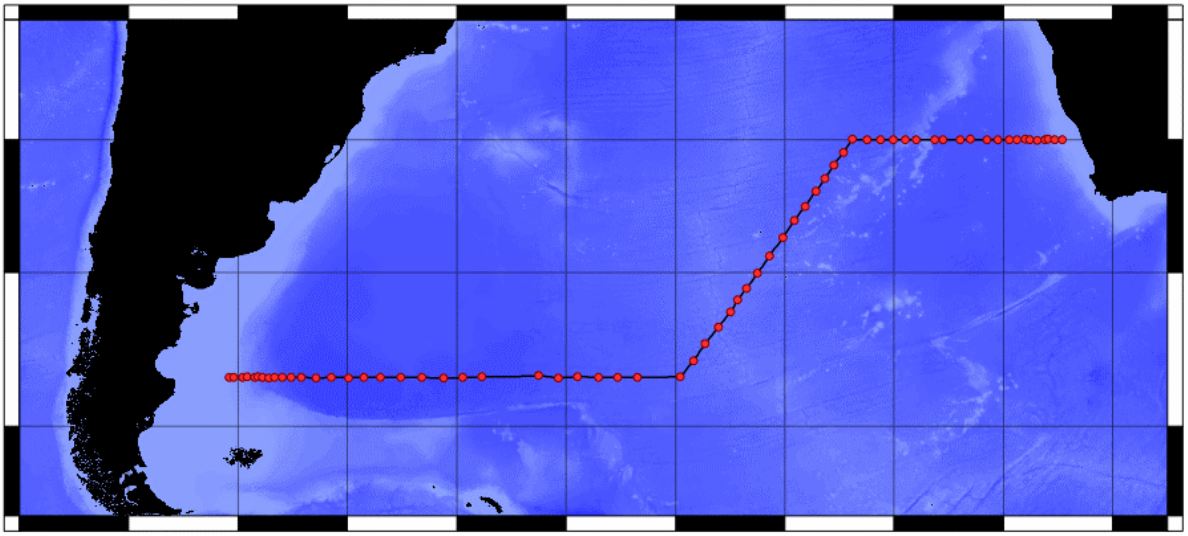
CRUISE REPORT: SAVE4

(Updated APR 2011)



HIGHLIGHTS

Cruise Summary Information

WOCE Section Designation	**SAVE4**
Expedition designation (ExpoCodes)	**318M19881207**
Chief Scientists	**Robert M. Key/Princeton**
Co-Chief Scientist	**Alberto R. Piola**
Dates	1988 December 7 - 1989 January 15
Ship	*R/V Melville*
Ports of call	Punta Arenas, Chile - Capetown, South Africa
Geographic Boundaries	29° 57.9' S 60° 49.2' W 15° 21.7' E 47° 4.3' S
Stations	29
Floats and drifters deployed	0
Moorings deployed or recovered	0

Chief Scientist Contact Information

Robert M. Key
Princeton University • Department of Geosciences
401B Sayret Hall • Princeton University • Princeton, NJ 08544
Phone: (609) 258-3595 • E-Mail: key@princeton.edu

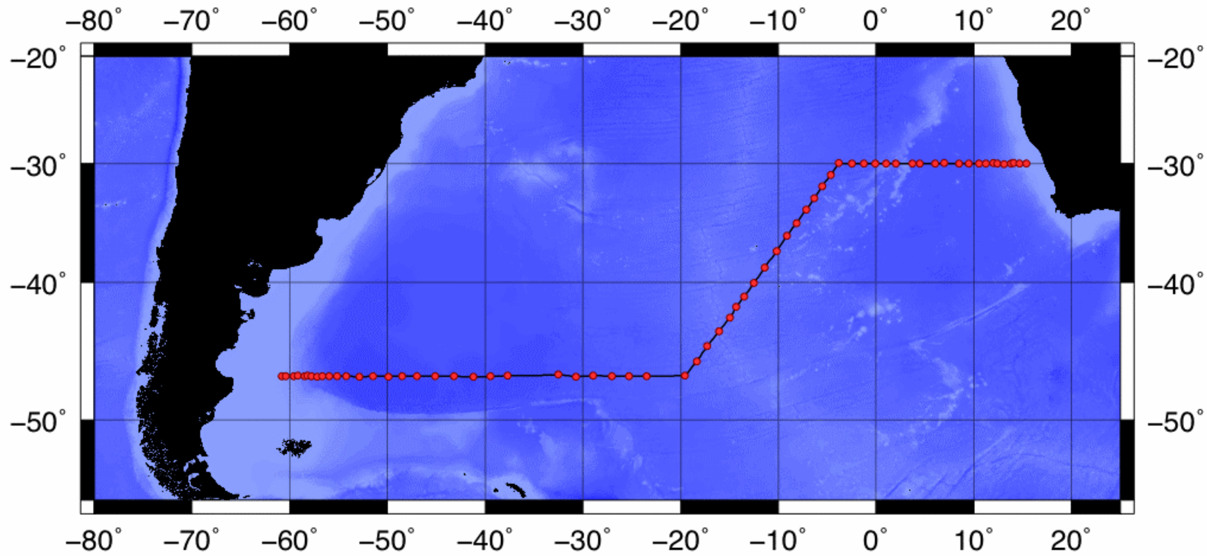
Alberto R. Piola
Departamento Oceanografia Servicio de Hidrografia Naval
Servicio de Hidrografia Naval • Avenida Montes de Oca 2124 • Buenos Aires, 1271 • ARGENTINA
Phone: +54-1-21-3091 or -2918 • Fax: +54-1-303-2299 • Email: apiola@oceanar.mil.ar

LINKS TO SELECT TOPICS

Shaded sections are not relevant to this cruise or were not available when this report was compiled

Cruise Summary Information	**Hydrographic Measurements**
Description of Scientific Program	**CTD Data:**
Geographic Boundaries	Acquisition
Cruise Track (Figure): PI CCHDO	Processing
Description of Stations	Calibration
Description of Parameters Sampled	Temperature Pressure
Bottle Depth Distributions (Figure)	Salinities Oxygens
Floats and Drifters Deployed	**Bottle Data**
Moorings Deployed or Recovered	Salinity
	Oxygen
Principal Investigators	Nutrients
Cruise Participants	Carbon System Parameters
	CFCs
Problems and Goals Not Achieved	Helium / Tritium
Other Incidents of Note	Radiocarbon
Underway Data Information	**References**
Navigation Bathymetry	
Acoustic Doppler Current Profiler (ADCP)	
Thermosalinograph	
XBT and/or XCTD	
Meteorological Observations	**Acknowledgments**
Atmospheric Chemistry Data	
Data Processing Notes	

SAVE4 Key/Princeton (MELVILLE 1988–1989) – 318M19881207



South Atlantic Ventilation Experiment (SAVE) Leg 4

Shipboard Chemical and Physical Data Report

PRELIMINARY

7 December 1988 - 15 January1989

R/V Melville

Data Report Prepared by:

Oceanographic Data Facility
Scripps Institution of Oceanography
University of California, San Diego

