Cruise Report

A. Cruise narrative[1]

A.1. Highlights

a. *WOCE designation:* SR04

b. *Expedition designation:* 06AQANTX_7

c. *Chief scientist:*
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d. *Ship:* Polarstern

e. *Ports of call:* Cape Town, South Africa to Ushuaia, Argentina

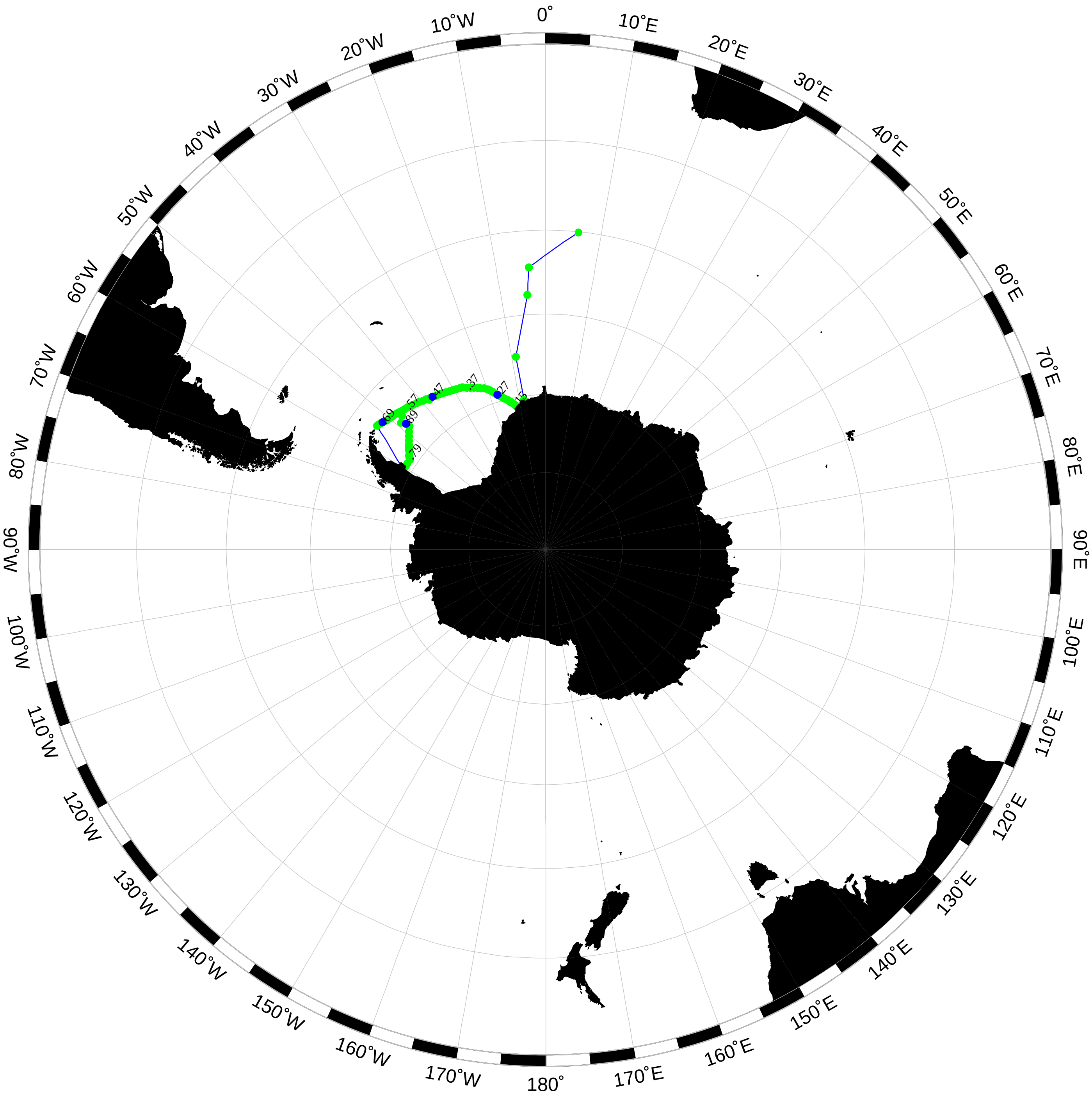
f. *Cruise dates:* December 3, 1992 to January 22, 1993

A.2. Cruise Summary Information

a. *Geographic boundaries:* The first part of the cruise involved a transit from Cape Town south-southwest to Neumayer Station. ADCP, XBTs, and some mooring work were done during that transit. The repeat section, SR04, was begun near 70°31´S 9°9´W and proceeded northwest through the Weddell Sea to finish near 61°S 58°25´W. Another CTD transect was completed to the east of the Larsen Ice Shelf in the area between 61°S and 69°S, 45°W to 60°42´W. The cruise finished with a transit from the South Shetland Islands across Drake Passage, during which ADCP and XBTs were done, to finish in Ushuaia near Cape Horn.

1. Sent to DIU March 14, 1995.

Station locations for SR04: FAHRBACH, 1993



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b. Stations occupied: 57 CTD-profiles (Conductivity, Temperature, Depth) and discrete samples for temperature, salinity, oxygen, nutrients and trace substances were done along SR04. A second transect with 20 stations was made from the edge of the Larsen Shelf Ice at 69°S 60°42´W towards the northeast.

c. Floats and drifters deployed: No floats or drifters were deployed on this cruise.

d. Moorings deployed or recovered: On the main section from Kapp Norvegia to Joinville Island 18 of 21 moorings were recovered (Fig. 7.2.3, Table 1) and 9 of them

TABLE 1: Moorings recovered during Polarstern cruise ANTX_7

	Deployment			Instrument			
Mooring	Lat. (S) / Long.(W)	Date, Time (UTC)	Depth (m)	Type	No	Depth (m)	Record length (days)
214/3	71°03.3´	14.02.92	380	AVTCP	9763	210	307
	11°44.1	10:42		AVT	9179	320	307
				WLR	1154	380	244
KN4	70°59.52	15.12.90	892	S	860019	328	lost
	11 °46.9´	09:55		AVTP	9209	333	lost
				S	860020	782	lost
				AVTPC	9210	810	lost
				UCM		811	lost
212/2	70°54.7´	14.12.90	1555	ULS	12/90	135	736
	11°57.8´	07:34		AVTP	8367	250	736
				AVTC	9401	760	384
				AVT	9402	1505	no data
211/2	70°29.7´	14.12.90	2450	AVP	10004	340	397
	13°08.9´	22:17		TK	1572		
				N ATR	1104	600	736
				AVTP	8396	1090	736
				AVT	9999	2296	lost
				AVT	9392	2402	lost
226	70°22.8´	13.12.90	2900	AVP	10003	190	373
	13°32.5´	00:57		AVP	9998	940	397
				AVTC	9207	2850	433
225	70°19.1´	12.12.90	4330	AVP	10002	270	100
	13°39.6´	18:19		AVTP	9783	1130	319
				AV	9997	2630	375
				AVT	9782	4280	408

TABLE 1: Moorings recovered during Polarstern cruise ANTX_7

Mooring	Deployment			Instrument			Record length (days)
	Lat. (S) Long.(W)	Date, Time (UTC)	Depth (m)	Type	No	Depth (m)	
210/2	69°39.6´	11.12.90	4750	ULS	10/90	151	736
	15°42.99´	16:50		AVTP	9201	270	392
				TK	1571		
				ATR	1103	520	741
				AVP	9995	1010	382
				AVT	9391	2521	no data
				ACM-2	1297	4694	no data
224	68°49.7´	10.12.90	4740	AV	9770	4240	330
	17°54.5´	13:38		ACM-2	1291	4690	698
223	67°59.8´	09.12.90	4885	AVTPC	9205	251	lost
	19°57.6´	17:24		AVTPC	9218	1010	lost
				AVT	9208	2520	lost
				ACM-2	1290	4834	lost
222	67°03.6´	07.12.90	4840	AV	9769	4340	398
	24°52.1´	22:54		ACM-2	1282	4790	699
209/2	66°37.3´	03.12.90	4860	ULS	14/90	147	lost
	27°07.1´	20:50		AVTP	9202	279	lost
				AVTPC	9216	1015	lost
				AVTPC	9217	2526	lost
				ACM-2	1289	4810	703
221	66°16.6´	02.12.90	4750	ADCP	378	212	762
	30°17.8´	10:49		AVTPC	9195	220	453
				TK	1426		
				ATR	943	470	628
				AVTP	9214	960	415
				AVT	9215	2470	372
				ACM-2	1288	4700	703
220	65°58.2´	30.11.90	4800	AV	9767	4300	396
	33°20.3´	15:43		AVT	9768	4748	no data
208/2	65°38.1´	29.11.90	4710	ULS	11/90	141	no data
	36°30.2´	18:27		AVTPC	9194	230	418
				AVT	9213	987	84
				S	890106	1070	
				AVT	9191	2475	426
				S	890108	4100	
				ACM-2	1285	46600	704
219	65°39.9´	28.11.90	4730	AVT	9187	4230	389
	37°42.5´	13:36		AVT	9188	4680	429
				AVT	9190	4722	no data

TABLE 1: Moorings recovered during Polarstern cruise ANTX_7

Mooring	Lat. (S) / Long.(W)	Date, Time (UTC)	Depth (m)	Type	No	Depth (m)	Record length (days)
	Deployment			**Instrument**			
218	64°48.9´	25.11.90	4650	AVTP	10005	225	no data
	42°29.3´	21:15		TK	1427		
				ATR	944	475	630
				AVTP	9212	960	433
				AVT	9186	2470	423
				ACM-2	1284	4600	659
217	64°25.1´	24.11.90	4390	ULS	13/90	110	736
	45°51.0´	21:26		AVTPC	9192	220	427
				S	890107	780	
				AVTC	9211	985	no data
				AVT	9185	2480	no data
				ACM-2	1281	4340	708
216	63°57.0´	24.11.90	3480	AVT	9182	2970	427
	49°09.2´	00:34		AVT	9184	3430	451
207/2	63°45.1´	23.11.90	2460	ULS	9/90	165	736
	50°54.3´	06:52		AVTPC	9206	300	391
				TK	1569		
				ATR	1100	550	685
				AVTPC	8395	1010	716
				AVT	8417	2150	664
				TK	1570		
				ATR	1102	2400	666
				AVT	8418	2410	740
206/2	63°29.6´	22.11.90	950	AVTP	8402	260	210
	52°06.3´	14:54		AVTP	9786	900	390
215	63°19.9´	21.11.90	448	AVTP	10001	291	lost
	52°59.1´	20:14		AVTP	9996	396	lost
				WLR	1155	447	lost

Abbreviations

ACM-2	Acoustic current meter, Neil Brown
ADCP	Acoustic Doppler current meter
ATR	Recording unit for thermistor cable
TK	Thermistor cable
AVTPC	Aanderaa current meter with temperature, pressure and conductivity sensor
S	Sediment trap
ULS	Upward looking sonar
WLR	Water level recorder

were exchanged (Table 2). The moorings to recover were equipped with 55 Aanderaa current meters (RCM4, RCM5 RCM7, RCM8) as well as six Aanderaa thermistor cables and two Aanderaa water level recorders. In the near bottom layer nine EG&G acoustic current meters were used (ACM-2). On six moorings, upward-looking sonars (ULS) built by the Christian Michelsen Institute, were installed to measure the ice thickness. One mooring carried an acoustic Doppler current profiler (ADCP) from RD Instruments. The locations of the instruments in the moorings are shown in Fig. 7.2.6.

