# J G O F S 9 0

# RV BELGICA CRUISE 90/18

**PARTICIPATING LABORATORIES FROM :**

**ULB - MUMM - VUB - ULg - RUG**

**MUMM contribution**

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**Computer logged oceanographic, navigational and meteorological data.**

**Nutrients analyses and Salinity measurements.**

VOLUME I : Report.

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# JGOFS 1990

## RV BELGICA CRUISE 90/18.

CONTENTS

# J G O F S  1 9 9 0

## RV BELGICA CRUISE 90/18.

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## 1. INTRODUCTION.

The RV BELGICA cruise 90/18, from the 2nd to the 18th of July 1990, is the second Belgian oceanographic campaign which took place as a contribution to the international program **Joint Global Ocean Flux Studies (JGOFS).** A preparatory campaign with the BELGICA took place in September 1989 (BELGICA campaign 89/21).

A summary of the objectives of the cruise is given in the cruise report "Rapport de mission du BELGICA 90/18 du 2 au 18 juillet 1990" (R. WOLLAST, Oct. 1991).

The BELGICA sailed from Zeebrugge on the 2nd of July and arrived at the port of call Vigo (Spain) on the 11th of July. Station S1 till S11 and 1 till 8 have been sampled during the first part of the cruise. A stop was made at the harbour of Plymouth in order to embark sediment traps borrowed from the Plymouth Marine Laboratory. In addition to the 10 planned "JGOFS" stations, 11 stations were sampled as a contribution to the international **FLUX MANCHE** program.

The BELGICA sailed from Vigo on the 15th of July and returned to Zeebrugge on the 18th of July. During this second part the remaining "JGOFS" stations 9 and 10 were sampled.

Prof. R. Wollast was the principal scientist aboard the BELGICA for this cruise. The following laboratories have participated :

* Université Libre de Bruxelles (ULB) - Laboratoire d'Océanographie.
* Vrije Universiteit Brussel (VUB) - Laboratorium voor Analytische Scheikunde.
* Université de Liège (ULg) - Laboratoire d'Océanologie
* Rijksuniversiteit Gent (RUG) - Sectie Marine Biologie.
* Koninklijk Belgisch Instituut voor Natuurwetenschappen (KBIN) - Afdeling Mineralogie en Petrografie.
* Ministry of Public Health and Environment - Management Unit of the North Sea and Scheldt Estuary Mathematical Model (MUMM).

MUMM was mainly charged with the automatic data acquisition and logging of oceanographic, meteorological and navigational data. It should be noted that just prior to the cruise a new SCTD profiling system (SEABIRD model SBE09) and a new rosette water sampling system (General Oceanics) have been installed. In addition to the data acquisition task, assistance was offered for the analysis of nutrients using the TECHNICON Autoanalyzer system.

Besides general assistance was offered in using the on board scientific instrumentation and related infrastructure, the 30 l Niskin bottle sampling, etc ...
Also samples for laboratory salinity measurements were taken, and these samples have been analyzed in MUMM's laboratory at Oostende.

The present report describes the computer logged oceanographic, meteorological and navigational data gathered during this cruise. Additionally the laboratory salinity measurements are included in the report and also the results of the nutrient analyses are recaptured.

## 2. COMPUTER LOGGED OCEANOGRAPHIC, NAVIGATIONAL AND METEOROLOGICAL DATA.

### 2.1. Navigational instrumentation

During this cruise, the data from the following navigational instruments connected to the shipborn computer system were logged by the so called Oceanographic Data Acquisition Software system "ODAS" :

* SHIPMATE RS4000 DECCA navigation system.
* NAVSTAR 602D DECCA navigation system.
  This 2 navigation systems have an accuracy of typically 50 to 400 meter, mostly depending on atmospheric conditions. In the centre of the Gulf of Biscay, the lack of a good DECCA coverage leads to errors of almost 1 nautical mile.
* Anshutz STD12 Gyro Compass.
* Raytheon DSN450 Doppler speed log and bathymetric depth.
* Atlas Deso 20 Scientific Echosounder.
  Both echosounders Raytheon and Atlas are shallow water echosounders, so no data is available at depths greater than 250-300m.

### 2.2. Oceanographic instrumentation

The seasurface temperature was measured continuously with a Rosemount temperature sensor installed at the inlet of the special seawater circuit situated at the bow of the vessel.

