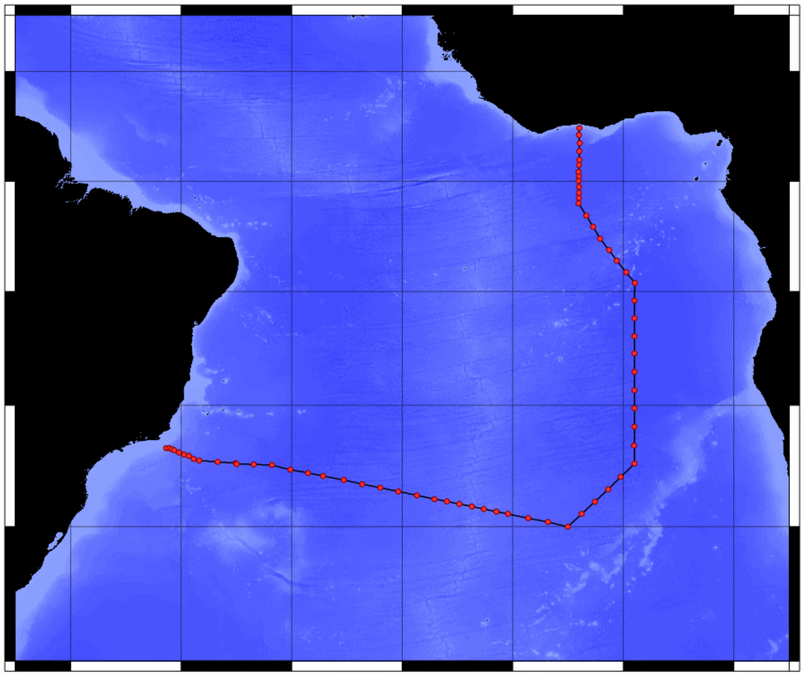
# CRUISE REPORT: SAVE3

*(Updated APR 2011)*



## HIGHLIGHTS

### Cruise Summary Information

| | |
|---|---|
| WOCE Section Designation | **SAVE3** |
| Expedition designation (ExpoCodes) | **316N19880128** |
| Chief Scientist | **William J. Jenkins/WHOI** |
| Co-Chief Scientist | **Donald B. Olson/UM** |
| Dates | 1988 JAN 28 - 1988 MAR 7 |
| Ship | *R/V Knorr* |
| Ports of call | Rio de Janeiro, Brazil - Abidjan, Ivory Coast |
| Geographic Boundaries | 4° 53.1' N<br>41° 23.3' W 1° 3.4' E<br>30° 1.9" S |
| Stations | 65 |
| Floats and drifters deployed | 0 |
| Moorings deployed or recovered | 0 |