TABLE 2: Moorings deployed during Polarstern cruise ANTX_7

Mooring	Latitude Longitude	Date Time (UTC)	Water Depth (m)	Type	Instrument Serial No.	Instrument Depth (m)
214/4	71°03.2´S	18.12.92	360	AVTP	9193	210
	11°43.9´W	13.13		AVTC	8401	310
				WLR	100312	360
212/3	70°54.55´S	20.12.92	1540	ULS	28/91	140
	11°57.89´W	07.25		AVTCP	10487	230
				AVTCP	10488	740
				AVT	10493	1500
210/3	69°38.46´S	23.12.92	4750	ULS	5/92	130
	15°43.58´W	03.05		AVTPC	10489	250
				AVTPC	10490	1030
				AVTPC	9920	2530
				AVT	10494	4700
209/3	66°37.43´S	31.12.92	4860	ULS	2/92	135
	27°07.22´W	03.27		SC	1167	150
				AVTPC	10491	150
				TK	1572	
				ATR	1104	400
				AVTPC	10492	1020
				AVT	10496	2530
				AVT	10498	4810
208/3	65°37.60´S	03.01.93	4766	ULS	29/91 -24	140
	36°29.38´W	22.40		AVTPC	10872	250
				AVTPC	9785	1040
				S	860009	1120
				AVT	10499	2530
				S	860012	4165
				AVT	10503	4725

TABLE 2: Moorings deployed during Polarstern cruise ANTX_7

Mooring	Latitude / Longitude	Date / Time (UTC)	Water Depth (m)	Type	Instrument Serial No.	Instrument Depth (m)
217/2	64°25.10´S	08.01.93	4420	ULS	3/92-26	145
	45°50.97´W	14.25		SC	166505	150
				AVTPC	10873	240
				AVT	10540	1010
				AVT	9782	2510
				AVT	9561	4370
207/3	63°45.05´S	10.01.93	2498	ULS	4/92-27	150
	50°54.32´W	11.28		AVTPC	9200	326
				ATR	943	
				TK	1420	580
				AVTPC	9204	1040
				AVTP	9783	2190
				ATR	1103	
				TK	1571	2430
				AVTC	9207	2450
206/3	63°29.55´S	11.01.93	960	AVTP	8370	245
	52°06.27´W	14.05		S	890106	315
				S	875	
				AVT	8367	915
215/2	63°19.89´S	12.01.93	450	AVT	9201	400
	52°59.07´W	00.07		WLR	1154	450

Abbreviations

ATR	Recording unit for thermistor cable
AVTPC	Aanderaa current meter with temperature, pressure and conductivity sensor,
S	Sediment trap
SC	Seacat
TK	Thermistor cable
ULS	Upward looking sonar
WLR	Water level recorder

The recovery of the moorings was hampered by the malfunction of the acoustic releases. In water depths greater than 1500 m no reply signal could be received from the moored releases neither after interrogating nor after releasing, even when the instruments were returned to the surface and floating in sight of the ship in a distance of a few hundred meters. The missing communication link made it impossible to use the available ranging and bearing systems. Only due to the favorable ice conditions, serious losses did not occur. Normally some floats reached the surface in open water between the ice floes and could be located visually. Only one mooring was completely hidden under the ice after its release and was found only after some hours of searching.

Five times a mooring did not appear at the sea surface after being acoustically released, and dredging had to be tried. In three cases dredging was at least partially successful. The dredged moorings could not be recovered completely, from one only the ground weight and the release was obtained. One mooring was lost due to the rupture of the Kevlar dredging cable, which was used in order to increase the cable length to pick up the mooring with the release. The successful dredging indicates that unreliable acoustic releases are the most likely reason for the failure. The mooring KN4 and two moorings of the University of Southern California which were acoustically released on earlier cruises were dredged unsuccessfully.

Mooring 215 in a water depth of 448 m was most likely lost by contact with icebergs. It could neither be dredged nor acoustically ranged or released in spite of the shallow depth. Three other moorings had obviously been touched by icebergs, but only mooring 206-2 was seriously affected by the loss of the uppermost floats. Because the risk of damage by icebergs had to be accepted in order to obtain ice thickness and upper layer current measurements, moorings and instruments were designed to reduce the resistance to an iceberg in case of contact. The ULS in 150 m depth were protected by a conical floatation collar and the main buoyancy of the mooring was only in 250 m depth to allow the upper part of the mooring to be depressed by icebergs. The recovery rate of five out of six ULS proved that the taken precautions were efficient.

As a consequence of three complete and two partial losses of moorings, we lost 15 current meters, one ULS and one water level recorder. From 59 recovered instruments, three were deployed only for one year and worked reliably, but only 18 of the ones deployed for two years recorded longer than 600 days, whereas 30 stopped after approximately one year due to the mismatch of power consumption and battery power, and eight instruments failed completely due to loss of memory or water intrusion. The five recovered ULS had to be returned to the Christian Michelsen Institute to read out the data due to a malfunction of the communication link.

Moorings recovered on the way from Cape Town to the Neumayer Station are shown in Table 3. Moorings deployed on the way from Cape Town to the same station are listed in Table 4.

A.3. List of Principal Investigators

Principal investigators for all measurements should be listed in Table 5.

TABLE 3: Moorings recovered on the way from Cape Town to the Neumayer-Station during Polarstern cruise ANTX_7

Mooring	Deployment Latitude / Longitude	Date / Time (UTC)	Depth (m)	Instrument Type	Instrument Number	Instrument Depth	Record length (days)
PF5	50°06.0´S	14.05.92	3700	AVTCP	10487	160	206
	05°55.4´E	11.58		S	860009	575	
				AVTCP	10488	650	206
				AVT	10493	1460	206
				AVT	10494	2930	206
				S	860012	3125	
				AVT	10495	3660	91
BO2	54°20.8´S	12.05.92	2670	AVTCP	10489	190	210
	03°23.6´W	13.12		AVTCP	10490	390	210
				S	860038	430	
				AVT	10496	1480	210
				S	890009	2160	
				AVT	10497	2600	210
400/1	57°37.8´W	10.05.92	4410	AVTCP	10491	180	213
	04°02.3´E	13.03		AVTCP	10492	380	213
				S		425	213
				AVT	10498	1470	
				AVT	10499	2970	213
				S		3015	
				AVT	10503	4360	213

TABLE 4: Moorings deployed on the way from Cape Town to the Neumayer-Station during Polarstern cruise ANTX_7

Mooring	Latitude / Longitude	Date / Time (UTC)	Water Depth (m)	Instrument Type	Instrument Ser. No.	Instrument Depth (m)
PF6	50°05.50´S	07.12.92	3778	AVTP	9765	190
	05°51.20´E	18.05		S		609
				AVTC	9400	687
				AVT	9564	1485
				AVT	9181	2994
				S		3043
				AVT	9784	3733
BO3	54°19.91´S	09.12.92	2734	AVTP	9766	230
	03°20.57´W	11.44		AVTPC	7727	437
				S		490
				AVT	9183	1539
				S		2239
				AVT	8037	2687

Abbreviations

AVTPC	Aanderaa current meter with temperature, pressure, and conductivity sensor
S	Sediment trap

TABLE 5: Principal investigators

Parameter	Investigator	Institution
CTD	E. Fahrbach	AWI
Salinity	E. Fahrbach	AWI
Oxygen	E. Fahrbach	AWI
Nutrients	K.-U. Richter	AWI
Carbon dioxide		
Moorings		
ADCP		
XBTs		
Thermosalinograph		
Meteorology		
Biological measurements		
Bathymetry		

A.4. Scientific Programme and Methods

Itinerary and summary

E. Fahrbach (AWI)

On 3 December 1992 the R.V. Polarstern left Cape Town to cross the Southern Ocean towards the Weddell Sea (Fig. 7.1.1). Oceanographic measurements from the moving ship started immediately on the continental shelf with XBT (Expendable Bathythermograph) and ADCP (Acoustic Doppler Current Profiler) profiles. Additionally, the COMED-system to measure mixed layer temperature, salinity and the concentration of chlorophyll-*a* and humic substances as well as Raman- and Mie-backscattering was activated. The measurements showed a warm Agulhas ring and the Subtropical, Subantarctic and Polar Fronts during the transect across the Antarctic Circumpolar Current. The first iceberg was sighted at 44°45´S, 10°23´E on 6 December and the Polar Front was crossed on 7 December at 48°20´S, 07°20´E. Two moorings with sediment traps were recovered and redeployed in the area of the Antarctic Polar Frontal Zone. At the mooring positions the first profiles with the CTD sonde (conductivity, temperature, depth) were measured. The ice edge was reached at 58°24´S, 02°15´E. The transition zone from the Antarctic Circumpolar Current to the Weddell Gyre was marked by a belt of frequent icebergs between 56° and 59°S. A third mooring was recovered in the northern Weddell Gyre boundary. On the way further south, towards Atka Bight we searched for some meteorological buoys and recovered one of them. At 65°00´S, 08°48´W, the first biological station was carried out with a multinet. The CTD-profile obtained at that station revealed a surprisingly high temperature of 0.9°C in the temperature maximum of the Warm Deep Water. Even if the ice belt extended extremely far to the north when we left Cape Town, it decayed dramatically during our way to the south with the consequence that we could proceed rather undisturbed by the ice and reached the wide coastal polynya on 16 December.

