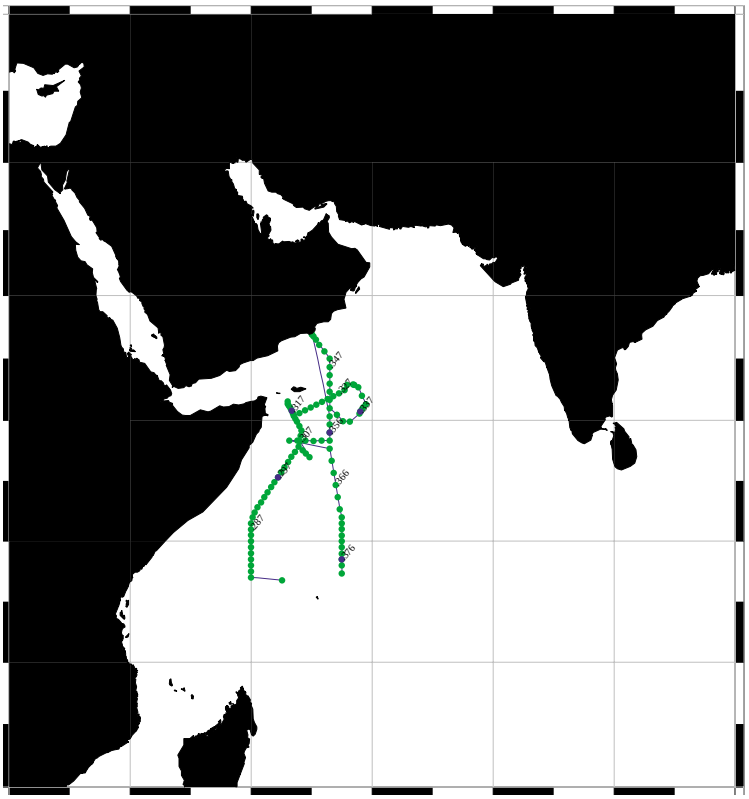
## A. Cruise Narrative: ISS02, IR03N (western Arabian Sea)



