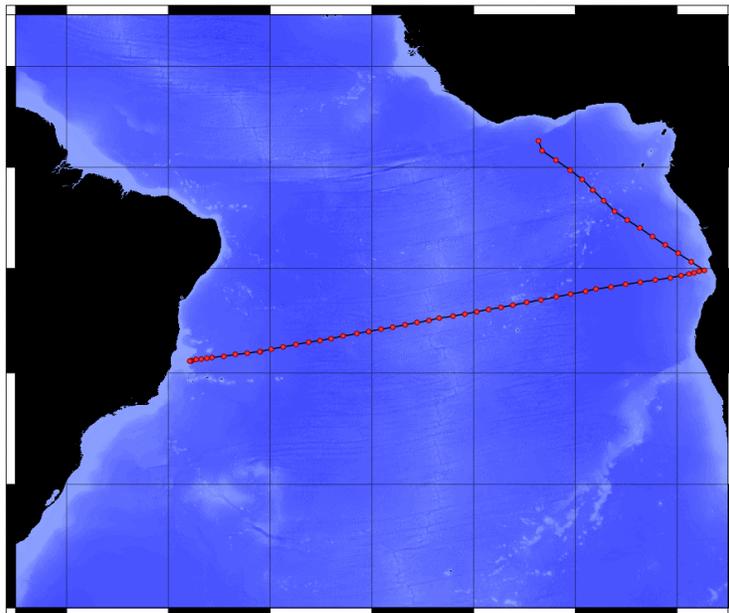


CRUISE REPORT: SAVE2

(Updated APR 2011)



HIGHLIGHTS

Cruise Summary Information

WOCE Section Designation	SAVE2
Expedition designation (ExpoCodes)	316N19871218
Chief Scientists	William M. Smethie/LDEO Stanley S. Jacobs/UW
Dates	1987 December 18 - 1988 January 21
Ship	<i>R/V Knorr</i>
Ports of call	Abidjan Ivory Coast - Rio de Janeiro, Brazil
Geographic Boundaries	2° 39' N 37° 52.8' W 12° 39.7' E 18° 53.8' S
Stations	62
Floats and drifters deployed	0
Moorings deployed or recovered	0

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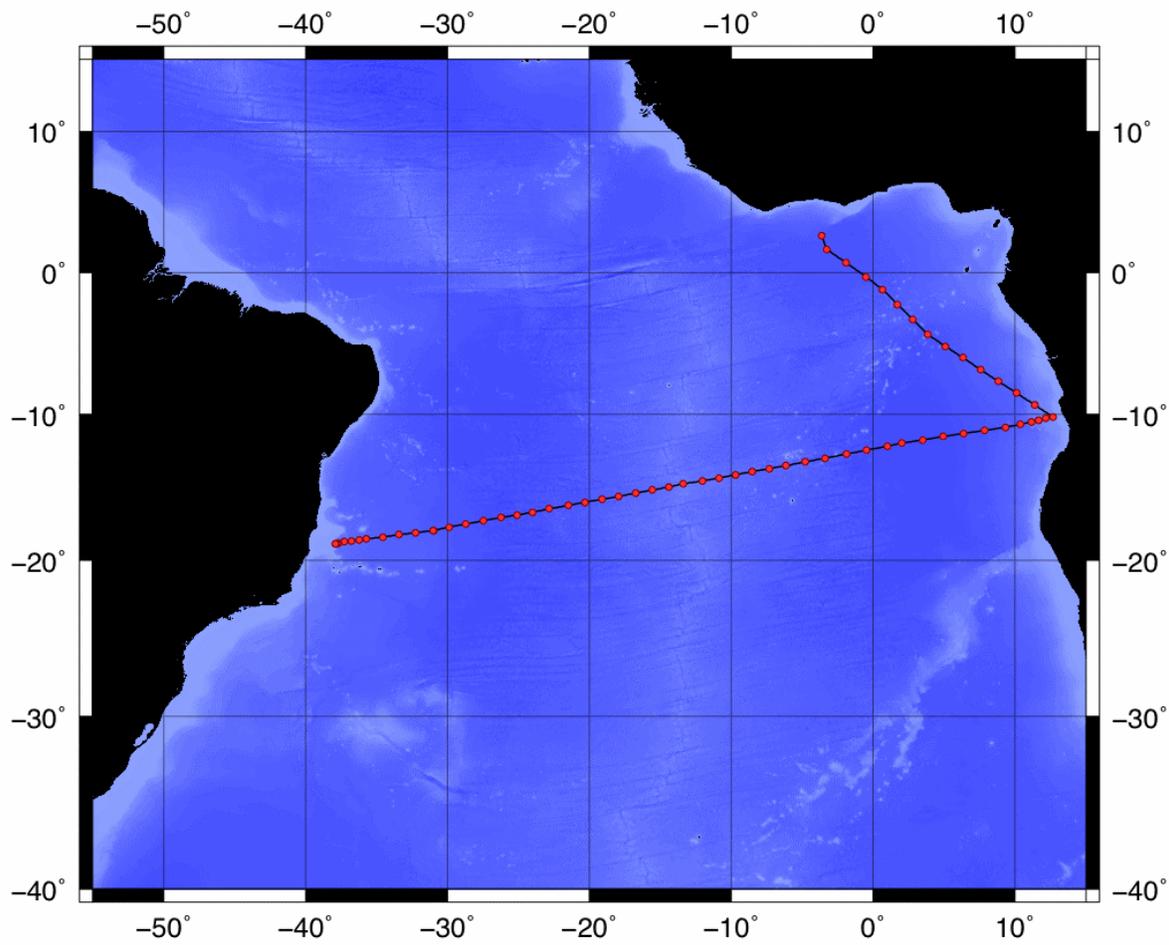
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LINKS TO SELECT TOPICS

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

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	

SAVE2 Smethie/LDGO (KNORR 1987-1988) - 316N19871218



South Atlantic Ventilation Experiment (SAVE) Leg 2
Shipboard Chemical and Physical Data Report

PRELIMINARY

19 December 1987 - 21 January 1988

R/V Knorr

Data Report Prepared by:

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

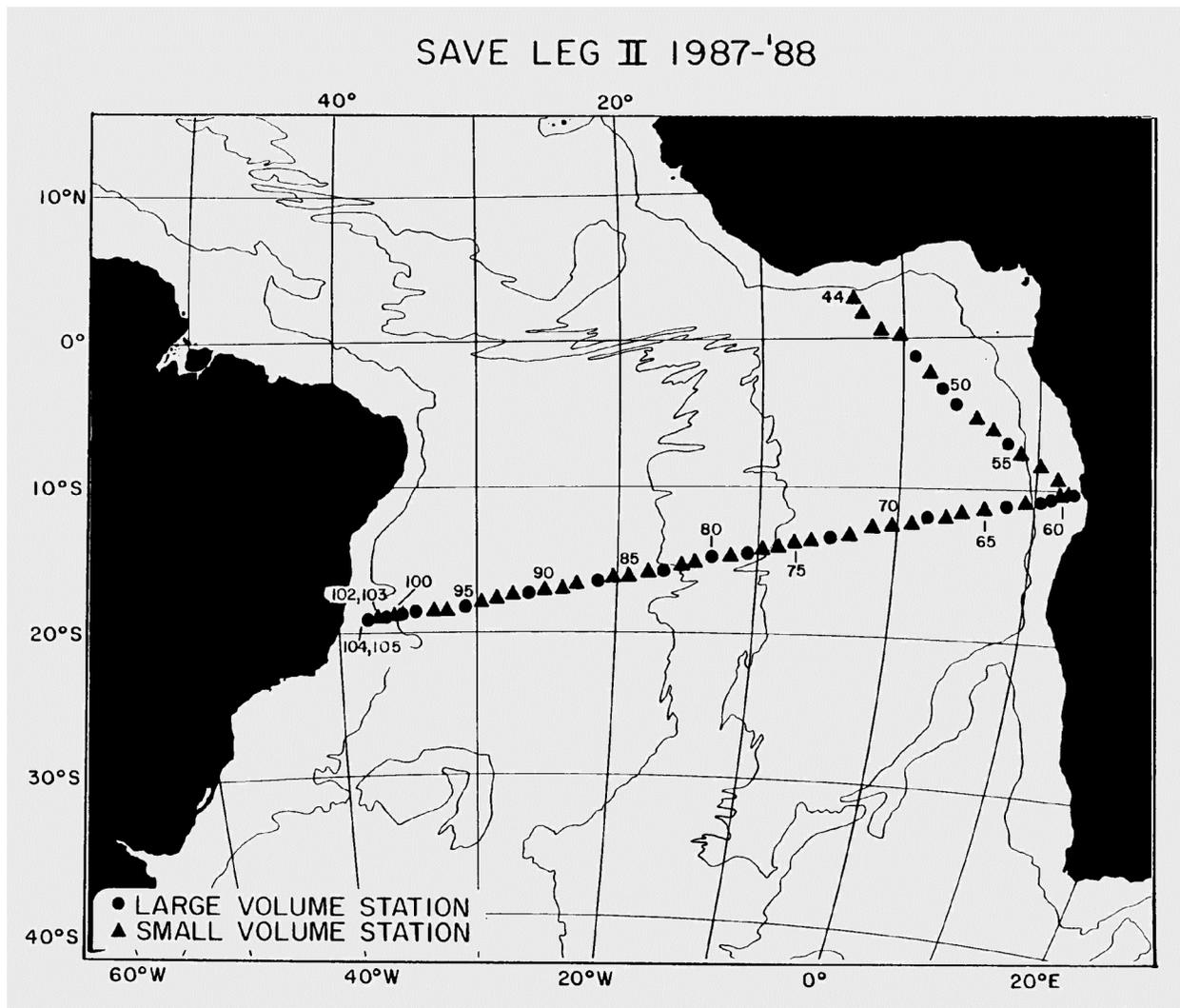
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ODF Publication No. 225

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OVERVIEW

R/V Knorr departed Abidjan at about 1800 Greenwich time on December 18, 1987, one day later than scheduled. While steaming to the first station, the CTD wire was streamed at sea and rewound onto the winch under tension. A test station was then taken to 1000 m depth so that analysts could re-start their systems and chlorofluoromethane (CFM) blanks could be checked for the rosette bottles and sampling syringes. The first official station, SAVE 45, was taken at 1°40' N, 3°15' W, 0540 Greenwich time on December 20. From there a line of stations was occupied to 10°10' S, 12°40' E, a point 40 miles off the coast of Angola (Figure 1). From this pivot station (#58), a section was made westward across the South Atlantic Ocean, with the last station (#105) taken on the Brazil continental shelf at 18°54' S, 37°52' W on January 21, 1988. The cruise ended in Rio de Janeiro at about noon local time on January 23, 1988. The cruise track for leg 2 was designed to provide good coverage of the oxygen minimum zone in the South Atlantic Ocean thermocline, which is most intense in the location of the pivot station off the Angola coast, and to provide a zonal section across the central Angola and Brazil basins for the purposes of investigating thermocline ventilation and spreading of AAIW, NADW, and AABW. Station spacing was about 90 na. mi. on the first section and across the Angola Basin and about 70 na. mi. across the

mid-ocean ridge and the Brazil Basin. Station spacing at the eastern and western boundaries varied between 8 and 30 na. ml. A total of 62 stations were taken which was 4 less than originally planned. The 4 stations were dropped from low horizontal gradient regions in the Angola Basin to make up for the day lost in port.

A number of problems were encountered on this cruise (see section on [operational problems](#)) but through the combined expertise of the ship's crew and the Ocean Data Facility personnel from Scripps, these problems were overcome and the cruise was successfully carried out. All objectives were met except one, the collection of large volume deep water samples for carbon-14, radium-228, and argon-39. Only 2 Gerard barrels were available to collect large volume samples, so in the time available it was not possible to obtain the deep vertical profiles that had been planned and complete other primary objectives. There was a medical emergency when one of the crew members became sick with malaria raising the possibility that the cruise would have to be aborted to obtain treatment. However, the medic provided the medical treatment needed and the cruise continued as scheduled. SHIPBOARD PROGRAMS Samples collected and analyzed

The core program consisted of XBT and CTD profiles; on board analysis of water samples for salinity, oxygen, nutrients (phosphate, nitrate, nitrite, silica), CFMs, total CO₂, and pCO₂; and collection of samples for shore based analysis for tritium, helium-3, carbon-14, radium-228, radium-226, krypton-85, and argon-39.

Ancillary programs carried out on this leg were transmissometer profiles taken with the CTD profiles, on board analysis and collection of samples for shore based analysis for suspended particulate matter, and collection of samples for shore based analysis for oxygen-18, nitrogen-5, barium, and total CO₂.

ROSETTE SAMPLING

Ten-liter water samples were collected using a dual rosette system that held 36 bottles (12 on an inner rosette and 24 on an outer rosette) interfaced to a CTD. Sampling depths were determined after viewing temperature, salinity, density, oxygen, and percent transmission from the down cast. Generally 36 samples were collected with the bottom sample between 10 and 15 m from the bottom.

