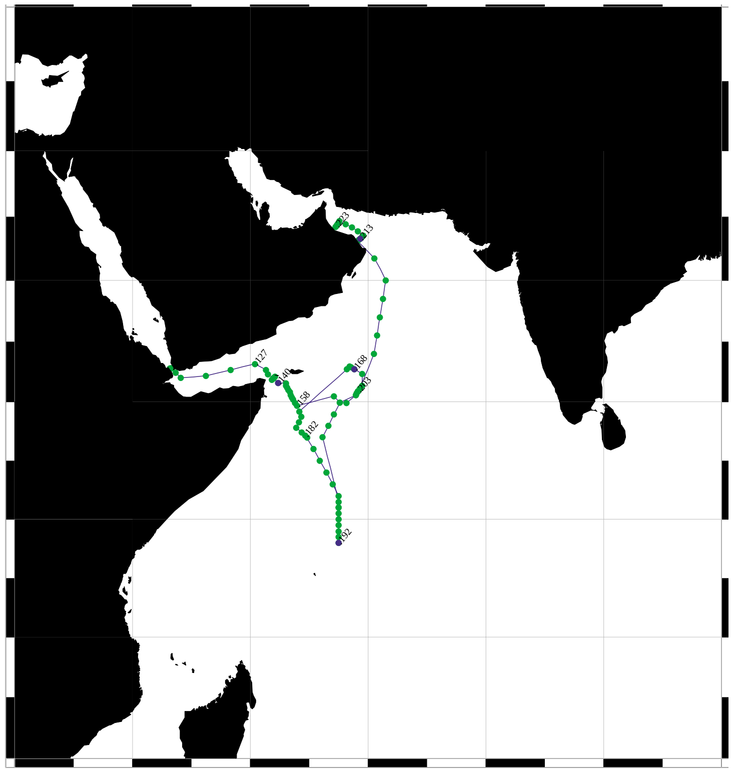
A. Cruise Narrative: ISS02, IR01W, IR03N (western Arabian Sea)