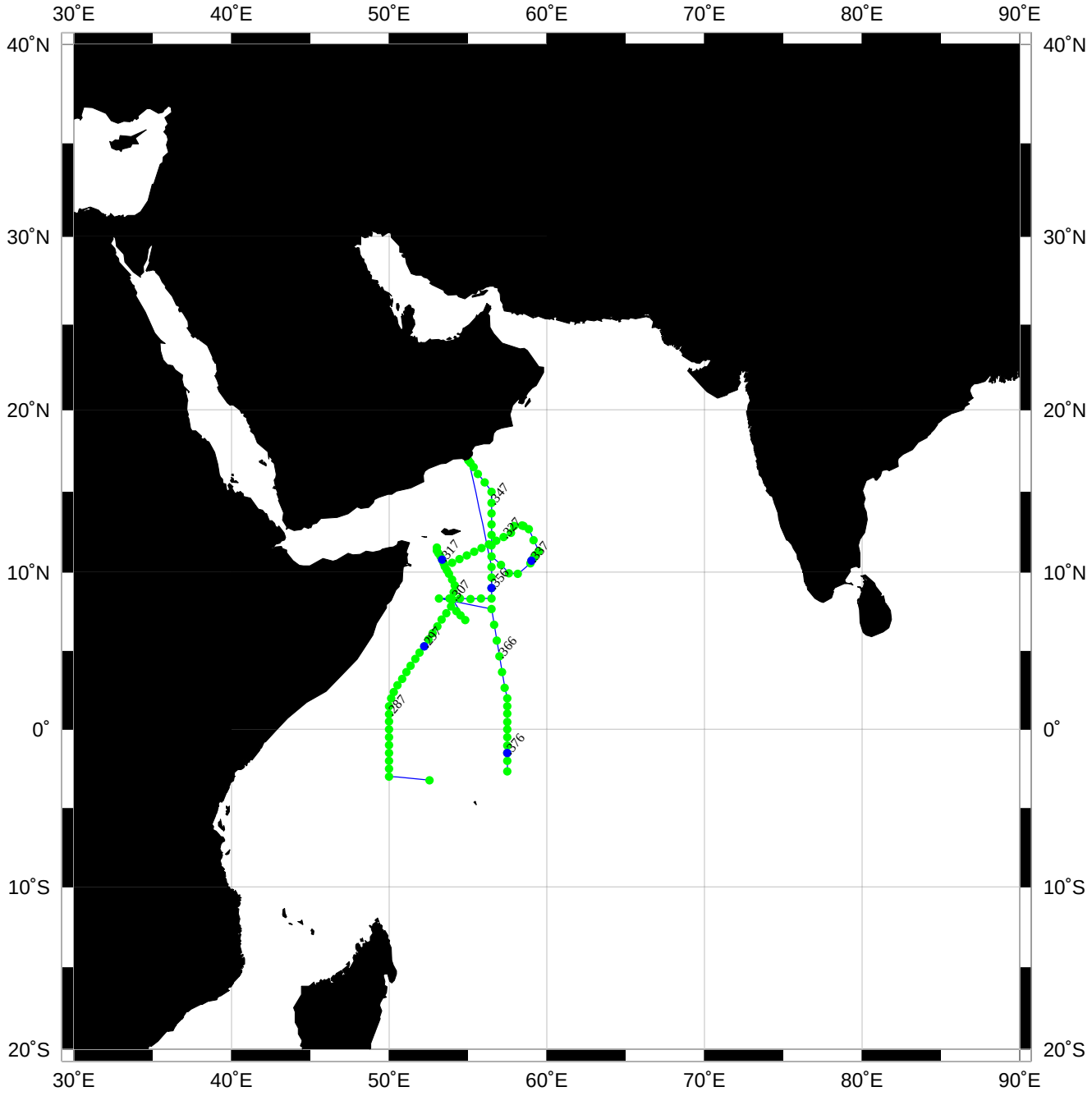
### A.1. Highlights

**WHP Cruise Summary Information**

| | |
|---|---|
| WOCE section designation | **ISS02, IR03N** |
| Expedition designation (EXPOCODE) | **06MT32_4** |
| Chief Scientist/affiliation | **Quadfasel / IfMH*** |
| Dates | 1995 JUN 8 - 1995 JUL 12 |
| Ship | RV METEOR |
| Ports of call | not reported |
| Number of stations | CTD: 102 |
| Geographic boundaries | 18°N<br>50°E 60°E<br>3°S |
| Floats and drifters deployed | not reported |
| Moorings deployed or recovered | not reported |
| Contributing Authors | Dr. Detlef R. Quadfasel |
| | Monika Rhein |
| | Olaf Plähn |

*Dr. Detlef R. Quadfasel
Institut für Meereskunde • Troplowitzstraße 7 • 22529 Hamburg • Germany
Tel. +49-40-4123-4206 • Fax. +49-40-4123-4644
e-mail: quadfasel@ifm.uni-hamburg.de

# Station locations for ISS02; JUN 1995 (Quadfasel)




Produced from .sum file by WHPO-SIO

## B. Scientific program

The cruise was designated to derive hydrographic data in the Arabian Sea during the summer monsoon as part of the WOCE Indian Ocean program.

## Parameters Reported

SALNTY
OXYGEN
SILCAT
NITRAT
NITRIT
PHSPHT
CFC-11
CFC-12
TCARBN
PH

## Participants

| | | |
|---|---|---|
| Detlef R. Quadfasel<br>quadfasel@ifm.uni-hamburg.de | Chief scientist | IfM Hamburg |
| Monika Rhein<br>monika.rhein@io-warnemuende.de | Chlorofluorocarbons | IfM Kiel |
| Olaf Plähn<br>oplaehn@ifm.uni-kiel.de | Chlorofluorocarbons | IfM Kiel |
| Martina Elbrächter<br>melbraechter@ifm.uni-kiel.de | CFC-Lab | IfM Kiel |