June 1989

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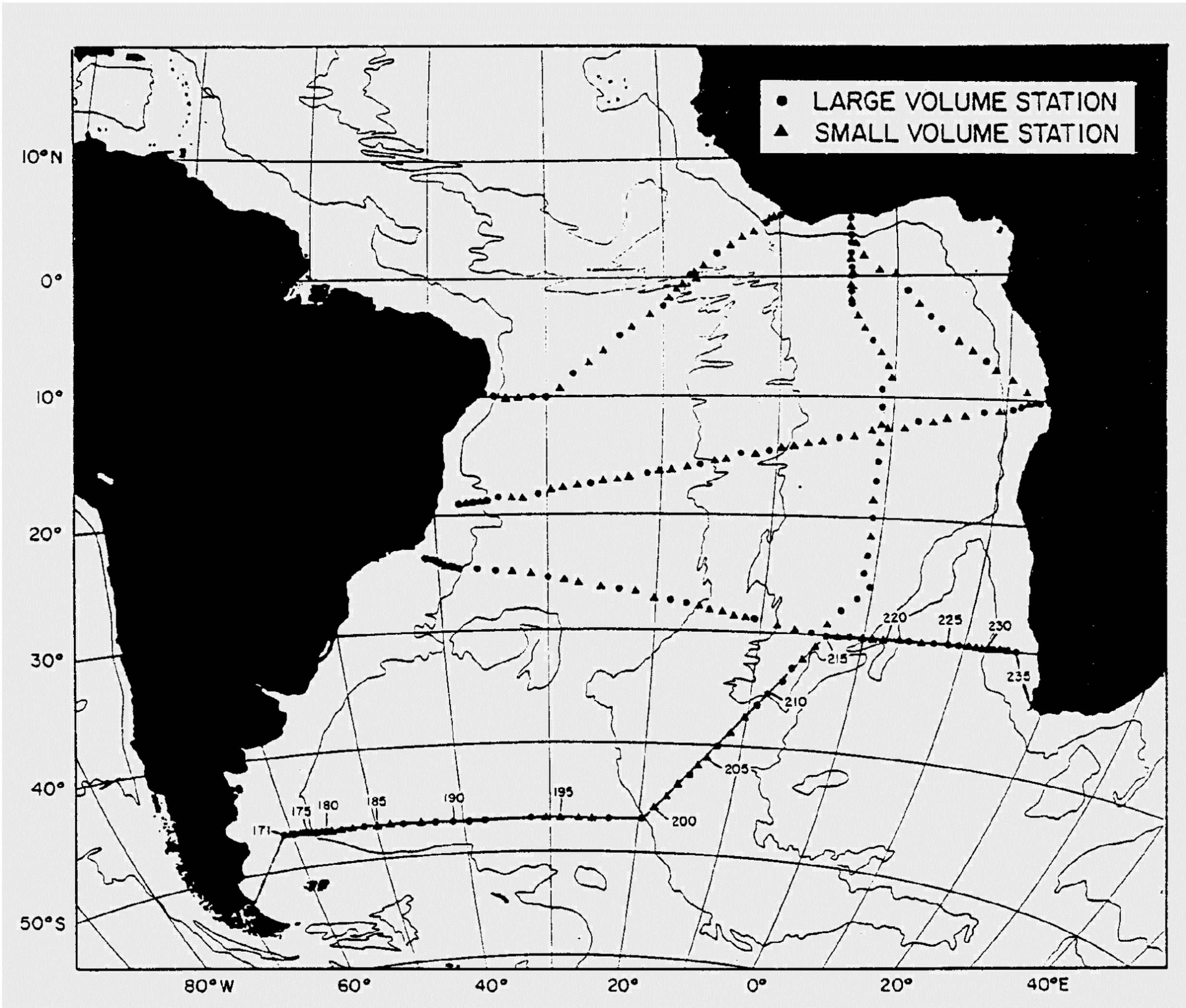
Grant OCE-86 13330

ODF Publication No. 227

South Atlantic Ventilation Experiment Leg 4
Punta Arenas, Chile to Capetown, South Africa
7 December 1988 - 15 January 1989



INTRODUCTION

The second phase of the South Atlantic Ventilation Experiment (SAVE) began on December 7, 1988. Leg 4 departed from Punta Arenas, Chile about 15:00 GMT aboard the R/V *Melville*.

The sailing date was delayed by a problem with a cam lobe on the main engine. After lengthy discussions the only reasonable solution was to have temporary repairs performed by a local ship yard. This patch job did not last the entire leg, however, we were able to maintain l0kts or better throughout the cruise. This was accomplished by running the engine on "low" cam and being assisted almost the entire crossing by tail winds.

After leaving the Straits of Magellan we proceeded north northeast to the shelf break at approximately 47°S and 61°W for the first station. The first portion of this leg (section A) was an east to west section along 4TS from the shelf break (station 171) across the southern region of the Argentine Basin to just west of the Mid Atlantic Ridge (station 199 at 19.5°W). This section was originally planned to continue eastward to the ridge axis, however, this was modified as a result of time loss due to bad weather. The second section of this leg (B) went northeast from station 199 to station 215 at 30°S and 3.75°W. The first half of this section was along the eastern shoulder of the ridge and passed over the Crawford Seamount. The second half was over the extreme southern end of the Angola Basin and relatively close to the ridge line which extends from the Crawford Seamount to the Walvis Ridge. Time loses during the first section and the fact that this section was not as clean, relative to basin scale interpretation, led us to decrease sample density along this section in order to carry out full sampling along the third and last section. From station 215 we proceeded due east along 30°S to station 235 at 15.3°E. This section (C) completed coverage of the southern end of the Angola Basin, crossed over the Walvis Ridge and Namibia Abyssal Plain, and ended with close spaced sampling up to the shelf break over the northern edge of the Orange River Cone. Leg 4 ended by deadheading to Capetown, South Africa.

SECTION 4A: STATION 171 - 199
47°S 60.8°W - 47°S 19.5°S

This section was designed to provide the primary zonal data for the Argentine Basin. The latitude was chosen to cross the Falkland Current and deepest portion of the Argentine Abyssal Plain. The original plan called for a total of 40 stations with increased sampling density near the western boundary. Of the 40 stations, 9 were to be large volume. When the sampling plan was made we intentionally allowed no time for weather and used cast estimates based on Knorr experience. Twenty-nine stations including 9 large volume were actually occupied along this section and the easternmost station was approximately 5 west of the planned turning point. In addition to weather losses, large volume stations took longer than planned because the maximum speed for the Melville coring wench was approximately 40m/min compared to 50-60m/min on Knorr. Small volume station spacing was increased during the last third of section A and on section B to compensate. Two rather bad storms resulted in a 400km gap between stations 192 and 193 (compared to the average of approximately 150km for open ocean) and a 300km gap between stations 198 and 199. A total of 51 XBT's were used between stations. The large volume sampling density is shown in figure 1.

Given the general foul weather we were fortunate to collect as dense a data set as we did without major injury or loss of equipment. Several 101 Niskin bottles were either lost or destroyed, however. The most notable near disaster occurred when a full Gerard barrel was pulled into the large A-frame sheave. In the process the piggyback Niskin exploded, parts of the Gerard were bent, the sheave was significantly rearranged and the deck crew was scared half to death. Obviously, the outcome could have been much worse.

Some major features of section A are illustrated by the temperature section (figure 2). In the upper kilometer, between stations 171 and 175, the Falkland Current is clearly defined along the western boundary. Further east the general confused nature of the isotherms in the upper water column is result of crossing in and out of the Antarctic Circumpolar Current. This is most clearly demonstrated by the two isotherm depression areas between approximately 45°W and 53°W. In the lower water column the isotherms roughly mirror the topography. In this section the most notable bottom water features are:

> The coldest (θ = ~0.3) and lowest salinity (<34.66‰) waters were found on the eastern side of the abyssal plain (station 192 at 37.7°W). Bottom waters on the eastern side of the basin generally had higher nutrient, oxygen and CFC (chlorofluorocarbon) concentrations than on the western side. This finding is opposite to what was expected because Antarctic Bottom Water was believed to flow northward in a deep western boundary current along the base of the South American

continental slope. The strong signal which we observed may result from significant AABW inflow east of the Islas Orcadas Rise. This is consistent with an inflow path suggested by Georgi (1981).

There is indication of a western boundary current with an AABW core along the continental slope at 4000m (station 177). This core is characterized by a potential temperature less than 0°, salinity less than 34.68‰ and high CFC concentration.