### Chief Scientist's Contact Information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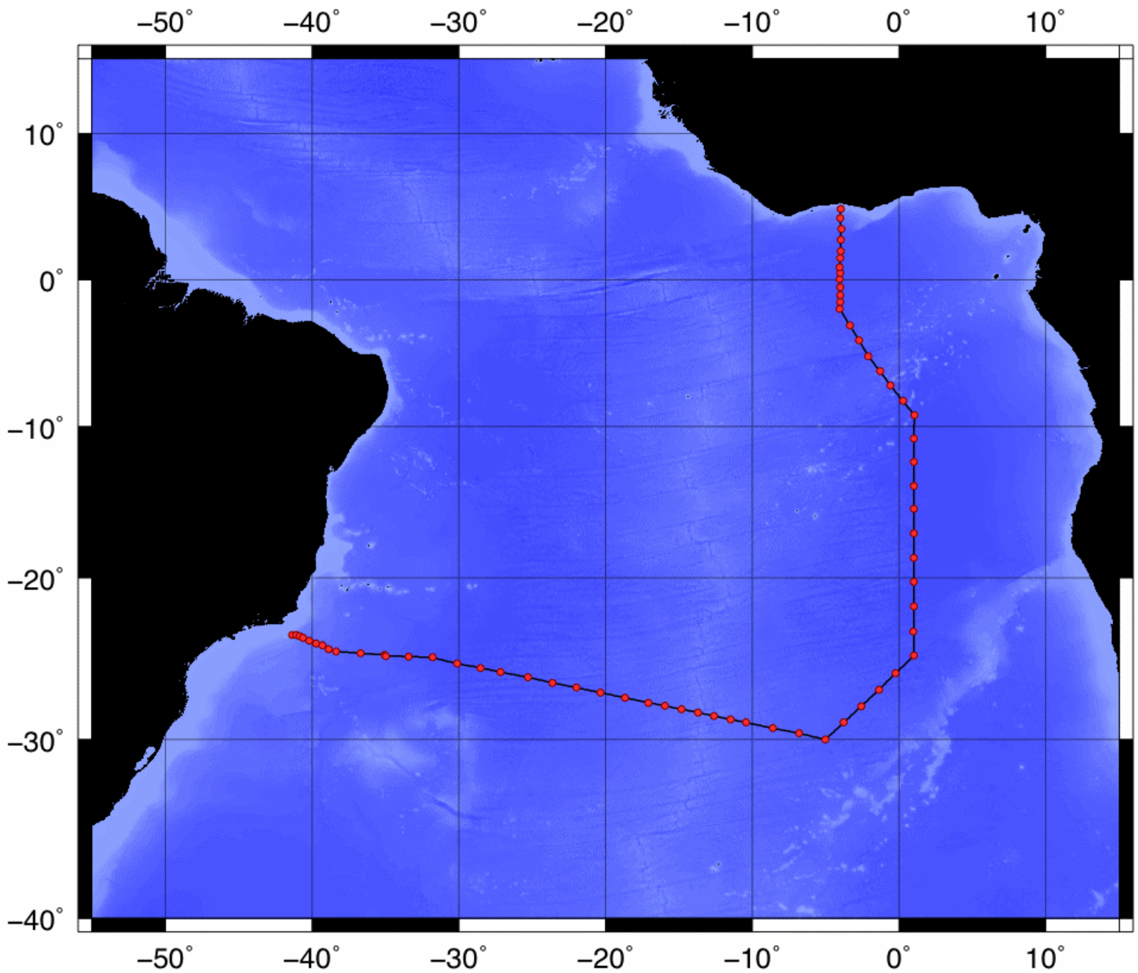
**LINKS TO SELECT TOPICS**

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

# SAVE3 Jenkins/WHOI (KNORR 1988) – 316N19880128



# South Atlantic Ventilation Experiment (SAVE) Leg 3

## Shipboard Chemical and Physical Data Report

PRELIMINARY

29 January - 7 March 1988

R/V *Knorr*

Data Report Prepared by:

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Scripps Institution of Oceanography
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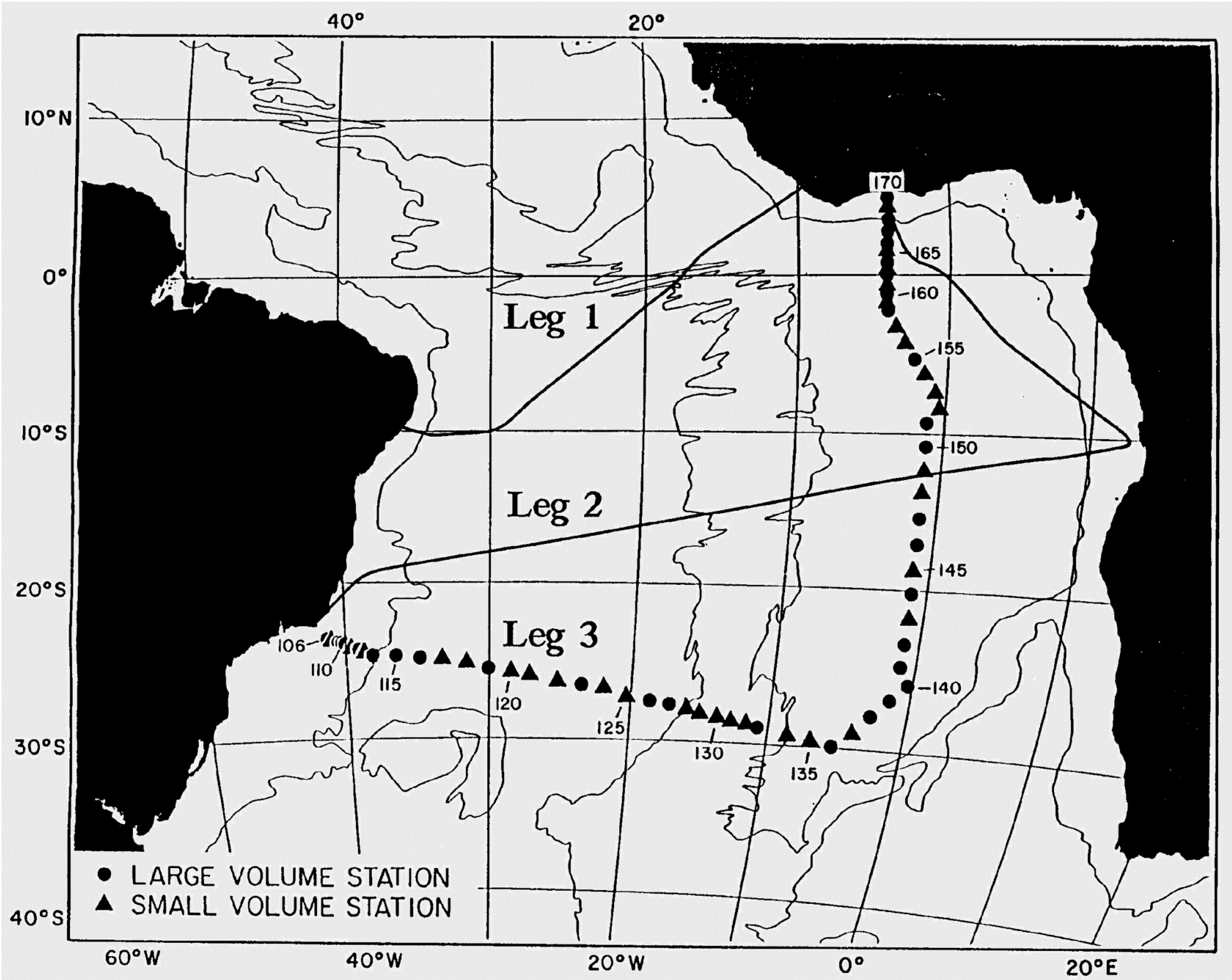


## INTRODUCTION

*(Donald B. Olson and William Jenkins)*

The third leg of the South Atlantic Ventilation Experiment (SAVE) sailed from Rio de Janeiro, Brazil on January 28, 1988 on a course across the South Atlantic to a point just short of the Walvis Ridge at 30°S (Figure 1) where the line turned north through the Angola Basin, across the equator and into Abidjan, Ivory Coast. This set of sections provides a line across the beginning of the Brazil Current and the northern side of the South Atlantic subtropical gyre, then northwards through the cyclonic circulation in the eastern subtropical basin and the equatorial domain. The latter section repeats the 1983 AJAX section (AJAX, 1985).

A total of 65 stations were occupied during this leg, which included 67 rosette casts and 60 Gerard casts. Difficulties were encountered with the new Gerard Barrels initially due to their requisite "break-in" period. Additional difficulties arose which were ultimately linked to excessive "whip-lash" action at the end of the trawl wire; a problem eventually remedied by augmenting the end weight. 3112 samples were analyzed for salinity, 2389 for oxygen and 2288 for nutrients. In addition, a 114 XBT profiles were obtained (drops made in between stations) and 71 "underway" surface samples were obtained for salinity, oxygen, nutrients, $\Sigma CO_2$ and $pCO_2$ determinations. Auxiliary sampling on the cruise included particulate samples, trace metal efforts and limited samples of phytoplankton near the equator for geological purposes.

The discussion begins with the eastward section outward from the South American coast. The section is nearly parallel to the CATO expedition's northern line taken in 1972 (Reid et al., 1977) across the western boundary region and therefore provides a high quality comparative cross section. The SAVE 3 section also provides comparison with two GEOSECS stations taken just north and south of the line.