IfM Hamburg: Institut für Meereskunde • 22529 Hamburg • Germany
IfM Kiel: Institut für Meereskunde • 24105 Kiel • Germany

## Chlorofluorocarbons

(Monika Rhein and Olaf Plähn)

### Sample collection and technique

All samples were collected from 10 L Niskin bottles. The bottles had been cleaned prior to the cruise using isopropanol. All 'O' rings, valves, and taps were removed, washed in isopropanol and baked in a vacuum oven for 24 hours. The rubber bands on all bottles were replaced by stainless steel springs. The personnel for all water sampling and handling procedures at the bottles wore one-way gloves to protect the valves from grease.

About 100 ml of water were taken from the water bottles with gas-tight glass syringes (Becton and Dickinson). Then 15-25 ml of the samples were transferred to a purge and trap unit and analyzed on board following the procedures described in Bullister and Weiss [1988]. The CFCs were separated on a packed stainless steel column filled with Porasil C and detected with an Electron Capture Detector (ECD). The carrier gas was ECD pure Nitrogen, which was additionally cleaned by molsieves (13X mesh 80/100).

The calibration was done using a standard gas with near air concentrations to convert the ECD signal in concentrations. The CFC values are reported in pmol kg-1 on the SIO93 scale (R. Weiss, SIO).

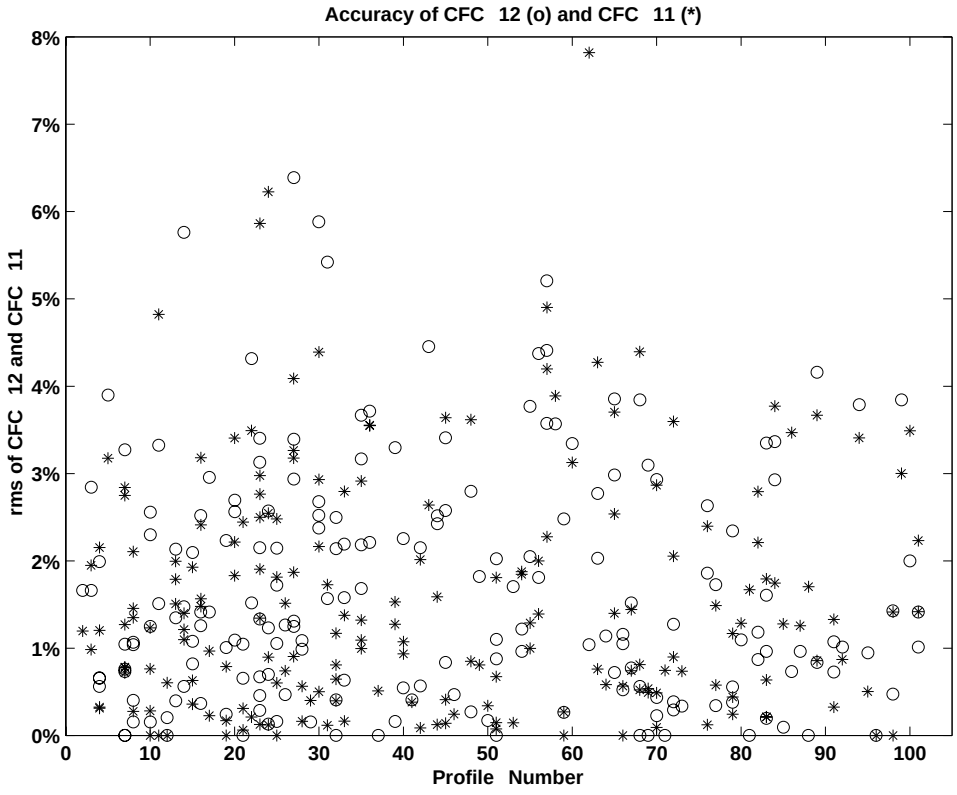



Figure 1: Accuracy of CFC-12 (o) and CFC-11 (*); replicate samples plotted vs. profile number.