A Seabird SBE19 Seacat CTD profiler was installed in the wet lab and connected to the special seawater circuit. The salinity was measured continuously using a personal computer with a dedicated software package from Seabird. The specifications of this CTD profiler are given in table 1.

| Parameter | Units | Range | Accuracy |
|---|---|---|---|
| TEMPERATURE | °C | -5 - +35 | 0.01 °C / 6 months |
| CONDUCTIVITY | S/m | 0 - 7 | 0.001 S/m / month |

Table 1. Seabird SBE19 Seacat specifications.

Salinity and density are calculated from conductivity, temperature and depth, in accordance to the 1978 Practical Salinity Scale from the IEEE Journal of Oceanic Engineering, January 1980.

A Turner 111 fluorimeter, also connected to the special seawater circuit, was used to indicate chlorophyll concentrations during the full campaign.

SCTD vertical profiles have been taken with the newly installed Seabird SBE09 CTD profiler. This instrument was just put into operation at the beginning of the campaign. The specifications of this CTD profiling system are given in table 2.

| Parameter | Units | Range | Accuracy (guaranteed) |
|---|---|---|---|
| DEPTH | m | 0 - 3000 | 0.1 % of full scale range |
| TEMPERATURE | °C | -5 - +35 | 0.01 °C / 6 months |
| CONDUCTIVITY | S/m | 0 - 6 | 0.001 S/m / month |
| DIS. OXYGEN | ml/l | 0 - 15 | 0.1 ml/l /day |
| pH | pH | 2 - 12 | 0.1 pH /day |

Table 2. Seabird SBE09 specifications.

## 2.3. Meteorological instrumentation

Following parameters were measured by the Friedrichs meteorological station :

- wind speed
- wind direction
- air temperature
- atmospheric pressure
- air humidity

In addition a solar radiation measuring device from Kipp & Zonen was installed.

The outputs of these sensors are analogous signals that are measured with the 4 ½ digit digital voltmeter incorporated in the ODAS system. The specifications of the meteo sensors are recaptured in Table 3.

| Parameter | Units | Range | Precision |
|---|---|---|---|
| WIND SPEED | m/s | 0 - 41 | 0.2 |
| WIND DIRECTION | degrees | 0 - 360 | 2 |
| ATMOSPHERIC PRESSURE | mbar | 950 - 1050 | 1.5 |
| RELATIVE HUMIDITY | % | 0 - 100 | 2.5 |
| AIR TEMPERATURE | °C | -35 - +45 | 0.2 |
| SOLAR RADIATION | Watt/m² | 0 - 1000 | 10 |

Table 3. Meteo sensor specifications.

## 3. DATA ACQUISITION SYSTEM.

### 3.1. HP1000 - ODAS system.

A Hewlett Packard HP1000 minicomputer system with a HP6942 multiprogrammer and an HP3497A digital voltmeter subsystem were used to provide continuously logged data at the following intervals :

10 min. : navigational, meteorological and oceanographic data during the whole cruise.

01 min. : navigational data, sea surface temperature and fluorescence during the full cruise.

0.5 sec. : solar radiation data (quantameter) during vertical profiles.

The Oceanographic Data Acquisition System "ODAS" software package has been used for this purpose.

This ODAS software package was designed to interrogate the different subsystems, instruments and sensors installed, and to gather in real time several groups of parameters at different time intervals. The data are stored on Winchester disc while at the same time the data can be listed or plotted in real time or off line. Selected parameters can also be distributed in real time to the video monitors installed in the laboratories and on the bridge.

The data are transferred to the shore based data processing centre of MUMM situated at Oostende using the integral cartridge backup system of the Winchester drive.

At the shore station the data is stored on an identical HP1000 system, hence the same ODAS software package can be used for further processing.

Additionally the data stored in the internal ODAS format (binary) have been converted to ASCII for transportation to a PC MS-DOS or a UNIX system, using the KERMIT data transfer package.

## 3.2. SCTD - Horizontal profiling system.

The Seabird SBE19 Seacat profiler was installed in a reservoir connected to the special seawater circuit. The data was recorded continuously to obtain horizontal salinity profiles during the trajectories or time profiles at the fixed stations. The data at 2 samples per second were averaged over a 1 minute interval in accordance with the acquisition rate of the sea surface temperature and the fluorescence. These data were stored on the harddisk of a portable personal computer. A graphical presentation of the data was available on the computer screen, while a hardcopy on matrixprinter was also possible. After the campaign these data were added to the HP1000 horizontal profile data.

