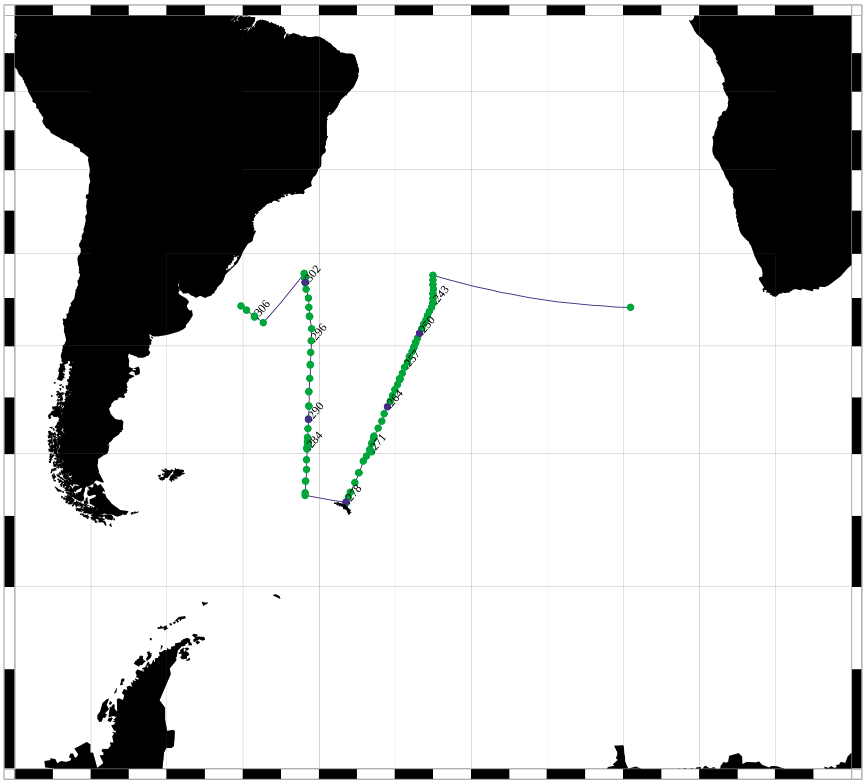
1. Cruise Narrative: A16S

(Last update: 2004.09.24)



1.1. Highlights

WHP Cruise Summary Information

WOCE section designation	**A16S**
Expedition designation (EXPOCODE)	**318MSAVE5**
Chief Scientist / affiliation	**Dr. William A. Smethie / LDEO**
	Dr. Michael McCartney / WHOI
Cruise dates	1989.JAN.23 - 1989.MAR.08
Ship	*R/V MELVILLE*
Ports of call	Cape Town, South Africa to Montevideo, Uruguay
Number of stations	73 CTD/Rosette (13 Large Volume)
Stations' geographic boundaries	32°16.70' S 50°15.60' W 00°59.10' E 53°58.10' S
Floats and drifters deployed	0
Moorings deployed or recovered	0

Chief Scientist contact info.

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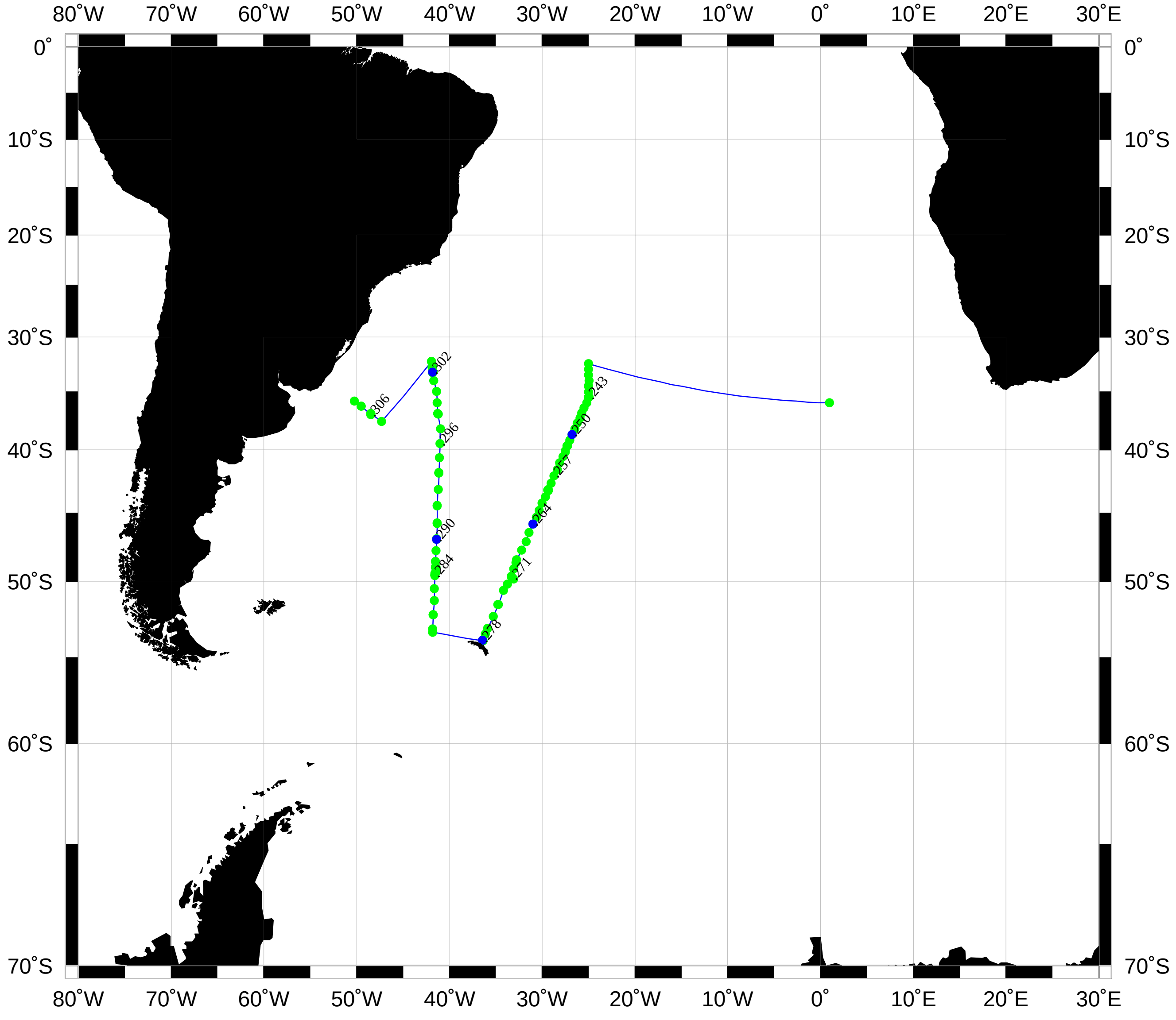
Click to go to text location or use Acrobat Reader navigation tools.
Shaded headings were not applicable to this cruise or were not available when this report was assembled.