## Performance

During the cruise M32/4 the Kiel CFC system worked continuously. Both CFC components CFC-11 and CFC-12 had been sampled on 100 CTD stations and 1290 water samples were analyzed. The accuracy was checked by measuring about 220 water samples twice or more (Figure 1). It was found to be for CFC-12 1.3% or 0.007 pmol kg-1 and for CFC-11 1.2% or 0.006 pmol kg-1 .

The mean blank of the sample transfer and the measurement procedure was determined by degassing 1 - 2 ml of CFC free deep water. During the cruise it was in the order of 0.004 pmol kg-1 for both components. Furthermore, CFC free water was created by degassing 5 L of seawater with ECD-pure nitrogen gas, to determine blanks of the measurement system and the syringes. Analysis of 25 ml of blankwater resulted in concentrations below 0.007 pmol kg-1 for both components.

The efficiency of the ECD was stable in time for both components (Figure 2). The temporal variations were only 15%. Relative to the start of the cruise the sensitiveness for the CFC-11 component first increased to 105%, decreased to 90% and increased again to about 95%. The CFC-12 component showed a decrease from 100% to less than 90% during the cruise. To correct the temporal drift of the ECD, a calibration curve with seven different gas volumes was taken before and after each station. The temporal change between two calibration curves was assumed to be linear in time. CFC concentrations were calculated by using the two neighboured points, supposing that the calibration curve is linear between these points.

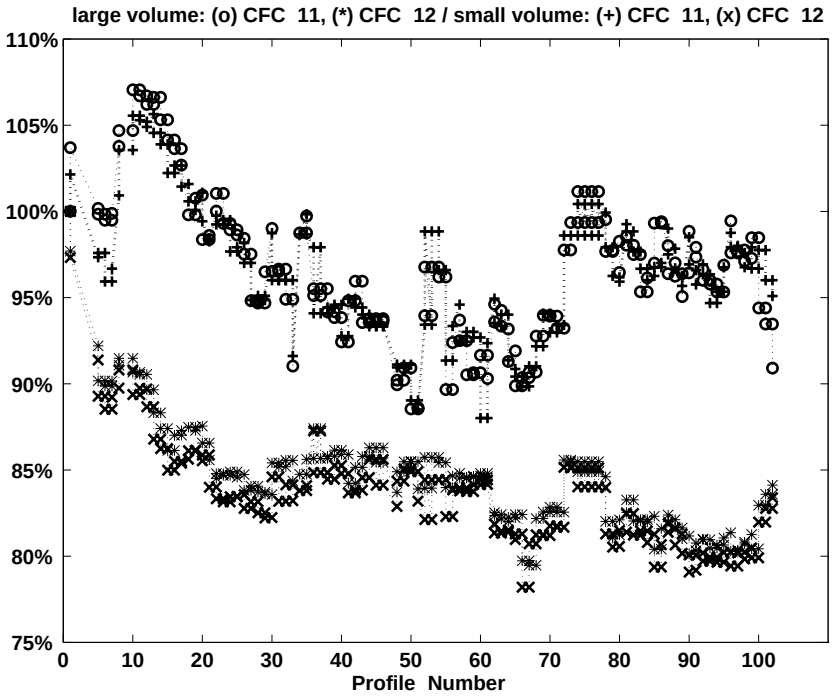



Figure 2: The temporal evolution of the ECD-efficiency during the cruise for the 0.5 ml volume (small) and the 2 ml volume (large).

## Contamination

At the end of the cruise painting work inside the vessel lead to contamination. Due to this activity three profiles (at most Station-No. 365) were disturbed by high CFC concentration of the laboratory air. On some stations, the CFC-12 peak was disturbed by the high N2O levels of the samples.

## Comments

At station 353 some bottles did not close, the profile was repeated down to 150 m. The second cast got the same station number, but the bottles were counted from 201-224 in the data-file 'meteor324.sea'.

'meteor324.sea' and the file 'meteor324.sum'.