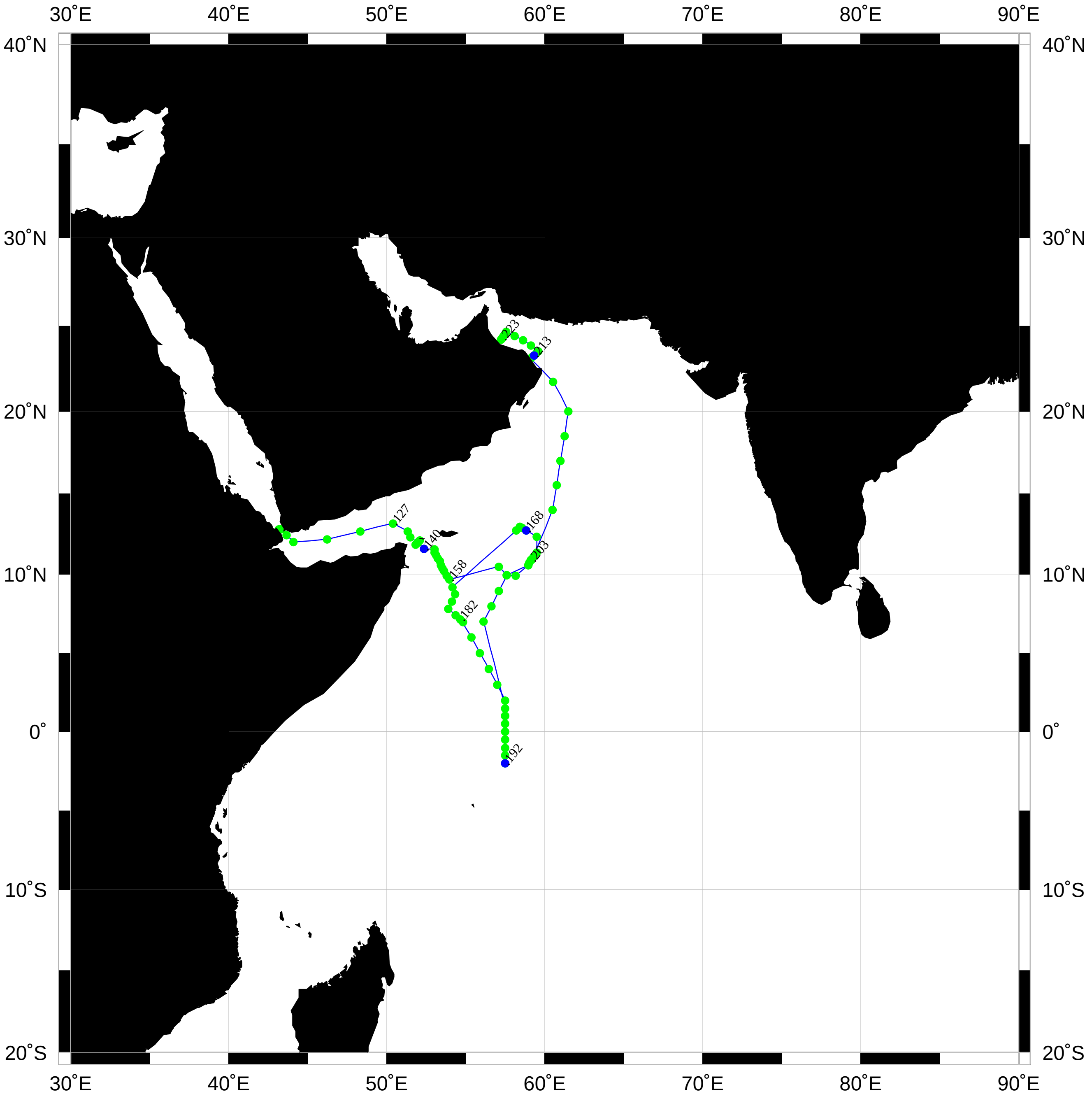
A.1. Highlights

WHP Cruise Summary Information

WOCE section designation	**ISS02, IR01W, IR03N**
Expedition designation (EXPOCODE)	**06MT32_1**
Chief Scientist/affiliation	**Friedrich Schott/IfM Kiel***
Dates	1995 MAR 23 - 1995 APR 26
Ship	RV METEOR
Ports of call	Djibouti to Muscat, Oman
Number of stations	CTD: 91 XBT: 45
Geographic boundaries of the stations	25°N 42°E 62°E 2°S
Floats and drifters deployed	0
Moorings deployed or recovered	?
Contributing Authors	Prof. Friedrich Schott
	Monika Rhein
	Olaf Plähn

*Prof. Friedrich Schott
Institut fuer Meereskunde • Duesternbrooker Weg 20 • 24105 Kiel • Germany
Tel. +49-431-600-4100 • Fax. +49-431-600-4102 • e-mail: fschott@ifm.uni-kiel.de

Station locations for ISS02, March 1995 (Schott)



Produced from .sum file by WHPO-SIO

Scientific program

The cruise was designated to derive hydrographic data in the Arabian Sea as part of the WOCE-program and to deploy several moorings in the western Arabian Sea.

Participants

Prof. Friedrich Schott fschott@ifm.uni-kiel.de	Chief scientist	IfM Kiel
Monika Rhein monika.rhein@io-warnemuende.de	Chlorofluorocarbons	IfM Kiel
Olaf Plähn oplaehn@ifm.uni-kiel.de	Chlorofluorocarbons	IfM Kiel
Martina Elbrächter melbraechter@ifm.uni-kiel.de	CFC-Lab	IfM Kiel

IfM Kiel: Institut für Meereskunde, 24105 Kiel, Germany

Chlorofluorocarbons
(Monika Rhein and Olaf Plähn)

Region: Arabian Sea, Gulf of Aden, Gulf of Oman,

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 gastight 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).