At the Neumayer-Station overwintering personnel and building crews disembarked to finish the new station and to dismantle the old one. Additional groups, which carried out drilling programs on the shelf ice with a hot water and an electrically heated system and the testing of an instrument to measure ice thickness by radar, I stayed at the station. Supply goods and equipment for the next overwintering period were deposited. During the night to 19 December we left the Atka Bight and followed the coastal polynya to the southwest.

The basic scientific program in the Weddell Sea, on a transect from Kapp Norvegia to Joinville Island (Fig. 7.1.1), consisted of the measurement of vertical profiles of temperature, salinity and natural trace substances at 57 hydrographic stations. On that transect 18 moorings with 79 instruments, current meters, thermistor chains, water level recorders and sediment traps were recovered and nine moorings were redeployed. Six upward-looking sonars are presently installed to measure ice thickness and five were recovered. The recovery was hampered by the malfunction of acoustic releases. The ones deeper than 1500 m meters and moored for two years did not respond with enough power to be acoustically ranged. Three of them did not release at all. Due to the favorable ice conditions and various dredging operations all but three moorings were recovered with a total loss of 16 instruments.

The measurements aim to determine the circulation and the water mass distribution in the Weddell Gyre with the transports of mass, heat and salt. The data allow to estimate the rate of bottom water formation in the Weddell Sea which controls to a large extent the vertical exchange and consequently the ability of the ocean to store heat and dissolved substances. Bottom water formation determines the contribution of the Weddell Sea to the effect of the world ocean on climate variations. The investigations are part of the Weddell Gyre Study which began in 1989 in the framework of the World Ocean Circulation Experiment (WOCE). The preliminary data show that the mass transport of the cyclonic gyre of 30 106 m3s-1 is mainly determined by the 500 km wide boundary currents. In the interior an anticyclonic gyre transports about 3 m^3s^{-1}. In most part of the gyre the current direction reverses with depth. The outflow cycle. Longer period changes are especially visible in the temperature field. The most obvious variation was measured in the maximum temperature of the Warm Deep Water which increased significantly from 1990 to 1992.

The knowledge of the physical conditions provides the basis for chemical, biological and biogeochemical investigations. The biogeochemical programs referred to cycles of different inorganic and organic compounds in sea water and the exchange of carbon dioxide between ocean and atmosphere. The biological work focused on phyto- and zooplankton ecology. For this purpose 21 biological stations with multi- and bongo-net catches were carried out. Distribution of microbial biomass and respiratory activity was studied. Dissolved organic carbon and humic substances as well as dissolved and particulate sterns were measured. Altogether these programs contribute to a better understanding of the global carbon cycle and are to be viewed in the context of the Joint Global Ocean Flux Study (JGOFS). Special emphasis was given to the investigation of the effect of increasing UV-B radiation on Antarctic marine organisms.

With moderate winds, air temperatures at the freezing point and overcast sky we reached on 7 January the western ice edge at 64°34´S,44°25´W where the ice cover decreased from 90 to 10% within a short distance. The ice cover was split in two large bands which were separated by a rather open area in the center of the gyre and surrounded by the wide eastern and western polynyas. This structure was reflected in the hydrographic conditions and the status of the biological systems. Whereas in the area of the ice belt winter conditions still prevailed, the open areas, where light was available and the water column was stabilized by warming and melt water input, rich blooms had developed. In the eastern coastal polynya an advanced bloom of diatoms and *Phaeocystis* was observed. The one in the center was much less intense and obviously affected by grazing. In the west, where spring conditions prevailed since several weeks, the maximum of the diatom bloom was passed due to intensive grazing and a strong *Phaeocystis* bloom dominated the system.

The station work on the main transect stopped east of Joinville Island. Due to the favorable ice conditions time was still available to take advantage at the unique conditions and to proceed to 69°S along the Larsen Ice Shelf (Fig. 7.1.1), 50 nautical miles further south than C. A. Larsen when he explored this ice shelf in 1893. On the way we passed the Argentine Station "Marambio" on Seymour Island, where we could cultivate the international relations by a reception on board of "Polarstern". The shelf was cut by a series of depressions to a depth of 600 m which seemed to steer the cross shelf circulation. Sea surface temperatures of up to 2°C were observed in the polynya.

From 64°34´S,44°25´W we directed a transect with 20 CTD and four biological stations towards the northeast (Fig. 7.1.1). On the shelf three hauls with the Agassiz Trawl were carried out. The location of the transect was determined according to SSM/I (Special Sensor Microwave/lmager) satellite data of the ice cover as obtained from the Ice Centre of the Atmospheric Environment Service, Canada. It was in accordance with the satellite data, that we met heavy ice conditions only around 66°25´S,47°55´W where we were forced to turn northwest and to finish the transect at 64°48´S,47°35´W at about 40 nautical miles from our main transect. The hydrographic conditions on that transect indicate by low saline water overlying a thin near bottom higher saline layer, the admixture of Larsen Shelf water to the northward flowing Weddell Sea Bottom Water.

From the end of the transect Polarstern proceeded through the Antarctic Sound to King George Island where we deposited material at the Argentine "Jubany" Station which is now used jointly with German scientists. In the Maxwell Bight we met the Spanish R.V. "Hesperides" which was working in the Bransfield Strait and we transferred one of our CTDs. On our way to the Drake Passage we passed by Deception Island where we continued the oceanographic work from the moving ship across the Antarctic Circumpolar Current with XBT, ADCP and COMED measurements. On 22 January 1993 "Polarstern" arrived at the port in Ushuaia.

SR04 — Physical oceanography

Water masses and circulation in the Weddell Sea

T. Boehme, J. Corleis v. d. Voet, E. Fahrbach, H. Fischer, R. Hamann, L. Kolb, A. Latten, G. Rohardt, E. Schutt, G. Seiss, V. Strass, H. Witte, F. Zwein (AWI)

Objectives

The physical oceanography work was aimed at investigating the water mass distribution and circulation in the Weddell Sea in order to understand the influence of ocean, ice and atmosphere on the formation of water masses which leave the Weddell Gyre and affect the characteristics of the bottom water of the world oceans. The activities during ANTX_7 are part of a multiyear program, the Weddell Gyre Study, which contributes to the World Ocean Circulation Experiment (WOCE). During this programme, a hydrographic section between the northern tip of the Antarctic Peninsula and Kapp Norvegia (Fig. 7.1.1) was repeated four times. The repetition of the same section during different seasons and years allows to measure longer term mean conditions of water mass characteristics and to assess the seasonal as well as the interannual variability. The programme was initiated in 1989 with a hydrographic survey in late winter during which a set of seven current meter moorings was deployed. A second survey in early spring followed in 1990 during which the first set of moorings was recovered and a new set of 21 moorings was deployed. Early winter conditions were observed in 1992. However, due to the severe ice conditions during that cruise the section could not be covered completely. The present cruise was aimed to recover the 21 moorings, to deploy a new set of 9 moorings and to obtain a summer survey.

The data from the moored current meters are used to describe the large scale current patterns of the Weddell Gyre and to estimate its volume transport. This can only be done with measurements from moored current meters, because of the contribution of the barotropic current field, which, for the time being, can only be derived from direct measurements as there is no indication on an appropriate reference level. Furthermore, intensive current fluctuations require long time series to determine statistically significant averages representative for those circulation patterns which are relevant to water mass formation. From the mass transport measured with the moored current meters and the water mass characteristics obtained during the hydrographic surveys, we can estimate heat and salt transports across the transect. The differences in volume between the water masses which are advected into the southwestern Weddell Sea and the ones which leave the area to the north reflect the formation of water masses south of the transect.

Work at sea

The distribution of water mass characteristics along the hydrographic section from Kapp Norvegia to Joinville Island at the northern tip of the Antarctic Peninsula (Fig. 7.2.1) was measured with 57 CTD-profiles (Conductivity, Temperature, Depth) and discrete samples for temperature, salinity, oxygen, nutrients and trace substances. A second transect with 20 stations was made from the edge of the Larsen Shelf Ice at 69°S60°42´W towards the northeast (Fig. 7.2.1). In order to measure during the available time the characteristics of the Weddell Sea Bottom Water as far south from the main section as possible, the location of the section was chosen to avoid areas with heavy pack ice.

Preliminary results

The sections of potential temperature, salinity and oxygen between Kapp Norvegia and Joinville Island (Fig. 7.2.9, 7.2.10, 7.2.13) show the typical water masses of the central Weddell Sea. The near surface layer is characterized during the summer by temperatures significantly above the freezing point, relatively low salinity and high oxygen concentrations. The Winter Water layer below it is obvious at a temperature minimum. In the section plots small scale structures and extreme values do not appear in the near surface and near bottom layers due to the applied smoothing procedures. The Winter Water is separated from the Warm Deep Water by a shallow thermo- and halocline. Its depth increases to several hundred meters from the open water towards the coast, above the upper continental slope in the east and the west. Due to its origin from the Antarctic Circumpolar Current the Warm Deep Water causes a temperature and salinity maximum as well as an oxygen minimum. The Warm Deep Water is most pronounced near the eastern and western boundaries. The deeper parts of the water column are filled by Antarctic and Weddell Sea Bottom Waters, separated by the potential temperature of –0.8°C. The newly formed Weddell Sea Bottom Water is most prominent at the western continental slope where the deepest temperatures and highest oxygen concentrations are found. On the continental slope off the Larsen Ice Shelf, between 1500 and 2500 m, a colder and saltier layer of only a few meters thickness is found under the lens of cold and fresh Weddell Sea Bottom Water (Fig. 7.2.11, 7.2.12). If the saline near bottom layer represents flow from the area of the Larsen Ice Shelf or water from the outflow of the Filchner Depression will be investigated in the course of the future analysis by use of all available parameters, in particular the stable isotope $^{18}0$. On the shelf, in front of the Larsen Ice Shelf, depressions of up 600 m depth (Fig. 7.2.15) could guide the flow to the deep sea. Significant variability of sea surface temperature and salinity are indicative of cross shelf flow, however, no supercooled water can be detected in the XBT records (Fig. 7.2.16).

