preliminary data report
May 11, 1995

A. Cruise narrative

A.1 Highlights

A.1.a WOCE designation SR4
A.1.b EXPOCODE 06AQANTIX/2
A.1.c Chief Scientist

Eberhard Fahrbach
Alfrd Wegener Institut fuer
Polar und Meeresforschung
D-2850 Bremerhaven, F.R.
Germany
phone: 49-471-4831-501
Fax: 49-471-4831-149
49-471-4831-425
Internet: efahrbach@awi.bremerhaven.de

A.1.d Ship RV Polarstern

A.1.e Ports of Call

A.2 Cruise Summary

Itinerary and summary by E. Fahrbach

On 17 November 1990 NPolarstern"-left Punta Arenas. In Drake Passage physical oceanography work was started with an XBT- transect (Expendable Bathythermograph) across the Antarctic Circumpolar Current. An Acoustic Doppler Current Profiler (ADCP) recorded the current field in the upper few hundred meters. The bathymetry and geology programmes began with soundings of Hydrosweep and Parasound which were continued during the complete cruise. Chemical investigations from the first leg were continued with underway measurements. They concentrated on biogenic sulfur compounds and their reaction products in sea water and the marine atmosphere with particular interest in DMS (dimethyl sulfide). Concentrations of nitric acid, ammonia and ammonium nitrate and organobromine compounds were investigated in the marine atmosphere.

We reached the Polar Front on 19 November at 57 23 S, 61 14 W. The first logistic task of the cruise was to deposit three German scientists with more than 8 tons of supply goods at the Soviet station Bellingshausen on King George Island. One scientist returned with us after an eleven months stay. After measuring the first CTD-profile (conductivitys temperature, depth) and making a catch with the multinet, we approached Joinville Island at the northeastern tip of the Antarctic Peninsula. There, two hauls with the Agassiz-trawl provided material for comparative studies on the temperature dependence and kinetics of digestive enzymes in crustaceans.

Still in open water we reached the western end of our main hydrographic transect crossing the Wedded Gyre towards Kapp Norvegia where the first of 21 current meter moorings was deployed and the first of seven recovered. On the shelf the first biology station took place including measurements with quantameter and Secchi disk, two CTD casts combined with a rosette water sampler and catches with multinet, bongo net, and plankton net. The water samples were used for biogeochemical investigations with special emphasis on the silica and nitrogen cycles. For this reason incubations were carried out to Al the uptake of radioactive 14C, 32Si and 32p and stable 15N. The nitrogen flux in the Antarctic food Webb could be determined from the water column to the zooplankton. In this context the phytoplankton bio mass and species distribution as well as reproduction and life cycles of dominant copepods were studied.

On 22 November at about 150 km from the coast we met at 63 30 S, 51 30 W the ice edge. The winds calmed down with increasing distance from the coast and air temperatures did not drop below -4 C. Rather quickly the swell disappeared and the floes increased in size. However, due to a system of leads, we could proceed along our course as planned. On 26 November at 65 34 S, 38 52 W we reached a deep sea channel which was surveyed with hydrosweep and parasound along 500-km profiles over a distance of 144 km. The structure is 1 to 3 km wide with a depth of 60 to 100 m below the adjacent sea level of about 4650 m. It extends with large meanders from westnorthwest to east northeast. Due to the heavy ice cover, consisting of floes a few kilometers in diameter and up to a meter thick, the track line could not be maintained as straight as desirable.

Bottom samples were collected with a minicorer which was hung under the CTD. This instrument was newly developed. During initial trials a procedure was achieved which allowed its use without significant additional shiptime. After this phase it was used routinely on 37 stations. The first recovery of a current meter mooring (208) within the ice (70 ice cover) occurred on 29 November. Before the acoustic release of the mooring the floes of up to 500 m in diameter were broken into smaller pieces to allow the floats to reach the surface. After the release 40 minutes of intensive search were necessary to sight a float before the recovery could be successfully finished. At mooring 209 on 3 December no float reached the surface and a time consuming acoustic ranging and breaking of ice floes finally permitted the detection and consequent recovery after 8 hours. This tedious technique had to be applied during all further recoveries, whereas the deployment of moorings could be accomplished without any problem.

The center of the Weddell Gyre at about 66 16 S, 30 18 W is marked by a relatively shallow surface mixed layer. It was reached on 2 December. For a better localization of the center a transect of 150 nm length consisting of 7 CTD- stations perpendicular to the main transect was carried out. On the basis of those data absolute velocities will be determined using the Beta spiral concept. During the Winter Weddell Gyre Study (WWGS) '89 higher mixed layer temperatures and more intense biological activity were found in that area. This was not observed during the present cruise possibly due to the different season. On 7 December the investigations in the "beta cross" area were terminated and the main transect was continued to the southeast with CTD-profiles, biology stations, mooring recoveries and deployments. The ice conditions became less favourable due to larger floes of less triable ice and closed leads because of colder temperatures.

The transect was finished on 15 December. The coastal polynya was only poorly established and highly variable. Because the biologists noted that there was no sign of a spring bloom, the planned stations were cancelled. The desert- like conditions in the water column, evidenced by a Secchi depth of 54 m were in sharp contrast to the abundant algae growth in the ice which gave rise to all colors from yellow to brown. Although small the narrow polynya was large enough for a haul with the Agassiz-trawl.
The offshore ice belt of the polynya confirmed the term "ice- factory". It provided the heaviest ice conditions during the cruise and made the recovery of mooring 214 impossible. The last station on the transect was located in an inlet of 1 km length and 400 m width. In this inlet casts with CTD, multi- and bongo net were carried out in open water in the vicinity of the 25m high shelf ice front. After a hydrosweep survey of the continental slope in the aera of the Explorer-Escarpement we left on 16 December towards the Georgvon-Neumayevr-Station (GvN).

The work along the transect between Joinville Island and Kapp Norvegia amounted to 82 CTD and rosette stations, 7 biology stations, 21 mooring deployments and 7 recoveries. The established mooring network represents a gigantic flow meter which measures the volume of water and its heat content entering the Weddell Gyre in the northeast and leaving it in the northwest. South of our transect, cooling due to contact with the atmosphere and the shelf ice, together witn salt release through ice formation, induces vertical descent of water masses to the bottom. Glacial meltwater has to be taken into account for a quantitative understanding of those processes. Because of the significance of deep reaching vertical mixing for the global abyssal circulation, our measurements are part of the World Ocean Circulation Experiment (WOCE).

The biogeochemical investigations of the cycles and budgets of various constituents represent a contribution to the international Joint Global Ocean Flux Study (JGOFS). They aim to explain the special role of the Weddell Gyre in the Southern Ocean and to estimate the significance of this area to the global carbon cycle. The contrast between the high nutrient availability and the low production remains unresolved. A chemical-biological project allowed for the first time, direct measurement of DMS-production of Antarctic phytoplankton and determination of the contributions of different species.

On 17 December we reached Atka-Bight. In the early morning "Polarstern" rammed into the fast ice to provide a safe platform for the unloading of about 100 tons of supply goods for the GvN-Station. First contacts with the female overwintering team had been established by a helicopter visit on 13 December to prepare the unloading procedure. The first treck with unloaded material left in the early afternoon towards the shelf ice edge and the station. Due to favourable conditions all loading was finished in the evening. "Polarstern" left the Atka-Bight at midnight of 18 December. On the way north air chemistry, XBT, hydrosweep and parasound measurements were continued. The ice edge was met at 68 00 S, 3 58 W where the ice concentration dropped within 30 nm from 70 to 10 . Here the last biology station was carried out. On 23 December we reached 54 20 S, 3 23 W about 200 nm west of Bouvet Island were mooring BO1 was deployed with two sediment traps. The Polar Front was crossed on 24 December at 51 45 S, 2 24 E. Christmas Eve was celebrated with a merry ceremony in the "Blue Saloon" and a delightful buffet. The recovery of the last mooring PF 3 and deployment of PF4 was achieved in the morning of the 25 December. When we reached the 200 nm limit research was terminated. On 30 December 1990 at 01.00 "Polarstern" reached the bunker pier of Cape Town.