The main water masses encountered along "A" are also illustrated by the oxygen and nutrient (nitrate in this case) data shown in figure 3. These data compare quite closely to the Western Atlantic GEOSECS data. As discussed above AABW is denoted by maxima in both nutrients and oxygen with the eastern half of the basin showing higher values than the western. The North Atlantic Deep Water core is centered around 2500m and marked by an oxygen maximum and nutrient minimum. Both NADW extrema are stronger in the western half of the basin than in the eastern. The extreme core values measured for these masses are summarized in table 1:

TABLE 1: Section A Deep Water Mass Extrema

Property	NADW	AABW	units
salinity	34.84	34.64	9100
oxygen	229	231	uM/kg
AOU	101	122	uM/kg
nitrate	24.6	34.8	uM/kg
phosphate	1.71	2.43	uM/kg
silicate	51.9	134.7	uM/kg

The thermocline region for this section is generally characterized by a nutrient maximum (e.g. 34-35 uM/kg in nitrate) directly overlying an oxygen minimum (~180 uM/kg) in the depth range 900-1500 m (see figure 3).

SECTION 4B: STATION 199-215
47°S 19.5°W - 30°S 3.75°W

This section was originally planned to begin at 47°S over the Mid Atlantic Ridge (~14°W) and continue to 30°S 5°W in the center of the southern extension of the Angola Basin. Rather than risk losing station density along the 30°S section (4C) we decided to move the turn point for the start of this section ~5° west and the end point ~1° east to make up the lost time. This resulted in an angled crossing of the Mid Atlantic Ridge, but allowed us to maintain approximately "standard" SAVE station spacing. A total of 17 stations were occupied along this track**.** This included 3 full water column and 2 upper water column LV stations. The large volume sample density and sv positions are shown in figure 4. Thirty-two XBT's were taken between stations. Once we crossed approximately 40°S the weather began to improve. As is generally the case, as the sea state improved, so did the station times. The largest factors were increased wench speed and shallower depths. By the end of the leg, Jim Wells had a station planning program working which was based on average steaming speed, wench speed and water depth. The program estimates proved to be very accurate and a great help in planning.

The major features of 4B are illustrated in the temperature (figure 5), salinity (figure 6a) and phosphate (figure 6b) sections. The strongest thennocline feature is the frontal zone between stations 202 and 204

(43.75-41.9°S) separating Subantarctic surface waters from South Atlantic surface waters. In many of the property sections the gradient clearly extended below 1km. The major water mass tongues (AAIW, NADW and AABW) are all easily discernable in these sections (especially phosphate, figure 6b). High bottom water phosphate values and. low potential temperatures at stations 210 & 211 (greater than 1.8 uM/kg and less than 1.6°C respectively) in the Angola Basin indicate a sill depth connection greater than 4km between the Angola Basin and the Cape Basin to the south. All of the bottom water nutrients along this track were significantly lower than along the GEOSECS section which was further east. The extreme core values for this section are summarized in table 2.

TABLE 2: Section B Water Mass Extrema

Property	AAIW	NADW	AABW	units
salinity	34.20	34.88	34.67	‰
oxygen	250	240	224	uM/kg
AOIJ	152	91	127	uM/kg
nitrate	36.8	23.4	35.1	uM/kg
phosphate	2.52	1.58	2.47	uM/kg
silicate	-60.0	51.0	124.8	uM/kg

SECTION 4C: STATION 215-235
30°S 3.75°W - 30°S 15.3°E

This final section of SAVE leg 4 was executed essentially as planned except for starting approximately 1 further to the east. Twenty-one stations were occupied including 5 full water column large volume stations. In addition, one near surface (Sta 226) and one near bottom (Sta 224) large volume profiles were obtained by hanging all of the Gerard barrels during the planned Argon casts. This proved to be a very good technique to increase LV sample density. Figure 7 which shows the large volume sampling density demonstrates that horizontal station separation was halved where these two casts were made. The time required to hang the extra bottles was small relative to wire time. Twenty-eight XBT's were taken between stations. Station planning and sampling went very well along this leg thanks in no small part to good weather conditions.

Sampling for Section 4C began in the southern part of the Angola Basin, continued across the Walvis Ridge and Namibia Abyssal Plain region of the Cape Basin and ended at the shelf-slope break on the northern portion of the Orange Cone. The main features seen in the thermocline were a general shoaling of isolines from west to east and two distinct areas of isoline depression (centered at station 220 ~2°E over the Walvis Ridge and between stations 223 and 224 ~6.5°E in the central Namibia Abyssal Plain). These details are clearly shown in the temperature section (figure 8). The two depression areas are probably remnants of rings shed in the Agulhas Retroflexion region.

Bottom waters in the Cape Basin were significantly fresher (34.73 vs 34.85‰) and colder (0.66 vs 1.82°C) than in the Angola Basin. The Cape Basin bottom waters also had the much higher nutrient and AOU levels indicative of AABW (see the silicate section figure 9). In the Cape Basin all the isolines tended to shoal both toward the Walvis Ridge and toward the African continental slope. Within this basin the bottom water extrema were found along the flank of the ridge (sta 221) and at the saddle point connecting the southeastern and northwestern areas of the Namibia Abyssal Plain. The mid-water column (2km - 3km) relative minimum in nutrients and AOU was defined more clearly in the Cape Basin than in the Angola Basin (see figure 9). This minimum was weaker at stations 223-224 where the isoline depression had been noted in the thermocline.

This section passed very close to GEOSECS station 102 (31.5°S 9.5°E). Comparison of the data shows the two to be comparable in all major characteristics. The extrema core values for this section are shown in table three. The GEOSECS East Atlantic section was used to help pick water mass cores. Note that the terminology AAIW is used very loosely both here and above. For example the AAIW salinity minimum listed below lies significantly above the nutrient maximum.

TABLE 3: Section C Water Mass Extrema

Property	AAIW	NADW	AABW	units
salinity	34.31	34.88	34.73	%0
oxygen	178	239	216	uM/kg
AOU	148	92	128	uM/kg
nitrate	33.5	23.4	31.0	uM/kg
phosphate	2.33	1.54	2.15	uM/kg
silicate	63.6	40.8	111.2	uM/kg