At station 95 (a reoccupation of GEOSECS station 55) total CO₂ samples were collected for shore based analysis by D. Keeling. Two casts were performed at this station and two bottles were tripped at each of the 16 depths where these samples were collected. Total CO₂ samples collected from these depths were also analyzed on board for a comparison between the two techniques.

Prior to SAVE leg 2, there was considerable discussion about ways to improve the 36-bottle rosette sampling procedures. Due to potential head space contamination problems, the primary concern was to shorten sampling time. In addition, we wanted to make better use of available personnel and to free up analysts who could thereby process more samples. As a result of those deliberations, the following sampling strategy was adopted for the small-volume rosette work on SAVE-2:

- 1) A sampling director, nominally one of the co-chiefs, choreographed the draw sequence for all Niskin bottles, and recorded bottle numbers as samples were taken. This was not simply a passive, recording-secretary role; but an interactive, real time scheduling process to minimize total gas sample draw time and maximize efficient use of personnel.

2) The most common sampling sequence was:

- a) CFMs
- b) Helium-3
- c) Oxygen
- d) Oxygen-18
- e) pCO₂
- f) TCO₂
- g) Tritium
- h) Nutrients
- i) Salinity
- j) Suspended particulates

However, only oxygen, nutrients and salts were drawn from all bottles on all stations. Helium-3 was frequently drawn first, particularly on deep bottles over the Mid Atlantic Ridge where helium was drawn before CFMs. In addition, various permutations were tried on specific sampling experiments, which are detailed separately in this report. When sealing problems occurred with the helium-3 samplers, second helium-3 samples followed oxygen but usually preceded CO₂ draws. On 3 stations, nitrogen-15 samples were collected after the salinity samples.

- 3) In an attempt to increase the total number of CFM and CO₂ analyses, those samples were usually not drawn by the analysts, but by other suitably-trained technicians. This allowed the CFM and CO₂ analysts to be chained to their respective benches for 12 hours at a stretch, except for meals, which the mess men refused to deliver. J. Kiddon, D. Robinson, M. Trunnel and the Brazilian observer, E. de Jesus, were particularly helpful as alternate samplers. Names (initials) of sample-persons were usually entered on the master sample log sheet so that individual performance could be monitored.
- 4) Sampling usually started with the bottom bottle (#36), 15-20 minutes after the rosette arrived on deck. However, in order to minimize total cast sample time and standby time by sample-persons, the bottles were frequently not sampled sequentially. On typical stations all gas sampling was completed within 1.5 hours of the time the first bottle was opened. In addition, all gas samples were usually drawn within 6 minutes after any particular bottle was opened. On the "Keeling Station" it took 8.25 minutes to draw oxygen, 2 Lamont CO samples, 2 Keeling CO₂ samples and 2 more Lamont CO₂ samples.

LARGE VOLUME SAMPLING

Large volume samples (250 k) were collected for carbon-14, radium-228, krypton-85, and argon-39. These constituents were extracted from the water on board ship and returned to various shore based laboratories for analysis. The water was collected using Gerard barrels (one barrel per sample except for argon-39 which required 6). Also barium samples were collected from the Niskin bottles attached to Gerard barrels. The normal procedure for obtaining a vertical profile of large volume samples is to perform two 9-barrels casts. However, with only 2 barrels available for leg 2, it was impractical to collect many deep samples. The upper 1000 m was sampled as planned by performing four 2-barrel casts and pumping a surface sample. Deep samples were obtained from the core of the AABW and NADW boundary currents in the Brazil Basin. Argon-39 samples were collected only from AAIW by performing three 2-barrel casts to the salinity minimum at about 700 m. To save time, the ship steamed toward the next station while the two barrels were being processed and stopped when the barrels were ready to reuse.

This resulted in a sample collected over a horizontal distance of 20–30 na. mi. in the relatively homogeneous AAIW.

In choosing the depths for the large volume samples, an attempt was made to sample the σ_θ surfaces 25.6, 26.2, 26.5, 26.8, 27.1, and 27.4, and the AAIW salinity minimum. To obtain good vertical coverage of the upper 1000 in and sample other features, one density surface often had to be dropped. CFM data collected at the previous station was used to aid in choosing sample depths. Underway/XBT Program

On SAVE-2, the underway XBT program was continued in approximately the same fashion as initiated on leg 1. Two T-7 (750 m) XBT casts were usually taken between each CTD station, accompanied by water samples for dissolved oxygen, $p\text{CO}_2$, TCO_2 , salinity and nutrients. Samples were drawn from the 10 l Niskin bottle mounted in the rosette room. Except during sampling, this bottle was continually being flushed via inflow through its stopcock and outflow thru its former air vent. The KNORR's clean seawater line draws from a depth of about 5 m and travels 60 m before reaching the Niskin bottle (Chief Eng'r, p.c.). A thermistor in-line ahead of the bottle was used to obtain the underway water temperature at 5-minute intervals. Acquisition and storage of this temperature data was overseen by PACODF's C. Mattson. An adjustment of $-.08^\circ\text{C}$ accounted for cooling while in the ship's line and agreed closely with 2 out of 3 CTD temperature checks. XBT casts and underway sampling were ably handled by the 3rd person on the deck watch, i.e., S. Birdwhistell and D. Kaminsky on SAVE-2.

Approximately 117 T-7 XBT casts were made on SAVE-2 with Sippican hand-launchers with only minor operational problems. A WHOI Sippican MK-9 XBT system interfaced with a HP-85 computer and two disk drives were utilized for data acquisition. The XBT data were stored on 3.5" floppy disks, but no post-cast plotting or data reduction has been done as of this writing. All plastic waste generated by the XBT program was retained aboard and offloaded with other trash in Rio.

BATHYMETRY

Depth was measured continuously along the entire cruise track using a 12 KHz precision depth recorder. The raw data was digitized by hand at 5 minute intervals and a tape of the reduced data will be produced by the Geological Data Center at Scripps.

NUMBER OF SAMPLES COLLECTED

On SAVE leg 2 there were 62 small volume (36-bottle rosette) stations, of which one (#44) was a test station (all bottles tripped at 1000 m). Several stations where the water was < 1500 m consisted of 24 or fewer bottles. In addition, 93 casts were made with large volume (Gerard) barrels, usually 2 barrels per cast in the upper 1000 m. The approximate number of samples processed or collected in each category was as follows:

Salinity	2,600
Oxygen	2,400
Nutrients	2,300 (silicate, phosphate, nitrate & nitrite)
Helium	600
Tritium	600
Total CO ₂	1,640
pCO ₂	990
Freons	1,760 (F-11 and F-12)
0-18	280
Suspended particulates	270
C-14	153
Ar-39	4
Ra-228	150
Barium	150
Kr-85	60
N-15	44

These estimates include underway samples, and replicates, and are not adjusted for blanks, standards or discarded samples.