Physical Oceanography

Water Masses and Circulation (Th. Behmann, H.-J. Brosin, C. Buxhoeveden, J. Dehn, E. Fahrbach, M. Harder, H.-H. Hinrichsen, M. Knoche, T. Markus, R. Plugge, H. Schafer, M. Schmidt, E. Schutt, U. Sterr, V.Strass, and A. Wisotzki)

Objectives

The aim of the physical oceanography programme is further understanding of the circulation in the Weddell Gyre and the related distribution of water masses. The operations contribute to a multiyear project, the Weddell Gyre Study, which is part of the World Ocean Circulation Experiment (WOCE). During this period a hydrographic survey along a transect from the northern tip of the

Antarctic Peninsula to Kapp Norvegia will be repeated four times, twice in summer and twice in winter, to measure the water mass distribution with its seasonal and interannual variability. The programme was initiated with a winter survey in 1989, the Winter Weddell Gyre Study (WWGS) '89, and will be continued with further surveys in austral winter 1992 and summer 1992/1993.

Simultaneously an extensive current meter mooring programme began with the deployment of seven current meter moorings. The data from those moorings will be used to estimate the volume transport in the Weddell Gyre. Direct current measurements are essential because they are the only way to obtain the barotropic fJow which determines the net volume transport. From the measured mass, heat, and salt transports across the transect we can derive water mass formation rates. The transformation of Winter Water (WW) and Warm Deep Water (WDW) in the inflow to Antarctic and Weddell Sea Bottom Water (AABW, WSBW) in the outflow is of special interest, because it results from a deep vertical exchange which is relevant to the large scale abyssal circulation of the world ocean. Present estimates show that about 70 of the Antarctic Bottom Water spreading into the world ocean obtains its water mass characteristics in the Weddell Sea. Beause the salt budget of the area is strongly influenced by ice formation and melting, special interest is focussed on the ice transport across the transect. Interaction with the ice shelves has to be taken into account for a quantitative understanding.

Work at sea

In order to obtain the water mass distribution, a hydrography section was carried out with 74 CTD-profiles (conductivity, temperature, depth) and discrete casts for temperature, salinity, oxygen, nutrients and tracers (helium, tritium and 180). On the eastern slope the station distance was small enough to resolve topographic features such as the Explorer-Escarpement Seven current meter moorings were recovered and 21 were laid (Tables 1 and 2). On six of them ice thickness will be measured by upward-looking sonars (ULS). The moorings will stay in position for two years. Vertical temperature and electrical conductivity profiles were measured with a Neil Brown Mark lil B CTD. The quality of the CTD-measurements was assured by reference measurements with a rosette sampler. Water samples were taken with a General Oceanic rosette composed of 24 bottles with 12 I volume each. Each time a water bottle was closed 50 cycles of pressure, temperature and conductivity were recorded with the CTD, quality controlled and averaged. Pressure and temperature measurements were corrected by means of a laboratory calibration carried out in the Scripps Institution of Oceanography before the cruise. A second calibration will be done after the cruise. Both calibrations will lead to a more elaborate correction of the data. However, the control by electronic as well as mercury reversing thermometers and pressure meters gives us confidence that the preliminary data have errors of less than 5 mK in temperature and 5 db in pressure.

The salinity data are given in PSU. They are based on the CTD conductivtiy measurements from which salinity was calculated using the Unesco Practical Salinity Scale (PSS78). The values were compared with the salinities from water bottle samples which were measured with a Guildline Autosal 8400 A in reference to l.A. P.S.O. Standard Seawater. The number of samples per profile, the mean difference between the samples and the CTD measurements as well as its standard deviation are shown in Preliminary data presented in this report were corrected with a constant offset of 0.023 to an accuracy of 0.005. The final data will be corrected in conductivity for time and depth dependence of the deviations. Afterwards salinity will be recalculated.

Oxygen was determined with an automatic titration unit, using the Winkler method with a photometric endpoint determination. The error in the oxygen determination is estimated to 1 . This results from intercomparisons at selected stations between the chemical oceanography group from the Oregon State University and the AWI group both using different instruments. Duplicate samples from the same water bottle were analysed during the complete cruise as a measure of precision.

Preliminary results

The hydrography features measured along the transect are presented as sections of potential temperature and salinity. Below a shallow surface layer of WW which deepens significantly towards the shelf edge a temperature and salinity maximum due to the WDW is found. It is more pronounced at the boundaries than in the interior with temperatures up to 0.8 C in the east and 0.4 C in the west evidencing the inflow in the east and the outflow in the west. The largest part of the water column with potential temperatures between 0 and -0.8 C and salinities from 34.67 to 34.64 is classified as AABW. Below we find WSBW with temperatures colder than -0.8 C which extends in the west in a shallow layer over the continental slope indicating the outflow of this freshly formed water mass. The young age of this water mass is suggested by the high oxygen content In the forthcoming analysis we will quantify the transformation which occurs south of our transect of inflowing water masses in the east into the outflowing ones in the west. Seasonal changes on that transect are most evident in the near surface layers. Relatively warm air temperatures and weak winds indicate the onset of spring. A comparison of surface layer temperatures and salinities measured in September and October during WWGS '89 with the ones obtained during the present cruise indicates a much more pronounced springtime warming in the west than in the east. The salinity decrease due to ice melting was more intense in the east than in the west. In the deeper layers fluctuations of a wide spectral range are expected to be at least as intense as the seasonal cycle. Consequently no seasonal change can be identified in the comparison of the two sections.

From CTD data on a straight section only geostrophic current shear can be estimated. Absolute currents can be obtained by the use of mass conservation of geostrophic currents in and out of a closed area or by the Beta-spiral method. Therefore, in the area of the gyre centre, which is indicated by the doming of the isotherms, a second section normal to the main section was carried out with a length of about 275 km. The estimate of absolute geostrophic current velocities by use of the Beta-spiral method will yield additional information on the location of the gyre center complementary to the moored current meter data. However, this method requires the calculation of the second derivative of isopycnals with respect to horizontal and vertical coordinates and is very sensitive to fluctuations. Thus, quantitative estimates need to be carried out with the final data.

The transects of the potential temperature along the Beta-cross show smoothly inclined isolines which seem to reflect the doming of the Weddell Gyre. The temperature maximum of the WDW increases towards the north. This can be taken as an indication that there is a southward component in this level and consequently the center of the gyre has to be located further to the west.

The interaction with the ice shelf was studied by means of a CTD profile which was measured in an inlet of the Quarisen northeast of Kapp. The temperature profile shows cold-WW above a sligthly warmer layer centered at 200 rn depth which tops a colder bottom layer. The salinity increases from top to bottom. Presently it is not possible to conclude if the deeper layer is the remnant of a WW-layer which reached to the bottom and is separated from a slightly warmed surface layer by an intrusion of warmer water from offshore, or if it represents water which emanates from under the ice shelf. Tracer data measured from the water samples will be used to answer this question.

Weather conditions by H. Erdmann, 1g. Kohler, and H. Sonnabend

At the beginning of the cruise the main cyclonic activity was located west of the Antarctic Peninsula. On 17 November, the steering cyclone moved slowly eastward with a minimum pressure below 960 hPa. Secondary lows passed the Drake Passage quickly and affected "Polarstern" with northwesterly winds Bft 8 and seas up to 5 m. South of the Polar Frontal Zone, visibility deteriorated due to northerly winds Bft 7. On 20 November, "Polarstern" reached Bellingshausen

Station with northwesterly winds Bft 7 and snow showers. Due to catabatic influence, the wind increased up to Bft 9 near the station; in spite of the unfavourable weather conditions, helicopter service was possible.

Due to the permanent influence of the wide-spread and stable lowpressure system with minimum pressure still below 960 hPa at the southwestern part of Bransfield Strait, wind turned from northwest to southeast Bft 5 on 21 November, while "Polarstern " left Bransfield Strait heading for the Weddell Sea. Snowfall coming up caused bad visibily later on and a decrease of air temperature down to -4-C. In the early evening, "Polarstern" approached an area densely covered with sea ice. During the following next four days, the ship operated within a low pressure area between the steering Weddell Sea cyclone and secondary lows in the north and northeast. Therefore, the pressure gradient as well as the winds were generally weak. Cold air mass advection gave rise to good visibility but was accompanied by some snow showers. On 26 and 27 November, the dominant cyclone remained stable over the northwestern part of the Weddell Sea and began to fill slowly. Therefore, "Polarstern" was affected by stronger cold air advection in the northwestern section accompanied by numerous polar cumulonimbus clouds and heavy snow showers .