## 3.3. SCTD - Vertical profiling system.

The vertical CTD profiles have been obtained with the Seabird SBE09 system installed on a General Oceanics Rosette sampler. The Seabird SBE09 measures the depth of the sensor package, water temperature, conductivity, pH and dissolved oxygen at a rate of 24 samples per second. These data were averaged in the Seabird deck unit over a 0.5 sec. time interval.

The averaged values were shown in real time on the PC display in a graphical way, allowing for an immediate decision of the water sampling depths. The Seabird CTD software also allows to mark the SCTD data when water bottle samples are taken so that the SCTD and related parameters are known at the exact depth.

## 4. INVENTORY OF AUTOMATICALLY LOGGED NAVIGATIONAL, METEOROLOGICAL AND OCEANOGRAPHIC DATA.

All datafiles created during the Belgica campaign 90/18 have been concatenated into the following data files :

| Filename | Acquisition rate | Type of data | Duration |
|---|---|---|---|
| M91800 | 10' | navig. + meteo | Full campaign. |
| O11800 | 1' | position + oceano. | Full campaign. |
| O51800 | 0.5" | quantameter | Station 1, 3 and 6. |
| JGOS01.DAT | 0.5" | | |
| JGOS02.DAT | 0.5" | | |
| JGOS03.DAT | 0.5" | | |
| JGOS04.DAT | 0.5" | CTD | CTD profiles at |
| JGOS05.DAT | 0.5" | | |
| JGOS06.DAT | 0.5" | vertical | the Channel |
| JGOS07.DAT | 0.5" | | |
| JGOS08.DAT | 0.5" | profile | stations. |
| JGOS09.DAT | 0.5" | | |
| JGOS10.DAT | 0.5" | | |
| JGOS11.DAT | 0.5" | | |
| JGOP01.DAT | 0.5" | | |
| JGOP02.DAT | 0.5" | | |
| JGOP03a.DAT | 0.5" | | |
| JGOP03b.DAT | 0.5" | CTD | |
| JGOP04.DAT | 0.5" | | CTD profiles in the |
| JGOP05a.DAT | 0.5" | vertical | |
| JGOP05b.DAT | 0.5" | | Gulf of Biscay. |
| JGOP06a.DAT | 0.5" | profile | |
| JGOP06c.DAT | 0.5" | | |
| JGOP07.DAT | 0.5" | | |
| JGOP08.DAT | 0.5" | | |
| JGOP09.DAT | 0.5" | | |
| JGOP10b.DAT | 0.5" | | |
| JGOP10c.DAT | 0.5" | | |

Table 4. Data file inventory.

These file names or derivatives occur on the different listings and plots.

## 5. REMARKS CONCERNING DATA ACQUISITION AND DATA VALIDITY.

### 5.1. Position registration.

During the whole JGOFS campaign, the Shipmate RS4000 and NAVSTAR 602 navigation systems were used as the primary positioning instruments. Both systems use the DECCA chain radio signals. In the centre of the Gulf of Biscay bad reception occurred, especially at night.

Besides these DECCA based systems a LORAN C receptor was used. However, the quality of the position given by the latter was very poor. Deviations of up to 5 miles as compared with the DECCA based systems were common.

### 5.2. Salinity measurements.

#### 5.2.1. Validation of the SCTD salinity measurements.

During the campaign vertical SCTD profiles have been taken with the SBE model 09 SCTD system. At different locations and multiple depths water samples have been taken to validate the salinity data of the SBE09 system. The water samples have been analysed in MUMM's laboratory at Oostende with a Beckmann RB7 laboratory salinometer.

The Beckmann salinometer is calibrated using IAPSO standard seawater capsules obtained from the Institute of Oceanographic Sciences (UK). The results of the analyses are given in Table 14 of "Volume II : Appendices".

These results have been compared with the Seabird SBE09 salinity measurements (see also Table 5 and Figure 1).

Standard deviation : 0.0055 ppt.
Corrolation coefficient : 0.99936
Maximal error : 0.017 ppt.