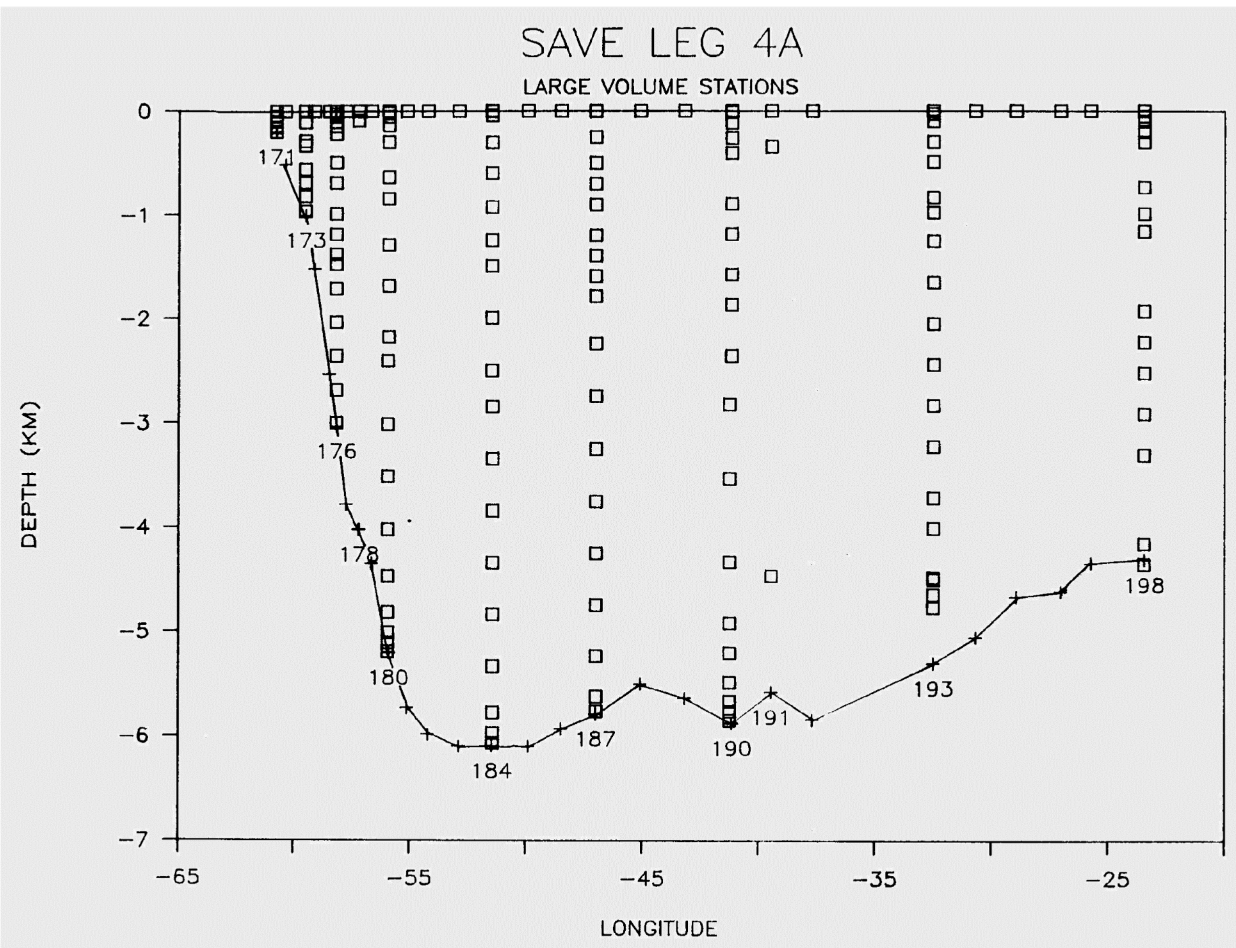


Figure 1

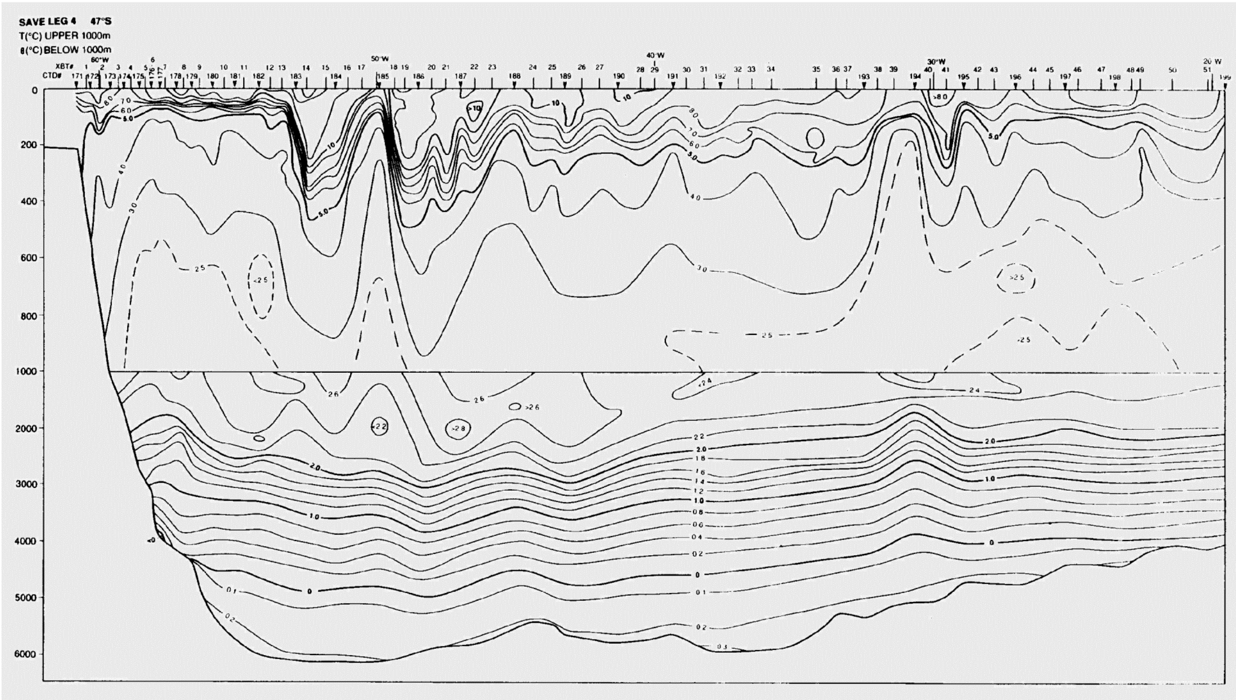

SAVE LEG 4 47°S
T(°C) UPPER 1000m
θ(°C) BELOW 1000m
60°W
50°W
40°W
30°W
20°W
XBT#
CTD#
0
200
400
600
800
1000
2000
3000
4000
5000
6000