OPERATIONAL PROBLEMS

On leg 1 there were two problems that affected leg. 2. Most serious was the loss of 9 Gerard Barrels when the trawl wire parted leaving only two Gerard Barrels on board. Eight more Gerard Barrels at Scripps were prepared for shipment and booked on flights scheduled to arrive in Abidjan on December 18. At 0200 on December 18, we were advised by phone that the barrels had not left Los Angeles, and at 1730 we were informed that at least a week would be required to ship the barrels to Abidjan because of Christmas shipments. At 1800 on 18 December R/V KNORR departed with only two Gerard Barrels on board. We were able to obtain all planned samples in the upper 1000 in as previously described, but time constraints allowed us to take only 8 deep samples at the western margin.

The second problem occurred on the last station of leg 1 when one of the three conductors in the CTD wire shorted out. The PACODF electronic technician, Carl Mattson, estimated from resistance measurements that the short was at about 6300 m from the working end of the wire. The wire was hand-wound onto a spool on the dock and inspected. No visible evidence of wire damage was seen near 6400 m and the short disappeared when the wire was not under tension. However, it was feared that the wire was damaged internally and that the problem would recur, possibly involving more than one conductor, when the wire was under tension. Therefore, it was decided to cut out the wire that had failed and the 6300 m of good wire was wound back onto the winch. The wire had to be streamed at sea and

rewound onto the winch under tension, which was done during the steam to the first station. During streaming, a knot developed at 200 m from the working end and the next 300 in was kinked. The knot was cut off and a decision made to use the wire with kinks so that the bottom could be reached on all stations. At this point the total length was about 5950 m with a working length of about 5700 m. The wire had begun to unlay at some of the kinks, but most strands worked back together with use and we were able to complete the leg without further substantial cuts.

Two accidents occurred on the cruise. The small Daybrook crane failed when the end cap to the main hydraulic piston blew off. The arm crashed to the deck, damaging the CTD cart track. Both the track and crane were repaired and no time was lost. The other accident was the loss of the CTD wire weight caused when the wire snagged on a notch in the cart guard rail. The weight was pulled off the wire and the 5 pound CTD clamp came back through the sheave and fell on deck from a height of about 20 feet, narrowly missing one of the deck crew. We were very fortunate that no one was injured from either of these accidents.

SAMPLE CONTAMINATION

During leg 1 there was considerable concern and some evidence that gas samples drawn from Niskin bottles (i.e., oxygen, CFM, helium-3, pCO₂, and total Ca²⁺) were being affected by interaction with the atmosphere during the time required to complete the sampling. We attempted to minimize this potential problem by reducing the time required for sampling as described previously. We also ran several experiments to determine how severe the problem was as a follow up to the experiments run on leg 1. The result of these experiments are summarized below.

Oxygen concentration versus time

Two experiments were run with Niskin bottles tripped in the oxygen minimum zone and sampled repeatedly for 15–25 minutes. For the first experiment, only oxygen samples were drawn and the oxygen concentration was constant within the precision of the measurement (0.005 ml/l) until 7.5 minutes (Figure 2), after which it increased, indicating atmospheric contamination. For the second experiment, oxygen and CFM samples were drawn sequentially and oxygen concentration was essentially constant for 10 minutes (Figure 3), after which it increased. Only 2 liters of water remained in the bottle after the last oxygen samples was drawn.

CFM concentration versus time

Three experiments were run with CFMs using samples collected from low-CFM water. In the first experiment, early in the cruise, CFM concentration increased, then decreased, and then increased again with time (Figure 4). In the other two experiments, CFM concentration was constant for 11 min. (Figure 3) and 18 min. (Figure 5) before beginning to increase.

Duplicate CFM samples

On most stations, one or two duplicate CFM samples were collected. The first CFM sample was the first sample to be collected from the Niskin bottle and the second sample was collected after either an oxygen sample or an oxygen and a helium-3 sample were drawn. The duplicate CFM samples were taken over a wide concentration range, but most samples were undersaturated so the second sample should have had a higher concentration if atmospheric contamination were occurring. Differences between the two samples reveals no systematic trend, but are higher than would be expected for the 0.005 pmol/l analytical precision (Figure 6).

Duplicate oxygen samples

On some stations, one or two Niskin bottles were sampled first for oxygen, followed by a CFM sample and then another oxygen sample. The differences in these oxygen replicates show that the second sample consistently had a higher concentration than the first by about 0.01 ml/l (Figure 7). However, at the station where Keeling CO₂ samples were collected, there was no difference in duplicate Niskin bottles tripped at the same depth (Figure 8). Oxygen was drawn first out of one bottle and after CFM and helium-3 from the other bottle.

Comparison of oxygen concentrations from Gerard and Rosette casts

On most large volume stations, the Gerard barrels provided oxygen samples which are less likely (than rosette bottles) to be affected by interaction with the atmosphere during sample drawing. A comparison between rosette and Gerard casts made by plotting oxygen against potential temperature for each station showed excellent agreement between the two casts. However, the change in oxygen concentration with respect to potential temperature was fairly large in the upper 1000 m and this technique was not sensitive to differences as small as 0.01 ml/l.

Salinity versus time

Two experiments were run in which about 1 liter of fresh water was added to a Niskin bottle at the top. This was suggested by T. Field as a barrier to retard gas exchange between the sea water and atmosphere. Mixing between the fresh water cap and the seawater sample should be retarded by the strong density gradient. Salinity samples drawn sequentially revealed salinity to be constant for 20 minutes i.e., until the Niskin bottle was half empty.

Conclusion

The general consensus of these experiments is that if gas samples are drawn within seven minutes after a Niskin bottle is opened atmospheric contamination is less than the error of the measurement. On SAVE leg 2, rarely was more than seven minutes required to draw gas samples.

PRELIMINARY COMPARISONS TO HISTORICAL DATA

Two CEOSECS stations and one AJAX station were reoccupied during this leg. Plots of several SAVE parameters and earlier measurements against potential temperature and pressure for depths greater than 2000 m indicated systematic offsets, which are summarized in Table 1.

Table 1: Comparison of SAVE data with previously collected data. Differences are SAVE minus previous data.