| Station # | Date | Time | Beckmann | Seabird | Error | Depth |
|---|---|---|---|---|---|---|
| | | | ppt | ppt | ppt | m |
| S1 | 2-7-90 | 21h15 | 34.971 | 34.965 | -0.006 | 3 |
| S2 | 3-7-90 | 05h25 | 35.100 | 35.098 | -0.002 | 3 |
| S3 | 3-7-90 | 08h37 | 35.034 | 35.033 | -0.001 | 3 |
| S4 | 3-7-90 | 13h04 | 35.070 | 35.072 | 0.002 | 3 |
| S5 | 3-7-90 | 17h47 | 34.988 | 34.988 | 0.000 | 3 |
| S6 | 3-7-90 | 22h10 | 35.223 | 35.227 | 0.004 | 3 |
| S8 | 4-7-90 | 04h33 | 35.222 | 35.226 | 0.004 | 3 |
| S9 | 6-7-90 | 21h22 | 35.337 | 35.336 | -0.001 | 3 |
| S10/03 | 7-7-90 | 10h25 | 35.266 | 35.262 | -0.004 | 3 |
| S10/20 | 7-7-90 | 10h22 | 35.257 | 35.254 | -0.003 | 20 |
| S10/40 | 7-7-90 | 10h20 | 35.388 | 35.395 | 0.007 | 40 |
| S10/60 | 7-7-90 | 10h18 | 35.393 | 35.395 | 0.002 | 60 |
| S10/100 | 7-7-90 | 10h16 | 35.393 | 35.397 | 0.004 | 100 |
| S11 | 7-7-90 | 20h28 | 35.488 | 35.488 | 0.000 | 3 |
| 3/03 | 8-7-90 | 08h42 | 35.607 | 35.612 | 0.005 | 3 |
| 3/20 | 8-7-90 | 08h39 | 35.607 | 35.611 | 0.004 | 20 |
| 3/50 | 8-7-90 | 08h37 | 35.622 | 35.618 | -0.004 | 50 |
| 3/80 | 8-7-90 | 08h34 | 35.618 | 35.627 | 0.009 | 80 |
| 3/100 | 8-7-90 | 08h33 | 35.604 | 35.614 | 0.010 | 10 |
| 3/130 | 8-7-90 | 08h30 | 35.608 | 35.615 | 0.007 | 130 |
| 3/180 | 8-7-90 | 08h27 | 35.602 | 35.604 | 0.002 | 180 |
| 5/5 | 9-7-90 | 09h22 | 35.749 | 35.747 | -0.002 | 5 |
| 5/20 | 9-7-90 | 09h20 | 35.739 | 35.741 | 0.002 | 20 |
| 5/40 | 9-7-90 | 09h18 | 35.728 | 35.729 | 0.001 | 40 |
| 5/60 | 9-7-90 | 09h16 | 35.675 | 35.683 | 0.008 | 60 |
| 5/100 | 9-7-90 | 09h13 | 35.645 | 35.656 | 0.011 | 100 |
| 5/130 | 9-7-90 | 09h11 | 35.605 | 35.611 | 0.006 | 130 |
| 5/200 | 9-7-90 | 09h07 | 35.605 | 35.616 | 0.011 | 200 |
| 5/400 | 9-7-90 | 09h01 | 35.553 | 35.562 | 0.009 | 400 |
| 5/600 | 9-7-90 | 08h54 | 35.472 | 35.479 | 0.007 | 600 |
| 5/750 | 9-7-90 | 08h45 | 35.579 | 35.591 | 0.012 | 750 |
| 6/3 | 10-7-90 | 19h20 | 35.686 | 35.688 | 0.002 | 3 |
| 6/10 | 10-7-90 | 19h19 | 35.681 | 35.676 | -0.005 | 10 |
| 6/20 | 10-7-90 | 19h16 | 35.681 | 35.680 | -0.001 | 20 |
| 6/30 | 10-7-90 | 19h14 | 35.681 | 35.680 | -0.001 | 30 |
| 6/40 | 10-7-90 | 19h12 | 35.681 | 35.685 | 0.004 | 40 |
| 6/60 | 10-7-90 | 19h10 | 35.681 | 35.675 | -0.006 | 60 |
| 6/80 | 10-7-90 | 19h08 | 35.628 | 35.626 | -0.002 | 80 |
| 6/100 | 10-7-90 | 19h06 | 35.620 | 35.622 | 0.002 | 100 |
| 7/10 | 11-7-90 | 10h47 | 35.692 | 35.692 | 0.000 | 10 |
| 7/25 | 11-7-90 | 10h45 | 35.692 | 35.697 | 0.005 | 25 |
| 7/40 | 11-7-90 | 10h43 | 35.702 | 35.705 | 0.003 | 40 |
| 7/60 | 11-7-90 | 10h42 | 35.735 | 35.749 | 0.014 | 60 |
| 7/80 | 11-7-90 | 10h39 | 35.782 | 35.780 | -0.002 | 80 |
| 7/100 | 11-7-90 | 10h36 | 35.761 | 35.762 | 0.001 | 100 |
| 7/200 | 11-7-90 | 10h32 | 35.631 | 35.636 | 0.005 | 200 |
| 7/300 | 11-7-90 | 10h28 | 35.585 | 35.590 | 0.005 | 300 |
| 7/400 | 11-7-90 | 10h23 | 35.539 | 35.550 | 0.011 | 400 |
| 7/500 | 11-7-90 | 10h11 | 35.577 | 35.594 | 0.017 | 500 |
| 7/600 | 11-7-90 | 10h01 | 35.721 | 35.726 | 0.005 | 600 |
| 7/750 | 11-7-90 | 09h56 | 35.999 | 36.006 | 0.007 | 750 |
| 10/3 | 17-7-90 | 03h21 | 35.455 | 35.452 | -0.003 | 3 |
| 10/5 | 17-7-90 | 03h20 | 35.442 | 35.446 | 0.004 | 5 |
| 10/10 | 17-7-90 | 03h19 | 35.442 | 35.451 | 0.009 | 10 |
| 10/15 | 17-7-90 | 03h17 | 35.446 | 35.443 | -0.003 | 15 |
| 10/20 | 17-7-90 | 03h16 | 35.451 | 35.462 | 0.011 | 20 |
| 10/40 | 17-7-90 | 03h14 | 35.455 | 35.465 | 0.010 | 40 |
| 10/60 | 17-7-90 | 03h12 | 35.455 | 35.471 | 0.016 | 60 |
| 10/100 | 17-7-90 | 03h10 | 35.471 | 35.476 | 0.005 | 100 |

