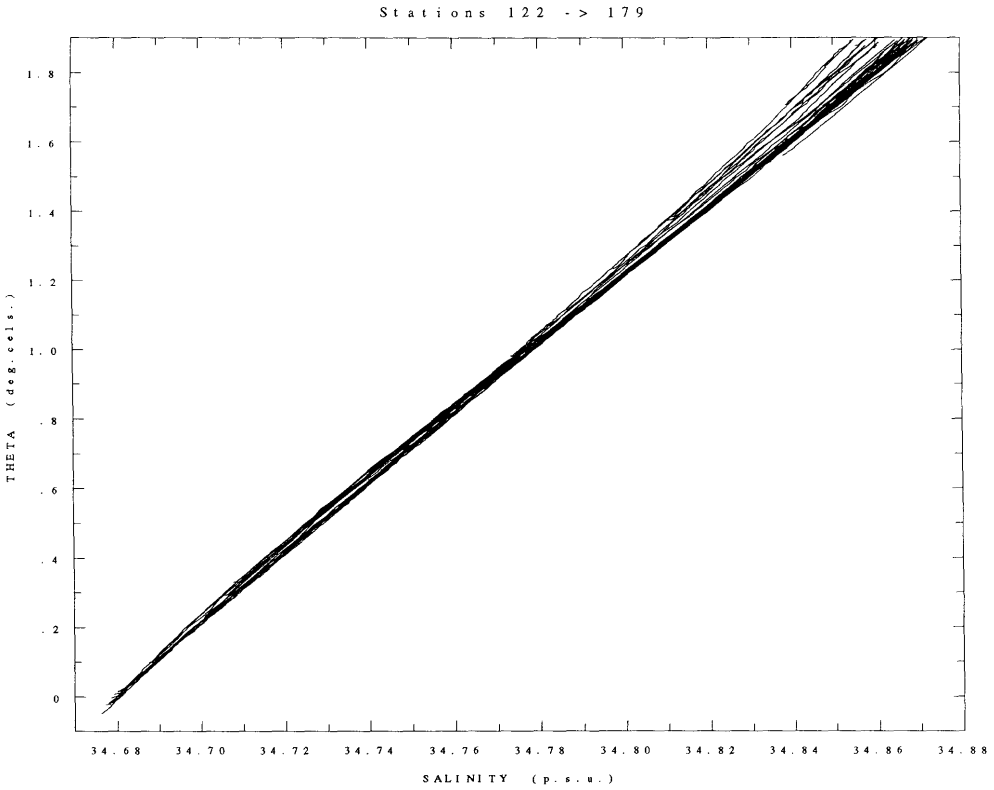

Stations 122 -> 179
THETA (deg.cels.)
SALINITY (p.s.u.)
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
34.68
34.70
34.72
34.74
34.76
34.78
34.80
34.82
34.84
34.86
34.88