Stations	Pot. Temp. Difference (°C)	Salinity Difference (psu)	Oxygen Difference (µM/kg)	Nitrate Difference (µM/kg)	Phosphate Difference (µM/kg)	Silica Difference (µM/kg)
SAVE 68 (CEOSECS 107)	-0.015	+0.004	-2.5	+0.4	+0.03	-1
SAVE 69 (AJAX 20)	+0.01	-0.002	-5	0	-0.04	-0.5
SAVE 95 (GEOSECS 55)	0	0	-2.5	+0.3	0	-1

The differences between SAVE and GEOSECS oxygen concentrations are similar to the differences between TTO and CEOSECS observed by Broecker et al. (1985) in the deep northeastern Atlantic Ocean and attributed by them to calibration differences between cruises. However, the differences between SAVE 68 and GEOSECS 107 in the Angola Basin could also be explained by an increase in degradation of organic matter because the decrease in oxygen is accompanied by an increase in nitrate and phosphate in roughly Redfield proportions. The oxygen difference between SAVE and AJAX is larger and is likely to represent a calibration problem since the decrease in oxygen is accompanied by a decrease in phosphate and no change in nitrate. Also, problems with the oxygen analysis resulting in high oxygen concentrations for the early portion of the expedition are reported in the AJAX data report (Nierenberg, et al. (1985).

PRELIMINARY UNDERWAY OBSERVATIONS

Plots of SAVE-2 underway data (e.g., [Figure 9](#)) show some of the large-scale trends and a general consistency between underway and station data. There are sections of the transects where underway values appear to be slightly higher or lower than the CTD/rosette values. Simultaneous comparisons were not made between samples from the rosette and underway systems at the same depth. A positive silicate anomaly coupled with a negative salinity anomaly extending over 200 km on the Abidjan to Angola transect may result from a Congo River plume. A cyclical surface temperature variability is suggestive of some diurnal heating pattern, but the ship's intake depth seems rather too deep to pick up that effect.

PRELIMINARY VERTICAL SECTIONS

Major features observed in vertical sections of temperature, salinity, oxygen and nutrients are highlighted below. Oxygen and nutrient distribution in the thermocline

There is a strong oxygen minimum in the thermocline that is most intense at about 10°S at the eastern boundary. This feature is centered at ~ 400 in and is present throughout both sections, but concentration increases to the north and west. A nutrient and total CO₂ maximum is situated about 200 in deeper than the oxygen minimum and also weakens to the north and west. Above the oxygen minimum, oxygen isopleths deepen from east to west, as do F-11 and F-12 isopleths, indicating stronger thermodynamic ventilation to the west.

Antarctic Intermediate Water

AAIW is observed throughout both sections as a salinity minimum at 700–800 in depth. It is most intense adjacent to the western boundary, where relatively high oxygen, F-11, and F-12 concentrations are also observed.

North Atlantic Deep Water

The NADW complex consists of upper NADW, lower NADW, and the water in between these two water types. Upper NADW is characterized by a vertically broad salinity maximum that is centered at about 1800 m. This feature is found throughout both sections, but highest salinity occurs at the western boundary and at the equator. CFM concentrations are also relatively high at these locations suggesting that the southward flow of upper NADW splits into two branches near the equator, one that flows eastward along the equator and one that flows southward along the western boundary.

Lower NADW is characterized by an oxygen maximum that is most intense at the western boundary and extends across the Brazil Basin to the midocean ridge.

Antarctic Bottom Water

AABW fills the Brazil Basin below about 3800 m. It is characterized by low temperature, salinity, and oxygen concentration and is found in its purest form at the bottom near the 4900 m isobath. Low CFM concentrations were observed in AABW with highest concentrations also at the 4900 m isobath. The presence of CFMs suggest a transport time from its region of formation of no more than 30 years.

Deep Angola Basin Water

The deep water of the Angola Basin has temperature and salinity characteristics of a mixture of NADW and AABW. However, the oxygen and nutrient concentrations have been altered by processes occurring within the basin. The most prominent feature in the deep water is an oxygen minimum which coincides with a nutrient and carbon dioxide maximum. This feature is most intense at the base of the continental slope and extends from there throughout most of the Angola Basin at a depth of about 3500 m. It may be caused by oxygen consumption and nutrient regeneration in the continental rise sediments.

Another important feature in the oxygen distribution is a maximum at the bottom banked against the mid-ocean ridge. This may be indicative of southward flow of deep water that has passed through the Romanche Trench to the north.

References

- Broecker, W.S., C. Rooth, and T.-H. Peng, 1985. Ventilation of the Deep Northeastern Atlantic. *J Geophys Res.* **90** (C4), 6940–694L.
- Nierenberg, W.A., and W.D. Nowlin, Jr., 1985. Physical, Chemical and In Situ CTD Data from the AJAX Expedition aboard R/V *KNORR*. 510 Ref. 85–24, Tamu Ref. 85–4–D, 275 pp.

