

**WOCE Line:** AR15  
**Expocode:** 06AQANTXII\_1  
**Ports of call:** Bremerhaven - Punta Arenas  
**Cruise Dates:** October 18 to November 21, 1994

**The Expedition ANTARKTIS X11 of RV "Polarstern" in 1994/95  
Reports of Legs ANT X11/1 and 2**

Die Expedition ANTARKTIS XII mit FS "Polarstern" 1994/95  
Bericht von den Fahrtabschnitten ANTX11/1 und 2

Edited by Gerhard Kattner and Dieter Karl Fütterer  
with contributions of the participants

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**1.1 SUMMARY AND ITINERARY**  
(G. Kattner)

The main objectives of the research program were in the field of physical and chemical investigations. Continuous underway measurements in air and surface water have been completed by station work where water sampling was performed down to the bottom. In the equatorial region and along the route to the Argentine Basin floats were launched which will drift in a depth of about 800 m. They will collect data on position, pressure and temperature. These studies are part of WOCE, a program to obtain the most comprehensive description and understanding of the circulation of the world oceans. The chemical investigations focused on trace substances of biogenic and anthropogenic origin. The measurements of dissolved organic substances will expand and generalize the present knowledge on larger scales. The same holds true for the determination of halogenated hydrocarbons as well as N<sub>2</sub>O, which were analyzed in water and air. Especially the contribution of the ocean to atmospheric methylbromide has been investigated. During the whole cruise trace metals were determined in surface water and air. Additional rain samples have been taken in the ITCZ to follow the atmospheric heavy metal flux to the Atlantic Ocean.

Samples to measure atmospheric mercury over the Atlantic Ocean have been taken. These measurements continue studies some years ago to obtain data for estimations of global trends. Hydrogen peroxide, formaldehyde, carbon monoxide and ozone were determined to provide further information about the chemistry of the atmosphere since these compounds are involved in many chemical atmospheric reactions. The distribution