Fig. 8a

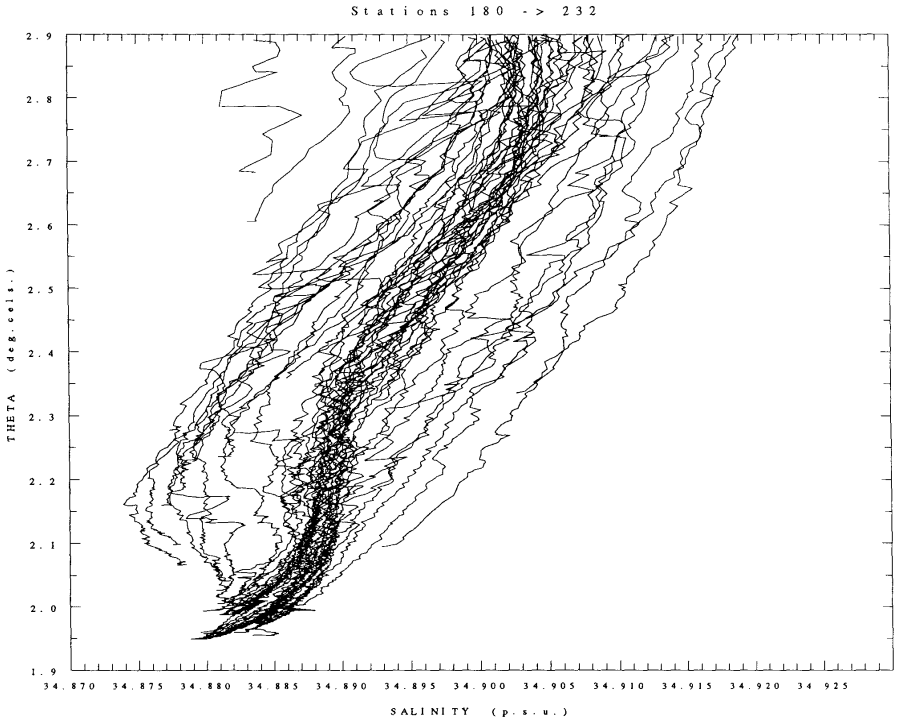

Stations 180 -> 232
THETA (deg.cels.)
SALINITY (p.s.u.)

Fig. 8b

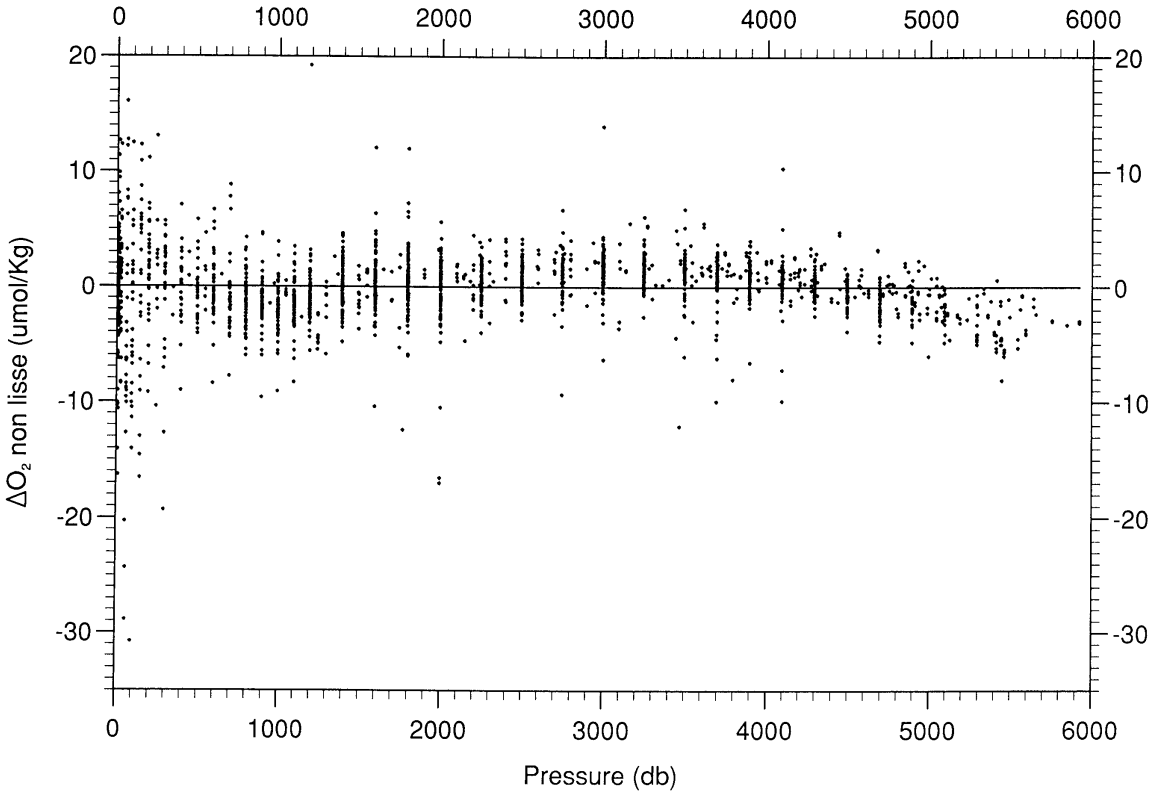

ΔO2 non lisse (umol/Kg)
Pressure (db)