The CFC concentrations decreased exponentially from the surface to about 1000 m depth (Figure 3). At larger depths, CFC concentrations were below detection limit. During this cruise the southwest monsoon started with wind-velocities up to 20 m s-1 . This strong wind forcing induced an intensive mixing of the upper layer, followed by a decrease of the sea surface temperature (SST) and the CFC surface saturation [Rhein et al., 1997]. The mean saturation was 92% for CFC-11 and 87% for CFC-12 (Figure 4). Higher values of the CFC-11 components compared to the CFC-12 saturation are caused by different velocities of the gas-exchange. At 400m depth the saturation of CFC-11 is only 0.4% higher than CFC-12 and at 800 m depth the saturations are equal. At the northern edge of the 'Great Whirl' (Stat. 319) and at the coast off Oman (Stat. 353) extremely low surface-saturations were measured, caused by upwelling processes [Plähn, 1999]. The mean CFC-11/CFC-12-ratio (Figure 5) increased from the surface (CFC-11/CFC- 12 ~ 1.8) down to 900 m (CFC-11/CFC-12>2.0). The accuracy of the ratio is less than 0.1 if the CFC-11 concentration it larger than 0.15 pmol kg-1 . For lower concentrations the error of the ratios increase.

## References


Bullister, J.L. and R.F. Weiss (1988). Determination of CCl3F and CCl2F2 in seawater and air. Deep-Sea Res., 35, S. 839-853.

Plähn, O. (1999). Ventilation und Zirkulation in der Arabischen See: Ergebnisse aus Beobachtungen und Modellanalysen. Dissertation, Universität Kiel.

Rhein, M., O. Plähn, and L. Stramma (1997a). Tracer distribution in the Arabian Sea, 1995. WOCE Newsletter, 27, S. 12-14.

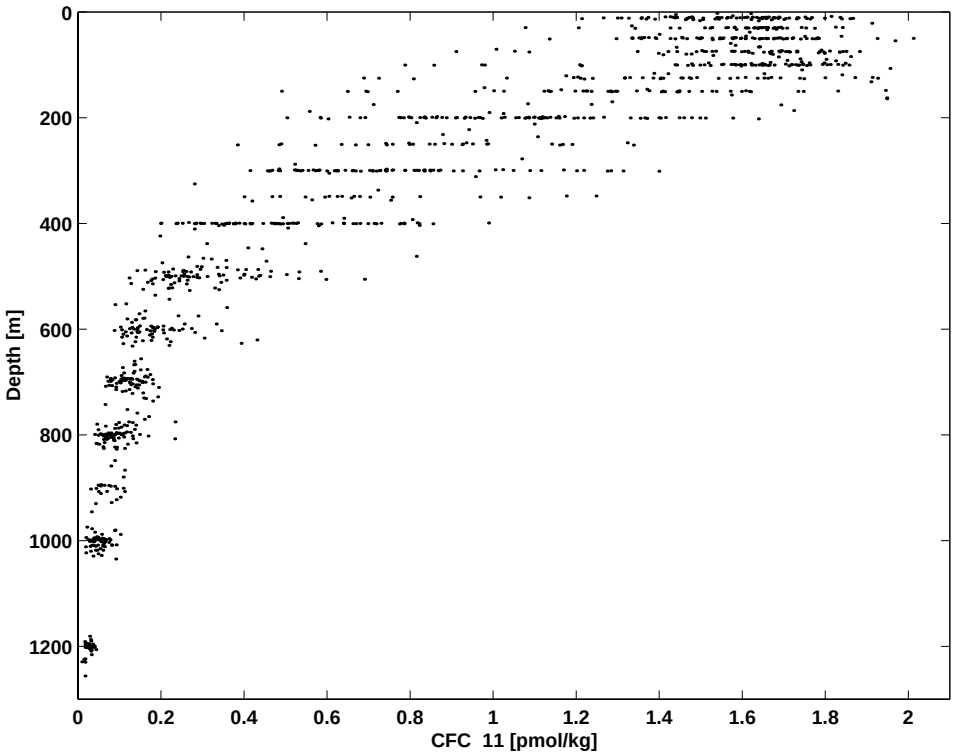



Figure 3: All CFC-11 concentration measured during M32/4 versus depth.