AR15 Polarstern: Krause/AWI, 1994

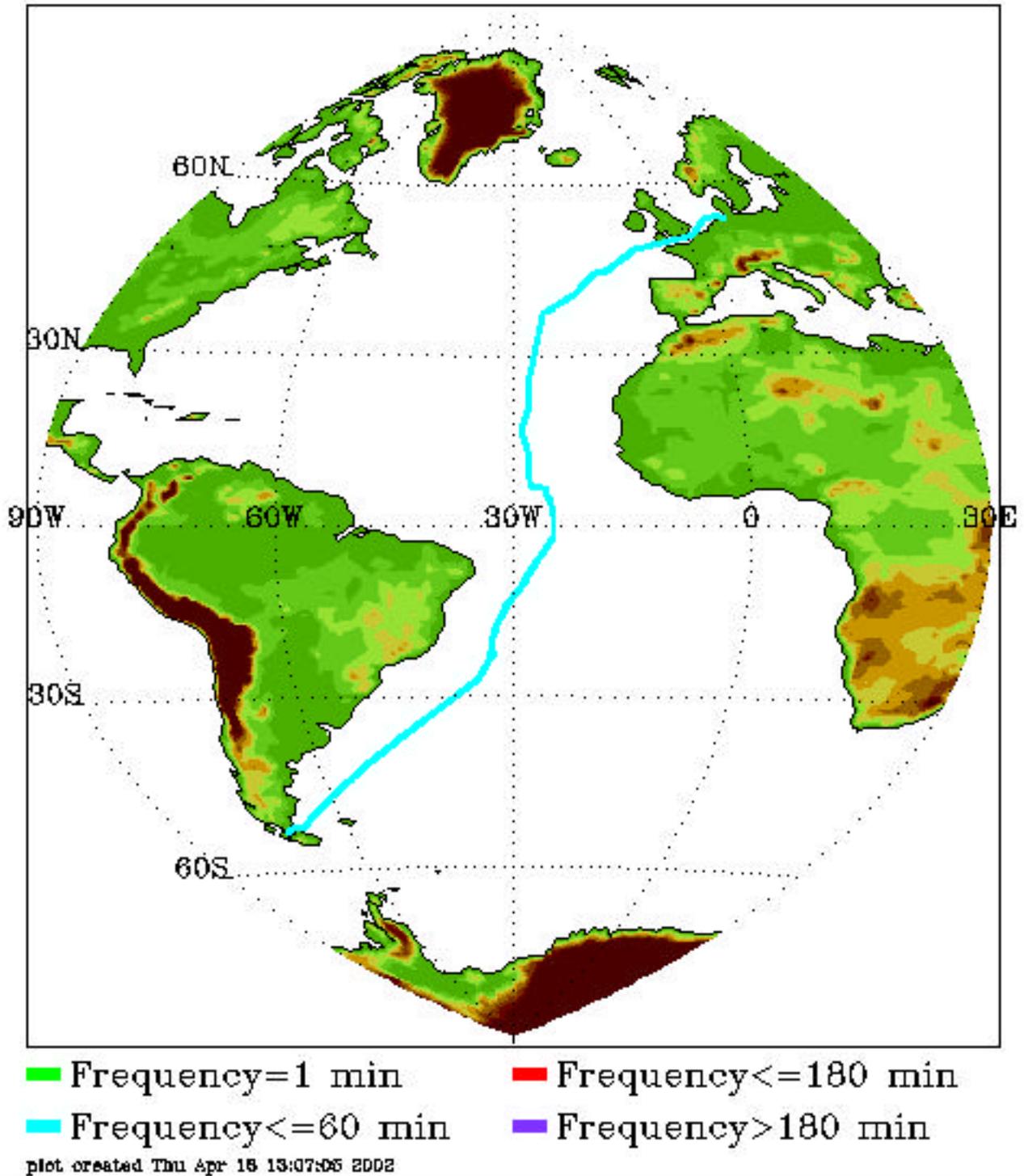


Figure 1

of aerosol particles was measured and will provide new information about nucleation, size and concentration of particles. A considerable number of investigations are connected to long-term research programs, which will contribute to the knowledge of global scale processes and trends. The cruise track is given in [Fig. 1](#).

At 10 o'clock on October 18th, 1994, the ANT X11/1 cruise started out of Bremerhaven. After passing the lock and leaving the Weser delta with course to the English Channel, onboard measurements already started. After a smooth beginning of the cruise during the first two days, we got caught in some heavy weather on October 20th south of Dover. RV "Polarstern" steamed and rolled through 8-10 m high waves and working got a little tiresome. Around noon of the 23rd we crisscrossed a certain area three times to test the Hydrosweep-Sidescan-System, that records bottom structures. All significant structures of a particular seamount could be found. Following that, the first CTD was deployed and water samples were taken. On October 24th thirteen cruise participants left the ship on the evening of that day on a little pilot boat to Punta Delgada on the Azores.

Since October 25th, the cruise continued in calm seas and rapidly got us close to the equator. The continuous measurements of all air and water scientists proceeded as planned and delivered large amounts of data. The cruise proceeded along 28°W longitude due south. We passed the Cape Verde Islands and only short interruptions were caused by the CTD and sampling from the bow crane, On the morning of the 30th, another short CTD was carried out and afterwards we started chasing rain. A lot of rain samples were collected along with simultaneously taken seawater samples. These samples will be analyzed later for trace metals in order to determine the input from rain into the surface water. On the afternoon of the 31st, during the equator ceremony 25 crew members and scientists were thoroughly cleansed.

On November 1st, we reached the position for the first float launching at 20° north. From now on, about 120 deployments of floats and surface drifters were performed on our way south. On November 9th, we were roughly at the latitude of Rio de Janeiro. On November 15th, a sound source was brought out to complete the web of sound sources that were deployed in the southwest Atlantic. On the 20th of November, we reached the Strait of Magellan and after another 100 nautical miles to go we reached Punta Arenas in the early morning of the 21st. The cruise had covered a total of 8600 nautical miles from Bremerhaven to Punta Arenas.