Fig. 9

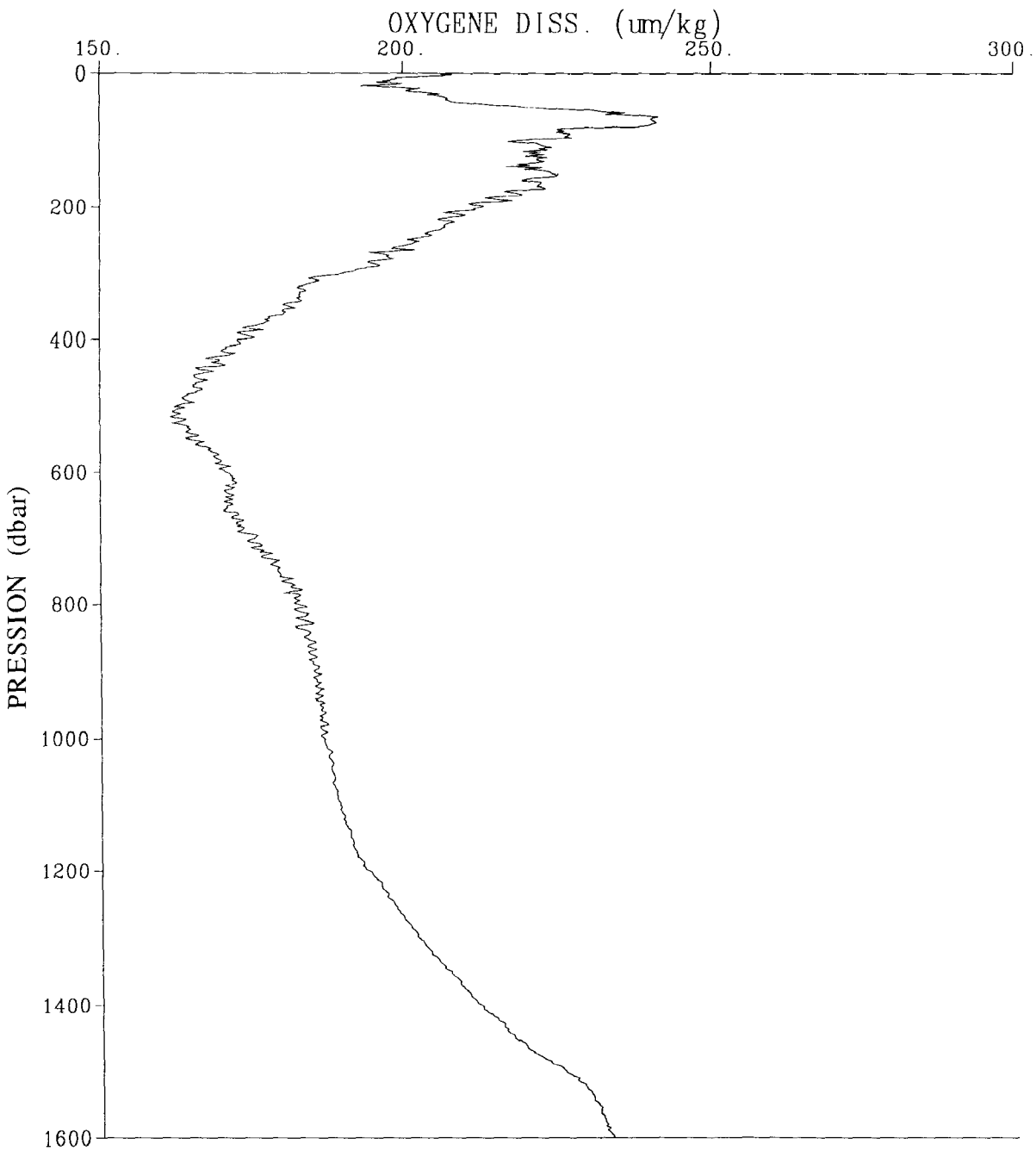

whpA9-20s
Lat:S 19 0.10
ST: 0154
Lon:W 023 14.90
OXYGENE DISS. (um/kg)
150.
200.
250.
300.
0
200
400
600
800
1000
1200
1400
1600
PRESSION (dbar)