Station locations for A16S • Smethie • *R/V Melville* • 1989



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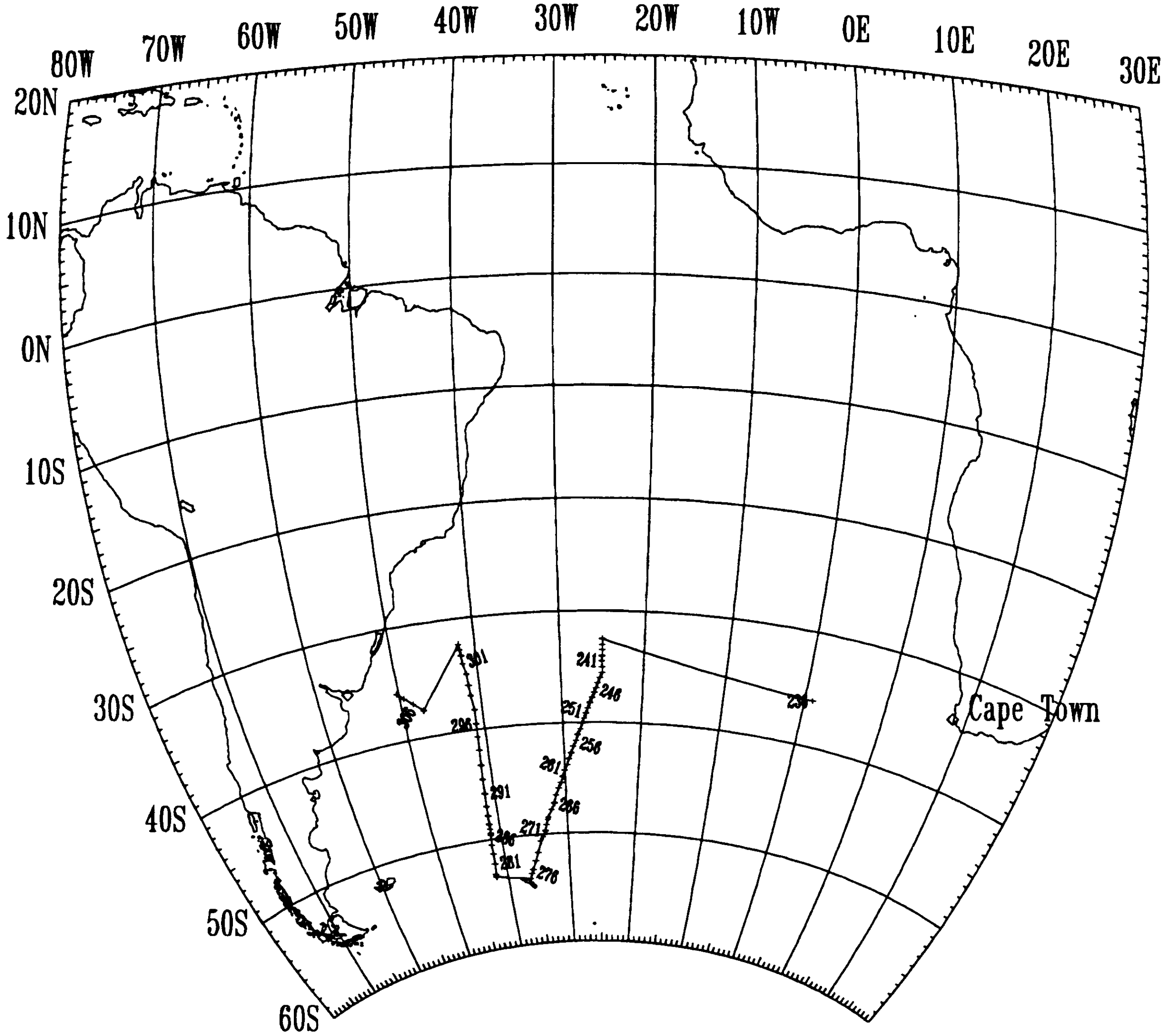
South Atlantic Ventilation Experiment