The section from the Brazilian coast out into the central gyre crosses the Brazil Current near its formation region. The near surface southward boundary current flow based on direct measurement by Evans and Signorini (1985) has a transport of $6X10^6 m^3/s$ above 400 m with a northward flow in the Antarctic Intermediate Water (AAIW) below this level. The baroclinic field on the SAVE 3 section supports a similar transport above the 400 m level but suggest on a property basis that the flow is more complicated in the sense that the salinity minimum associated with the AAIW is stronger offshore beyond the extent of the Evans and Signorini (1985) section. The baroclinic shear reverses offshore suggesting a northward flow of similar magnitude a few hundred kilometers off the coast. In general the water mass properties show a rather confused picture of alternating northern and southern origin waters through the intermediate layers near the coast. These variations are most prominent in the oxygen signal although they also show in the nutrients and salinity on density surfaces.

The deep water complexes (i.e. North Atlantic Deep Water [NADW] and modified Circum-polar Deep Waters [CDW]) dominate the water column between 1000 and 3500 dbars. The most striking contrast between southern and northern waters is seen in the silica distribution, which shows the northern (low silica) waters hugging the boundary, while the upper CDW influence increases 500 km seaward. The NADW complex appears as a series of property extrema embedded between this intermediate depth tongue and the Antarctic Bottom Water AABW below. The NADW is capped by a potential temperature and salinity maxima centered at 1700 dbars along the Brazil Coast. This feature is above the silicate minimum associated with Labrador Sea Water and the salinity maximum of the Upper NADW proper. The oxygen maximum of the Middle NADW is found even deeper just above the rapid change in stratification separating these northern source waters from the (AABW). The core of the AABW is shifted further seaward and is found on deeper isobaths than at the sill to the south in the Vema Passage (Hogg et al., 1982). There is a transition to more southern influence in deep waters on the offshore portion of the section as the line crosses the longitude of the Rio Grande Rise. This tendency is seen as a truncation of the temperature maximum and rapid freshening at the $\sigma_2 = 36.84$ level.

The section to the Mid Ocean Ridge was fairly uneventful with the exception of an unexpected seamount (the "Olson" seamount based on the P.I. who inadvertently placed a station on it) which leads to a discontinuity in the sampling of the deep waters. On a more serious note there was time to complete enhanced sampling in the AAIW and ABW for Krypton and Argon (Kr 85, Ar 39). This increased sample density for these trace gasses and better resolution in the vertical for Radium and $C^{14}$ partially made up for the decreased sample density on SAVE 2 which resulted from the loss of Gerrard barrels on the first leg of the program. The SAVE program includes some of the highest quality $CO_2$ system sampling available to date in the world's oceans with the SIO, Weiss underway system and the Lamont *in situ* work. Samples to back calibrate earlier estimates were taken near GEOSECS stations with replicate samples drawn for repeat analysis following the original protocol specified by Keeling.

East of the Mid Ocean Ridge we increased XBT sampling frequency to monitor for anomalies of Agulhas origin in terms of rings (Olson and Evans, 1986; McCartney, per. comm.). Based on the depth of the 10°C isotherm on the section no ring related perturbations where found despite eternal and dogged vigilance on the part of our crack XBT and underway team. This conclusion can be tested in terms of existing satellite data based on GEOSAT altimeter (Brown and Evans, 1988; Gordon and Haxby, 1988).

The edge of the Subtropical Gyre in the eastern basin of the South Atlantic is marked by a frontal zone which has a strong baroclinic signature around 20°S but an *in situ* front in terms of gas ($O_2$ and freon) concentration approximately two degrees farther to the north (18°S). This latter feature separates the fairly well ventilated waters of the subtropical gyre from the oxygen minimum in the upper layers of the cyclonic circulation in the Angola Basin. The intercomparison of transient gas concentrations based on chlorofluoromethane (freon) measurements on AJAX and SAVE (Warner and Weiss, per. comm.) suggest significant measurable changes in the cross frontal and vertical extent of these tracers.