Fig. 10a

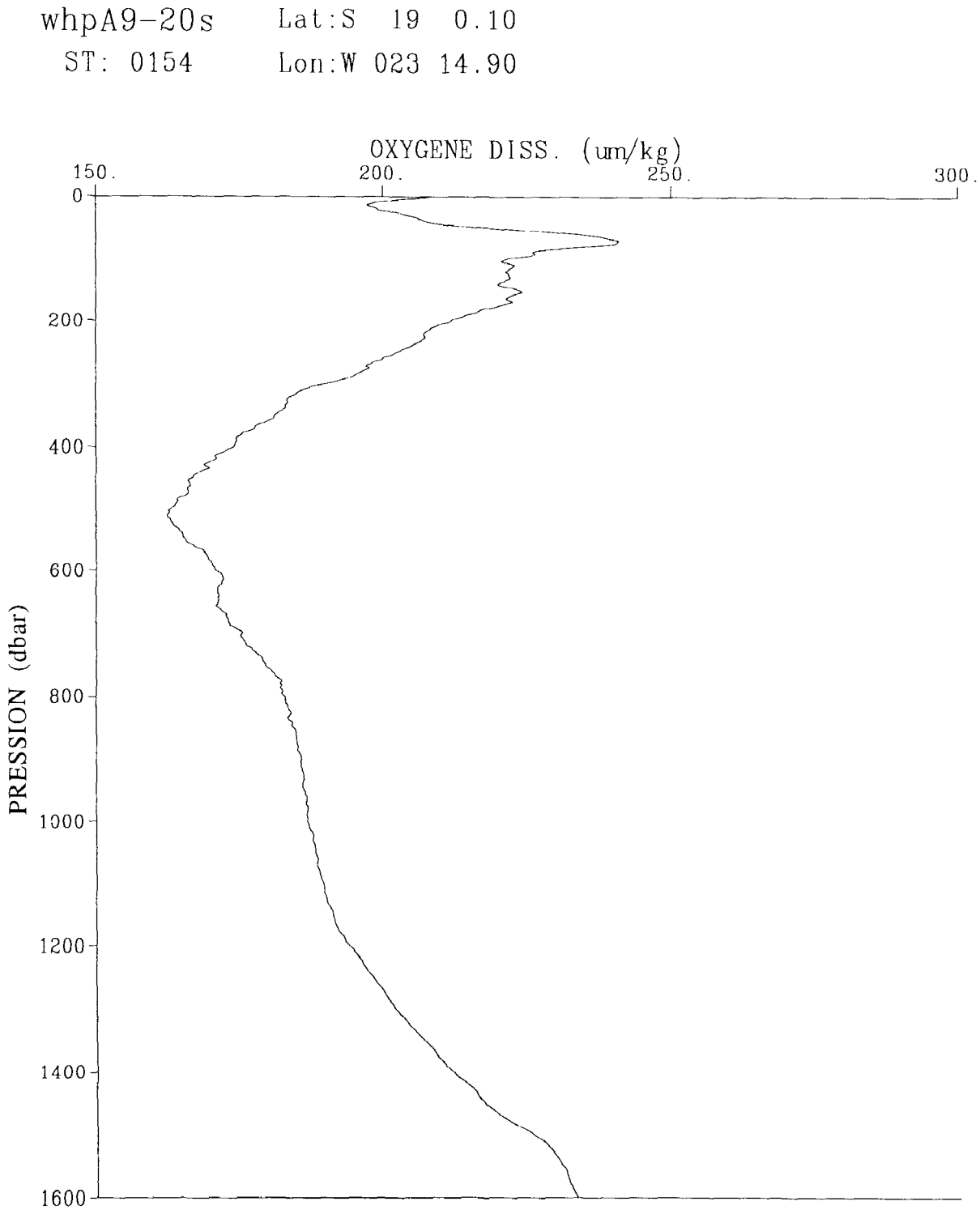

whpA9-20s
Lat:S 19 0.10
ST: 0154
Lon:W 023 14.90
OXYGENE DISS. (um/kg)
150.
200.
250.
300.
0
200
400
600
800
1000
1200
1400
1600
PRESSION (dbar)