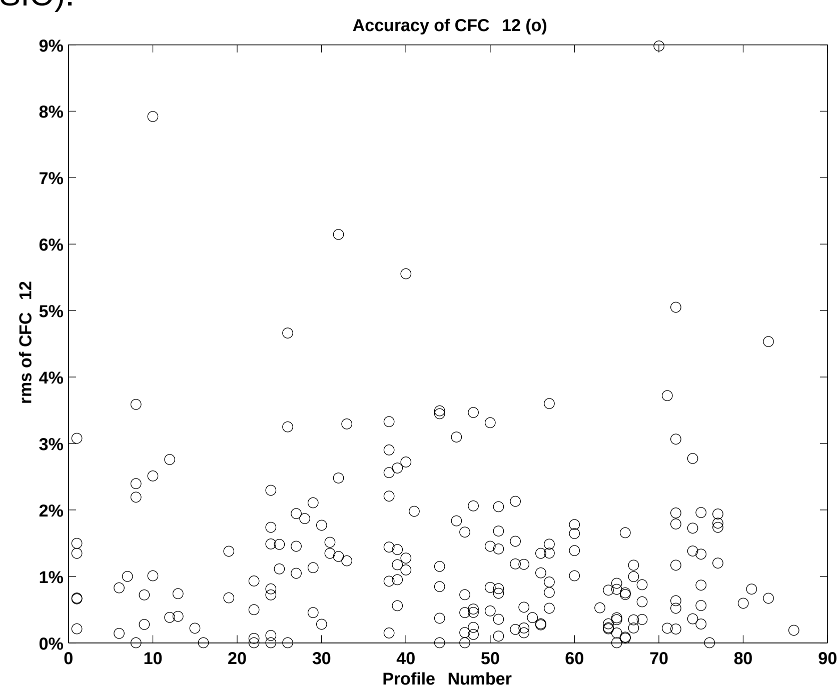


Figure 1: Accuracy of the CFC-12 component; replicate samples plotted vs. profile number.

Performance

During the cruise M32/1 the Kiel CFC system worked continuously. Both CFC components CFC-11 and CFC-12 had been sampled on 75 CTD stations and 880 water were analyzed.

The accuracy was checked by measuring about 220 water samples twice or more. It was found to be for CFC-12 1.3% or 0.005 pmol kg^{-1} (Figure 1). The CFC-11 component could not be analyzed successfully (see para 'Contamination').

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 0.005 pmol kg^{-1} for CFC-12. 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 for the CFC-12 component. During the cruise the efficiency decreased only 20% (Figure 2). 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.

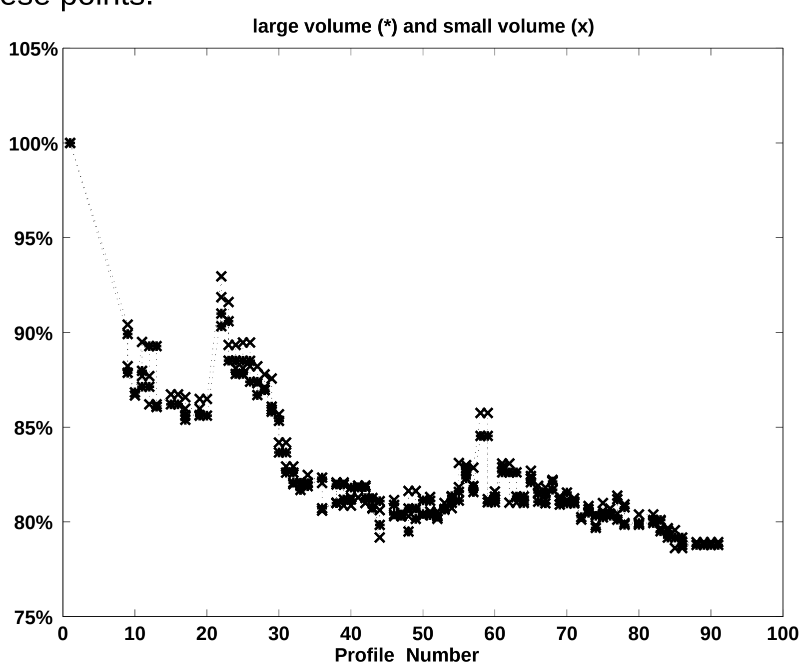


Figure 2: The temporal evolution of the ECD-efficiency during the cruise for the 0.5 mL volume (small) and the 2 mL volume (large).