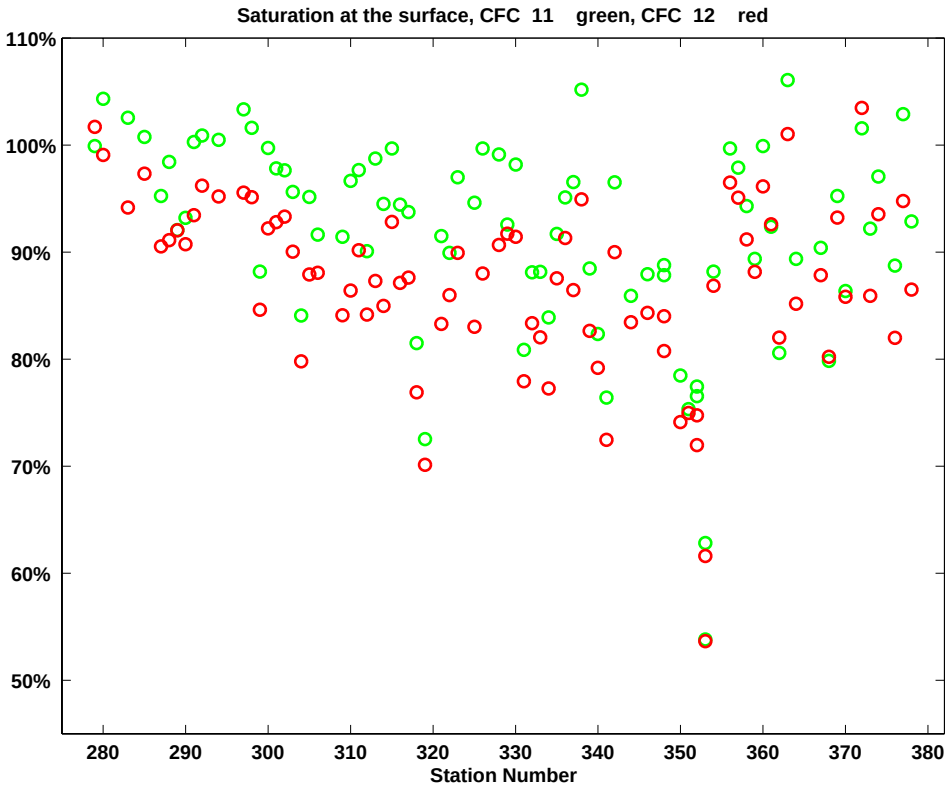



Figure 4: CFC-11 (green) and CFC-12 (red) saturation at the surface

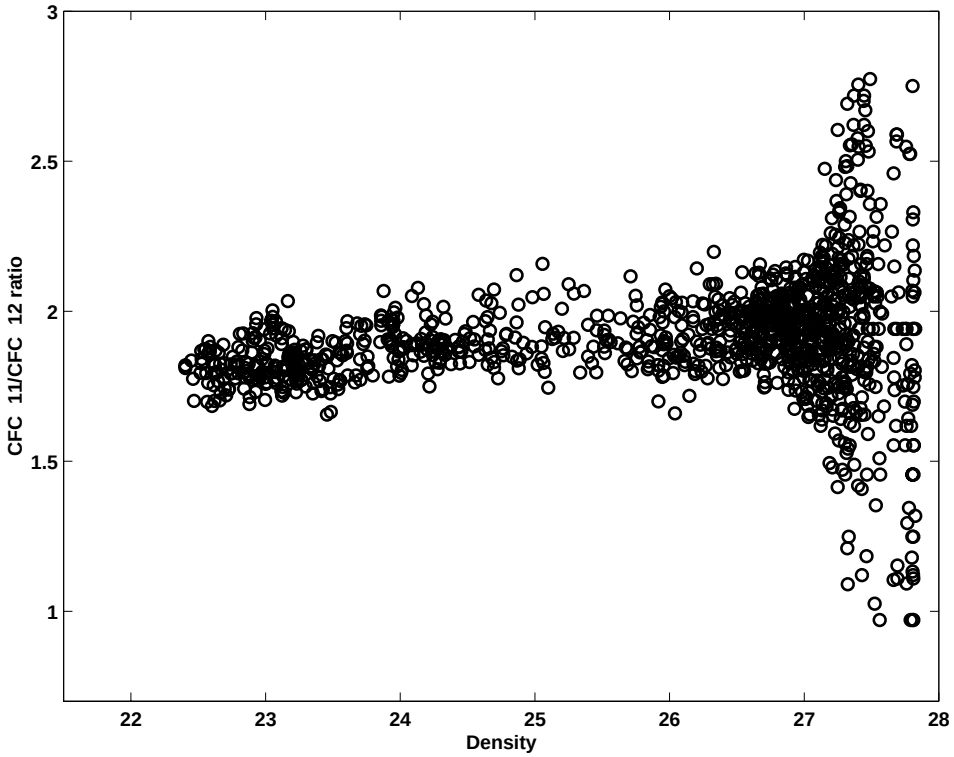



Figure 5: CFC-11/CFC-12 ratio versus density

## Appendix

Leg 4 is part of the 1995 Kiel CFC data set including the M32 legs 1 and 6 in the Arabian Sea.

| The station file 'meteor324.sum' includes: | | The bottle file 'meteor324.sea' includes: | |
|---|---|---|---|
| 1 | station number | 1 | station number |
| 2 | year | 2 | bottle number |
| 3 | month | 3 | depth (dbar) |
| 4 | day | 4 | in-situ temperature (°C) |
| 5 | hour: minutes in decimal system | 5 | salinity (psu) |
| 6 | latitude: minutes in decimals | 6 | CFC-12 (pmol kg-1) |
| 7 | longitude: minutes in decimals | 7 | CFC-11 (pmol kg-1) |
| 8 | water depth (m) | 8 | WOCE quality flag for CFC-12 and CFC-11 |
| 9 | depth of CTD profile (m) | | |

## Technical Information

| | |
|---|---|
| Gas chromatograph | Shimadzu GC 14 |
| GC column | stainless steel, packed with Porasil C |
| Cooling trap | with Porapak T and Porasil C |
| Trap temperatures | 30°C, 100°C |
| Column temperature | 70°C, isothermal |
| ECD temperature | 300°C |
| Electron capture detector | Shimadzu |