The edge of the Subtropical Gyre in the South Atlantic in the eastern basin is coincident with top to bottom gradients in water mass properties. The change is more gradual in the deeper layers which are dominated by a NADW source along the equator (Romanche fracture zone). There are however changes which suggest a weak secondary exchange across the Mid Ocean Ridge near 20°S and modification of oxygen and nutrient profiles due perhaps to interaction with the Congo fan. Again, these signals while obvious in the tradition tracer fields, i.e. temperature, salinity, oxygen and nutrients; also show up in the trace metal field (Measures, per. comm.). Similar conclusions concerning a secondary source of properties from the western basin and a detailed picture of the possible flow regime in the Angola basin can be found in Speer (1986). The additional tracer information in the deep waters as part of SAVE 2 & 3 will provide further constraints on the processes in this basin.

The Leg 3 line across the equator along with those taken on the previous SAVE efforts provide a detailed picture of the distribution of water mass properties along the equator. Station spacing was reduced in proximity of the equator in order to resolve possible deep equatorial jets. These features were first described in the Indian Ocean by Luyten and Swallow (1976) and have since been identified as a feature of the deep equatorial circulation in all three oceans (Eriksen, 1982). Recent theoretical studies and numerical model runs by Kawase (1987) has suggested some of the deep along equator flow may result from the introduction of deep waters from the western boundary layer. The vertical structure on the equator in the SAVE data set is consistent with deep jets but the strongest water mass signals are shifted off the equator. The strongest NADW signals in terms of oxygen, salinity and chlorofluoromethanes occur in the southern hemisphere along X°S. The maximum oxygen signal occurs at 1900 m in what is traditionally noted as the Middle NADW. In contrast there is a tongue of chlorofluoromethane bearing fluid centered at 1600 m depth at the upper portion of the Labrador Sea Water. This is the continuation of the flow first described by Weiss *et al*. (1985) near the equator. One puzzle concerning this transient tracer distribution is that the chlorofluoromethanes are found south of the equator in the SAVE 1 and 3 sections but is found north of the equator in the eastward-most SAVE 2 line.

## References

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## List of Participants

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Observers
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    Lt. Bakary Coulibaly, Cote D'Ivoire Observer

## CCHDO Data Processing Notes

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

Notes on Save Leg 3 rosette sample data. EXPOCODE 316N19880128 110406/dm

1. Temperature, salinities, oxygen and nutrients taken from ODF data, whprpasave3, 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.
   Station 136 Cast 3 Sample 5 99.7db PCO2 180 high. ODF water samples deleted "bottle tripped about 385db".
   Deleted PCO2 and TCARBN.
   Station 136 Cast 3 Sample 27 PCO2 80 low. ODF samples okay. Flag PCO2 "3".
3. Duplicate Bottle 30, Cast 1, Station 120: CFC-12 0.001 in first entry and 0.003 in second entry. Used first entry.
   station nosamp day month year latitude longitude maxdepth maxsampdepth bottle cast depth temperature salinity
   pressure oxygen nitrate nitrite silicate phosphate alk tco2 pco2 cfc11 cfc12
   120 37 6 2 1988 -25.675 -28.513 5433 5433 30 1 4059 1.673 34.819 4124 242 25.4 0 70.3 1.73 -999 -999 -999 0.003 0.001 2 2 2 2 2 2 2 9 9 9 2 2
   120 37 6 2 1988 -25.675 -28.513 5433 5433 30 1 4061 1.673 34.819 4124 242 25.4 0 70.3 1.73 -999 -999 -999 0.003 0.003 2 2 2 2 2 2 2 9 9 9 2 2
4. Deleted Station 108 Cast 3 Bottle 30 from SAVEsv.csv. Cast 3 is Gerard cast, Bottle 30 is rosette bottle.
   Deleted Station 167 Cast 2 Bottle 25 from SAVEsv.csv. Cast 3 is Gerard cast, Bottle 25 is rosette bottle.
   Deleted Station 114 Cast 2 Bottle 29 from SAVEsv.csv. Cast 2 is Gerard cast, Bottle 29 is rosette bottle.