SAVE LEG II 1987-'88

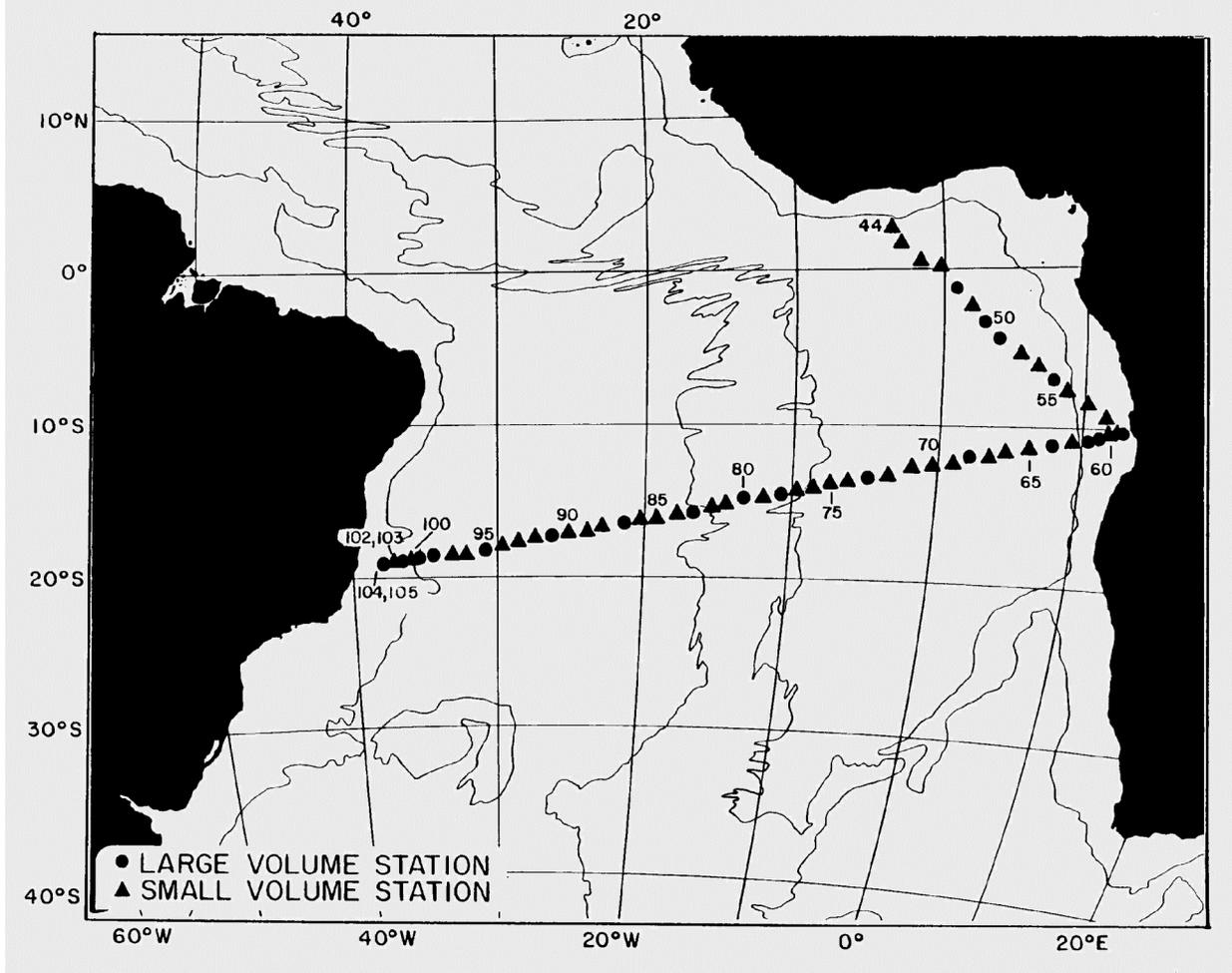


Figure 1: Station locations for SAVE Leg 2.

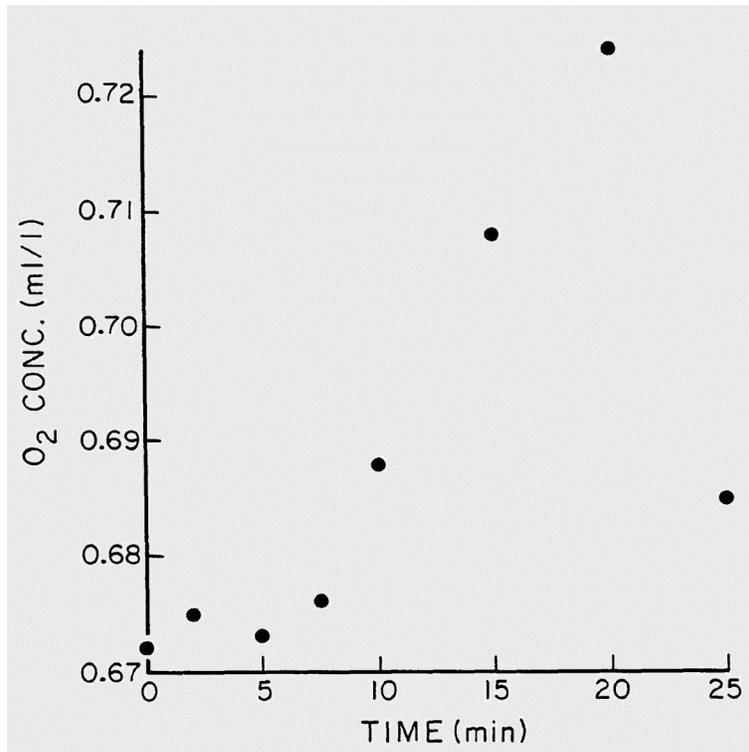


Figure 2: Oxygen concentrations vs. time after initial sample for a Niskin bottle.

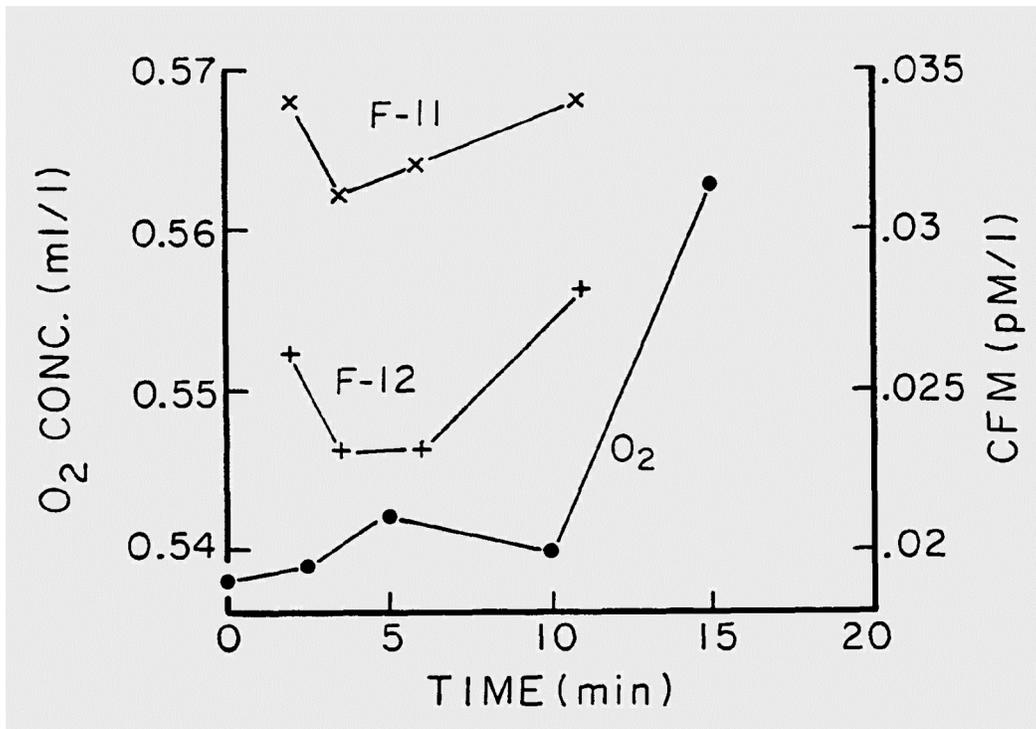


Figure 3: Oxygen, F-11, and F-12 concentrations vs. time after initial sample for a Niskin bottle.