Contamination

During the whole cruise, the CFC-11 measurements were deteriorated by contamination of the water bottles. Neither the numerous cleaning procedures of the water bottles/rosette nor the replacement of water bottles did remove the exceptionally high and variable contamination for CFC-11. For instance, the CFC-11 saturation in surface water was between 135-180%. The CFC-12 concentrations presumably remained unaffected, with surface saturations between 95 and 110%. On some stations, the CFC-12 peaks were disturbed by the high N2O levels, these data were removed.

Comments

The CFC concentrations decrease exponentially from the surface to about 1000 m depth. At greater depths, CFC concentrations were below detection limit (Figure 3). In the western Gulf of Oman (stations 210-224) the CFC-12 concentrations in the density range of the PGW (Persian Gulf Water, 26.3<SIGMAtheta<26.8) were up to three times higher than in ambient surface water (Figure 3). The saturations reached 270% (Figure 4), which is usually not observed in the ocean [Rhein et al., 1997b]. The supersaturations were not caused by contamination of the Niskin bottles, syringes, or of the CFC purge and trap system. Different bottles and syringes were used to sample the signal on each station and samples were taken from the respective bottles and syringes in depths not affected by the CFC maximum. The PGW was probably contaminated in the Persian Gulf, as the signal was restricted to the density of the PGW and the outflow

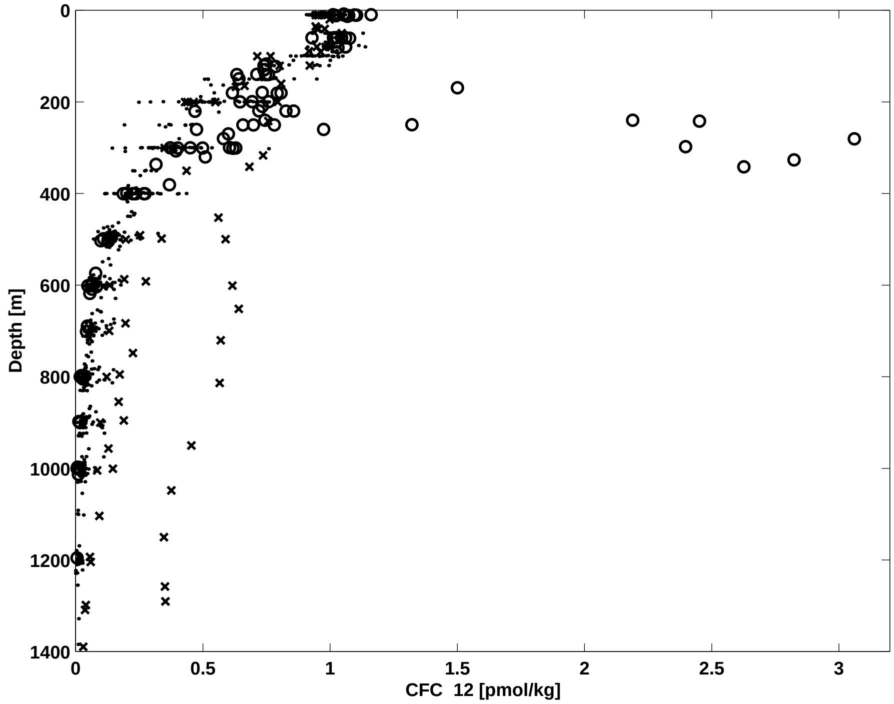


Figure 3: All CFC-12 concentrations measured during the cruise M32/1 versus depth. The samples collected in the Gulf of Aden are marked by crosses (x) and the data from the Gulf of Oman are marked by circles (o).

region in the Gulf of Oman [Plähn et al., 1999]. The signal was also observed during the Knorr cruise 145, in August 1995 (R. Fine, RSMAS Miami, USA) and during the Sonne cruise 128, in January 1998 (O. Plähn and M. Rhein, IfM Kiel, Germany).