Comparison of the near surface water mass characteristics observed during the present cruise, with the ones measured during ANT IX/2 from 17 November to 31 December 1990 and ANT VIII/2 from 6 September to 30 October 1989, reveals the seasonal progress by the development of the summer surface water layer with increasing temperatures and decreasing salinities (Fig. 7.2.17) from late winter through spring to summer. However, as the present cruise occurred only two to four weeks later than ANT IX/2, not only seasonal change contributes to the differences, but interannual variability has also to be taken into account. It is obvious from the ice conditions that the present observations are subject to significant interannual variations. This is supported by the conditions in the Winter Water and Warm Deep Water layers (Fig. 7.2.18) which are significantly warmer during the present survey than in 1990.

The measurements from the moored current meters reveal the large scale circulation pattern of the Weddell Gyre. The record long average flow across the transect from Kapp Norvegia to Joinville Island is shown in Fig. 7.2.19. The structure of the cyclonic gyre is determined by the western and eastern boundary currents with annual mean speeds of up to 16 cm/s in the east and 11 cm/s in the west. The volume transport of the boundary currents which are approximately 500 km wide amounts to 25 x 10^6 m^3/s. The interior of the Weddell Sea circulation consists of an anticyclonic circulation cell of about 1000 km diameter. There, the current has an important component in the direction of the transect. Therefore, the annual mean speeds amount to 1 cm/s, whereas the flow across the transect is smaller than 0.5 cm/s. The transport of the interior anticyclonic gyre amounts to 3 x 10^6 m^3/s. The vertical distribution of the current indicates a significant baroclinic component. Almost in the whole basin the flow reverses in the near bottom layers. This flow pattern suggests that the newly formed Weddell Sea Bottom Water leaves the southern part of the basin in the west. Partly, it recirculates in the interior supporting a secondary outflow in the east.

The average current system is subject to intensive fluctuations. Whereas the seasonal cycle dominates the variability of the eastern boundary current, it is barely visible in the west (Fig. 7.2.20). However, the temperature of the outflowing Weddell Sea Bottom water is subject to a clear seasonal cycle. In the interior only higher frequency fluctuations are present. The currents do not show a significant longer term trend, while the records of the thermistor cables (Fig. 7.2.20) indicate an increase of the maximum temperature in the Warm Deep Water layer during the two years of the observation period. This is consistent with the CTD measurements. Simultaneously, the temperatures of the outflowing Weddell Sea Bottom Water decrease (Fig. 7.2.20). The correlation of the observed seasonal and interannual variability of the oceanic circulation and temperatures with the fluctuations of the atmospheric driving forces and ice conditions will be investigated when the complete data sets will be available.

Structure of the Antarctic Circumpolar Current

T. Boehme, J. Corleis v. d. Voet, M. Damm, E. Fahrbach, H. Fischer, R. Hamann, L. Kolb, A. Latten, G. Seiss, V. Strass, M. Tibcken, H. Witte, F. Zwein (AWI)

Objectives

The Antarctic Circumpolar Current is the connection between three ocean basins. Its major transport occurs in oceanic fronts, the Subtropical, the Subantarctic and the Polar Front. In the area of our observations the boundary between the Antarctic Circumpolar Current and the Weddell Gyre is of special interest. In spite of the dominant zonal component of the mean current, significant meridional transports occur which are to a large extent caused by mesoscale fluctuations. These fluctuations are of interest also to the dynamics of the current, because they are transferring the momentum from the surface to the deep water. Measurements in the Antarctic Circumpolar Current, made repeatedly underway and by moored current meters, aim at obtaining better statistics of the fluctuations and the fronts.

Work at sea

On the way to and from the major working area 166 XBTs (Table 10 and Table 11) were launched and current profiles were measured with a vessel mounted acoustic Doppler sonar current meter (VM-ADCP) to gather information on the variability of the Antarctic Circumpolar Current. In the area of the Antarctic Polar Frontal Zone and the northern boundary of the Weddell Gyre three current meter moorings were recovered and two were deployed (Table 3 and Table 4). The COMED system was recording temperature, salinity, Raman- and Mie-backscattering, fluorescence and chlorophyll in the ice free parts of the transects.

Preliminary results

The data from the XBTs show the typical structure of the Circumpolar Current with the associated fronts on the southbound transect from Cape Town to Antarctica (Fig. 7.2. 21) and in Drake Passage (Fig. 7.2.22). A statistical analysis is only possible in connection with the data from previous and further cruises.

A.5. Major Problems and Goals Not Achieved

On the transect across the Drake Passage, the VM-ADCP measurements are degraded due to the failure of the ship´s pitch and roll platforms.

A.6. Other Incidents of Note

None noted.

A.7. List of Cruise Participants

Cruise participants are listed in Table 6. The participating institutions and their

TABLE 6: Cruise participants

Responsibility	Name	Institution
	Ahlers, Petra	AWI
	Balen van, Antonius	NIOZ
	Baumann, Marcus	AWI
	Boehme, Tobias	AWI/FPB
	Brandini, Frederico	CBM
	Büchner, Jurgen	HSW
	Corleis v. d. Voet, Janja	AWI
	Döhler, Gunter	BIF
	Fahl, Kirstin	AWI
Chief scientist, CTD, salinity, oxygen	Fahrbach, Eberhard	AWI
	Fischer, Haika	AWI/FPB
	Goeyens, Leo	AWI/VUB
	Gorny, Mathias	AWI
	Günther, Sven	AWI

TABLE 6: Cruise participants

Responsibility	Name	Institution
	Hamann, Rudolph	AWI/FPB
	Hanke, Georg	AWI
	Hillebrandt, Marc-Oliver	HSW
	Hoppema, Mario	AWI/NIOZ
	Jesse, Sandra	AWI
	Klatt, Olaf	AWI/FPB
	Kolb, Leif	AWI/FPB
	Kurbjeweit, Frank	AWI
	Latten, Andrees	AWI/FPB
	Lundström,Volker	HSW
	Nachtigäller, Jutta	DUI
Nutrients	Richter, Klaus-Uwe	AWI
	Riegger, Lieselotte	AWI
	Rohardt, Gerd	AWI
	Röttgers, Rudiger	AWI
	Schreiber, Detlef	HSW
	Schröder, Sabine	AWI
	Schütt, Ekkehard	AWI
	Schweimler, Imgrun	AWI/FPB
	Seifert, Wolfgang	DWD
	Seiss, Guntram	AWI/FPB
	Skoog, Annelie	AMK
	Sonnabend, Hartmut	DWD
	Strass, Volker	AWI
	Tibcken, Michael	AWI
	Vosjan, Jan H.	NIOZ
	Wedborg, Margareta	AMK
	Witte, Hannelore	AWI
	Zwein, Frank	AWI/FPB
To Neumayer-Station		
	Ahammer, Heinz	PM
	Behnsen, Uwe	AWi
	Behrens, Detlev	KRA
	Damm, Michael	AWI
	Eckstaller, Alfons	AWI
	El Naggar, Saad El D.	AWI
	Etspüler, Wolfgang	AWI
	Gruhne, Mario	AWI
	Heinrich, Andreas	TRE
	Hofmann, Jorg	AWI
	Koenig, Roland	TRE
	Mertens, Rolf	KRA
	Muhle, Heiko	AWI

TABLE 6: Cruise participants

Responsibility	Name	Institution
	Nixdorf, Uwe	AWI
	Nolting, Michael	AWI
	Reder, Giselher	CN
	Reiter, Alois	AWI
	Rosenberger, Andreas	AWI
	Schneider, Hans	AWI
	Strecke, Volker	AWI
	Terzenbach, Uwe	AWI
	Trendelkamp,Joseph	TRE
	Tüg, Helmut	AWI
	Wlcht, Manfred	AWI
	Wissing Manfred	TRE
	Witt, Raif	AWI
	Wunder, Hans	CN
	Zmmermann, Frerich	CN

addresses and the abbreviations used in this report are given in Table 7.

TABLE 7: Participating Institutions

Germany	
AWI	Alfred-Wegener-lnstitute fur Polar- und Meeresforschung Columbusstrasse 275 68 Bremerhaven Aussenstelle Potsdam Telegraphenberg A43 144 73 Potsdam
BIF	Johann Wolfgang Goethe-Universitat Botanisches Institut Siesmayerstr. 70 W-6000 Frankfurt am Main 11
DUI	Deutsches Obersee-lnstitut Neuer Jungfernstieg 21 W-2000 Hamburg 36
DWD	Deutscher Wetterdienst, Seewetteramt Bernhard-Nocht-Str. 76 2000 Hamburg 4

TABLE 7: Participating Institutions

FBB	Universitat Bremen Meeresbotanik, FB2 Postfach 33 04 40 2800 Bremen 33
FGB	Universitat Bremen Fachbereich Geowissenschaften FB5 Postfach 33 04 40 2800 Bremen 33
HSW	Helicopter Service, Wasserthal GmbH Katnerweg 43 2000 Hamburg 65
IFM	Institut fur Meereskunde Abt. Planktologie Dusternbrooker Weg 20 2300 Kiel 1
SFB	Universitat Kiel SFB 313 Olshausenstr. 40-60 2300 Kiel 1
UOL	Universitat Oldenburg Fachbereich Physik 8 Carl-von-Ossietzky-Str. 9-11 2900 Oldenburg
UNU	Universitat Ulm Abt. Analyt. Chemie & Umweltchemie Albert-Einstein-Allee 11 7900 Ulm
	Belgium
VUB	Vrije Universiteit Brussel-Anch Pleinlaan 2 B-1050 Brussel, BELGIUM
ULB	Groupe de Microbiologie des Milieux Aquatiques Universite Libre de Bruxelles ULB Campus de la Plaine, CP 221 B-1050 Brussels, BELGIUM
	Brasil
CBM	Centro de Biologia Marinha/UFPr Av. Beira Mar s/n, Pontal do Sul Paranagua 83200, PR, Brasil
	Denmark
MBL	K0benhavns Universitet Marine Biological Laboratory Strandpromenaden 5 DK-3000 Helsing0r, Denmark