## **1.2 METEOROLOGY**

### **1.2.1 WEATHER CONDITIONS**

(Klaus Dittmer and H. Köhler)

At the beginning of the cruise the synoptic situation was dominated by a high over eastern Europe and a low with winds of gale force near Ireland. Easterly winds increased to 7, for a short time 8 Bft, between these two pressure systems in the North Sea and English Channel. However, the sea and swell remained relatively low due to short fetch.

From October 19th to 22nd a large-scale depression moved from the West Atlantic to England, taking a relative southern track. Minimum pressure in the centre of the low was about 973 hPa. In the region of the trough of this system westerly winds up to 10 Bft were measured in the early morning of October 22nd. Windsea and swell could develop to mature stage, in this case 8 to 10 m, associated with isolated freak waves of 11 to 13 m. The synoptic development as well as the sea state were calculated very accurately by the numerical models of the German weather service, thus a warning could be issued on time.

West of 15°W wind and sea decreased rapidly. Approaching the Azores a flat low with intermittent rain was passed, but some miles northeast of Sao Miguel, the clouds broke up at sea and only the mountains of the island were still covered by cumulonimbus. On the route to the tropics the airmass was still unstable in a northerly flow and showers occurred at times. The Intertropical Convergence (ITC) was reached near 7°N on October 30th. At this time it was poorly developed. Just in the direct convergence of northeasterly and southeasterly winds a line of isolated showers could be observed. For 24 hours it was intended to get as much samples of rain as possible; therefore showers were detected by Radar. During the measuring campaign the convective belt intensified slowly. The water surface temperatures were 29 to 30°C in the ITC, which is about 2 degrees above the normal climatological values for this time.

In the South Atlantic RV "Polarstern" first sailed at the edge of the subtropic anticyclone. Southeasterly winds from 4 to 6 Bft and a southerly swell of about 3 m were encountered. The swell was caused by a storm west of the subtropical high. The storm depression developed off the coast of North-Argentina and drifted eastward very slowly. Thus, the sea reached its possible maximum height due to long fetch and duration of high wind speeds. Until about 20°S the vertical formation of layers was unstable up to 2 km height. The cloud base was near 500 m. Nevertheless isolated short showers developed. The cold front of a storm depression near South Georgia became stationary along 25°S and began to clear when we arrived in this area.

On November 9th a wave depression had built up over the River Plate mouth. It developed to an intensive low of 995 hPa and moved eastwards very slowly. Thus, we remained on the front side for a longer time and the maximum winds from north encountered were 7 Bft. In the rear of the weakening low westerly winds of about 5 Bft affected the vessel. On November 13th and 14th RV "Polarstern" sailed in the area of a high pressure system with light and moderate winds.

The coldfront of a low between the South Orkney and South Shetland Islands became stationary for a time east of Bahia Blanca on October 15th and waves developed along the front. Crossing the front winds increased up to 7 Bft in showers. During the night from October 15th to 16th the front moved backwards and fog patches occurred in light warm northerly winds. On October 16th a new wave along the front developed to a complex low of less than 990 hPa in a rather unexpected manner. It moved eastward just south of our position. For a short time maximum winds were 10 Bft in the rear of the center. On

October 17th a high pressure system built up over northern Argentina and strong, later moderate cold southwesterly winds affected RV "Polarstern".

To the end of this leg a secondary depression belonging to the typical large scale low over the Bellingshausen Sea developed west of the Strait of Magellan. It crossed southern Patagonia during the night from of November 19th to 20th. Strong northerly winds occurred in front of this system, strong westerly winds in the rear. With the passage of the frontal trough wind speeds of Bft 8 were measured. Due to short duration of the gale no significant sea could develop.

### **1.3 Physical OCEANOGRAPHY**

#### **1.3.1 RAFOS FLOATS IN THE SOUTH ATLANTIC**

(O. Boebel, M. Menzel, C. Schmidt and A. Pinck)

A contribution to the understanding of the deep circulation is one of the goals of the IfM Kiel 'RAFOS float' project. In the South Atlantic, the advection of the Antarctic Intermediate Water (AAIW) shall be explored. This water mass is found beneath the South Atlantic Central Water at latitude dependent core depths ranging from 700 to 900 m. It may be distinguished from the water above and the North Atlantic Deep Water below, by its distinctive salinity minimum and oxygen maximum. The AAIW may be observed in the subtropical and tropical regions of the South Atlantic. The site of formation is supposedly close to the Subpolar Front.