In the Gulf of Aden the CFC-12 saturation in the Red Sea Water (SIGMA theta ~ 27.2) was determined to be 65% near the Strait of Bab el Mandeb [Rhein et al., 1997a]. However, this signal decreased eastward and only 20% of the source signal could by found near the island of Socotra, which is in good agreement with the dilution of the salinity signal [Plähn, 1999]. In September 1995 the outflow of the Red Sea was investigated during the Knorr cruise 145, too (M. Warner, Seattle, USA). During that cruise the largest CFC-12 saturation in the RSW was only about 40% [Mecking and Warner, 1999]. The reason of this difference is caused by the variable flow field in the Strait of Bab el Mandeb. In the Arabian Sea the saturation decreased southward to about 1.5-3.5% southern of 8

Outside the Gulf of Aden and Gulf of Oman the CFC-12 saturation, within the density range of the PGW (26.3< SIGMA theta <26.8), was between 15 and 30%. At some stations (No. 146, 149, 170, and 217) a CFC-12 saturation at the surface of more than 108% was found (Figure 5). The reason of this anomaly is unknown. These supersaturations are not correlated with the SST (sea surface temperature) and the samples are not influenced by a N_2O peak. Thus it is assumed that they are real.

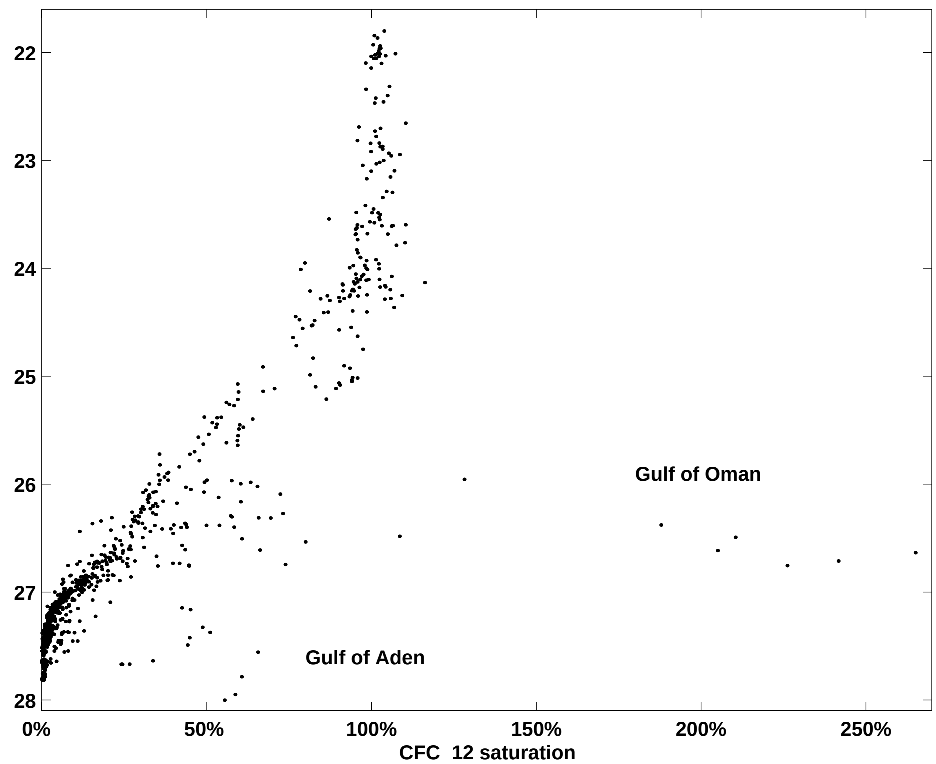


Figure 4: Saturation of all measured CFC-12 concentrations during the cruise M32/1 versus density.