| Software for chromatogram analysis | Shimadzu C-R4A |
| Standard gas | ALM 83959, R. Weiss, SIO |
| Accuracy | CFC-11: 1.3% , CFC-12: 1.2% |
| Blanks | CFC-11: 0.004 pmol kg-1, |
| | CFC-12: 0.004 pmol kg-1 |

**WHP Data Processing Notes:**

| Date | Contact | Data Type | Data Status Summary |
|---|---|---|---|
| 08/16/95 | Quadfasel | SUM | Submitted |
| 11/05/96 | Quadfasel | CTD | Submitted |
| 11/05/96 | Quadfasel | BTL | T/S/O, NUTs, CFCs, TCARBN Submitted |
| 12/17/99 | Rhein | CFCs | Doc submitted |
| 04/23/01 | Bayer | He/Tr/C14 | Measured, Not Submitted |
| | The data (we) received from Meteor cruise 32, leg 4 to the Indian Ocean have not been sent yet. However, the data (about 150 tritium, 270 helium and 70 AMS-C14) are available in a laboratory internal format. The person responsible for this cruise is still around here and plans to merge the data to the hydrographic data (WHP format) including quality flags by summer/fall 2001. If this is not ok for you and you prefer to have the data on short notice we surely will be able to send them in a format similar to the one used for the Hjort 1994 cruise.<br><br>YES, ALL OUR DATA SUBMITTED TO WHPO ARE PUBLIC! | | |