On 28 November a new gale center developed in the western part of the Drake Passage and moved to the South Shetlands. On 29 November its frontal systems approached "Polarstern" near 66-S, 37-W while activity was decreasing. Therefore, wind turned northeasterly while decreasing to Bft 3 to 4. Occasionally occuring snowfall diminished visibility until the end of November. At the beginning of December, a flat high developed in the central Weddell Sea. Therefore, the wind was light and varying, the visibility very good and the clouds dissolved. A small-ranged but heavy cyclonic development north of "Polarstern's" operating area caused heavy snowfall on 3 December, which was accompanied by strong easterly winds up to force Bft 7. Therefore helicopter service was not possible on this day. During the night of 4 December, the cyclone moved south while decreasing and crossed the position of "Polarstern" to the west. The wind was backing to the north and caused low level warm air advection with rising dew point

near 0 C. As a consequence, fog persisted for about 4 hours.
On the same day, another but stronger cyclonic development evolved near South Georgia. This new storm center moved quickly southeast; with its rear and southerly gales up to force Bft 9 it affected "Polarstern" in the central Weddell Sea during 4 December. The maximum wind speed measured on board at the marine meteorological station was 55 knots within gusts. The chill temperature was -27 C and rendered open air work almost impossible. A small wedge within the advanced polar air gave rise to better weather conditions on December but caused decreasing temperatures with morning minimum temperatures near -8 C. In the course of the next 3 days, weather remained fair, sometimes even sunny with only light winds generally from west, due to the influence of a relatively high pressure center north of. the ship's position.
During the night hours, ice covering fog patches developed due to heat loss and disappeared when sun rose.

In the eastern section of a quasi-stationary but developing low, strong warm air advection mainly in the upper troposphere produced widespread snowfall also in the operation area of "Polarstern" near 67 S, 23 W on 9 December. During the next 24 hours, temperatures rose to 0 G and wind turned northerly with force up to Bft 7. From 10 to 14 December, a dynamic high developed above the northern part of the Antarctic continent with its center (1004 hPa) near 70 S, 05 W . Therefore, a strong inversion near 1000 m-level caused overcast stratocumli with some snow showers and light winds. On 15 December "Polarstern" reached Kapp Norvegia in sunshine and light winds produced by the still stationary high near Neuschwabenland.

The weather conditions were still good when "Polarstern" was stationed at the shelf ice near Georg-von-Neumayer-Station for unloading. In spite of overcast sky with a ceiling near 800 feet and occasional "whiteout" conditions, helicopter service was not affected. When "Polarstern" left for Cape Town on 19 December, the synoptic situation changed. The dominant high at Neuschwabenland moved southwest while weakening and the low system east of South Georgia moved east. Therefore an easterly wind increased up to force Bft accompanied with some snowfall and bad visibility.

On 20 December "Polarstern" left the closely packed sea ice near 68 S 03 W. On the southern edge of a heavy steering low near 60-S, 05 W (958 hPa), which moved eastsoutheast very slowly, wind increased up to force Bft 7 to 8 while turning from east to southeast for some hours. Next day wind turned southwest while decreasing slowly. Wind seas and swell of about 3 m affected the voyage of "Polarstern" only little. On 24 December a new low developed northeast of South Georgia moving southeast slowly. Its frontal systems affected "Polarstern" on 25 December north of Bouvet Island with northerly gales Bft 8 to 9 northwest but decreasing slowly. Shortly before arrival in Cape Town, light winds, sunshine and warm temperatures were encountered.

Ice conditions by H.-J. Brosin and D. Zippel

Visual observations of the ice conditions were performed between 22 November and 20 December according to instructions given by the Glaciological Section of the Alfred-Wegener-lnstitute .Altogether 236 observations were realized together with an additional 70 observations on the distribution of algae in the ice. The first iceberg was observed on 20 November at the position 62 12 S, 57 56 W, the last one on 23 December. The ice edge was crossed at 63 30 S, 51 30 W 150 km distant from the nearest shoreline on 22 November. It was passed again at the position 68 S, 04 W on 20 December. The shelf ice edge was reached for the first time at 71 07 S,11 23 W on 15 December. The portion of white ice amounted to 40 to 100 of the total ice cover. The thickness mostly varied between 0.5 and 1.5 m and was estimated to be up to 2 m in a few cases. A distinct increase of the size of Ice floes to a diameter of more than 1 km was observed at the position 65 39 S, 39 W, an evident reduction of the floe size occured only close to the end of the observations at 70 25 S, 13 25 W. The thickness of the snow cover on the ice varied between 20 and 50 cm. Marked melting effects at the bottom layers of ice floes were observed for the first time at the position 66 22 S, 29 32 W on 2 December. Local new ice formation (nilas, grey-white ice) were repeatedly observed after a larger decrease in air temperature.

A wide spread occurence of icebergs was observed particularly at the western edge of the working area between 64 and 65 50 S, 49 and 40 W (up to 41 icebergs within the field of view) and at the southeastern edge from 69 15 S to 70 30 S, 16 45 to 10 W (up to 52 icebergs seen simultaneously).

A.2.a Geographic boundaries

A.2.b Total number of stations

A.2.c Floats and drifters deployed

A.2.d Moorings deployed or recovered

Table 1: Moorings deployed during "Polarstern" cruise ANT IX/2

Mooring	lat(S)	Long(W)	Time	Date	Water Depth m(uncorr)	Type	Instr. No.	Depth
215	63 19.89	52 59.07	2014	211190	448	AVTP	10001	291
						AVTP	9996	396
						WLR	1155	447
206/2	63 29.55	52 06.27	1454	221190	942	AVTP	8402	253
						AVTP	9786	891
207/2	63 45.05	50 54.32	0652	231190	2498	ULS	9/90	165
						AVTP	9206	326
						TK	1569	
						ATR	1100	578
						AVTCP	8395	1037
						AVT	8417	2187
						TK	1570	
						ATR	1102	2439
						AVT	8418	2447
216	63 56.96	49 09.21	0034	241190	3477	AVT	9182	2968
						AVT	9184	3426
217	64 25.10	45 50.97	4424	241190	4424	ULS	13/90	141
						AVTPC	9192	250
						S890107		796
						AVTC	921	1010
						AVT	9185	2510
						ACM-2	1281	4373
218	64 48.87	42 29.28	2115	251190	4688	AVTP	10005	252
						TK	1427	
						ATR	944	505
						AVTP	9212	993
						AVT	9186	2503
						ACM-2	1284	4636
219	65 39.87	37 42.45	1336	281190	4732	AVT	9187	4226
						AVT	9188	4674
208/2	65 38.14	36 30.20	1827	291110	4776	ULS	11/90	171

```
                                AVTPC  9194  281
                                  S890108  4165
                                             ACM-2  1285 4725
220   65 58.19 33 20.33  1543 301190 4799       AVT  9767 4300
                                               AVT  9768 4748
211/2   70 29.67 13 08.85  2217 141290 2381      AVTP 10004  270
                                  TK  1572
                                 ATR  1104  523
                                AVTP  8396 1012
                                               AVT  9999 2222
                                               AVT  9392 2329
KN4   70 59.51 11 46.86  0955 151290  892        S860019   328
                                 AVTP 9209  333
                                                 S860020   782
                                               AVTPC 9210  810
                                                 UCM       811
214/2 71 02.93 11 41.25  1256 151290  378        AVTP 8370  213
                                   AVT 9403  318
                                                 WLR 1044  377
BO1   54 20.30 23 12.90  1643 231290 2734          S860024  423
                                   AVT 7727  474
                                                  S890005 2196
                                                 AVT 8037 2217
PF4   50 07.60 05 52.00  1031 251290 3807          S860038  625
                                   AVT 9803  646
                                                  S890009 3267
                                                 AVT 9805 3290
221   66 16.63 30 17.78  1049 021290 4784        ADCP       236
                                              AVTPC 9195  247
                                                 TK      1426
                                                 ATR  943  499
                                               AVTPC 9214  985
                                               AVTPC 9215 2499
                                               ACM-2 1288 4732
209/2       66 37.35 27 7.10   2050 031290 4862        ULS 14/90  147
                                               AVTP  9202  279
                                              AVTPC  9216 1015
                                              AVTPC  9217 2526
                                              ACM-2  1289 4809
22    67 03.56 24 52.11  2254 071290 4836        AVT  9769 4336
                                              ACM-2  1282 4785
223   67 59.84 19 57.64  1724 091290 4885      AVTPC  9205 251
                                              AVTPC  9218 1010
                                                AVT  9208 2520
                                              ACM-2  1290 4834
224   68 49.65 17 54.49  1338 101290 4740        AVT  9770 4239
                                              ACM-2  1291 4689
210/2       69 39.63 15 42.90  1650 111290 4745        ULS 10/90 151
                                               AVTP  9201 270
                                                 TK 1571
                                                ATR 1103 523
                                               AVTP 9995 1012
                                                AVT 9391 2521
                                              ACM-2 1297 4694
225   70 19.11 13 39.61  1819 121290 4329        AVTP 10002 275
                                      AVT 9783 1124
                                                AVT 9997 2625
                                                AVT 9782 4278
226   70 22.84 13 32.53  0057 131290 2943        AVTP 10003 231
                                               AVTP 9998  980
                                                AVT 9207 2892
212/2       70 54.67 11 57.80  0734 141290 1555        ULS 12/90 135
                                               AVTP 8367  254
```