TABLE 7: Participating Institutions

	Estonia
IEMR	Institute of Ecology and Marine Research Paldiski Road 1 200031 Tallinn, Estonia
	France
IEM	Universite de Bretagne Occidentale Institut d'Etudes Marines Laboratoire de Chimie des Ecosystemes Marins Avenue V. Le Gorgeu F-29287 Brest Cedex, France
	Netherlands
NIOZ	Nederlands Instituut voor Onderzoek der Zee NIOZ Postbox 59 NL-1790 AB Den Burg, The Netherlands
IBN	Institute for Forestry & Nature Research (IBN-DLO) Postbox 167 NL-1790 AD Den Burg, The Netherlands
	Sweden
AMK	University of Goteborg and Chalmers University of Technology Analytical and Marine Chemistry S-412 96 Goteborg, Sweden
	United States of America
OSU	Oregon State University College of Oceanography Oceanography Admin. Bld. 104 Corvaliis, Oregon 97331-5503, U.S.A.
	To Neumayer Station
CN	Fa. Christiani & Nielsen Basedowstr. W-2000 Hamburg 26
KRA	Fa. J.H. Kramer Labradorstr. W-2850 Bremerhaven
TRE	Fa. Trendelkamp Stahl und Maschinenbau Westring 18 W-4418 Nordwalde
PM	POLARMAR GmbH Burger W-2850 Bremerhaven

B. Underway Measurements

B.1. Navigation and bathymetry

B.2. Acoustic Doppler Current Profiler (ADCP)

B.3. Thermosalinograph and underway dissolved gasses

B.4. Expendable bathythermograph and salinity measurements

XBT sections were carried out during the crossing of the western ice edge (Table 8) and off the Larsen Ice Shelf (Table 9). Because the XBTs had a high failure rate, most likely due to the low water temperatures, the sections have large gaps.

TABLE 8: XBTs launched during the crossing of the ice edge

Number	Date	Time (UTC)	Latitude	Longitude	Depth (m)
157	07.01.93	22:03	64°29´S	45°11´W	4502
156		21:51	64°30´S	45°08´W	4499
155		21:45	64°30´S	45°06´W	4498
154		21:30	64°31´S	45°01´W	4489
153		21:15	64°32´S	44°56´W	4505
152		21:00	64°33´S	44°50´W	4498
151		20:45	64°33´S	44°44´W	4496
150		20:30	64°34´S	44°39´W	4516
149		20:17	64°35´S	44°34´W	4500
148		20:13	64°35´S	44°33´W	4572
147		20:10	64°35´S	44°31´W	4569

The deployment locations of XBTs launched during the transit of the Antarctic Circumpolar Current from Cape Town to Atka Bight are given in Table 10. The launch locations of XBTs deployed during the transit across the Drake Passage are given in Table 11.

TABLE 9: XBTs launched during the transit from Joinville Island to the Larsen Ice Shelf

Number	Date	Time (UTC)	Latitude	Longitude	Depth (m
160	14.01.93	23:30	67°12´S	60°21´W	401
167		01:31	67°35´S	60°30´W	487
168		01:36	67°36´S	60°31´W	491
170		01:48	67°39´S	60°32´W	503
174		02:24	67°46´S	60°32´W	537
175		03:19	67t57´S	60°31´W	577
177		03:34	68°00´S	60°34´W	590
178		03:49	68°02´S	60°35´W	607
183		05:43	68°24´S	60°41´W	564
186		07:03	68°38´S	60°29´W	400
187		07:32	68°44´S	60°27´W	251
191		08:40	68°54´S	60°41´W	299
192		09:05	69°59´S	60°43´W	289

TABLE 10: XBTs launched during the transit of the Antarctic Circumpolar Current from Cape Town to Atka Bight

No.	Date	Time (GMT)	Latitude	Longitude	Depth (m)
1	03.12.92	16:43	34°12´S	18°05´E	218
2		17:20	34°20´S	18°00´E	276
3		18:17	34°30´S	17°53´E	400
4		19:33	34°45´S	17°44´E	1740
5		20:57	35°00´S	17°33´E	2605
6		22:21	35°15´S	17°24´E	2975
7		23:50	35°30´S	17°12´E	3506
8	04.12.92	01:22	35°45´S	17°01´E	4071
9		02:56	36°00´S	16°51´E	4291
10		04:34	36°15´S	16°41´E	4383
11		06:15	36°30´S	16°31´E	4477
12		08:05	36°45´S	16°17´E	4572
13		10:15	37°00´S	16°02´E	4646
14		11:35	37°15´S	15°54´E	4687
15		12:55	37°30´S	15°46´E	4746
16		14:20	37°45´S	15°36´E	4784
17		15:45	38°00´S	15°27´E	4822
18		17:10	38°15´S	15°16´E	4784
19		18:34	38°30´S	15°05´E	4795
20		19:59	38°45´S	14°55´E	4794
21		21:20	39°00´S	14°45´E	4727
22		22:40	39°15´S	14°35´E	4698

TABLE 10: XBTs launched during the transit of the Antarctic Circumpolar Current from Cape Town to Atka Bight

No.	Date	Time (GMT)	Latitude	Longitude	Depth (m)
23	05.12.92	00:10	39°30´S	14°22´E	4743
24		01:38	39°45´S	14°10´E	4671
25		03:01	40°00S	14°00´E	4174
26		04:34	40°15´S	13°48´E	4764
27		05:59	40°30´S	13°37´E	4865
28		07:22	40°45´S	13°26´E	4864
29		10:18	41°00´S	13°12´E	4538
30		11:38	41°15´S	13°01´E	4877
31		13:05	41°30´S	12°51´E	6308
32		14:28	41°45´S	12°40´E	3398
33		15:49	42°00´S	12°31´E	5113
34		17:17	42°15´S	12°18´E	3582
35		18:40	42°30´S	12°08´E	4390
36		19:15	42°34´S	12°04´E	4689
37		21:45	43°01´S	11°43´E	4718
38		23:05	43°13´S	11°34´E	4666
39	06.12.92	00:35	43°28´S	11°22´E	4981
40		02:05	43°45´S	11°10´E	4440
41		03:20	43°58´S	10°58´E	4363
42		04:50	44°15´S	10°47´E	4669
43		06:16	44°28´S	10°35´E	4852
44		07:38	44°45´S	10°21´E	4660
46		09:01	45°01´S	10°10´E	4711
47		10:12	45°15´S	9°59´E	4769
48		11:38	45°30´S	9°45´E	4495
49		12:46	45°43´S	9°35´E	4545
50		14:07	46°00´S	9°23´E	4645
51		15:21	46°15´S	9°11´E	4684
52		16:50	46°33´S	8°55´E	4353
53		17:44	46°43´S	8°47´E	3704
54		18:59	47°00´S	8°33´E	3506
55		20:13	47°15´S	8°21´E	1714
56		21:26	47°30´S	8°07´E	2622
57		22:40	47°45´S	7°56´E	3083
58		23:54	48°00´S	7°44´E	4170
59	07.12.92	01:06	48°15´S	7°30´E	2224
61		02:26	48°32´S	7°16´E	3527
62		03:34	48°45´S	7°04´E	3907
63		04:46	49°00´S	6°52´E	3629
64		06:00	49°15´S	6°39´E	3442
65		07:10	49°30´S	6°27´E	2953
66		08:20	49°44´S	6°14´E	3630
67		09:35	50°00´S	5°58´E	3708
68		22:28	50°15´S	5°31´E	3610

TABLE 10: XBTs launched during the transit of the Antarctic Circumpolar Current from Cape Town to Atka Bight

No.	Date	Time (GMT)	Latitude	Longitude	Depth (m)
69	08.12.92	00:43	50°30´S	5°00´E	3397
71		03:01	50°45´S	4°28´E	3312
72		05:15	51°00´S	3°54´E	3454
73		07:15	51°15´S	3°25´E	3404
74		09:01	51°30´S	2°54´E	3423
75		11:00	51°45´S	2°19´E	3001
76		13:10	52°02´S	1°41´E	2778
77		14:43	52°15´S	1°15´E	2510
78		16:28	52°30´S	0°43´E	2834
79		18:26	52°45´S	0°09´E	2785
80		20:19	53°00´S	0°22´W	2461
81		22:14	53°15´S	0°54´W	2403
82	09.12.92	00:01	53°30´S	1°26´W	2836
83		01:48	53°45´S	2°00´W	2124
84		03:45	53°59´S	2°35´W	2723
85		05:30	54°15´S	3°12´W	2461
86		15:42	54°30´S	2°59´W	2758
87		17:36	54°45´S	2°30´W	2587
88		19:30	54°59´S	1°56´W	1948
89		21:20	55°15´S	1°25XW	3979
90	10.12.92	23:35	55°30´S	0°51´W	3351
91		01:10	55°45´S	0°11´W	3881
92		03:25	56°00´S	0°17´E	3481
93		04:58	56°13´S	0°47´E	3770
94		07:07	56°30´S	1°26´E	4140
95		09:02	56°44´S	1°59´E	4317
96		10:28	56°55´S	2°24´E	4324
97		12:44	57°15´S	3°07´E	4429
98		14:43	57°30´S	3°45´E	4410
99	11.12.92	22:53	57°45´S	3°44´E	4828
100		01:31	58°00´S	3°10´E	3386
101		04:10	58°15´S	2°36´E	4896
102		05:43	58°23´S	2°18´E	4771
108		10:48	58°50´S	1°17´E	4939
109		13:36	59°00´S	0°53´E	5212
111		16:30	59°17´S	0°12´E	5202
112		19:34	59°30´S	0°16´W	5240
113		19:40	59°30´S	0°18´W	5345
115		23:02	53°45´S	0°59´W	5010

TABLE 10: XBTs launched during the transit of the Antarctic Circumpolar Current from Cape Town to Atka Bight