### **RAFOS-FLOATS**

RAFOS floats are well suited to explore this water mass. These drifters float freely at a predetermined depth. They house a microcomputer, which determined the float's position by acoustic tracking and measures pressure (p) and temperature (T) once a day. The acoustic tracking is achieved by measuring time of arrivals (JOA) of coded sound signals transmitted by moored sound sources. The data quintuplet (p,T,3xTOA) is stored and subsequently transmitted to Kiel by ARGOS satellite system, once the float has returned to the sea surface after finishing its underwater mission, which may last for up to two years.

The POLARSTERN cruise ANT X11/1 was the last of three float seedings performed in the area by IfM Kiel. During the previous expeditions METEOR 22 (M22) and METEOR 28 (M28) 23 and 29 floats were seeded, respectively. During the ANT XII/1 cruise a total of 42 RAFOS floats were deployed, one at every degree of latitude, covering the western South Atlantic from the equator to 39°S. The floats were programmed to mission lengths ranging from 361 days (1 year) to 721 days (2 years), as shown in more detail in Tab. 1. This results in a total of 52 float years or an average under water mission length of 14.8 month per float.

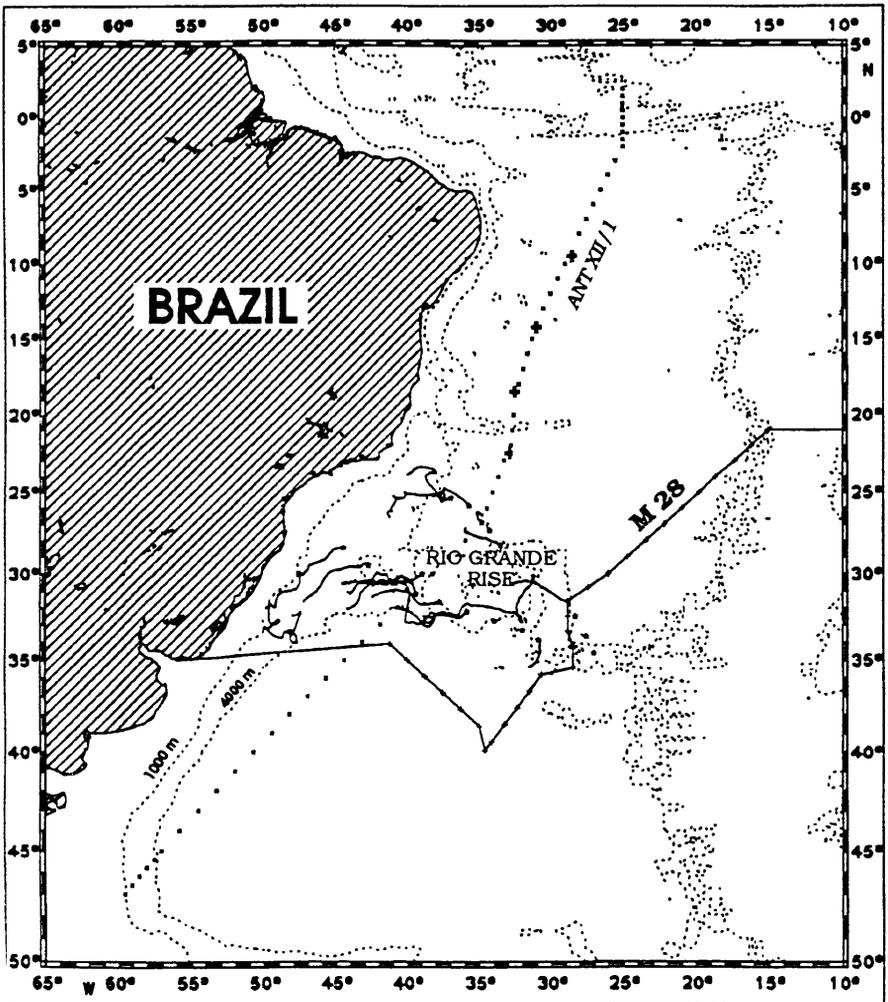