AVTC 9401 759
AVT 9402 1504

Tables 2: Moorings recovered during "Polarstern" cruise ANT IX/2

206	63 29.6	52 07.4	1113	130989	946	AVT	229
						S	349
			0852	221190		AVT	876
207	63 45.8	50 54.3	1039	140989	2503	AVTPC	263
						AVTPC	952
			0041	231190		AVT	2162
						AVT	2410
208	65 36.3	36 29.9	1830	240989	4768	AVTPC	288
						AVTPC	1037
			1300	291190		S	1090
						AVT	2610
						S	4122
						AVT	4631
209	66 36.8	27 07.4	1028	011089	4863	AVTC	293
						AVTPC	993
				031290	0916	AVT	2653
						AVT	4725
210	69 38.9	15 44.5	2111	051089	4751	AVTC	289
						AVTPC	988
			1429	111290		AVT	2547
						AVT	4617
211	70 29.5	13 07.0	0013	6/7/1089	2402	AVTC	247
						AVTPC	856
			1428	141290		AVT	2066
						AVT	2313
212	70 59.2	11 49.4	1655	081089	1069	AVTPC	309
						AVT	999
			2250	131290			
PF3	50 70.60	05 50.0	1034	091189	3785	S	625
						AVT	645
			0830	251290		S	3200
						AVT	3220

Abbreviations:
AVTPC: Aanderaa current meter with temperature, pressure and conductivity sensor. In brackets instruments with poor data quality.
S: Sediment trap
ACM-2: Acoustic current meter, Neil Brown
ADCP: Acoustic doppler current meter
ATR: Recording unit for thermistor chain
UCM: Acoustic current meter, Simtronics
ULS Upward Looking sonar
WLR Water level recorder

A.3 List of Principal Investigators for all Measurements

A.4 Scientific Programme and Methods

A.5 Major Problems and Goals not Achieved

A.6 Other Incidents of Note

A.7 List of Cruise Participants

Table 3: Cruise Participants

Name	Institution*
Baumann, Marcus	AWI
Behmann, Thomas	AWI
Bluszcz, Thaddaus	AWI
Brandini, Frederico	AWI
Brandini, Frederico	AWI
Brosin, Hans-Jurgen	IfMW
Buxhoeveden, Cristina Isabel	ITBA
Corradi, Pio Ante	AF
Dehn, Joachim	AWI
Dittrich, Birgit	AWI
Erdmann, Holger	DWD
Frhrback, Eberhard	AWI
Goeyens, Leo	VUB
Goldkamp, Ulrich	AWI
Harder, Markus	FPB
Heitmueller, Karl-Heinz	HSW
Hillebrandt, Oliver	HSW
Hinrichsen, Hans-Harald	FPB
Knoche, Martin	AWI
Kohler, Herbert	DWD
Krest, Jim	OSU
Kubrjeweit, Frank	AWI
Lengacher, Dieter	AF
Leynaert, Ande	IEM
Lindenmaier, Patrick	AF
Lindner, Louis	RUU
Markus, Thorsten	AWI
Monk, Juergen	AWI
Papenbrock, Thomas	RUB
Pauls, Margarete	AWI
Pereira, Brandini, Frederico	CBA
Pfeiffenberger, Hans	AWI
Plugge, Rainer	AWI
Queguiner, Bernard	IEM
Ragueneau, Olivio	IEM
Rauschert, Martin	FfW to K.G.I
Riewesell, Christian	HSW
Ross, Andy	OSU
Schafter, Hartmut	FPB
Schlumpf, Hans-Ulrich	AF
Schmidt, Martin	IfMW
Schoch, Roland	FPB
Schoffmann, Erhard	FGB

*See Table 4 for list of Institutions

Table 4: List of Institutions

Abbreviations	Institution
AWI	Alfrd-Wegener-Institut fuer Polar und Meeresforschung Columbusstrabe 2850 Bremerhaven Germany
DWD	Deutscher Wetterdienst

Seewetteramt
Bernhard-Nocht-Str. 76
2000 Hamburg 4
Germany

FGB	Universitat Bremen Fachbereich Geowissenschaften FB5 Postfach 33 04 40 2800 Bremen 33 Germany
FiW	Forschungsstelle Fuer Wirbeltierforschung Akademie der Wissenschaften der DDR Am Tierpark 125 O-1136 Berlin Germany
FPB	Universitat Bremen Fachbereich Physik FB1 Postfach 33 04 40 Germany
HSW	Helicopter-Service Wasserthal GmbH Katnerweg 43 2000 Hamburg 65 Germany
IfMG	Johann Wolfgang Goethe-Universitat Institut fuer Meteorologie und Geophysik Feldbergstr 47 Postfach 11 19 32 6000 Frankfurt am Main 11 Germany
fIfMW	Institut fuer Meereskunde Akademie der Wissenschaften der DDR Seestr. 15 O-2530 Rostock-Warnemunde Germany
RUB	Ruhr-Universitat Bochum Fakultat fuer Chemie/ Physikalische Chemie Postface 10 21 48 4630 Bochum 1 Germany
TA	TERRAQUA Indersdorfer Str. 16 8061 Arnbach Germany
ITBA	Instituto Technologico de Buenos Aies Avda Enardo Madero 351/99 1106 Buenos Aires Argentina
VUM	Vrije Universiteit Brussels Laboratory for Analytical Chemistry Pleinlaan 2 B-1050 Brussels Belgium

CBM	Centro de Biologia Marinha/UFPR AV. Beira Mar Ponta do Sul Paranagua 83200 Pr. Brazil
IEM	Institut d'Etudes marines Universite de Bretagne Occidentale 6 Avenue Le Gorgeu F-29287 Brest Cedex France
RUU	Rijksuniversiteit te Utrecht Faculteit der natuur en sterrenkunde Princetonplein 5 NL-3508 TA Utrecht Netherlands
AF	Arian Film AG Postfach 835 CH-8025 Zurich Switzerland
OSU	Oregon State University College of Oceanography Oceanography Administration Building 104 Corvallis, Oregon 97331-5503

B. Underway Measurements

B.1 Navigation and bathymetry

B.1.a Bathymetry by U. Goldkamp, J. Monk and S. Vucelic

Rise and heading for Cape Town until the end of the leg.
After reaching the known position of the channel at 65-40 S and 38 45 W and passing the first turning points of the survey pattern, the track had to be modified, because the ice conditions made it impossible to follow a prescribed course. Nevertheless, the width of the channel was recorded in its whole extent along the channel axis from east to west which was possible because frequently leads were alligned along the channel axis. At the eastern part of the survey, large ice floes prohibited following the course of the channel. The hydrosweep screen on the bridge allowed changes in the course to be made in a way, that the survey of this part of the channel was achieved despite the ice cover. The channel was surveyed over a total length of 144 kilometers with a track line of 500 kilometers.

On the shelf and the continental slope off Kapp Norvegia, several hydrosweep profiles could be run in spite of unfavourable ice conditions to supplement data in the area east of the Wegener Canyon. the route to Atka Bight was used to run a profile parallel to former courses .

For the passage to Cape Town a course was chosen so as to cross over the eastern slope of Maud Rise from south to north. The online constructed 'soiine-plot showed small cone-like structures in this area, even above Maud Rise.

During the complete leg, GPS-satellites could be used for positioning. Offsets, positioning errors and failing data were recorded, which were due to changes in position of the satellite, inter-satellite constellation and the time free of GPS. Offsets and positioning errors were corrected within one day, which resulted in a more exact ship's position. Therefore, postprocessing results in an exact positioning of the fansweep profile of Hydrosweep as well as good agreement in the isobaths crossing the fansweep profiles.