Figure 2

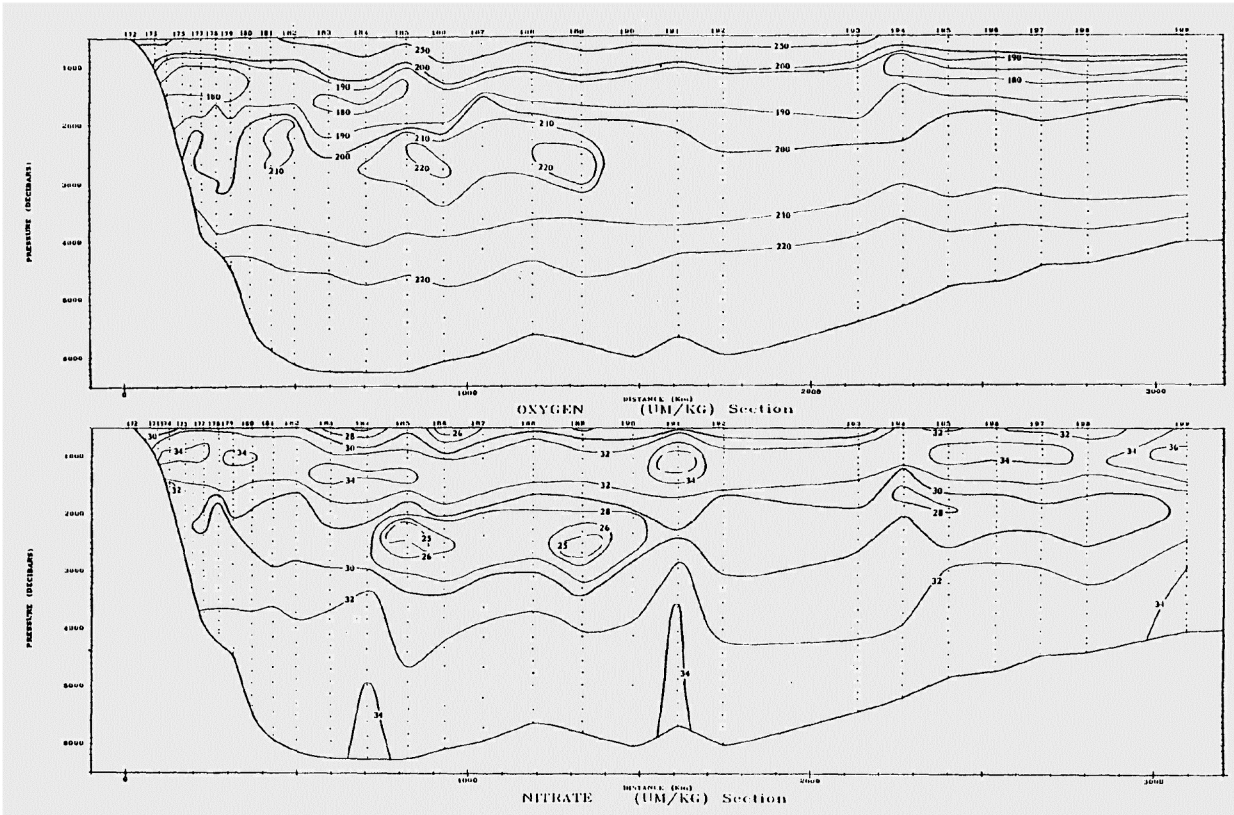
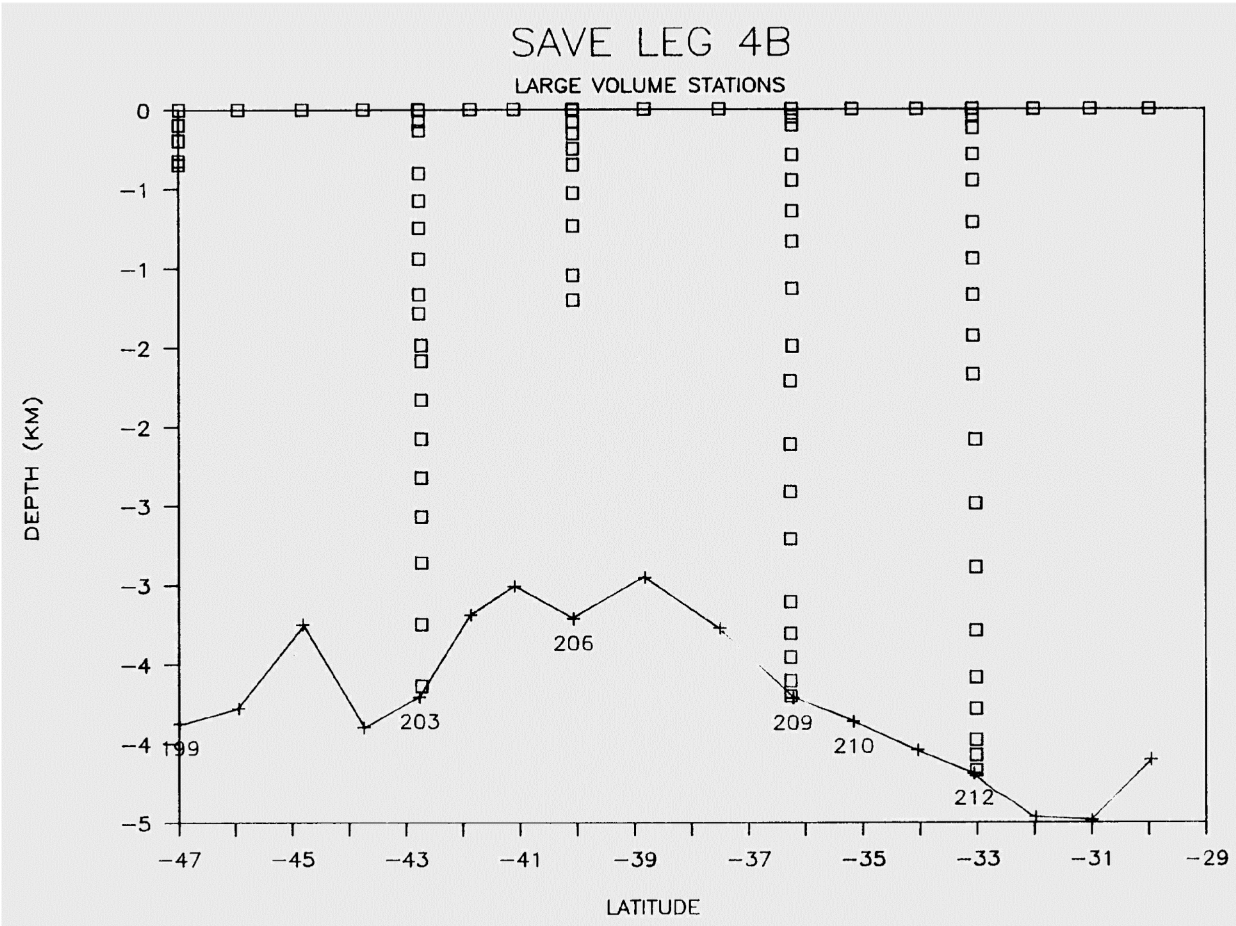


Figure 3



SAVE LEG 4B
LARGE VOLUME STATIONS
DEPTH (KM)
0
−1
−1
−2
−2
−3
−3
−4
−4
−5
199
203
206
209
210
212
−47
−45
−43
−41
−39
−37
−35
−33
−31
−29
LATITUDE