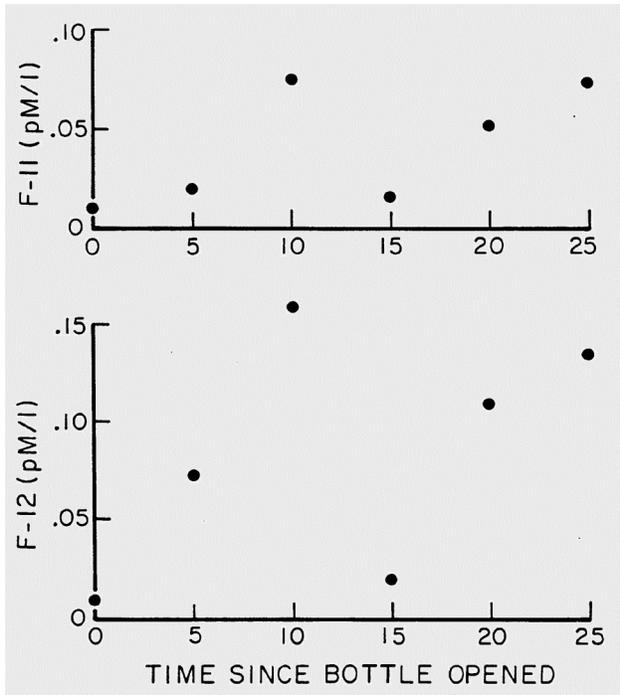


Figure 4: *F-11 and F-12 vs. time after initial sample for a Niskin bottle.*

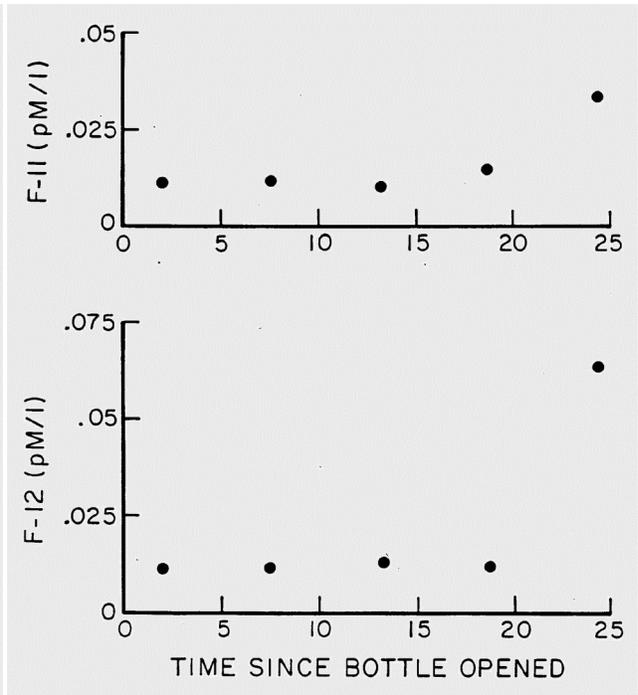


Figure 5: *F-11 and F-12 vs. time after initial sample for a Niskin bottle.*

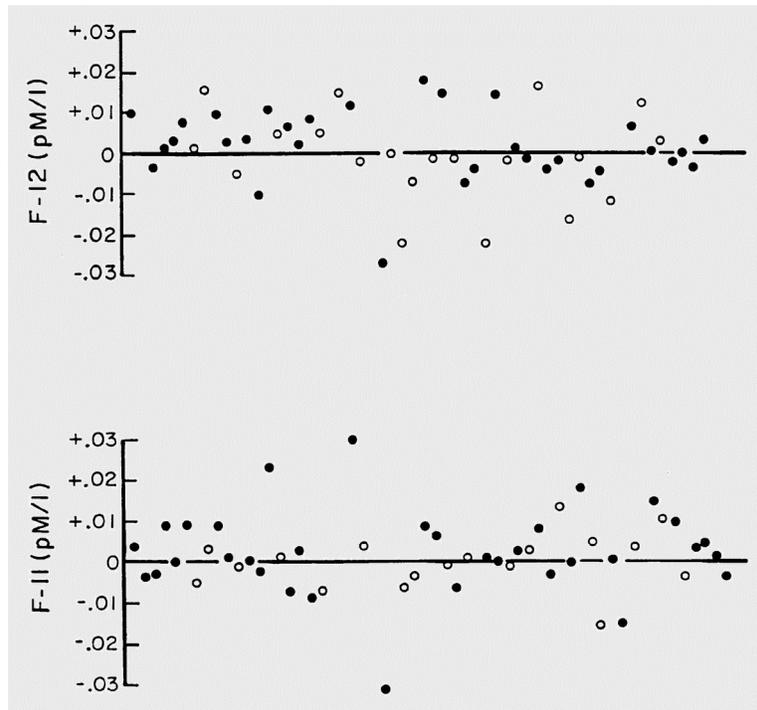


Figure 6: *Difference in F-11 and F-12 concentrations for replicate samples. Initial CFM sample was the first sample to be drawn from the Niskin bottle. Solid circles represent an oxygen sample drawn between the CFM replicates and open circles represent an oxygen and a helium-3 sample drawn between the CFM replicates.*

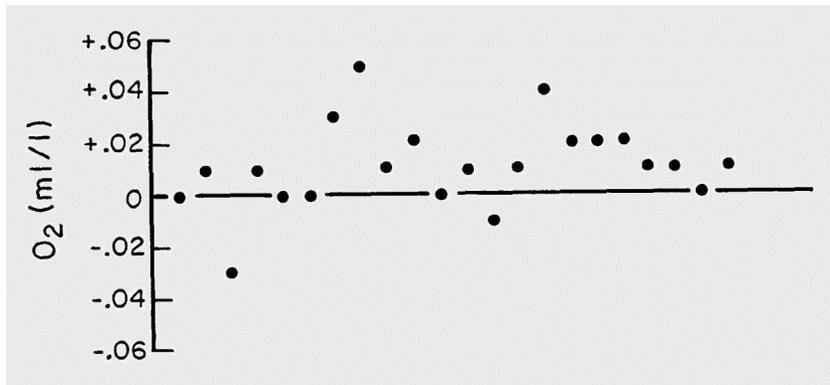


Figure 7: Difference in oxygen concentrations for replicate samples. The initial oxygen sample was the first sample drawn and the second oxygen sample was drawn after a GEM sample.