Fig. 1.3.1-1: This figure depicts the western South Atlantic, with isobaths at 1000 and 4000m indicated by dashed lines. Solid curves in the vicinity of the Rio Grande Rise depict float trajectories launched during M22 (Dec. 1992). The eastwest oriented solid line represents the wake of M28 (May 1994), crosses indicating launch positions of floats. The northsouth oriented sequence of crosses mark the launch positions of floats and drifters during ANT XII/I.

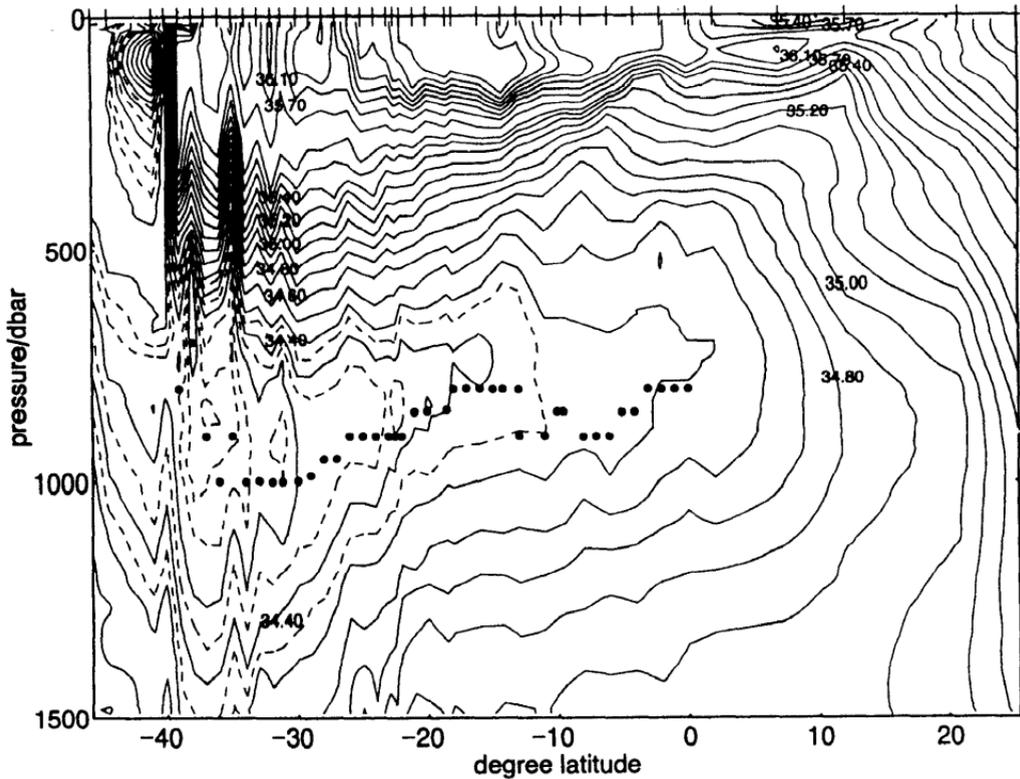


Figure 2: Section of salinity based on preliminary data, obtained by CTD-casts taken during ANT XII/1. The bullets represent launch positions of RAFOS floats at their target depth.

Tab. 1.3.1-1: Mission lengths of RAFOS floats

mission length [month]:	12	13	15	18	21	24
[days]:	361	391	451	541	631	721
number of instruments deployed:	14	7	11	5	3	2

The floats were ballasted to reach neutral buoyancy at the depth of the salinity minimum of the AAIW. This depth was determined using CTD-casts taken (in most cases) just before float launch. Trajectories obtained so far from 15 floats (Fig. 1.3.1 - 1) launched during M22 show a mean flow of 5 cm/s in dominantly western directions between 25°S and 32°S. The ALACE (see below) data provided by R. Davis, however, depicts a strong eastward flow at 40°S. Thus, for a working hypothesis, the assumption of the center of a recirculation cell of AAIW at 36°S is reasonable, and was used for the determination of the sound source position and float deployment pattern.