Figure 4

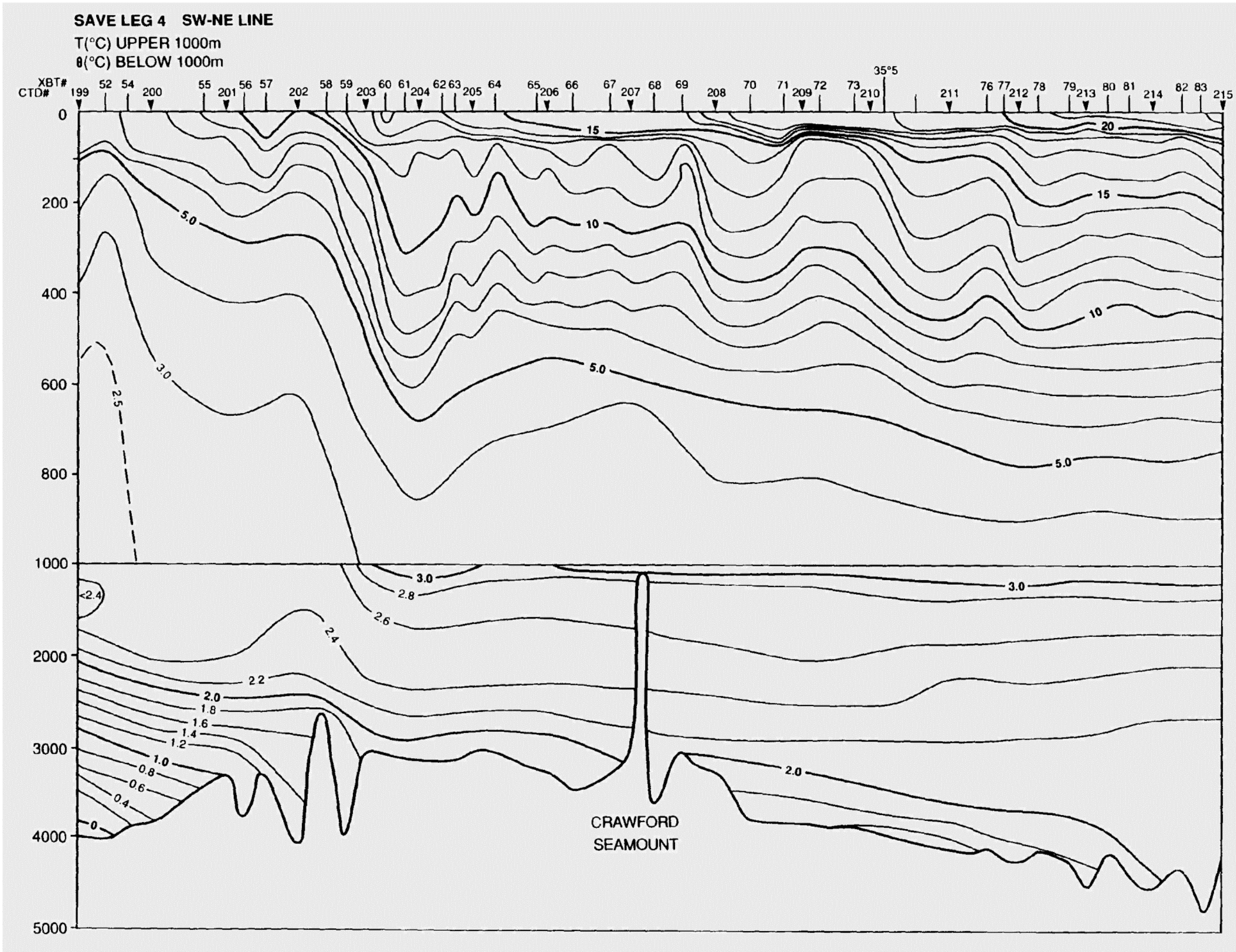
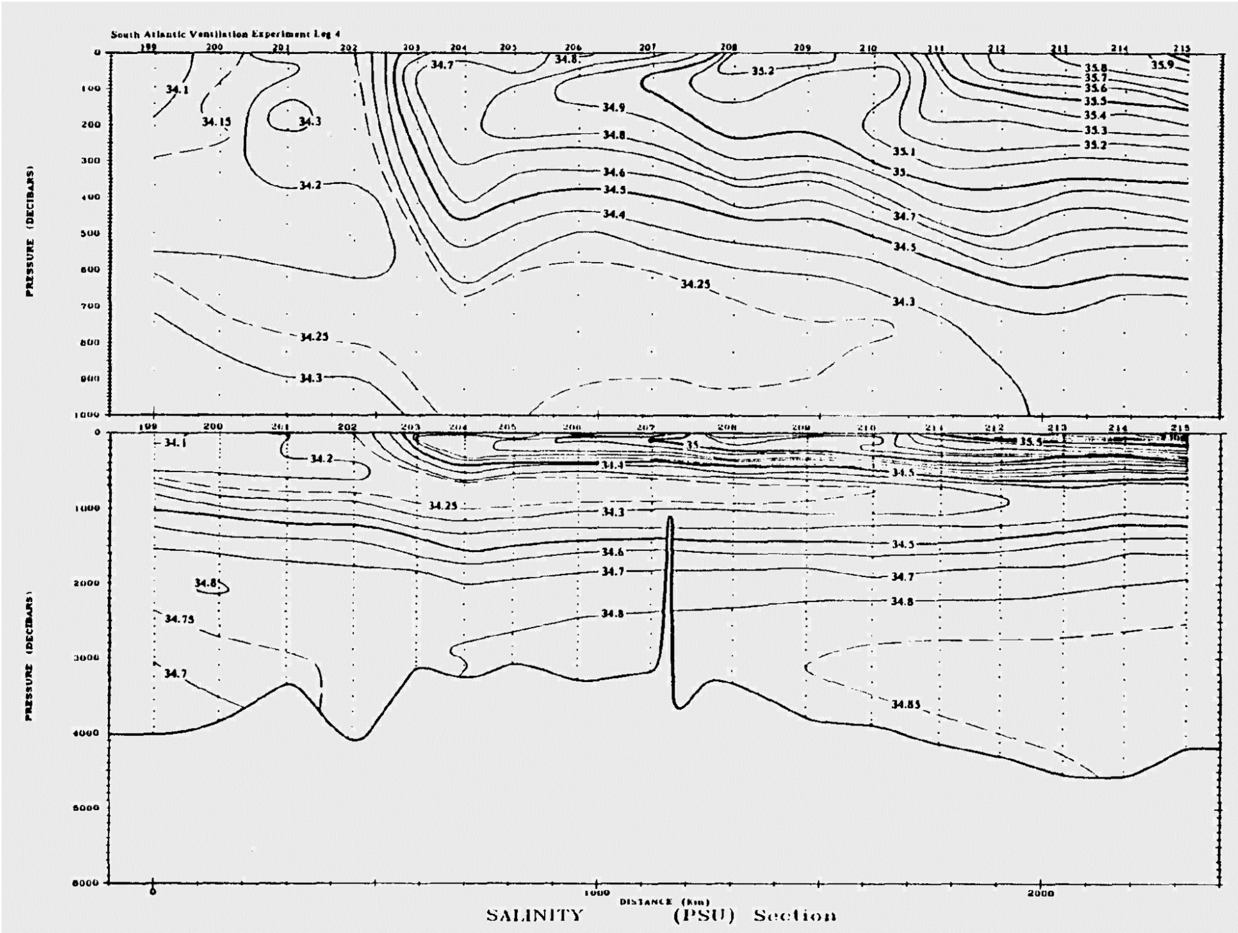

SAVE LEG 4 SW-NE LINE
T(°C) UPPER 1000m
θ(°C) BELOW 1000m
XBT#
CTD#
35°S
CRAWFORD
SEAMOUNT

Figure 5



South Atlantic Ventilation Experiment Leg 4
PRESSURE (DECIBARS)
DISTANCE (km)
SALINITY (PSU) Section