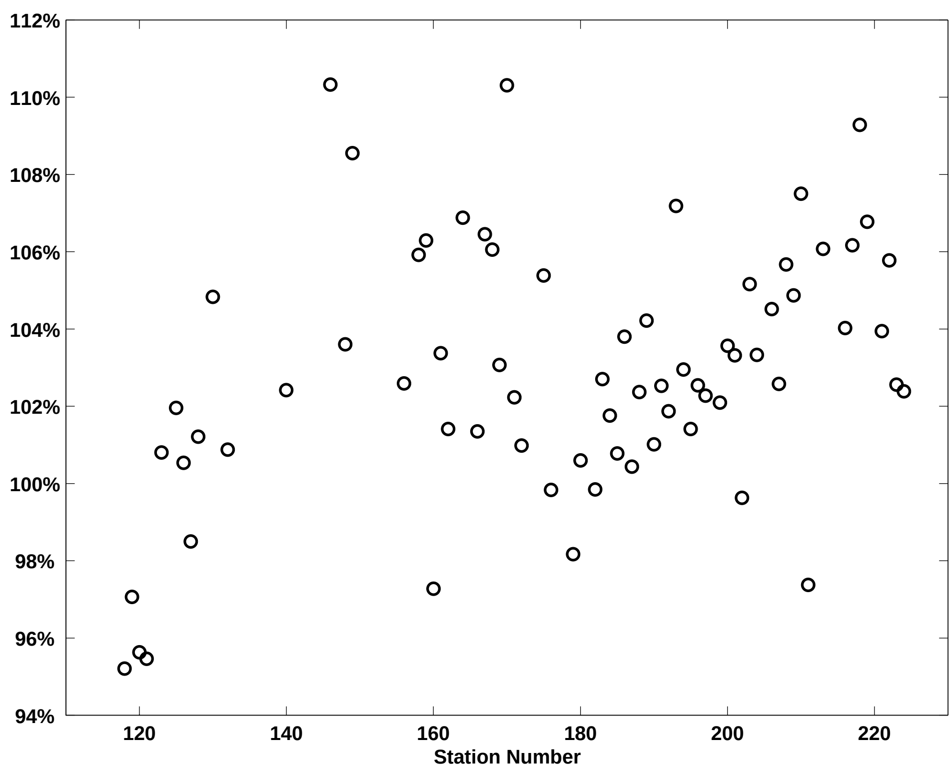


Figure 5: CFC-12 surface saturation measured during the cruise M32/1.

References

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Mecking, S. and M.J. Warner (1999). Ventilation of Red Sea Water with respect to chlorofluorocarbons. J. Geophys. Res., 104, S. 11087-11097.

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

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

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Appendix

- Leg 1 is part of the 1995 Kiel CFC data set including the M32 legs 4 and 6 in the Arabian Sea.
- The station file 'meteor321.sum' includes:
  1 station number
  2 year
  3 month
  4 day
  5 hour: minutes in decimal system
  6 latitude: minutes in decimals
  7 longitude: minutes in decimals
  8 water depth (m)
  9 depth of CTD profile (m)
- The bottle file 'meteor321.sea' includes:
  1 station number
  2 bottle number
  3 depth (dbar)
  4 in-situ temperature (-C)
  5 salinity (psu)
  6 CFC-12 (pmol kg^{-1})
  7 CFC-11 (pmol kg^{-1})
  8 WOCE quality flag for CFC-12 and CFC-11

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
Precision	CFC-12 10%
Accuracy	CFC-12: 1.3%
Blanks	CFC-12: 0.005 pmol kg^{-1}

WHPO Data Processing Notes:

Date	Contact	Data Type	Data Status Summary
5/8/00	Rhein	CFCs	Data are Public
	06MT32_1 06MT32_6 can be made public and included in the CD_ROM		
10/3/02	Uribe	SUM, CTD	Website Updated; Exchange file online
	· Casts changed to match SUM · CTD was converted to exchange. · CTD Casts were changed from increasing order to match the sumfile. · All data still Encrypted. No update on status.		
3/20/03	Stramma	CTD/BTL	Website Updated; Data are public
	I saw that there are three references with CTD and bottle data listed as non-public. These are: · 06MT32_1 · IR03N 06MT32_1 · IR03N 06MT32_6 We would like to ask you to make these data public.		
3/26/03	Bartolacci	CTD/BTL	Data are Public; Files unencrypted
	I have unencrypted the bottle and ctd files for this cruise. Completed minor edits on the bottle file (column alignment and header asterisk ajustments as well as expocode correction) in order to create exchange and netCDF files. With help from Karla there are now netCDF ctd files as well. All are now public, as per Dr. Strama (for Dr. Schott). However, please note that there is still no documentation for this cruise. Emails will be sent requesting a cruise doc.		
7/1/03	Kappa	DOC	PDF & Text reports assembled
	Both PDF and Text docs contain: · Cruise summary information · CFC Report · These WHPO Data Processing Notes PDF report also contains: · Figures for CFC report · Cruise Track · Links to Figures from text references		