No.	Date	Time (GMT)	Latitude	Longitude	Depth (m)
116	12.12.92	01:46	60°00´S	1°31´W	5360
117		04:16	60°15´S	2°03´W	5260
118		07:20	60°28´S	2°38´W	5376
119		11:47	60o48~S	2°58´W	5145
120		14:06	60°58´S	3°51´W	5312
121		16:36	61°12´S	4°10´W	4782
123		23:42	61°40´S	5°26´W	5277
124	13.12.92	02:24	61°51´S	6°01´W	5290
125		04:41	62°07´S	6°21´W	5275
126		06:50	62°19´S	6°36´W	5250
128		09:07	62°26´S	7°04´W	4875
131	14.12.92	05:57	64°15´S	8°55´W	5161
132		09:57	64°56´S	8°50´W	5100
133		14:00	65°00´S	8°41´W	5087
134	15.12.92	08:11	67°37´S	8°28´W	4889
135		12:08	68°19´S	8°10´W	4334
137		14:46	68°51´S	7°52´W	3630
138		18:36	69°34´S	8°07´W	3015
139		20:39	70°00´S	7°58´W	1546
140		21:47	70°15´S	7°59´W	1675
141		22:51	70°30´S	8°07´W	269
142	18.12.92	03:49	70°30´S	8°59´W	435
143		05:28	70°38´S	9°38´W	455
144		05:38	70°39´S	9°42´W	457
145		06:49	70°44´S	10°O9´W	360
146		08:55	70°53´S	10°57´W	290

B.5. Meteorological observations

W. Seifert, H. Sonnabend (DWD)

During the first week of December the South Atlantic high-pressure-centre was situated relatively far north, near 25°S. Therefore a strong westerly flow formed an intensive frontal zone with a well developed gale centre southwest of Bouvet Island. It forced warm wave depressions from subtropical latitudes and secondary lows moving form the Drake Passage eastward in its steering circulation system which maintained the baroclinic structure. "Polarstern" passed the rear of the gale centre with southwesterly gales and wave heights up to 5 m. Reaching the sea-ice-belt the sea state weakened in spite of crossing cold fronts with snow showers and gusty conditions.

By mid-December the circulation pattern changed. The development of an intensive gale centre at the Antarctic Peninsula and the southeastern Weddell Sea generated a high pressure ridge over the eastern Weddell Sea with a descending air flow and rapidly decreasing cloud cover giving rise to sunny sky with light to moderate southerly winds during the stay at the Neumayer-Station.

TABLE 11: XBTs launched during the transit of the Antarctic Circumpolar Current in the Drake Passage

Number	Date	Time (GMT)	Latitude	Longitude	Depth (m)
194	20.01.93	10:09	63°02´S	60°43´W	286
195		10:59	62°58´S	61°13´W	277
196		12:02	62°53´S	61°45´W	280
197		12:57	62°42´S	61°56´W	313
198		13:58	62°27´S	61°59´W	790
199		14:56	62°13´S	61°59´W	1884
200		15:59	61°58´S	62°00´W	3s30
201		16:57	61°43´S	62°01´W	4316
202		17:06	61°42´S	62°02´W	4244
203		18:02	61°28´S	62°02´W	3734
204		19:00	61°13´S	62°04´W	3561
205		20:00	60°59´S	62°05´W	3845
207		22:06	60°30´S	62°08´W	3814
209		23:08	60°16´S	62°10´W	3800
210	21.01.93	00:06	60°03´S	62°11´W	3755
211		01:01	59°47´S	62°13´W	4144
212		02:00	59°33´S	62°14´W	4032
213		02:59	59°20´S	62°14´W	3936
214		04:02	59°17´S	62°15´W	3846
215		05:08	58°48´S	62°17´W	3253
217		06:06	58°34´S	62°18´W	3016
218		06:57	58°22´S	62°20´W	3476
219		07:56	58°10´S	62°32´W	3056
220		08:59	57°59´S	62°47´W	3651
221		10:01	57°47´S	62°59´W	3823
222		11:00	57°40´S	63°07´W	3623
223		12:00	57°33´S	63°16´W	3622
224		13:01	57°25´S	63°24´W	3747
225		13:59	57°19´S	63°33´W	3910
226		14:56	57°13´S	63°41´W	4186
227		15:49	57°07´S	63°47´W	4032
228		16:52	56°59´S	63°46´W	3973
229		18:01	56°53´S	64°06´W	3946
231		19:05	56°41´S	64°15´W	4146
232		20:03	56°33´S	64°25´W	1890
233		21:03	56°26´S	64°34´W	3112
234		21:59	56°18´S	64°43´W	2643
235		22:59	56°10´S	64°53´W	3283
236		23:59	56°02´S	65°03´W	3910
237	22.01.93	01:00	55°53´S	65°12´W	3651
238		01:58	55°45´S	65°19´W	2768
239		02:59	55°37´S	65°27´W	3230
240		04:02	55°25´S	65°41´W	1819

During the following week the high pressure ridge moved northward while secondary lows formed at the western flank of the low east of Bouvet Island near 20°E. Wave depressions embedded in the southwesterly flow produced gusty flurries. The weak anticyclonic southwesterly flow, locally interrupted by small embedded mesoscale waves persisted until 10. January 1993. The development of such waves is frequently observed in the Weddell Sea. It is caused by the vertical transport of mass and water vapor over regions with no or weak ice cover and water temperatures higher than –1°C. The typical range of the mesoscale waves is 200 to 500 km. They form a vortex with frontal structures and the associated wind and weather conditions.

Towards mid-January, the high pressure system weakened and one of the mesoscale lows moved from the Filchner Shelf west-northwestwards under the influence of an upper secondary trough as part of the northeastern Antarctic low pressure system. It developed to a gale centre and became stationary two days later northeast of the Antarctic Sound with a core pressure below 975 hPa. At its rear the southerly winds increased to gale force Beaufort 8 to 9 with gusty snow showers and sea heights in open waters up to 3 m. The southerly winds were forced as barrier winds by the Antarctic Peninsula from southwest to northeast. By 15 January the low filled slowly up, while a high was moving from the southern Pacific across the Antarctic Peninsula to the western Weddell Sea inducing a weak pressure gradient with light southeasterly winds.

During the last five days of the cruise an intensive storm centre formed far northwest of the Drake Passage with eastward moving secondary lows developing at the occlusion point off the Drake Passage. With strong northerly winds and gusty snow showers "Polarstern" crossed the Antarctic Sound and reached the "Jubany" station under a following high pressure ridge. Another intensive gale centre west of the Drake Passage produced a stormy secondary low moving quickly east with northeasterly gales, force Beaufort 8, and waves up to 3.5 m. In a following ridge the wind decreased to force 4 Beaufort but the visibility became rather poor.

The meteorological conditions were favorable to achieve the objectives of the cruise. The wind statistics show that 70% of all observations were below force 6 Beaufort (22 knots). The predominant wind directions were southerly to southwesterly in contrast to other years as 1990 when during ANTIX/2 easterly directions were frequently observed (Fig. 7.5.1). The zonal wind component averaged along the main transect was approximately 5 knots, while the longtime mean value for December and January averaged along 65°S over the same longitudes is –2 knots,**** *How can wind velocity, here expressed as magnitude, be negative?***** representing easterly wind components. The circulation seemed to differ from the typical pattern with a dominant low over the western Weddell Sea which would produce easterly winds south of 65°S due to the frequent formation a high pressure ridge over the Weddell Sea (Fig. 7.5.2). From the time series of surface air temperature, surface pressure and wind direction it appears that the wave depressions were triggered convective processes and not by advection.

B.6. Ice conditions

T. Boehme, E. Fahrbach, H. Fischer, R. Hamann, L. Kolb, A. Latten, G. Seiss, F. Zwein (AWI)

On 10 December 1992 hourly routine ice observations began with a more detailed observation every three hours. The first iceberg had been sighted at 44°45´S, 10°23´E on 6 December. The ice edge was reached at 58°24´S, 02°15´E. The transition zone from the

Antarctic Circumpolar Current to the Weddell Gyre was marked by a belt of frequent icebergs between 56° and 59°S. Even if the ice belt extended extremely far to the north when we left Cape Town, it decayed dramatically during our way to the south with the consequence that we could proceed rather undisturbed by the ice and reached the wide coastal polynya on 16 December. The ice concentration on a transect from Kapp Norvegia to Joinville Island was split in two large scale bands which were separated by a rather open area in the center of the gyre and surrounded by the wide eastern and western polynyas (Fig. 7.6.1, 7.6.2). The western ice edge, where the ice cover decreased from 90 to 10% within a short distance was reached on 7 January at 64°34´S, 44°25´W. From 64°34´S, 44°25´W, we directed a transect towards the northeast according to the satellite data on the ice cover which we obtained from the Canadian Ice Center of the Atmospheric Environment Service. We met heavy ice conditions only at 66°25´S, 47°55´W which forced us to turn northwest and to finish the transect at 64°48´S, 47°35´W at about 40 nautical miles from our main transect. The ice observation record is available on diskette.

C. Hydrographic Measurements

C.1. CTD

The CTD-measurements were carried out with a NB Mark IIIB sonde connected to a General Oceanics rosette water sampler with 24 12-liter bottles.

The quality of the CTD-data relies on the laboratory calibrations of the temperature and pressure sensors made before the cruise at the Scripps Institution of Oceanography. The performance of the instrument during the cruise was controlled by use of SIS digital thermometers and pressure meters as well as Gohla mercury reversing thermometers. The pre-cruise temperature and pressure calibration values were applied to the measurements on board. ****Need these calibration values and how the measurements were fit to the calibrations* **** The conductivity readings of the CTD were corrected by means of salinity measurements from the rosette water samples. The means and the standard deviations of the salinity differences between bottle samples and CTD readings for each profile are shown together with the number of samples for each profile in Fig. 7.2.2. Due to the stratification of the water column the scatter of the differences is higher in the upper levels. Therefore only differences in levels deeper than 500 m are used and displayed in Fig. 7.2.2 to get an impression of the quality of the instruments and processing. The preliminary data presented in this report are corrected by a constant offset of 0.0588. The accuracy of the preliminary data was estimated to 4 m°C in temperature, 4 dbar in pressure and 0.005 PSU in salinity. The final data will be available after the post cruise laboratory calibration. The salinity correction will take into account the slight time drift which was observed.