Figure 6a

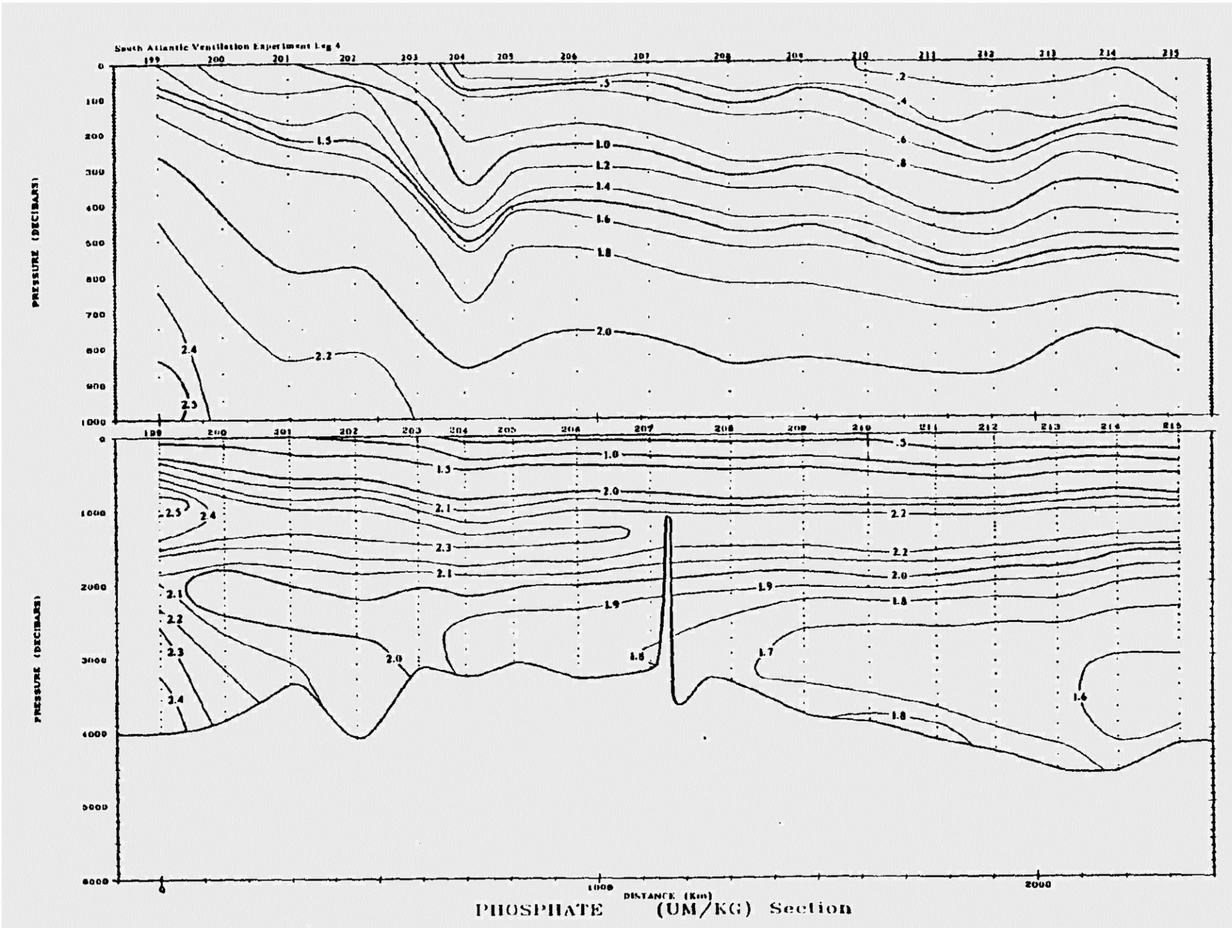

South Atlantic Ventilation Experiment Leg 4
PRESSURE (DECIBARS)
DISTANCE (Km)
PHOSPHATE (UM/KG) Section

Figure 6b

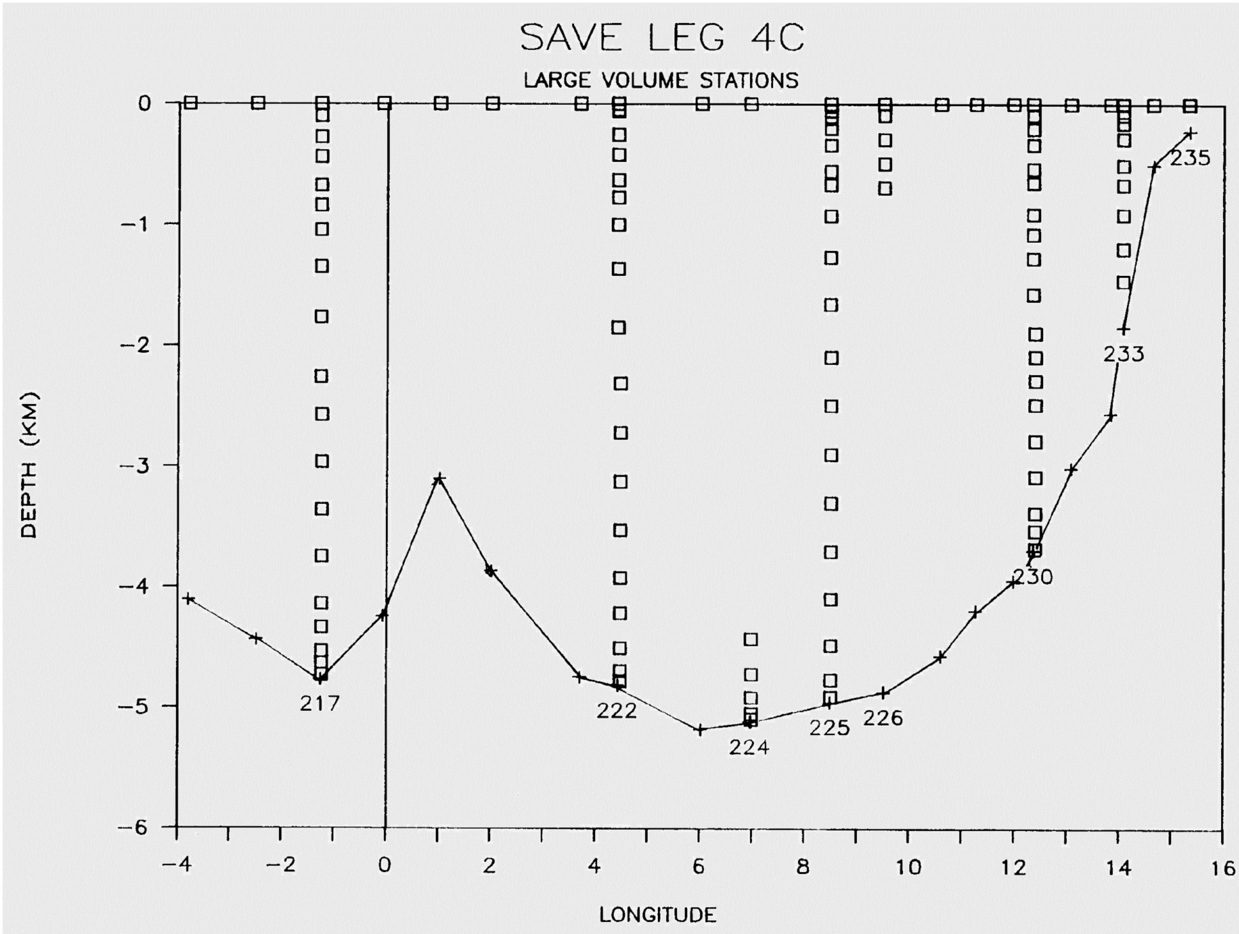

SAVE LEG 4C
LARGE VOLUME STATIONS
DEPTH (KM)
0
−1
−2
−3
−4
−5
−6
217
222
224
225
226
230
233
235
−4
−2
0
2
4
6
8
10
12
14
16
LONGITUDE