Fig. 10b

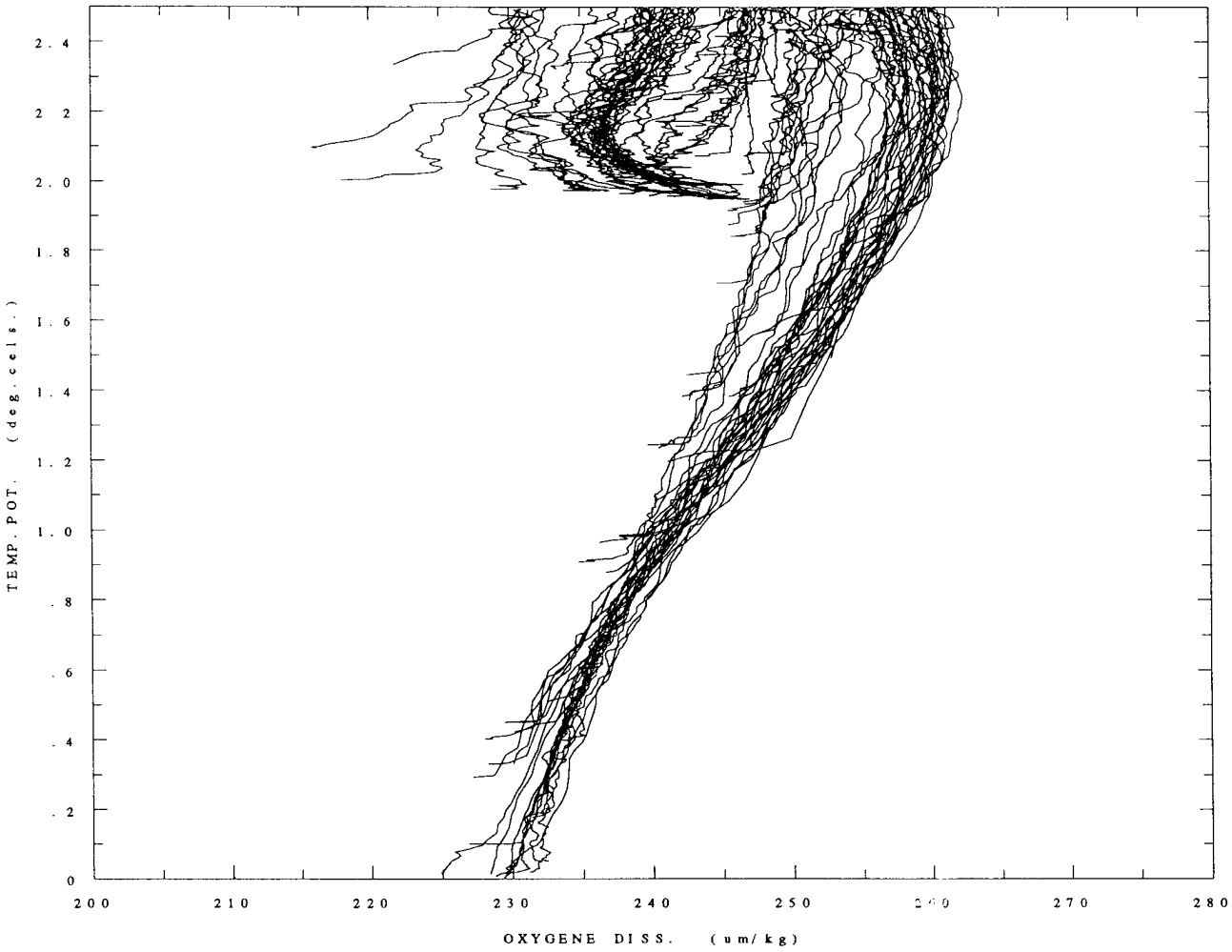

TEMP. POT. (deg. cels.)
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
200
210
220
230
240
250
260
270
280
OXYGENE DISS. (um/kg)

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. 19ºS 1ºE.