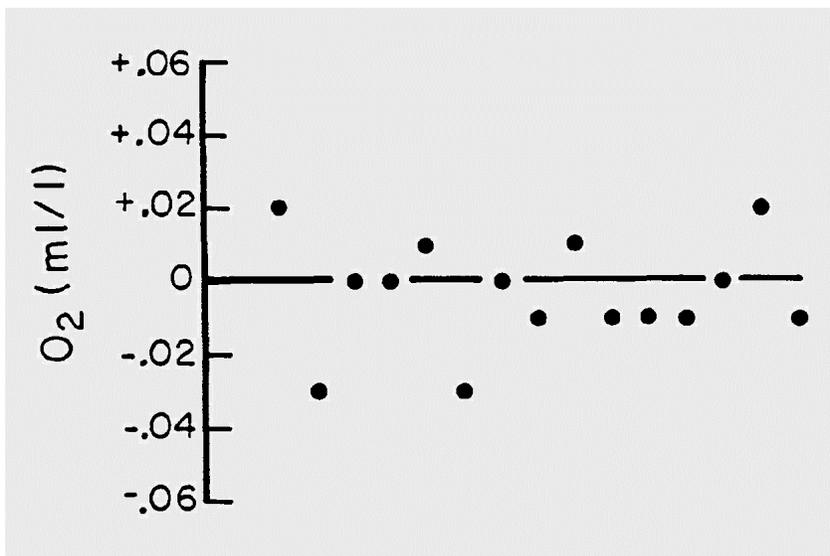


Figure 8: Difference in oxygen concentration between two Niskin bottles tripped at the same depth. Oxygen was drawn first from one of the Niskin bottles and in its normal sequence from the other Niskin bottle.

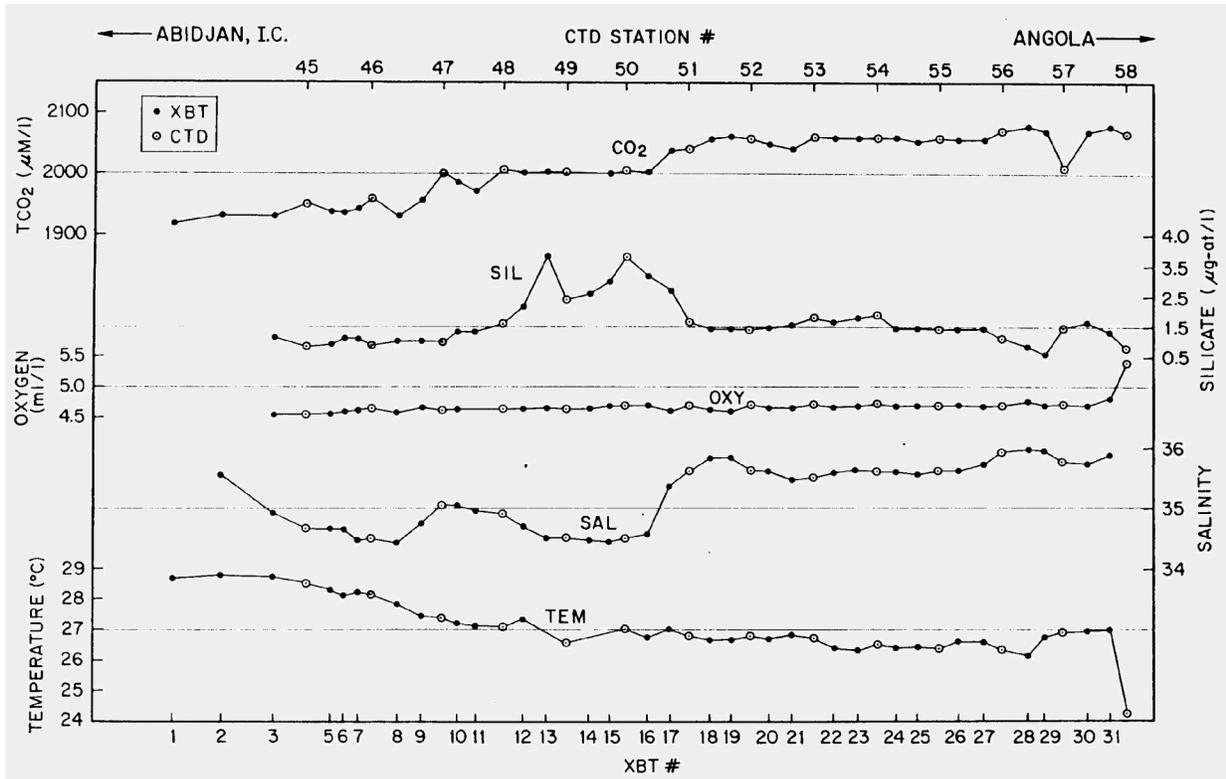


Figure 9: Sea surface observations at the locations of CTD and XBT casts between the Ivory Coast and Angola (Figure 1). Preliminary and partial data.

List of participants

Ship's Captain

Richard Bowen - Woods Hole Oceanographic Institution

Chief Scientist

William M. Smethie
Lamont-Doherty Geological Observatory

Co-chief Scientist

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Scot P. Birdwhistell
Danuta Karninski

Brazilian Naval Observer

Cpt. Emmanuel Bonfim de Jesus

CCHDO Data Processing Notes

Event Date	Contact	Date Type	Summary
2011-04-08	<i>Muus, Dave</i>	BTL	Exchange, NetCDF, WOCE files online Notes on Save Leg 2 rosette sample data. EXPOCODE 316N19871218 110406/dm 1. Temperature, salinities, oxygen and nutrients taken from ODF data, whprpasave2, dated Aug 25, 2005. 2. CFCs and CO2 data merged from file SAVEsv.csv received from R. Key Dec 10, 2010. 3. No PCO2 flags in SAVEsv.csv. Assigned flag 2 to all PCO2 values. Sta 89 Ca 1 Btl #23 PCO2 is 155 UATM high; changed flag from 2 to 3. Sta 91 Ca 1 Btl #12 PCOS is 700 UATM low; changed flag from 2 to 4. 4. Deleted Station 48 Cast 2 Bottle 18 from SAVEsv.csv. Cast 2 is Gerard cast, Bottle 18 is rosette bottle. Deleted Station 64 Cast 3 Bottle 24 from SAVEsv.csv. Cast 3 is Gerard cast, Bottle 24 is rosette bottle. Deleted Station 68 Cast 4 Bottle 13 from SAVEsv.csv. Cast 4 is Gerard cast, Bottle 13 is rosette bottle. Deleted Station 83 Cast 4 Bottle 14 from SAVEsv.csv. Cast 4 is Gerard cast, Bottle 14 is rosette bottle. Deleted Station 87 Cast 2 Bottle 17 from SAVEsv.csv. Cast 2 is Gerard cast, Bottle 17 is rosette bottle. Deleted Station 91 Cast 2 Bottle 21 from SAVEsv.csv. Cast 2 is Gerard cast, Bottle 21 is rosette bottle. Deleted Station 95 Cast 3 Bottle 1 from SAVEsv.csv. Cast 3 is Gerard cast, Bottle 1 is rosette bottle. 5. CTDTMP units ITS-68 not ITS-90.