B.2 Acoustic Doppler Current Profiler(ADCP)
B.3 Underway dissolved oxygen, fluorometer, etc
B.4 XBT and Thermosalinograph

Underway measurements of current profiles, XBTs and the thermosalinograph by Th. Behmann, H.-i. Brosin, C. Buxhoeveden, J. Dehn, E. Fahrbach~ M. Harder, H.-H. Hinrichsen, M.Knoche, T. Markus, H. Schafer, M. Schmidt, U. Sterr, V. Strass, and A. Wisotzki

Objectives

The Antarctic Circumpolar Current is subject to a wide range of temporal and spatial variability. The repeated crossings of "Polarstern" are used to obtain a data set which is suitable to address longer term variability of the thermal field and spatial variability of the velocity field. The temperature profiles are inserted in the Integrated Global Ocean Services System (IGOSS).

Work at sea

This goal approached by usage of the Vessel Mounted Acoustic Doppler Current Profiler (VM-ADCP, manufactured by RD Instruments, San Diego) which allows us to monitor the current profile in the upper 350 m of the water column from the ship moving at full speed. Sea surface temperature and salinity is recorded by a thermosalinograph . By use of the ADCP a cross section of the upper ocean velocity profile through the Circumpolar Current was recorded through Drake Passage to the Antarctic Peninsula. A set of calibration data were collected by running a cross-shaped course pattern on the shelf of the Antarctic Peninsula. During the calibration courses the ADCP was operated in its bottom track mode; a variety of control parameter settings were used during the measurements in order to optimise the instrument's psrformance. The data sampled were transferred to the ship s VAX computer for processsing and plotting. During the measurements the ADCP was run without the occurence of major problems. However, during a later phase of the cruise no more data were obtained for two reasons:

First, in its mode of operation the ADCP s transducer sits at hull depth (approx. 11 m) in the ship s well without any protection against mechanical damage by ice floes pushed under the ship. When the ship moves through the ice the transducer is protected by a lid consisting of two stainless steel sheets of 8 mm thickness. With the transducer behind the protective lid the ADCP not able to function. Consequently, no ADCP measurements of current profiles could be obtained along the Weddell Sea cross section.

Second, it appeared that the protective lid was not strong enough to withstand the collisions with ice floes. When we tried to reactivate the ADCP in ice-free waters after having left the GvN-Station, we noticed that the lid was deformed by the impacts from ice floes and the transducer assembly was severely damaged. All four transducer heads were scoured off at their outer periphery, and in one case the metal cage embedding the transducer face was torn. Moreover, two of the transducer heads were loosened from their proper connection to the transducer electronics housing because the connecting bolts had been lengthened by leverage, leading to gaps of up to 3 mm wide between the transducer heads and the electronics housing. Through these gaps sea water flooded the electronics housing. Because of the severeness of the damages, there was no way of repairing the transducer assembly on board of the ship and to employ the ADCP during the further parts of the cruise.

The thermal structure of the upper 700 to 800 meters was measured by 194 XBT-profiles which were recorded with a Nautilus-system. Times and locations of the individual profiles are given in Table 5. Comparison between 8 XBT and CTD measurements at the same stations confirmed the accuracy of 0.2 K given by the manufacturer. Sea surface temperature and salinity were recorded continously in the bow thruster channel at about 5 m depth with a thermosalinograph supplied by Meerestechnik-Electronik (ME). The data were controlled by salinity samples taken at the inlet to the instrument and the temperature measurements of the CTD. The following corrections have to applied to the recorded data:

Ttrue=0.921 Trecorded - 0.253
Strue=0.949 Srecorded - 1.772

The corrected data will then be accurate to 0.03 K and 0.03. However, it has to be taken into account that occasionally a water-ice mixture is flowing in sensor head which results in erroneous data. The error is obvious by the reduced conductivty due to the ice. Therefore we do not use the thermosalinograph data along the transect but refer to the CTD-data in 10m depth.

Table 5: XBT's

St. No.	Date	Time GMT	Position Lat S	Position Long W	Depth M uncorr.
1	181190	2357	54 39	63 31	122
2	191190	0112	54 54	63 19	>1800
3		0203	55 07	63 08	2639
4		0307	55 20	62 57	4171
5		0403	55 34	02 48	4141
6		0518	55 48	62 35	4090
7		0625	56 01	62 25	3953
8		0745	56 15	62 11	4040
9		0850	56 29	62 00	4100
10		0958	56 42	61 48	3000
11		1058	56 56	61 39	>3000
12		1158	57 09	61 27	3819
13		1258	57 23	61 14	3845
14		1405	57 38	61 02	3631
15		1456	57 50	60 52	3601
16		1601	58 04	60 42	4305
17		1739	58 28	60 21	3073
18		1831	58 31	60 12	3600
19		1930	58 44	60 03	3715
20		2035	58 58	59 50	6428

21		2135	59 11	59 39	4090
22		2250	59 25	59 27	4298
23	201190	0004	59 40	59 13	2142
24		0108	59 52	59 02	5930
25		0209	60 06	58 49	3490
26		0321	60 20	58 36	3868
27		0421	60 33	58 23	3912
28		0526	60 47	58 11	4266
29		0633	61 00	57 58	4910
30		0739	61 14	57 45	2499
31		0840	61 27	57 33	903
32		0945	61 41	57 18	399
33		1042	61 54	57 10	259
34		1201	62 06	57 26	743
35		1315	62 13	58 02	1280
36		1403	62 17	58 24	1100
37		1501	62 17	58 44	464

106	201290	0406	68 11	0428	4086
107		1000	67 45	03 09	4283
108		1435	67 32	01 04	>4000
109		1717	67 15	00 24	3451
110		1920	67 00	00 52	>4500
111		2220	66 30	01 49	4080
112	211290	0005	66 15	02 21	3680
113		0155	66 00	02 51	3390
114		0340	65 45	03 17	3669
115		0625	65 15	03 21	2627
116		0744	65 00	03 23	2530
117		0906	64 45	03 26	
118		1031	64 30	03 29	2177
119		1157	64 15	03 31	2600
120		1316	64 00	03 34	3159
121		1411	63 45	03 36	4365
122		1601	63 30	03 37	4940
123		1722	63 15	03 41	5055
124		1844	63 00	03 44	5360
125		2001	62 45	03 31	5340
126		2125	62 30	03 16	5378
127		2240	62 15	03 02	5372
128		2355	62 00	02 49	5380
129	221290	0120	61 45	02 34	5378
130		0230	61 30	02 20	5376
131		0350	61 15	02 07	5122
132		0510	61 00	01 53	3341
133		0607	60 48	01 42	5400
134		0745	60 30	01 27	4181
135		0902	60 15	01 15	4303
136		1136	59 45	00 51	4924
137		1245	59 30	00 39	>4200
138		1517	59 00	00 14	4488
139		1637	58 45	00 02	4599
140		1800	58 29	00 12	4428
141		1905	58 15	00 22	3885
142		2010	58 00	00 34	3900
143		2135	57 45	00 45	4210
144		2250	57 30	00 58	3905
145	231190	0006	57 15	01 10	3368
146		0235	56 45	01 33	3563
147		0350	56 30	01 44	4187
148		0504	56 15	01 55	4045
149		0640	55 58	02 09	3386
150		0745	55 44	02 18	3371