> 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. 19ºS 25ºW.

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 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | ******** | ******** | ******** | ********** | | |
| 122 | 1 | 12 | 2998.0 | | | | 1.14 | ~~~2 | ~~~3 |
| 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 |
| 125 | 1 | 12 | 6.0 | | | 0.85 | | ~~2~ | ~~3~ |
| 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 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | ********* | ********* | ******** | ********** | | |
| 132 | 1 | 13 | 28.0 | | | 0.43 | | ~~2~ | ~~3~ |
| 132 | 1 | 13 | 63.0 | | | 0.31 | | ~~2~ | ~~3~ |
| 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 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | ********* | ********* | ******** | ********** | | |
| 143 | 2 | 14 | 2243.0 | | 19.37 | | | ~2~~ | ~3~~ |
| 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 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | ********* | ********* | ******** | ********** | | |
| 148 | 1 | 14 | 98.0 | | 1.55 | | | ~2~~ | ~3~~ |
| 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 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | ********* | ********* | ******** | ********** | | |
| 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 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | ********* | ********* | ******** | ********** | | |
| 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 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | ********* | ********* | ******** | ********** | | |
| 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 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | ******** | ******** | ******** | ********** | | |
| 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 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | ********* | ********* | ******** | ********** | | |
| 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 through job. But with the information that was provided, I generated station listings for the values of CFC11, CFC12, CFC11/CFC12 ratio, percent saturation of $O_2$, $O_2$, 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 $O_2$ 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 | SAMPNO | CTDPRS | 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 | SAMPNO | CTDPRS | 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, were 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 0.0 1±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