| | |
|---|---|
| R Squared | 0.999362 |
| standard deviation | 0.005472 |
| Maximal error | 0.017 |

Table 5. Data Seabird SBE 09 versus Beckmann RB7 salinometer.

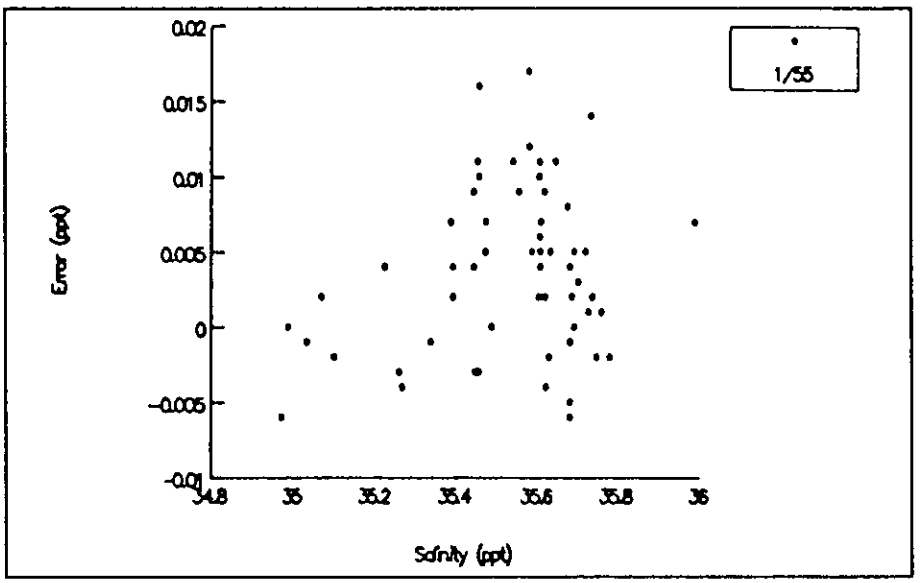


Figure 1. Error Seabird SBE 09 versus Beckmann RB7 salinometer.

5.2.2. Salinity spiking of the SCTD measurements.

In order to improve the performance of the SCTD salinity measurements, the Seabird SBE09 has a Temperature and Conductivity (TC) duct with an inertia-balanced pump flow ( see Figure 2 ).