151		0855	55	30	02	29	2640
152		1013	55	15	02	41	2460
153		1124	55	01	02	51	3143
154		1244	54	45	03	03	2645
155		1356	54	30	03	14	2606
156		1835	54	20	03	24	2702
157		1915	54	15	03	15	2400
156		2120	54	00	02	36	2495
157		2317	53	45	01	59	2040
158	241290	0110	53	30	01	25	2658
159		0305	53	15	00	50	2358
160		0416	53	05	00	29	2600
161		0454	53	00	00	19	2481
162		0645	52	45	00	15	2720
163		0820	52	30	00	46	2800
164		1015	52	15	01	19	2800
165		1204	52	00	01	52	2600
166		1355	51	45	02	24	3053
167		1545	51	30	02	57	3485
168		1735	51	15	03	28	3390
169		1825	51	00	04	00	3608
170		1950	50	57	04	06	3553
171		2125	50	45	04	30	3231
172		2314	50	30	05	02	3349
173	251290	0145	50	15	05	33	3659
174		1120	50	00	05	58	3711
175		1300	49	45	06	11	3519
176		1440	49	30	06	23	3500
177		1625	49	13	06	37	3464
178		1830	49	00	06	48	3684
179		2036	48	45	07	02	3890
180		2245	48	29	07	15	2182
181	261290	0039	4815		07	27	2465
182		0247	47	59	07	43	4158
183		0430	47	45	07	53	3090
184		0630	47	30	08	05	2550
185		0819	47	15	08	18	1837
186		1004	47	00	08	31	3452
187		1152	46	45	08	43	3685
188		1337	46	30	08	55	4420
189		1520	46	15	09	07	4680
190		1655	46	01	09	19	4650
191		1850	45	45	09	32	4563
192		2230	45	30	09	43	4513
193		2220	45	15	09	55	4610
194	271290	0005	45	00	10	08	4710
195		0144	44	45	1020		4748
196		0321	44	30	10	31	4981
197		0509	44	15	10	43	4231
198		0647	44	00	10	55	4305
199		0930	43	45	11	07	4409
200		1120	43	28	11	19	4980
201		1250	43	15	11	31	4591
202		1430	43	00	11	43	4703
203		1610	42	45	11	55	4505
204		1742	42	30	12	06	4606
205		1933	42	13	12	20	3239
206		2048	42	00	12	29	5102
207		2217	41	45	12	40	3329
208		2349	41	30	12	51	2930
209	281290	0013	41	15	13	02	2100
210		0140	41	00	13	10	4500
211		0322	40	45	13	22	4626

212		0506	40	30	13	36	4934
213		0652	40	15	13	48	4842
214		0835	40	00	13	59	4135
215		1010	39	45	14	10	4679
216		1321	39	29	14	21	4760
217		1453	39	13	14	31	4730
218		1514	39	00	14	40	4744
219		1657	38	57	14	51	4853
220		1830	38	29	15	04	4856
221		2253	37	51	15	33	4866
222		2335	37	45	15	37	4396
223	291290	0104	37	30	15	49	4788
224		0229	37	15	15	58	4708

B.5 Meteorological observations

B.6 Atmospheric chemistry

C. Hydrographic Measurements

C.1 Helium and Tritum

Tritium and Helium measurements by R. Well

Objectives

Within the scope of the physical oceanography programme the tritium and helium-isotope contents of the water samples serve as tracers for water mass characteristics. In addition, they can yield information about the time scales of exchange of the water masses within the Weddell Gyre. On this cruise - for the first time - we degassed water samples at sea. This procedure is expected to reduce the contamination caused by longtime storage and can simplify the handling of the sample containers. For this purpose we tested new degassing equipment on board and will compare the results with those obtained with the traditional method.

Work at Sea

We took water samples at 6 CTD-stations on the shelf and continental slope of the Antarctic Peninsula in water depths of about 400, 1000, 2200, 2500, 3550 and 4200 m, at 3 CTD-stations in the central Weddell Sea at water depths of about 4700, 476n and 4860 m and at 4 CTD-sta tions on the eastern continental slope off Kapp Norvegia in water depths of about 4400, 2400, 1600 and 500 m.
Altogether about 50 double-samples were taken. One half of them were degassed on board, the other half will be degassed after our return in the laboratory, the helium- and neon-isotope contents will be compared.

Preliminary Results

As the measurements of the samples have to be done with a mass spectrometre in the laboratory we can not present data or quantitative results of the intercomparison here. The degassing technique on board did not show serious technical problems. Some problems occurred with the melting off procedure of the glass ampoules so that presently we Kitcan not generally guarantee that the extracted gas is well caught in the glass ampoule.

C.2 Natural radioactive isotopes in the water column by E. Schoffmann and M. Seal

Objectives of.

Investigations on sediment samples from the area off West Africa and from the Polar Front show that in areas with high biological activity, the flux of radioisotopes such as 10Be and 230Th to the sediments increases the production of the isotopes. This is due to scavenging of the isotopes by settling particles. This causes a concentration gradient of the isotopes from high to less productive areas which might allow former biological activity to be deduced.

Work at sea

To quantify these effects, samples for 10Be measurements were taken on 4 stations of the Weddell Sea transect. The investigations on these samples will be linked to investigations on 230Th in the Weddell Sea by the geochemistry group of the AWI, and to results of measurements of 10Be and 230Th in the South Atlantic by the FBG.
To get the 30 of water needed for a 10Be analysis, water from different depths within the same water layer was combined. A well known amount of 9Be carrier was added and Be, together with Mg and other elements, was precipitated at a pH of 8 - 9. The water was decanted, and the precipitate will be prepared for measurements with the accelerator mass spectrometer of the ETH Zurich.
Additionally at all the minicorer-stations 10 Be samples have been 10Be taken from the sediment surface.

C.3 Postinstallation work on the computer system by H. Pfeiffenberger-Pertl

Objectives

A new central computer system and two local area networks were installed aboard "Polarstern" in October 1990. Five VAX-VMS systems of different capabilities, configured as a cluster, replace one older :VAX-VMS corTlputer. The local area networks, using ethernet and LocalTalk cabling, provide the possibility to connect PCs and Workstations in all locations used for scientific purposes to each other, the central system and its resources, i.e. printers, plotters, etc.
The most important objective of the work at sea was to observe this rather complex system under real conditions, in order to see if the concepts leading to its hardware- and softw-are-configurationdo work, and how the system is utilized by the scientists and how its utility could be improved, which problems are encountered and how,to fix them. The result of this work should be a users manual for scientists and support personnel on board that provides advice on this specific installation in the most compact way possible.

Work at sea

The information necessary to meet the objectives was collected while giving advice or help to scientific users and support personnel. Some programming was neccesary to fix problems, support routine operation of the system and to meet requests from scientists for access to specific data. The documentation most urgently needed was written.

Preliminary results

In general the VAX systems worked as planned. The single most important task, namely quasi-realtime data logging and processing on one of these machines, worked without problems.

The disc and file services for PCs are made available on board in the same way as at the institute in Bremerhaven. Due to a much higher demand for data transfer between VAX-, IBM-compatible and Macintoshsystems, problems up to now unknown appeared. They could be solved by a file conversion utility and some documentation giving recipes.

Observations on the use of the publicly available PCs led to the conclusion that these will produce more work for the support personnel (or less utility to the scientists) than the VAX-systems, if their users are not very disciplined and they are managed as personal PCs Further work has to be done on this problem.

C. 3 Distribution of dissolved inorganic nutrients in the water column: by J. M. Krest and A. A. Ross

Objectives

By obtaining high quality nutrient data from late winter and early spring, we will improve on the sparse historical data set of the central Weddell Sea. The repeated "Polarstern" transects should permit the seasonal and interannual variability of the major water masses to be assessed. This data set will be used to study the evolution of WW which is the mixed layer beneath the seasonal pack ice. WW properties change with length of time.under the ice due to continuous mixing of warmer, higher nutrient waters (WDW) from just below the pycnocline. From the analysis of nutrients in this surface layer, we plan to extend and refine our earlier estimates of net primary productivity in the Weddell Sea.

Work at Sea

At 88 CTD casts, water samples were taken and analyzed for Silicic Acid, Phosphate (Ortho-Phosphate), Nitrate + Nitrite (N+N), Nitrite, and Ammonium. Analyses were performed using the ALPKEM RFA-300 continuous flow analysis system. The entire water column was sampled for nutrients, but at this time, only the surface water in the primary northwest-to-southeast transect has been cursorily examined for silicic acid, phosphate and N+N.

Preliminary Results

Contour plots of nutrients in the upper 500 meters show a fairly well defined layer of WW from approximately 50 W to 14 W. In the WW-layer which occupies the top 100 meters of the water column silicic acid concentrations range from 70 to 80 uM, N+N concentrations from 28 to 30 AM, and phosphate concentrations from about 2.0 to 2.1 uM. Underlying this WW-layer is a reasonably strong nutricline, varying in depth from 100 to 150 meters. In this nutricline, silicic acid increases in concentration to 110 micromolar, N+N increases to 33 uM, and phosphate increases to 2.3 uM.

For all three nutrients, concentrations are most elevated in the center of this gyre, indicating a general upwelling trend. At two locations, 40 and 32- W. the contour plots for all three nutrients indicate strong vertical mixing between the WW and the underlying water mass. At the western and eastern boundaries, intense vertical mixing causes nearly vertical nutrient isolines. In the WSBW a tongue of low concentration silicic acid can be seen which extends laterally more than halfway across the Weddell Sea Basin at a depth of approximately 4500 to 5000 meters. Initial comparisons were made with data obtained by Oregon State University's group during WWGS '89 and show good agreement.