Figure 7

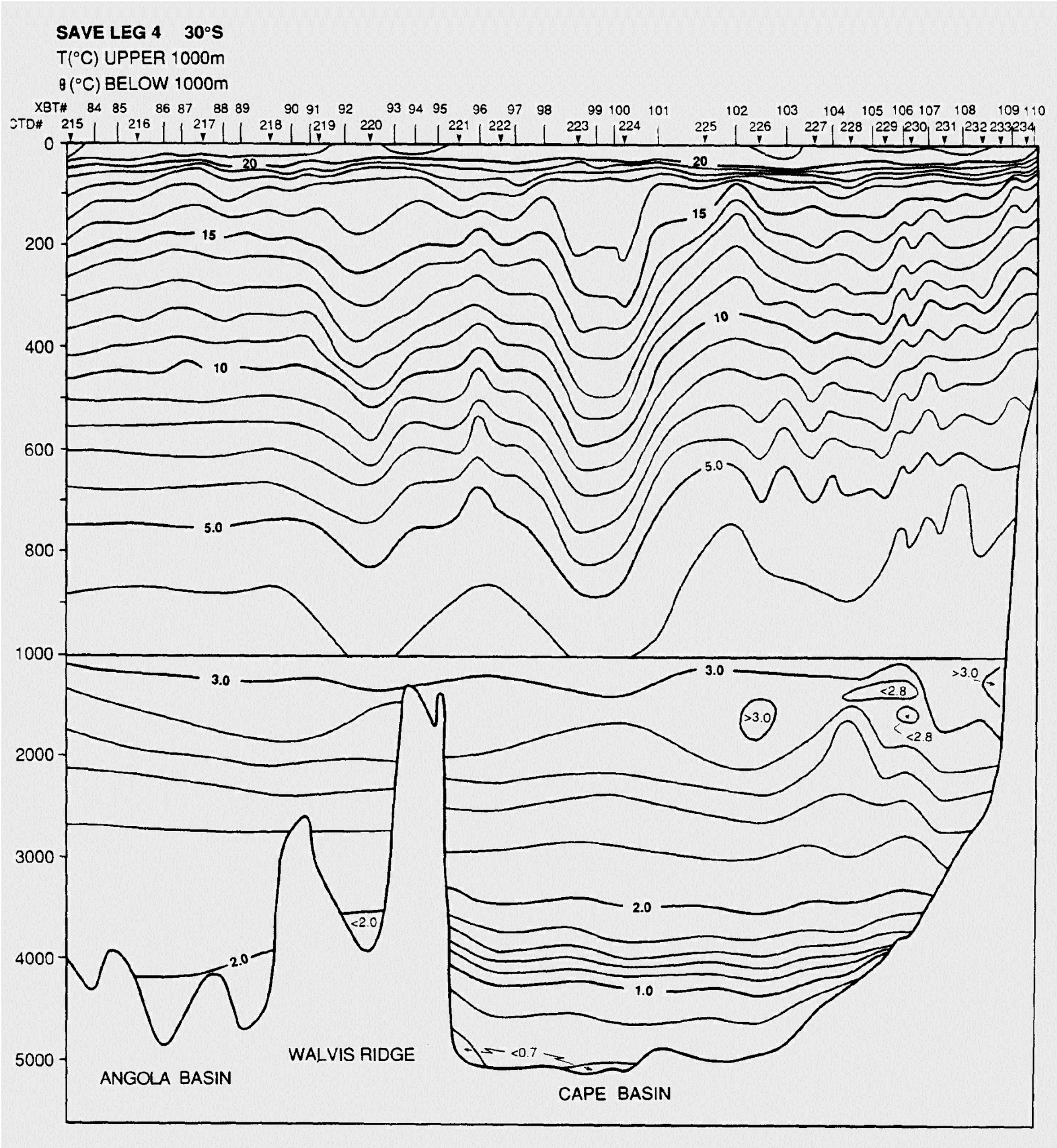

SAVE LEG 4 30°S
T(°C) UPPER 1000m
θ (°C) BELOW 1000m
XBT#
CTD#
ANGOLA BASIN
WALVIS RIDGE
CAPE BASIN

Figure 8

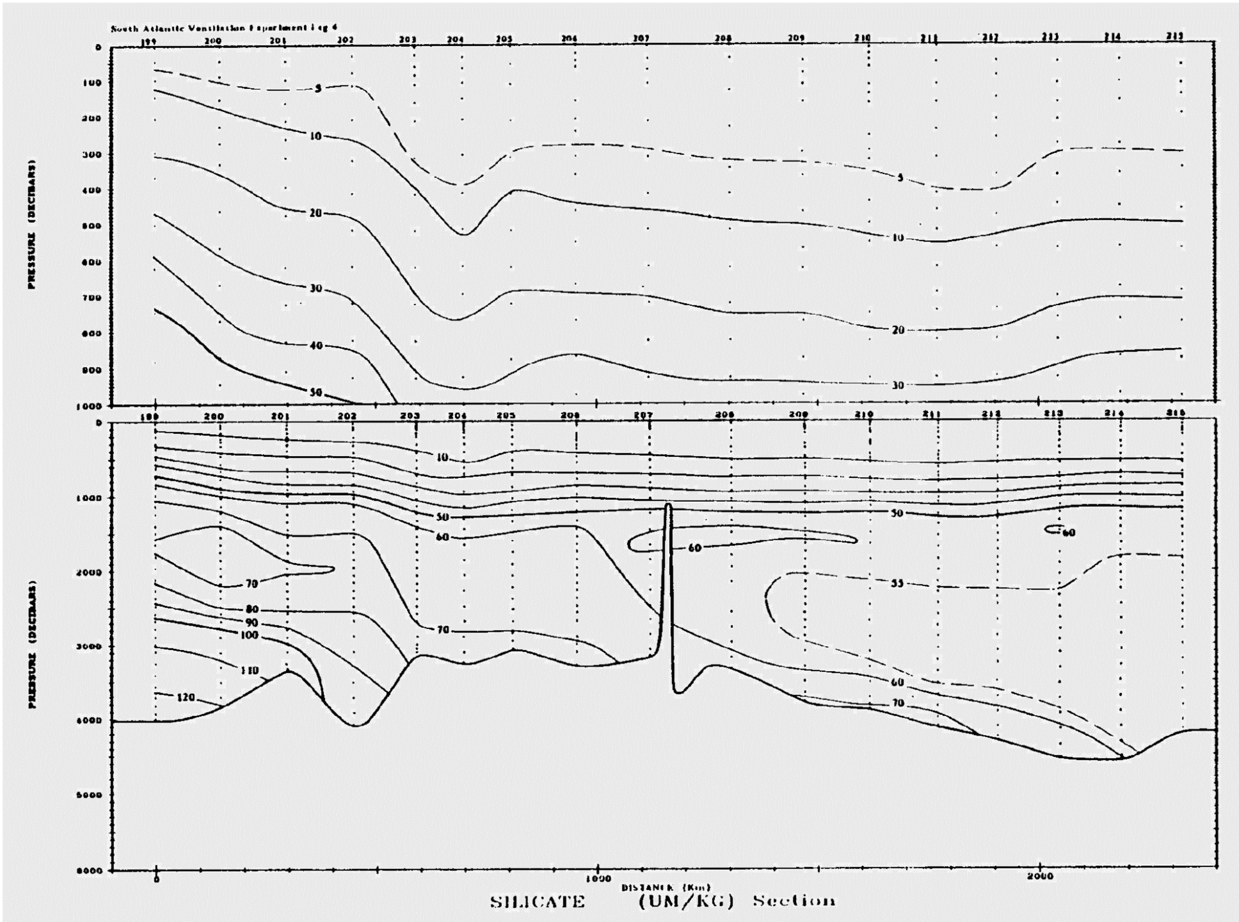

South Atlantic Ventilation Experiment Leg 4
PRESSURE (DECIBARS)
DISTANCE (Km)
SILICATE (UM/KG) Section

Figure 9

List of participants

Ship's Captain

Curtis D. Johnson - Scripps Institution of Oceanography

Chief Scientist

Robert M. Key
Princeton University

Co-chief Scientist

Alberto R. Piola
Servicio de Hidrografía Naval - Argentina

Lamont-Doherty Geological Observatory

Michael T. Benjamin
David W. Chipman
Amy Ffield
Guy Mathieu
Maureen K. Noonan

Princeton University

Gerard J. McDonald

Scripps Institution of Oceanography/ODF

David L Boa
Marie-Claude Beaupre
Carol Conway
Tim Field
Mary C. Johnson
Carl W. Mattson
Kristin M. Sanborn
James A. Wells

Scripps Institution of Oceanography

John T. Boaz
Leonard T. Lopez
Mark J. Warner

Texas A&M University

Bret B. Bergland

University of Washington

David Straub

Woods Hole Oceanographic Institution

Scot P. Birdwhistell

CCHDO Data Processing Notes

Event Date	Person	Date Type	Summary
2011-04-08	*Muus, Dave*	BTL	Exchange, NetCDF, WOCE files online

Notes on Save Leg 4 rosette sample data EXPOCODE 318M19881207 110406/dm

1. Temperature, salinities, oxygen and nutrients taken from ODF data, whprpasave4, dated Aug 25, 2005.
2. CFCs and CO2 data merged from file SAVEsv.csv received from R. Key Dec 10, 2010.
   PCO2 values in file but no flags. Added flag 2 for all PCO2s.
3. Sta 230 Cast 1 Sample 31 leaked. Nutrients not analyzed, Oxygen, Salinity & Alkalinity deleted.
   TCARBN & PCO2 values exist but are very low.
   ODF notes say "Bottle appears to have leaked". Deleted TCARBN and PCO2.
4. Deleted Station 173 Cast 2 Bottle 21 from SAVEsv.csv. Cast 2 is Gerard cast, Bottle 21 is rosette bottle.
   Deleted Station 203 Cast 3 Bottle 18 from SAVEsv.csv. Cast 3 is Gerard cast, Bottle 18 is rosette bottle.
5. CTDTMP units ITS-68 not ITS-90.