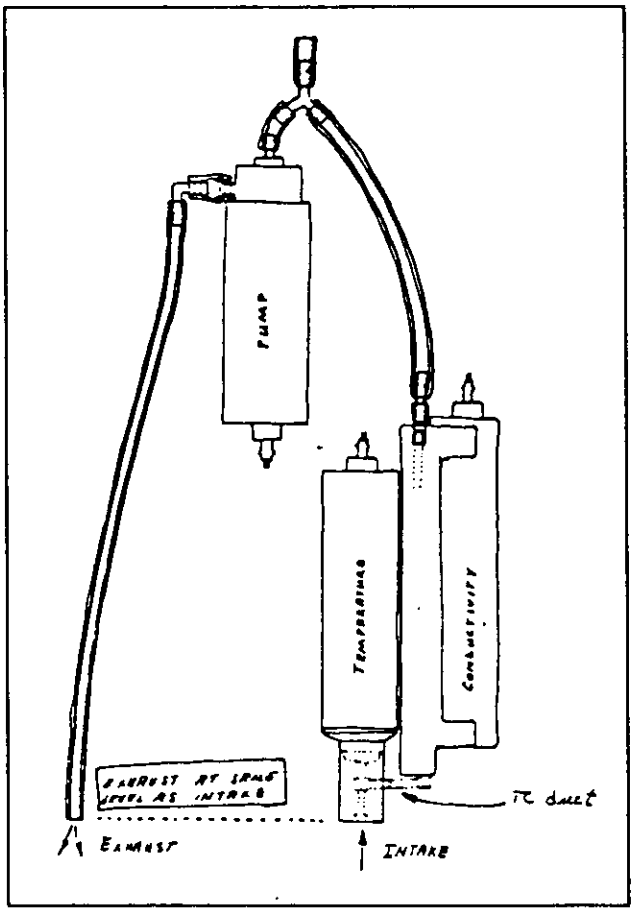


Figure 2. Schematic diagram of the typical inertia-balanced plumbing arrangement with TC duct.

The figure shows that conductivity measurements are made down-stream of the temperature sensor in the TC duct and are therefore made at a later time on a given parcel of water flowing along the duct. The exact time delay between the measurements depends on the flow rate in the duct and the time constants of the sensors. To compute salinity without spikes, the temperature and conductivity measurements must be aligned in time. The best indicator of alignment is the salinity spikes themselves ( see Figure 3.). In a downward going profile where temperature decreases with depth :

if salinity spikes are negative : conductivity must be lagged (negative advance)
if salinity spikes are positive : conductivity must be advanced

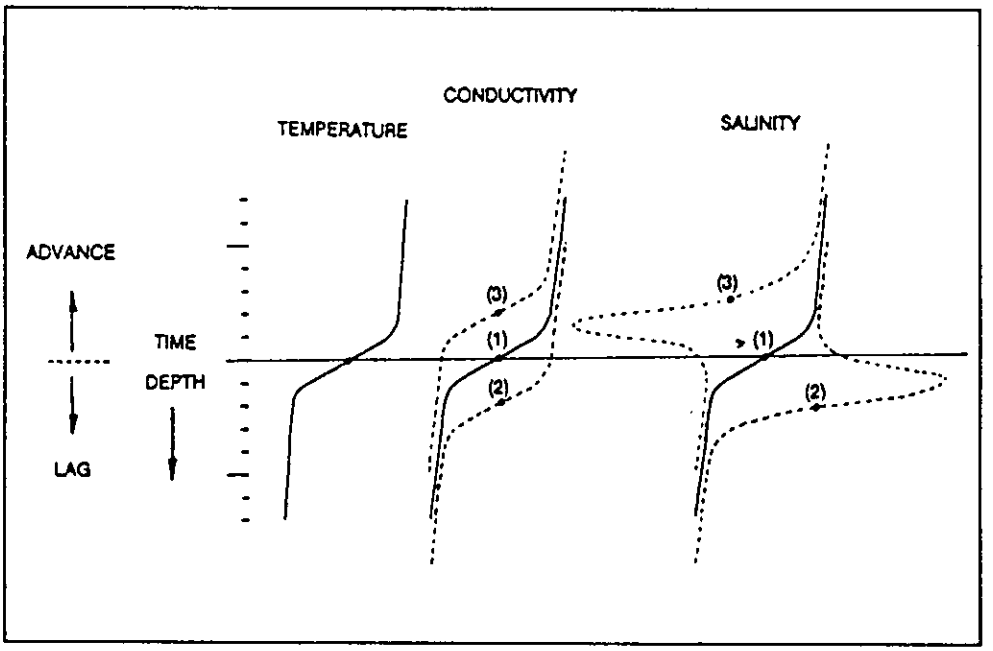


Figure 3. The shift of conductivity data relative to temperature.

(1) The real oceanic alignment of the conductivity relative to temperature.
(2) The salinity spike is positive, the conductivity must be advanced.
(3) The salinity spike is negative, the conductivity must be lagged.

The precise time-advance of conductivity that minimizes spiking for a specific CTD configuration is determined with a computerprogram. Therefore it is necessary to acquire data at the highest speed possible. This was done during this campaign at the first 3 stations with a speed of 12 samples per second. The align computerprogram showed that the applied shift for the conductivity gave minimal spiking.