C.2. Water sample salinities

The salinity of the water samples was determined with a Guildline Autosal 8400 A salinometer in reference to IAPSO Standard Seawater (**** *Need batch number*****)*. The salinities are given in PSU and calculated by use of the UNESCO Practical Salinity Scale (PSS78).

C.3. Water sample oxygen measurements

During the cruise the concentration of dissolved oxygen was measured by means of a computer controlled SIS Winkler-titrator from 1923 water samples taken at 81 stations. The precision of the measurements was estimated by means of three calibration stations where all water bottles were closed in the same depth and 24 samples were taken. The standard error of each station ranged between 0.04 and 0.09 pM with a standard deviation from 0.19 to 0.44 µM corresponding to a precision of 0.1 to 0.2%. For the continuous control of precision, 238 double samples were taken from the same bottle during the cruise.

C.4. Distribution of nutrients in the Weddell Sea

P. Ahlers, K.-U. Richter, S. Schroder (AWI)

Objectives

The near surface layers, in particular the Winter Water, of the Weddell Gyre are supplied with nutrients by entrainment and upwelling of Warm Deep Water. Therefore, macronutrients are generally not considered as limiting factors for phytoplankton production in the Weddell Sea. Our objective was to measure the distribution of the nutrients on a transect through the Weddell Gyre from Kapp Norvegia to the Antarctic Peninsula and on a second transect from the Larsen Ice Shelf to the northeast.

Work at sea

Water samples were collected with the oceanographic rosette sampler and analyzed on a Technicon Autoanalyzer II system. Nitrate was determined as nitrite after reduction with cadmium and reaction with sulfanilamide and N-(1naphtyl)-ethylendiamin dihydrochloid as red colored azodye at λ=520 nm. Ammonium was measured as blue colored indophenole at λ=630 nm after the reaction with phenolate and hypochlorite under alkaline conditions (Berthelot reaction). For the determination of silicate and phosphate the compounds react with ammonium molybdate by forming a blue molybdate-complex that was measured at λ=660 nm respectively at λ=880 nm.

Preliminary results

As an example for the distribution of nutrients in the different water masses of the Weddell Sea the concentration of silicate is shown on the transect from Kapp Norvegia to Joinville Island (Fig. 7.3.1). The near surface layers are characterized by a strong vertical gradient due to nutrient consumption by phytoplankton in the euphotic zone. In the deeper layers of the Warm Deep Water and the Antarctic Bottom Water the concentration values between 120 and 130 µM vary only slightly with two exceptions. Silicate values higher then 130 µM indicate the inflow of silicate enriched Antarctic Bottom Water from the Enderby Basin near the eastern continental slope below 4000 m depth. At the western continental slope a distinct silicate minimum below 1500 m depth is related to the Weddell Sea Bottom Water. It is most pronounced with values of less than 95 µM between 2000 and 3000 meters depth. The low silicate concentrations near the bottom extent almost over the total Weddell Basin and indicate the spreading of the Weddell Sea Bottom Water. The nitrate values show comparable structures with a strong gradient in the near surface layers and the influence of the Weddell Sea Bottom Water (Fig. 7.3.2). A nutrient maximum is related to the Warm Deep Water which is more pronounced in the western part of the gyre (Sta. 44 - 61) with maximum nitrate concentrations higher then 35 µM between 300 and 1000 m. In the Weddell Sea Bottom Water the concentration decrease to values below 33 µM.

The surface values of nitrate, silicate and phosphate reflect the biological conditions (Fig. 7.3.3). Due to the extensive bloom of large phytoplankton stocks in the coastal polynya off Kapp Norvegia (Sta. 13 to 23) and off the Antarctic Peninsula (Sta. 61 to 64), nutrients were remarkably depleted. The silicate concentration reached values of less than 58 µM in the eastern bloom and 62 µM in the western one. Similar minima are found in the nitrate and phosphate concentrations for both bloom areas with nitrate values of 19.8 µM in the east and 16.7 µM in the west and with phosphate values of

1.43 µM and 1.12 µM respectively. A slight depletion at approximately 700 km from the western boundary, at the Sta. 47 to 49, can be related to a third bloom area. In contrast to the bloom areas, the nutrient concentrations are high elsewhere (Sta. 24 to 44). The concentrations range from 70 µM to 77 µM for silicate, from 26.2 µM to 30.0 µM for nitrate and from 1.77 µM to 1.99 µM for phosphate.

C.5. Carbon dioxide chemistry in the Weddell Sea

J.M.J. Hoppema, I. Schweimler (AWI)

Objectives

Carbon dioxide is a widely known greenhouse gas, whose concentration in the atmosphere has increased because of anthropogenic causes. The oceans are the most important sink of anthropogenic CO_2 and among those the polar oceans are thought to be pivotal. For the Southern Ocean the details of the possible uptake of CO_2 are still unclear. Particular attention will be given to the following points:

1. Partial pressures of CO_2 in sea water and atmosphere. The difference between those two is the driving force for the exchange of CO_2 between both reservoirs, which will be used to estimate the sink (or source) function of the Weddell Sea.
2. Factors governing the CO_2-system. For this purpose the total-CO_2 and alkalinity will be correlated with other properties such as salinity, oxygen, nutrients etc.
3. Total-CO_2 and alkalinity are unique properties of water masses. Their potential as a tracer will be investigated.
4. Differences between the present measurements and those in winter, which were performed during June and July 1992 in the Weddell Sea, will be analyzed.

Work at sea

CO_2 dissolved in sea water is actually part of a system of chemical equilibria, where the main component is the bicarbonate ion. Because of this it is not trivial to measure CO_2, but rather one has to determine the CO_2-system. Knowing two measurable quantities of the system enables calculation of all other system parameters. During this cruise, measurements were done of three parameters, notably, total-CO_2 (TCO_2), which is all inorganic carbon, total alkalinity and the partial pressure of CO_2 (pCO_2). In addition, the pCO_2 of air was measured.

On almost all stations, where water was collected with the CTD-Rosette sampler TCO_2 was determined with a standard coulometric method. Thus complete depth profiles were obtained for TCO_2. Alkalinity was measured by means of a rapid potentiometric titration with open vessel. The alkalinity will be calculated from the titration data using the Gran method. As for TCO_2, samples were analyzed for alkalinity at almost all CTD-stations, but at about half of the stations only the surface layer until 200 m was sampled. In between stations semi-continuous measurements for pCO_2 were done. The water was taken in from about 9 m below the surface and continuously sprayed into an equilibrator where it was brought to equilibrium with air. Via a chemical dryer this air was pumped through a non-dispersive infrared Analyzer (Li-cor) where the absorption caused by CO_2 was recorded. In the same way the CO_2 concentration of marine air from approximately 20 m above sea level was obtained.

Preliminary results

Fig. 7.3.4 shows a depth profile of TCO_2 of a station in the centre of the Weddell Gyre. It has to be kept in mind that data are indeed preliminary and further processing has to be done. This can change the figure slightly, but will not significantly affect the shape of the profile. The profile shows a CO_2 depletion in the surface layer compared to the deep and bottom waters, which is mainly biologically mediated. At about 500 m there is a TCO_2 maximum, indicating the depth where the Warm Deep Water exerts its largest influence. The depth of the TCO_2 maximum in the Weddell Sea is not constant. In the surface layers a large variation of the TCO_2 content was observed, with generally high values in the centre of the Weddell Gyre and values up to 100 µmol/l lower in the western Weddell Sea. The TCO_2 values in the central Weddell Sea were comparable to values measured in the winter. The continuous pCO_2 measurements confirmed this trend in the TCO_2 data. In the central Weddell Sea the pCO_2Of the sea water was always close to atmospheric values, whereas in the western Weddell Sea there was always undersaturation of CO_2 with respect to the atmosphere, with values decreasing to approximately 150 ppm.

C.6. Organic carbon and humic substances in the Weddell Sea

A. Skoog, M. Wedborg (AMK)

Objectives

Dissolved organic matter (DOM) in the ocean is the largest organic carbon reservoir in the global carbon cycle. It may be of importance as a sink of atmospheric carbon dioxide. Substantial quantities of DOM, mainly in the form of humic substances (HS), are added to the ocean by the rivers. The fate of this DOM, which is often referred to as biologically refractory, is uncertain. In the literature it has been reported that structural units, typical of terrestrial vascular plants are present in HS from the deep ocean, and that the marine HS can be quite old, between 5,000 and 10,000 years. This suggests that terrestrial DOM may be of significance as a part of the marine HS. The objective of this project was to increase the scarce information on total/dissolved organic carbon (TOC/DOC) and HS in the open ocean. The Weddell Sea is of special interest because the direct influence from the Antarctic continent is assumed to be negligible, while the biological productivity in the water column can be high.

Work at sea

Water samples for determination of TOC/DOC and HS were taken at all but ten CTD stations. TOC/DOC was determined by the high temperature catalytic oxidation method, and HS by fluorescence spectrophotometry, excitation 350 nm, emission 450 nm. The samples were normally processed within a few hours after sampling. HS were isolated on Amberlite XAD-2 columns, mainly for the purpose of estimating the fraction of TOC/DOC that is present as HS.

Preliminary results

The concentrations of TOC/DOC and HS found in the Weddell Sea were slightly lower than those from the Atlantic water in the deep Skagerrak, approximately 40 to 50 mM of TOC/DOC and 0.2 to 0.7 mg/l (as quinine sulphate equivalents, QS) of HS. For TOC/DOC, the concentration normally increased towards the surface, whereas for

HS the lowest concentrations were in most cases found at the surface, and a maximum at approximately 500 to 1000 m. At a few stations, some of which had a high biological productivity (e.g. Sta. 14 and 62, 72 to 76), the HS profile showed an increase at the surface but the TOC profiles for the stations with a high biological productivity were not notably different from those of the other stations (Fig. 7.3.5). For stations 79 to 85 the HS profiles resembled that of Sta. 62, with a marked decrease near the bottom, but without the increase at the surface (Fig. 7.3.5). The concentrations of TOC and HS in brown ice were found to be two to ten times as high as in the water column.