## CTD & ROSETTE

A total of 43 CTD casts were taken during ANT XII/1. The CTD was used with a 24 bottle (10 L each) rosette to draw water samples. At seven stations, deep casts were taken to at least 3000m, in order to provide the organic and anorganic chemists on board with water from different water masses. In particular, water was taken from the Mediterranean Outflow Water, the upper, middle and lower North Atlantic Deep Water, the Antarctic Intermediate Water and the Antarctic Bottom Water. The majority of the casts however, were terminated at 1500 m, covering the AAIW layer to determine the depth of the salinity minimum.

Originally, the CTD-data, using an ICTD from FSI, was noisy, especially with respect to pressure spikes. During profile #10, the CTD finally broke down, due to the failure of a DC/DC converter, as determined later. While repairing the broken unit, the opportunity was used to change the release unit of the rosette from a non-interrupting type (EG&G) to an interrupting type (GO). This change resulted in a much better data quality, starting with station #11. However, a mismatch of the time constants of the conductivity and the temperature sensor results in false on line salinity data especially in layers of high temperature gradient. Thus, the raw data distributed to various groups aboard the ship should be used for qualitative statements only. A revised data set, using the data of the CTD-bound fast temperature sensor to calculate salinity, will be available later.

The accuracy of the CTD-data was controlled by use of reversing thermometers and water samples of the bottles taken, analyzed using an Autosal 2000. The bias observed by reversing thermometers as compared to the CTD data is less than 0.002 C. The salinity data indicated that the raw data shall be corrected by +0.018 psu to a slightly higher (real) salinity.

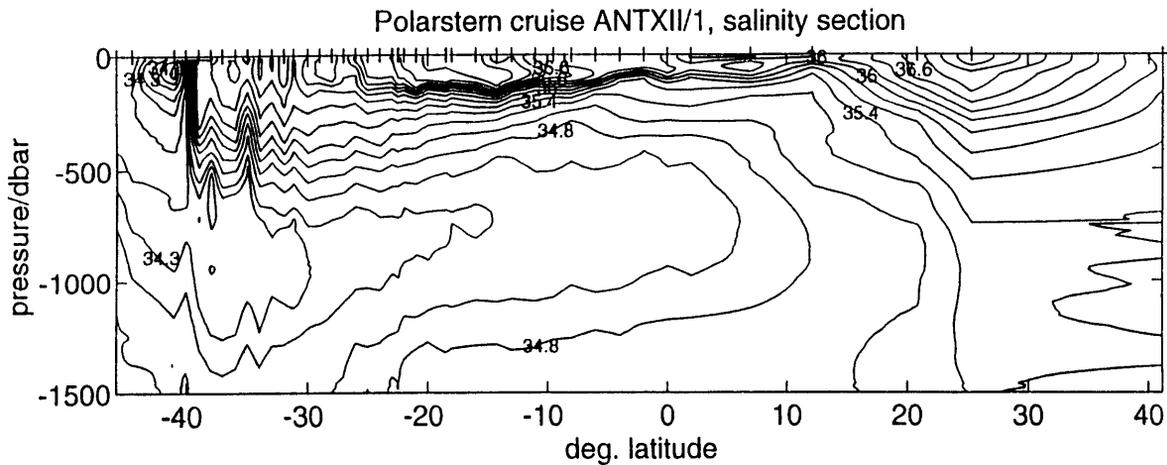
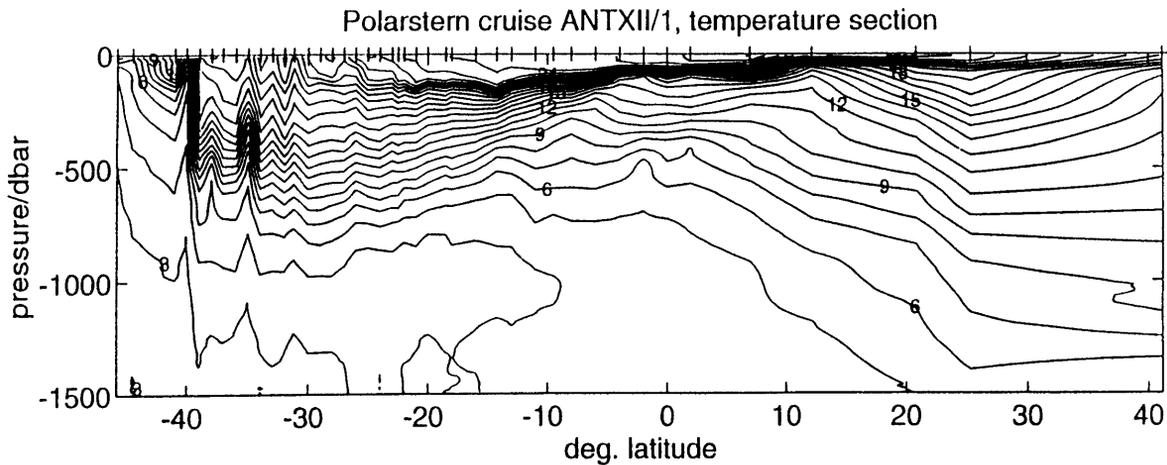