5.3. Dissolved oxygen.

The SEABIRD SBE09 SCTD system has been installed just prior to the cruise 90/18. The DO calibration data supplied by Sea-Bird Electronics, Inc. were not installed in time. Obviously obsolete calibration data have been compiled into the conversion program and consequently the DO-data distributed in the preliminary report were raw DO-data only.

In the appendices to this report the DO data have been compiled using the correct calibration data. The DO-data obtained with the SBE09 profiler have been compared with the in situ DO-oxygen analyses (Winkler method) carried out by the ULg - Laboratoire d'Océanologie.

In addition a postcalibration was executed at MUMM's laboratory in Oostende. This postcalibration demonstrated an offset of about 0.7 ml/l compared to the original calibration data.

In Figure 4 DO-data are shown at 20 meters depth in a number of stations. The graph shows the SBE09 DO-data without and with the postcalibration correction, as well as all DO-data obtained from the ULg-laboratory.

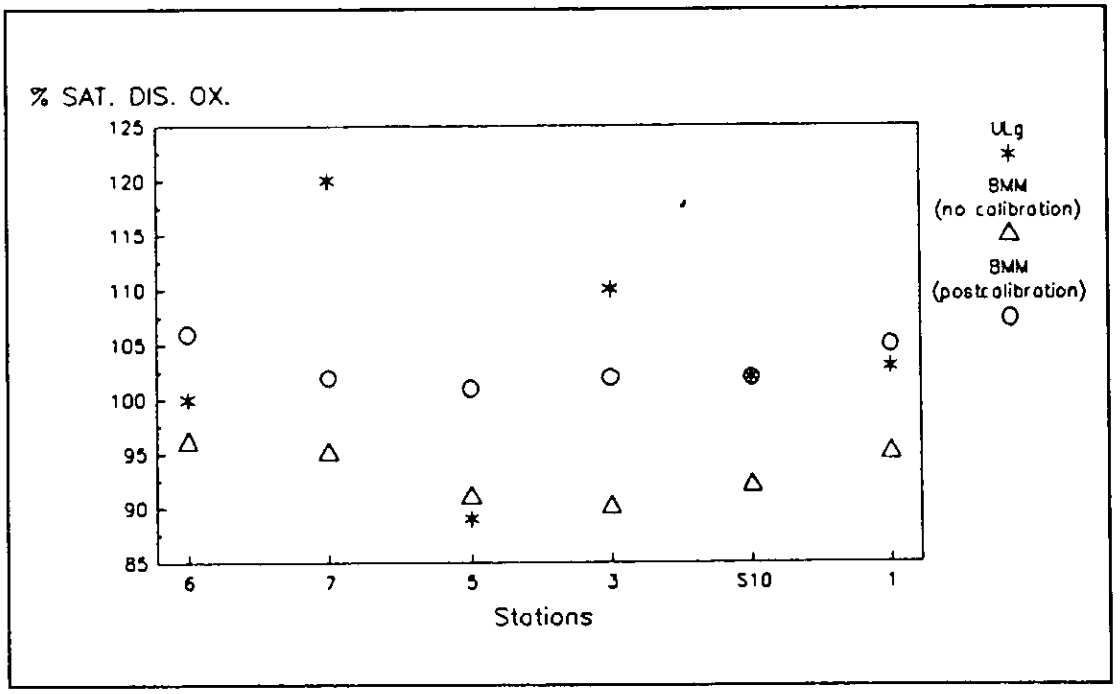


Figure 4. Comparison of ULg, MUMM-uncorrected and MUMM-corrected results for dissolved oxygen at 20 m depth in a number of stations

## 5.4. pH sensor measurement resolution.

Due to the A/D convertor applied by Sea-Bird and the extended range of the pH sensor (pH 0 - 14), a rather poor resolution of 0.018 pH is obtained. This can still be seen clearly in the figures 30 to 53 of the Volume II, Appendices, although the data have been averaged over a one meter depth interval.

Sea-Bird Electronics, Inc. specifies a drift of 1% per day for the pH sensor. A postcalibration executed at MUMM's laboratory in Oostende showed an offset of +0.11 pH. This postcalibration value was not applied to the data in the preliminary report. The appendices to this report contain the corrected data.

## 5.5. Data validity.

One of the features of the ODAS package is that it verifies all subsystems, instruments and parameters interrogated.