D. Acknowledgements

When we left "Polarstern" in Ushuaia, we all felt that we had an extremely successful cruise which was obviously to a large extent due to the most favorable ice and weather conditions and due the outstanding technical facilities of "Polarstern". However, it was obvious to us all, that only the continuous efforts of Master Jonas, his officers and his crew gave us the possibility to use this outstanding instrument. It was not only the active support which helped us to overcome difficult situations, but it was the hearty mood on board which made this cruise not only to a scientific success, but a cheerful adventure.

E. References

APPENDIX I: CTD Measurements during AQANTX_7

```
Instrument : Neil Brown CTD, Mark IIIB, Sn: 1069, BJ: 1984

             CTD temperature sensor : Rosemount Platinum
                                      Thermometer
             resolution :     0.0005 deg C
             accuracy   : +/- 0.005  deg C
             CTD pressure sensor    : Paine Model
             resolution :     0.1 dbar
             accuracy   : +/- 6.5 dbar
             CTD conductivity sensor : EG&G NBIS
             resolution :     0.001 mmho
             accuracy   : +/- 0.005 mmho

Software   : EG&G Oceansoft MkIII/SCTD Aquisition Version 2.01
                               CTD postprocessing Version 1.12
Time lag   : 0.05 s
```

Pressure pre-cruise calibration coefficients

```
a1 = -1.022974E+01
a2 =  6.503845E-03
a3 = -1.175345E-05
a4 =  7.631715E-09
a5 = -2.169818E-12
a6 =  2.851089E-16
a7 = -1.427193E-20

dp = a1 +a2*p +a3*p**2 +a4*p**3 +a5*p**4 +a6*p**5 +a7*p**6
 p = p + dp
```

no post-cruise calibration for the calibration data are the same

Temperature pre-cruise calibration coefficients

```
a1 = -2.992423E+00
a2 = -6.467617E-04
a3 = -1.247109E-05
a4 =  1.406644E-06
a5 = -1.906594E-08

dt = a1 +a2*t +a3*t**2 +a4*t**3 +a5*t**4
 t = t + dt
```

no post-cruise calibration for the calibration data are the same

correction of the CTD-conductivity data with the bottle-samples
(conductivity of the salinometer data)
evaluation of the coefficients with the mean of 14 stations
CD = (CONDUCTIVITY SALINOMETER - CONDUCTIVITY CTD) * 1000
CD = A0 + A1*PRES + A2*PRES**2 + A3*PRES**3

STATION	A0	A1	A2	A3
00301	0.40097E+02	0.13961E-02	-0.62035E-06	0.78273E-10
00501	0.40097E+02	0.13961E-02	-0.62035E-06	0.78273E-10
00801	0.40097E+02	0.13961E-02	-0.62035E-06	0.78273E-10
01003	0.40097E+02	0.13961E-02	-0.62035E-06	0.78273E-10
01101	0.40097E+02	0.13961E-02	-0.62035E-06	0.78273E-10
01202	0.40097E+02	0.13961E-02	-0.62035E-06	0.78273E-10
01301	0.40097E+02	0.13961E-02	-0.62035E-06	0.78273E-10
01401	0.40097E+02	0.13961E-02	-0.62035E-06	0.78273E-10
01501	0.40097E+02	0.13961E-02	-0.62035E-06	0.78273E-10
01702	0.40097E+02	0.13961E-02	-0.62035E-06	0.78273E-10
01901	0.40097E+02	0.13961E-02	-0.62035E-06	0.78273E-10
02001	0.40097E+02	0.13961E-02	-0.62035E-06	0.78273E-10
02101	0.40097E+02	0.13961E-02	-0.62035E-06	0.78273E-10
02201	0.40097E+02	0.13961E-02	-0.62035E-06	0.78273E-10
02301	0.40097E+02	0.13961E-02	-0.62035E-06	0.78273E-10

correction of the CTD-conductivity data with the bottle-samples
evaluation of the coefficients with the running mean of 7 stations

02401	0.44965E+02	-0.86689E-03	0.42263E-06	-0.47595E-10
02505	0.44965E+02	-0.86689E-03	0.42263E-06	-0.47595E-10
02601	0.44965E+02	-0.86689E-03	0.42263E-06	-0.47595E-10
02702	0.44965E+02	-0.86689E-03	0.42263E-06	-0.47595E-10
02802	0.43822E+02	0.48446E-03	-0.25160E-06	0.42966E-10
02901	0.43835E+02	0.32420E-03	-0.14951E-06	0.28644E-10
03001	0.43919E+02	0.18689E-03	-0.10745E-06	0.23665E-10
03102	0.44038E+02	0.21539E-04	-0.73212E-07	0.21681E-10
03201	0.44107E+02	0.58768E-04	-0.83728E-07	0.20917E-10
03301	0.44296E+02	-0.26691E-03	0.46702E-07	0.29663E-11
03401	0.44689E+02	-0.51701E-03	0.15368E-06	-0.10712E-10
03501	0.45097E+02	-0.10554E-02	0.44458E-06	-0.52303E-10
03606	0.45559E+02	-0.14528E-02	0.55199E-06	-0.61322E-10
03701	0.45726E+02	-0.18585E-02	0.80565E-06	-0.98044E-10
03804	0.45772E+02	-0.20032E-02	0.84883E-06	-0.10243E-09
03901	0.45779E+02	-0.20912E-02	0.87895E-06	-0.10570E-09
04002	0.45903E+02	-0.21774E-02	0.91354E-06	-0.10854E-09
04105	0.45454E+02	-0.98999E-03	0.38891E-06	-0.44703E-10
04201	0.45211E+02	-0.14068E-03	-0.65040E-08	0.59972E-11
04301	0.44979E+02	0.48931E-03	-0.26277E-06	0.34550E-10
04405	0.45075E+02	0.90788E-03	-0.52558E-06	0.76034E-10
04501	0.45334E+02	0.82027E-03	-0.48796E-06	0.75557E-10
04601	0.45851E+02	0.46172E-03	-0.34841E-06	0.59039E-10
04709	0.45734E+02	0.38609E-03	-0.33138E-06	0.59671E-10
04802	0.45946E+02	0.21605E-03	-0.41581E-06	0.83885E-10
04901	0.46239E+02	-0.68338E-03	-0.13293E-07	0.35283E-10
05001	0.46660E+02	-0.15578E-02	0.48073E-06	-0.32647E-10
05107	0.47010E+02	-0.21735E-02	0.70932E-06	-0.55246E-10
05201	0.47566E+02	-0.31364E-02	0.11145E-05	-0.10517E-09
05301	0.47907E+02	-0.36161E-02	0.13570E-05	-0.13784E-09

STATION	A0	A1	A2	A3
05409	0.48284E+02	-0.23454E-02	0.69915E-06	-0.51260E-10
05501	0.48173E+02	-0.21436E-02	0.90543E-06	-0.99688E-10
05601	0.48565E+02	-0.22444E-02	0.96576E-06	-0.10912E-09
05704	0.48100E+02	-0.16081E-02	0.55235E-06	-0.44177E-10
05801	0.48070E+02	-0.17760E-02	0.67554E-06	-0.68829E-10
05904	0.47483E+02	-0.72877E-03	0.18102E-06	-0.60924E-11
06001	0.47238E+02	-0.37313E-03	0.27003E-07	0.11686E-10
06101	0.47019E+02	-0.63778E-03	0.20635E-06	-0.17690E-10
06204	0.47084E+02	-0.47038E-03	-0.53129E-09	0.21141E-10
06303	0.47289E+02	-0.99113E-03	0.26980E-06	-0.21588E-10
06401	0.47328E+02	-0.14829E-02	0.59135E-06	-0.72485E-10
06501	0.47322E+02	-0.17544E-02	0.85824E-06	-0.12835E-09
06804	0.47449E+02	-0.18297E-02	0.76997E-06	-0.93999E-10
06904	0.47992E+02	-0.35443E-02	0.20304E-05	-0.36930E-09
07002	0.48227E+02	-0.48164E-02	0.34287E-05	-0.78486E-09
07104	0.49396E+02	-0.11713E-01	0.12510E-04	-0.39442E-08
07201	0.49853E+02	-0.14506E-01	0.18912E-04	-0.85326E-08
07304	0.50611E+02	-0.26918E-01	0.76237E-04	-0.75660E-07
07402	0.49996E+02	-0.10873E-01	-0.11264E-04	0.64430E-07
07501	0.50713E+02	-0.30963E-01	0.98277E-04	-0.86457E-07
07603	0.49564E+02	-0.13137E-01	0.30550E-04	-0.21597E-07
07701	0.49193E+02	-0.75210E-02	0.11256E-04	-0.53980E-08
07801	0.47759E+02	0.62618E-03	-0.56092E-06	0.27427E-11
07901	0.47730E+02	0.13132E-02	-0.13962E-05	0.26690E-09
08004	0.47470E+02	0.28071E-02	-0.30814E-05	0.82316E-09
08101	0.47496E+02	0.13994E-02	-0.10899E-05	0.20585E-09
08201	0.47560E+02	0.97582E-03	-0.70183E-06	0.11414E-09
08301	0.47733E+02	0.85061E-03	-0.77909E-06	0.15358E-09
08404	0.47811E+02	0.25509E-02	-0.22105E-05	0.45056E-09
08501	0.47768E+02	0.29178E-02	-0.22634E-05	0.44073E-09
08601	0.47543E+02	0.27148E-02	-0.16473E-05	0.27629E-09
08701	0.47875E+02	0.18920E-02	-0.13298E-05	0.24001E-09
08801	0.47627E+02	0.20224E-02	-0.11203E-05	0.17250E-09
08901	0.47627E+02	0.20224E-02	-0.11203E-05	0.17250E-09
09001	0.47627E+02	0.20224E-02	-0.11203E-05	0.17250E-09
09101	0.47627E+02	0.20224E-02	-0.11203E-05	0.17250E-09

The CTD-temperature is IPTS-68

CTD-Files column 5 : transmissiometer (TRANSM)
raw data , range between 0 - 5 volt
input voltage 5 volt
maximum level output voltage 4.81 volt
zero level 0.026 volt
station 15 to 91: the transmissiometer don't work

The *.SEA file:

The variable in column 15 : TCARBN is Total-CO2