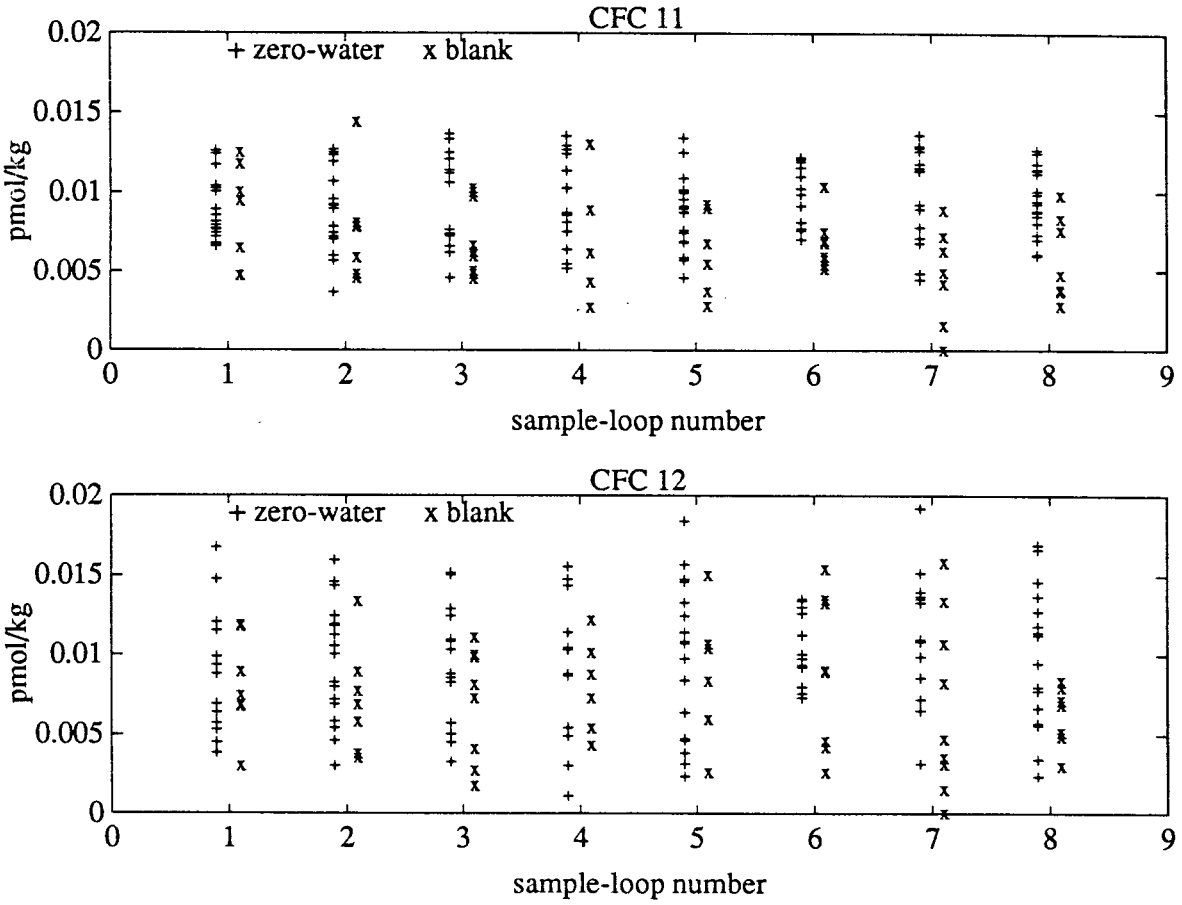



Fig. 1: #172 - #196

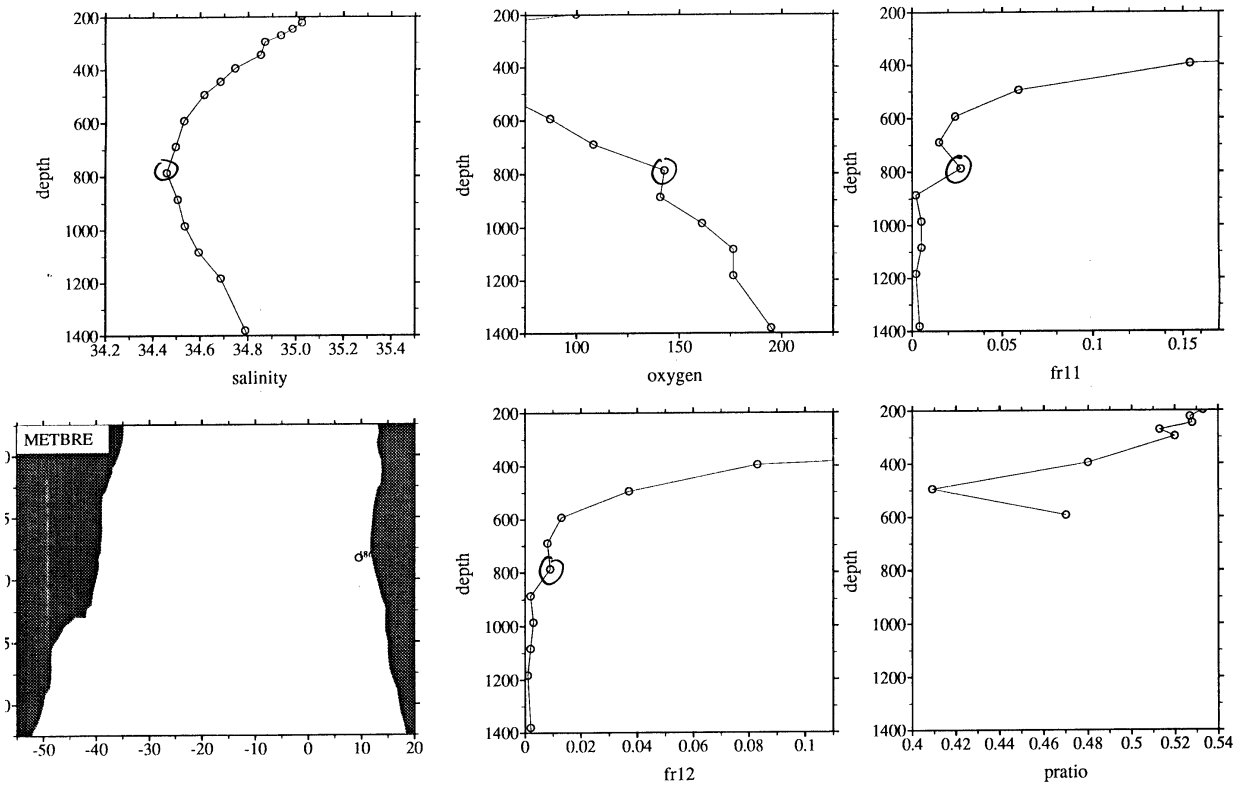



Fig. 2: #229

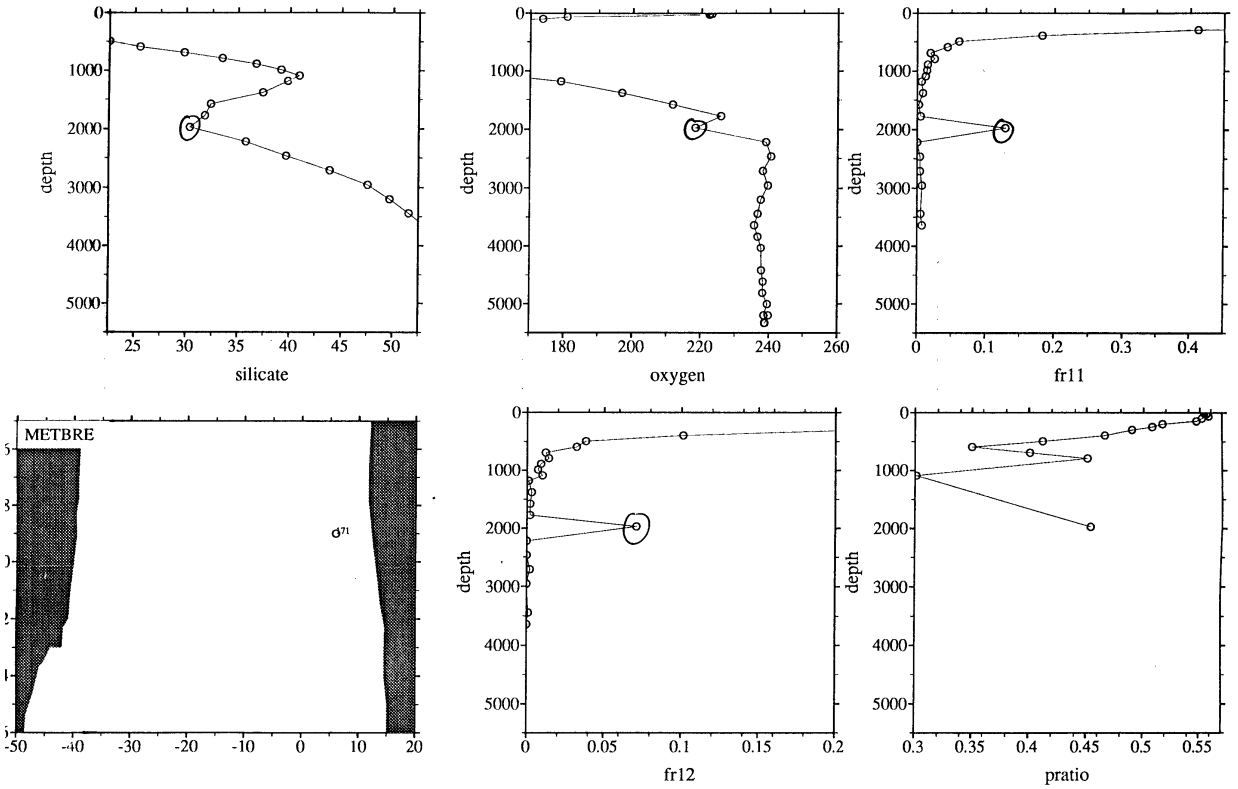



Fig. 3: #214

1997.04.03

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: CCl4
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

The quality code is defined as follows (Woce standard basically with minor modification):
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

General comments:
Helium and Neon measurements
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.

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 continuously 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