To each parameter value, subsequently logged in the ODAS files, one byte is added to take into account these data validity checks.

The validity is also shown on the data listings (see Volume II, Appendices) and transferred to the ASCII files. The following code is used :

| Code | Meaning |
|---|---|
| M | Malfunction of a subsystem. |
| U | No update of the data since the previous logged value. |
| V | Data not valid (e.g. test on data string format failed). |
| D | Range error of the DVM subsystem. |
| R | Lower/upper range test. |
| G | Gradient test. |
| = | Not used. |
| S | Suspected data indication given by e.g. a positioning system. |

## 6. NUTRIENT ANALYSES

The determination of nitrate, nitrite, phosphate and silicate was carried out by using the continuous flow method of the TECHNICON AUTOANALYZER II installed aboard the oceanographic ship "A962 BELGICA".

The automated procedures are based on the formation of a colored reagent whose concentration is read colorimetrically.

1° Nitrate and nitrite (Total $NO_x$) :
reduction of nitrate to nitrite by a copper-cadmium reductor column and formation of a reddish-purple azo dye. Measurement at wavelength 550 nm.

$NO_x$ Industrial Method N° 158-71W ; Dec. 1972
Detection limit : 0.1 $\mu$molN/l

Interferences: the concentration of potentially interfering metal ions like divalent mercury and divalent copper are well below the limits causing interferences.

2° Nitrite :
the nitrite level must be substracted from the total level (see 1°). It can be determinated by eliminating the reductor column.

3° Phosphate :
formation of a phosphomolybdenum blue complex. Measurement at wavelength 880 nm.

$PO_4$ Industrial Method N°155-71W ; Jan. 1973
Detection limit : 0.08 $\mu$molP/l

Interferences: although arsenate produces a simular color to phosphate, sea water rarely contains arsenate in concentrations high enough to interfere.

4° Silicates :
reduction of a silicomolybdate to "molybdenum blue" by ascorbic acid. Measurement at wavelength 660 nm.

Si Industrial Method N° 186-72W ; June 1977
Detection limit : 1.0 $\mu$molSi/l

Interferences: large amounts of iron, color, turbidity and sulfide interference.

All chemicals were of reagent grade quality and were supplied by Merck-Belgolabo (Belgium).
Reagents and standards were prepared using ultra-pure Milli-Q water (resistivity = 18 MΩ).

All the recipients were washed out before use with 1N hydrochloric acid and rinsed thoroughly with distilled water to avoid contamination.

Nitrate/nitrite (flask of polyethylene) and phosphate (flask of glass) samples were kept in the deepfreezer before analysis; silicate (flask of polyethylene) samples were refrigerated at 4°C.

## 7. REVIEW OF LISTINGS AND PLOTS.

All listings and plots of the RV BELGICA JGOFS 90/18 campaign are compiled in "VOLUME II : Appendices". A review of the contents of this volume is given in supra.

Appendix 1. Plot with station annotations and list of positions.

**Table 1.** Station positions.

**Figure 1.** Station positions on chart.

Appendix 2. Position data and meteorological data during the complete campaign.

**Listing 1.** Navigational data every 15 minutes.

**Listing 2.** Meteorological data every 2 hours.

**Figure 2.** Trackplot of the complete campaign.

Appendix 3. Horizontal profiles.

**Listing 3.** Oceanographic data, listed every 30 minutes.

**Figure 3 & 4.** Graphplot showing seatemperature and fluorescence during horizontal profiling.

**Figure 5.** Graphplot showing salinity and density ( sigma $\Theta$ ) during horizontal profiling. Density data are approximative due to the temperature gradient of about 0.3 deg. C of the seawater between the inlet of the seawater circuit and the position of the salinometer.

Appendix 4. Vertical profiles with SCTD.

**Tables 2 to 13.** Tables giving the values of the oceanographic parameters at the SCTD water sampling points.

**Figure 6 to 29.** Vertical profiles of temperature, salinity and density

**Figure 30 to 53.** Vertical profiles of pH and dissolved oxygen.

Appendix 5. Vertical profiles of incident light (quantameter).

**Listing 4 to 6.** Listing of incident light, 1 value per meter.

**Figure 54 to 56.** Graphplot of incident light vs. depth.

Appendix 6. Nutients analyses.

**Table 14.** Results of the laboratory salinometer analyses and the nutrients analyses of the SCTD water samples.

**Figure 57 to 65.** Graphplot of the nitrates,nitrites,phosphates and silicates vs. depth at the SCTD water sampling points.