C.4 CTD

CTD Measurements during AQANTIX/2

```
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   : 0.13 s

Pressure pre-cruise calibration coefficients
a1 = -1.1552376e+1
a2 =  7.014388e-3
a3 = -1.236572e-5
a4 =  7.641595e-9
a5 = -2.052136e-12
a6 =  2.544142e-16
dp = a1 +a2*p +a3*p**2 +a4*p**3 +a5*p**4 +a6*p**5
 p = p + dp

Temperature pre-cruise calibration coefficients
a1 = -2.99299
a2 = -7.18462e-4
a3 =  4.44174e-5
a4 = -1.43668e-6
a5 =  2.67305e-8
dt = a1 +a2*t +a3*t**2 +a4*t**3 +a5*t**4
 t = t + dt

the post-cruise calibration data are the same

correction of the CTD-conductivity data with the bottle-samples
( conductivity of the salinometer data )
evaluation of the coefficients of each station
--------------------------------------
CD = ( CONDUCTIVITY SALINO - CONDUCTIVITY CTD ) * 1000
COND :== CONDUCTIVITY SALINOMETER
--------------------------------------
CD = A0 + A1*COND + A2*PRES + A3*PRES**2
--------------------------------------
```

station no.	A0	A1	A2	A3
03501	-0.51872E+02	0.24728E+01	-0.63940E-02	0.79995E-05
03601	-0.51872E+02	0.24728E+01	-0.63940E-02	0.79995E-05
03901	-0.51872E+02	0.24728E+01	-0.63940E-02	0.79995E-05
04001	-0.51872E+02	0.24728E+01	-0.63940E-02	0.79995E-05

04101	-0.51872E+02	0.24728E+01	-0.63940E-02	0.79995E-05
04201	-0.59161E+02	0.26925E+01	-0.35827E-02	-0.59052E-05

dc = A0 + A1*COND + A2*PRES + A3*PRES**2
C(ctd) = C(ctd) + dc/1000.

correction of the CTD-conductivity data with the bottle-samples
evaluation of the coefficients with the running mean of 10 stations

\--------------------------------------

CD = A0 + A1*PRES + A2*PRES**2 + A3*PRES**3 + A4*PRES**4

\--------------------------------------

station no.	A0	A1	A2	A3	A4
4301	0.16057E+02	-0.53003E-02	0.36477E-05	-0.77356E-09	0.43815E-13
4401	0.16057E+02	-0.53003E-02	0.36477E-05	-0.77356E-09	0.43815E-13
4501	0.16057E+02	-0.53003E-02	0.36477E-05	-0.77356E-09	0.43815E-13
4601	0.16060E+02	-0.52277E-02	0.35370E-05	-0.75885E-09	0.44722E-13
4701	0.16060E+02	-0.52277E-02	0.35370E-05	-0.75885E-09	0.44722E-13
4801	0.16275E+02	-0.59179E-02	0.41748E-05	-0.97715E-09	0.69451E-13
4901	0.16108E+02	-0.60083E-02	0.49328E-05	-0.13678E-08	0.12189E-12
5001	0.16102E+02	-0.54978E-02	0.43413E-05	-0.11653E-08	0.99760E-13
5101	0.16899E+02	-0.77574E-02	0.66678E-05	-0.20257E-08	0.20231E-12
5201	0.16881E+02	-0.59944E-02	0.44888E-05	-0.13842E-08	0.14902E-12
5501	0.17761E+02	-0.70108E-02	0.56046E-05	-0.17661E-08	0.19017E-12
5601	0.17937E+02	-0.75108E-02	0.63627E-05	-0.20726E-08	0.22755E-12
5701	0.18022E+02	-0.64782E-02	0.53523E-05	-0.16870E-08	0.17910E-12
5801	0.18156E+02	-0.62368E-02	0.50660E-05	-0.15814E-08	0.16690E-12
5901	0.18156E+02	-0.62368E-02	0.50660E-05	-0.15814E-08	0.16690E-12
6001	0.18178E+02	-0.63440E-02	0.54099E-05	-0.17589E-08	0.19218E-12
6101	0.18370E+02	-0.59355E-02	0.48751E-05	-0.15619E-08	0.16985E-12
6201	0.18148E+02	-0.42419E-02	0.30712E-05	-0.86105E-09	0.82874E-13
6301	0.17937E+02	-0.26588E-02	0.15897E-05	-0.37211E-09	0.30423E-13
6401	0.17782E+02	-0.17227E-02	0.63312E-06	0.26379E-11	-0.17070E-13
6501	0.17723E+02	-0.12923E-02	0.25428E-06	0.12091E-09	-0.28589E-13
6601	0.17461E+02	-0.67162E-03	0.21007E-06	-0.21894E-10	0.11939E-14
6701	0.17694E+02	-0.13889E-02	0.65721E-06	-0.12674E-09	0.94644E-14
6801	0.17450E+02	-0.97850E-03	0.27286E-06	-0.15240E-10	-0.48745E-15
6901	0.17563E+02	-0.15356E-02	0.71896E-06	-0.15865E-09	0.15453E-13
7001	0.17563E+02	-0.15356E-02	0.71896E-06	-0.15865E-09	0.15453E-13
7101	0.17479E+02	-0.96447E-03	-0.73640E-07	0.16015E-09	-0.23761E-13
7201	0.17006E+02	-0.11719E-03	-0.62758E-06	0.27564E-09	-0.29867E-13
7301	0.16916E+02	-0.78963E-03	-0.29516E-07	0.39261E-10	-0.17887E-15
7401	0.16904E+02	-0.21073E-02	0.12650E-05	-0.40022E-09	0.48944E-13
7501	0.16726E+02	-0.18753E-02	0.10196E-05	-0.34344E-09	0.46267E-13
7601	0.16753E+02	-0.19489E-02	0.99166E-06	-0.30502E-09	0.39144E-13
7701	0.16940E+02	-0.26189E-02	0.15238E-05	-0.44051E-09	0.49389E-13
7801	0.16764E+02	-0.97997E-03	-0.79946E-08	0.76954E-10	-0.96646E-14
7901	0.16953E+02	-0.13147E-02	0.11905E-06	0.74029E-10	-0.12693E-13
8001	0.16250E+02	-0.28762E-03	-0.63608E-06	0.30982E-09	-0.38113E-13
8101	0.16592E+02	-0.93415E-03	-0.59756E-07	0.10940E-09	-0.14970E-13
8201	0.16592E+02	-0.93415E-03	-0.59756E-07	0.10940E-09	-0.14970E-13
8301	0.16971E+02	-0.19752E-02	0.84813E-06	-0.16722E-09	0.12449E-13
8401	0.17508E+02	-0.21779E-02	0.61323E-06	0.24780E-10	-0.18108E-13
8501	0.17608E+02	-0.13212E-02	-0.44565E-06	0.46132E-09	-0.74966E-13
8601	0.17806E+02	-0.95871E-03	-0.10371E-05	0.69309E-09	-0.10154E-12
8701	0.17901E+02	-0.50715E-03	-0.16823E-05	0.97189E-09	-0.13764E-12
8801	0.17782E+02	-0.15468E-03	-0.16149E-05	0.82369E-09	-0.10936E-12
8901	0.17752E+02	-0.12688E-02	-0.54494E-06	0.46368E-09	-0.68610E-13
9001	0.17595E+02	-0.44907E-03	-0.13521E-05	0.75085E-09	-0.10213E-12
9101	0.17818E+02	0.10371E-02	-0.27966E-05	0.12559E-08	-0.16210E-12
9201	0.17739E+02	0.92340E-03	-0.21876E-05	0.93502E-09	-0.11655E-12
9301	0.17696E+02	0.18375E-02	-0.32648E-05	0.13364E-08	-0.16358E-12
9401	0.17379E+02	0.36388E-02	-0.52546E-05	0.21307E-08	-0.26343E-12