Fig. 1.3.1-2: Sections of salinity and temperature based on raw data, obtained by CTD-casts taken during the cruise. This data should be used for qualitative statements only.

**Fig. 1.3.1-2** shows the salinity and temperature section obtained from the raw data. One can clearly observe the salinity minimum of the AAIW ranging from 40°S to 20°S. The AAIW tongue ceases at 20°N, where it faces high salinity water from the north. At 40°S the northern border of the probable formation area of AAIW is indicated by an outcrop of the isohalines and isotherms. Here, the lowest salinities during the whole cruise were observed. The salinity minimum of the AAIW rises slowly from approximately 950 dbar at 40°S to 700 dbar at 10°N. The overlying thermocline water reached a temperature and salinity maximum slightly north of the equator at 5°N.

## **SOUND SOURCES**

During M22, four sound sources were deployed around the Rio Grande Rise in addition to an American sound source array deployed farther north. During M28 two sound sources were added by IfM Kiel. The sound source K6 deployed during POLARSTERN cruise ANT XII/1 in the western Argentine Basin at 40°03.14'S, 50°08.54'W extends the area covered by sound signals to the south in order to track floats as far as 40°S. The sound source was programmed to beep at 00:30 GMT and is approximately 1.5 s late.

In preparation of the mooring, the release unit was tested, lowering it to 2000m. An attempt to acoustically communicate with the unit by use of a passive hydrophone failed at this depth, much like a second attempt at 1000 m. However, one of the 4Release4 commands given at 2000 m and 1000 m release unit depth resulted in the release of a chain attached to the release unit.

## **ALACEs and Marvors**

In addition to the Kiel RAFOS floats, eight ALACE floats (Autonomous Lagrangian Current Explorer) were launched to cover the region south of the sound source array, particularly the Falkland Current. These instruments operate independent of sound coverage and were kindly provided by Ray Peterson (Scripps Institution of Oceanography). Every fortnight, they return from their 800 m or 1000 m drifting depth to the sea surface for a few days and are positioned using the ARGOS system. The resulting data gives a coarse picture of the deep circulation.

Further, 29 MARVOR floats seeded during this cruise by Michel Ollitrault, IFREME Brest, will broaden the emerging picture concerning diffusivity and advection.

## **SURFACE DRIFTERS**

In addition to subsurface drifters the motion of the upper layer is observed by the use of surface drifters drogued at 100 m. These drifters were provided by W. Kraus IfM Kiel, and shall monitor the motion of the thermocline water. During previous expeditions a total of

150 drifters were deployed in the South Atlantic. During the cruise 35 drifters were seeded between 2°S and 46°S at positions uncovered so far by trajectories.

## **ACKNOWLEDGEMENTS**

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