9501	0.16627E+02	0.44116E-02	-0.55975E-05	0.21872E-08	-0.26592E-12
9601	0.16501E+02	0.44658E-02	-0.55051E-05	0.21473E-08	-0.26200E-12
9701	0.16684E+02	0.44739E-02	-0.55477E-05	0.21310E-08	-0.25597E-12
9801	0.17031E+02	0.31220E-02	-0.38486E-05	0.14558E-08	-0.17342E-12
9901	0.16900E+02	0.39229E-02	-0.47820E-05	0.17983E-08	-0.21271E-12
10001	0.16896E+02	0.38833E-02	-0.53216E-05	0.21346E-08	-0.26184E-12
10101	0.16874E+02	0.37733E-02	-0.54502E-05	0.22433E-08	-0.27886E-12
10201	0.16902E+02	0.37003E-02	-0.55233E-05	0.23019E-08	-0.28783E-12
10301	0.17029E+02	0.29472E-02	-0.48717E-05	0.21078E-08	-0.26871E-12
10401	0.16995E+02	0.16188E-02	-0.32527E-05	0.15057E-08	-0.19816E-12
10501	0.16995E+02	0.16188E-02	-0.32527E-05	0.15057E-08	-0.19816E-12
10601	0.16995E+02	0.16188E-02	-0.32527E-05	0.15057E-08	-0.19816E-12
10801	0.16995E+02	0.16188E-02	-0.32527E-05	0.15057E-08	-0.19816E-12
10802	0.16995E+02	0.16188E-02	-0.32527E-05	0.15057E-08	-0.19816E-12
10901	0.16995E+02	0.16188E-02	-0.32527E-05	0.15057E-08	-0.19816E-12
11301	0.16995E+02	0.16188E-02	-0.32527E-05	0.15057E-08	-0.19816E-12
11401	0.16995E+02	0.16188E-02	-0.32527E-05	0.15057E-08	-0.19816E-12
11402	0.16995E+02	0.16188E-02	-0.32527E-05	0.15057E-08	-0.19816E-12
11501	0.16995E+02	0.16188E-02	-0.32527E-05	0.15057E-08	-0.19816E-12
11502	0.16995E+02	0.16188E-02	-0.32527E-05	0.15057E-08	-0.19816E-12
12001	0.16995E+02	0.16188E-02	-0.32527E-05	0.15057E-08	-0.19816E-12
12101	0.16995E+02	0.16188E-02	-0.32527E-05	0.15057E-08	-0.19816E-12
12102	0.16995E+02	0.16188E-02	-0.32527E-05	0.15057E-08	-0.19816E-12
04502	0.16057E+02	-0.53003E-02	0.36477E-05	-0.77356E-09	0.43815E-13
04802	0.16275E+02	-0.59179E-02	0.41748E-05	-0.97715E-09	0.69451E-13
05602	0.17937E+02	-0.75108E-02	0.63627E-05	-0.20726E-08	0.22755E-12
06302	0.17937E+02	-0.26588E-02	0.15897E-05	-0.37211E-09	0.30423E-13
07502	0.16726E+02	-0.18753E-02	0.10196E-05	-0.34344E-09	0.46267E-13
09402	0.17379E+02	0.36388E-02	-0.52546E-05	0.21307E-08	-0.26343E-12

----

dc = A0 + A1*PRES + A2*PRES**2 + A3*PRES**3 + A4*PRES**4
C(ctd) = C(ctd) + dc/1000.

CTD-Files column 5 : number = -9 :== unknown data , it
was not possible to restore this data

NOTES ON THE NUTRIENT DATA FILES FOR SWGS 90 (ANTIX/2)

From:
M. Consuelo Carbonell-Moore
Joe C. Jennings, Jr.
Louis I. Gordon

STATIONS WITH MISSING NUTRIENTS:

STATION	MISSING NUTRIENT	BOTTLE
040	NH4	ALL
043	PO4	3;13-16
044	NH4	1-4
046	NH4	ALL
062	NH4	3
066	NH4	14
067	PO4	6
067	N + N	6
072	PO4	ALL
073	PO4	5,6

075	N + N	14
078	Si(OH)4	10,11
083	NH4	ALL
084	PO4	ALL
087	N + N	4
087	NH4	1-8
090	N + N	6
090	NH4	4,6
091	PO4	ALL
092	PO4	ALL
092	NH4	4,7
093	NH4	21
096	PO4	18,19
098	NH4	ALL
099	NH4	ALL
105	PO4	ALL
106	PO4	ALL
106	NH4	1-4
115	PO4	ALL

NOTES ON NITRITE (NO2) AND AMMONIUM (NH4):

Because deep ocean nitrite and ammonium values are usually near the limit of detection, small shifts in baseline and/or blank levels can lead to the calculation of concentrations which are negative. Although these negative nitrite and ammonium values are physically impossible, we report them as an indication of the imprecision associated with the analysis.

NOTES ON PHOSPHATE (PO4):

Low phosphate values in stations 050 and 051 might be doubtful as there was and equipment change after station 049. Values at station 053 agree with those at station 049.

There is a wide spread in deep phosphate values: 2.19 micromol/liter to 2.42 micromol/liter, many stations showing high values, higher than those from Wepolex and Ant V/2 cruises in the same region, but lower than WWGS 89. Deep phosphates increase in concentration from station 60 through station 83, increase which we can not account for. These high values might be an artefact from a change in blank values due to changes in either the deionized water or in the low nutrient seawater used to prepare standards. There is no informatio in the laboratory notebooks, logs or recorder charts that allows us to either correct or delete these data. However, they are of doubtful quality. The increase of phosphate values in these stations is 0.1 micromol/liter. Nitrate concentration values did not show the same trend.

D. Acknowledgements

When we left "PolarsternH in Cape Town, we felt that we have had an extremely successful cruise and a enjoyable life on board. We are aware that master Jonas with his officers and his crew took good care of our needs with engagement and patience which garanteed effective work and good humour.
public of Germany

E. References

Unesco, 1983. International Oceanographic tables. Unesco Technical Papers in Marine Science, No. 44.

Unesco, 1991. Processing of Oceanographic Station Data. Unesco memorgraph By JPOTS editorial panel.

F. WHPO Summary

Several data files are associated with this report. They are the ANTIX.sum, ANTIX.hyd, ANTIX.csl and *.wct files. The ANTIX.sum file contains a summary of the location, time, type of parameters sampled, and other pertinent information regarding each hydrographic station. The ANTIX.hyd file contains the bottle data. The *.wct files are the ctd data for each station. The *.wct files are zipped into one file called ANTIX.wct.zip. The ANTIX.csl file is a listing of ctd and calculated values at standard levels.

The following is a description of how the standard levels and calculated values were derived for the ANTIX.csl file:

Salinity, Temperature and Pressure: These three values were smoothed from the individual CTD files over the N uniformly increasing pressure levels. using the following binomial filter-

$$t(j) = 0.25ti(j-1) + 0.5ti(j) + 0.25ti(j+1) \quad j=2....N-1$$

When a pressure level is represented in the *.csl file that is not contained within the ctd values, the value was linearly interpolated to the desired level after applying the binomial filtering.

Sigma-theta(SIG-TH:KG/M3), Sigma-2 (SIG-2: KG/M3), and Sigma-4(SIG-4: KG/M3): These values are calculated using the practical salinity scale (PSS-78) and the international equation of state for seawater (EOS-80) as described in the Unesco publication 44 at reference pressures of the surface for SIG-TH; 2000 dbars for Sigma-2; and 4000 dbars for Sigma-4.

Gradient Potential Temperature (GRD-PT: C/DB 10-3) is calculated as the least squares slope between two levels, where the standard level is the center of the interval. The interval being the smallest of the two differences between the standard level and the two closest values. The slope is first determined using CTD temperature and then the adiabatic lapse rate is subtracted to obtain the gradient potential temperature. Equations and Fortran routines are described in Unesco publication 44.

Gradient Salinity (GRD-S: 1/DB 10-3) is calculated as the least squares slope between two levels, where the standard level is the center of the standard level and the two closes values. Equations and Fortran routines are described in Unesco publication 44.

Potential Vorticity (POT-V: 1/ms 10-11) is calculated as the vertical component ignoring contributions due to relative vorticity, i.e. pv=fN2/g, where f is the coriolius parameter, N is the buoyancy frequency (data expressed as radius/sec), and g is the local acceleration of gravity.

Buoyancy Frequency (B-V: cph) is calculated using the adiabatic leveling method, Fofonoff (1985) and Millard, Owens and Fofonoff (1990). Equations and Fortran routines are described in Unesco publication 44.

Potential Energy (PE: J/M2: 10-5) and Dynamic Height (DYN-HT: M) are calculated by integrating from 0 to the level of interest. Equations and Fortran routines are described in Unesco publication 44.

Neutral Density (GAMMA-N: KG/M3) is calculated with the program GAMMA-N (Jackett and McDougall) version 1.3 Nov. 94.

G. Data Quality Evulation