Cape Town, South Africa to Montevideo, Uruguay
23 January 1989 - 8 March 1989
Stations 236 through 308



SAVE-5/HYDROS-3
R/V MELVILLE

Lambert equal-area Projection

SOUTH ATLANTIC VENTILATION EXPERIMENT
(SAVE)
Leg 5
R/V MELVILLE
23 January 1989 - 8 March 1989
Cape Town, South Africa to Montevideo, Uruguay

Data Report Prepared by:

Oceanographic Data Facility
Scripps Institution of Oceanography
University of California, San Diego
April 1992

Sponsored by:

National Science Foundation
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SIO Reference 92-10

Chief Scientist's Overview

Leg 5 of SAVE (denoted Hydros 3 by Scripps, and A16C for the WOCE project) was carried out on the R/V Melville and was actually a combination of a meridional section across the Argentine Basin at 41°W and a short section perpendicular to the western boundary at about 35°S planned as part of SAVE, and the southern end of a meridional. long line in the Atlantic Ocean planned by M. McCartney, L. Talley and M. Tsuchiya that extended from 32.5°S, 25°W to South Georgia Island

The cruise departed from Cape Town on January 23,1989 at 1400. The first station, a reoccupation of AJAX station 44 at 36°S, 1°E, was taken on January 26. Work began on the 25°W line on February I with station 237 taken at 32°30' S, 25°00' W. The southernmost station (278) just north of South Georgia Island was taken on February 17. The station spacing was about 30 na. mi. along this line. The section along 41°W (stations 279-304) was occupied between February 18 and March 2 with a station spacing of about 65 na. mi. The portion of the western boundary section outside Uruguay's 200 mile zone (stations 305-308) was taken between March 4 and March 6. Stations inside Uruguay's 200 mile zone were taken on the following leg when an Uruguayan observer was on board. The cruise ended in Montevideo on March 8, one day later than scheduled. The one day delay was caused by a breakdown of the main engine, which was repaired at sea.

The total number of miles steamed was 5989 and the total number of CTD-rosette stations occupied was 73. These stations were taken using a Neil Brown CTD interfaced to a Scripps Ocean Data Facility rosette equipped with thirty-six 10 liter bottles. At 13 of the stations large volume samples were collected using Gerard barrels. Generally 18 large volume samples were collected between the surface and the bottom. The total steaming time for the cruise was 25 days, 15 hours and the total station time was 17 days, 5 hours. Originally, 81 stations had been planned, but 8 stations were dropped because of time lost during rough weather. Approximately 1.25 days were lost because of slow steaming and greater time required to complete casts in rough weather and an equal amount of time us lost because of equipment failures during rough weather. Most of the equipment failures were Gerard barrels not tripping properly and breaks in the CTD termination.

List of Participants

Ship's Captain	Curtis D. Johnson	Scripps Institution of Oceanography
Chief Scientist	William M. Smethie, Jr.	Lamont-Doherty Geological Observatory
Co-chief Scientist	Michael S. McCartney	Woods Hole Oceanographic Institution

IFREMER, Brest, France	Kevin G. Speer
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	Richard P. Cember
	Mieczyslawa Klas
	Kathy A. Tedesco
Massachusetts Institute of Technology	Stephen G. Zemba
Physics Institute of Bern, Switzerland	Jose M. Rodriguez
Princeton University	Richard J. Rotter
Scripps Institution of Oceanography/ODF	David L. Bos
	Carol Conway
	Frank M. Delahoyde
	Arthur W. Hester
	John K. Jain
	Leonard T. Lopez
	Douglas Masten
	David A. Muus
Scripps Institution of Oceanography	George H. Bouchard
	Ronald L. Comer
	Frederick A. Van Woy
Texas A&M University	Bret B. Bergland
Woods Hole Oceanographic Institution	Danuta Kaminski
	Jan C. Zemba

Leg	**STATIONS**	**DEPARTURE**	**ARRIVAL**
1	1 through 43	Recife, Brazil	Abidjan, Ivory Coast
		23 November 1987	13 December 1987
2	44 through 105	Abidjan, Ivory Coast	Rio de Janeiro, Brazil
		18 December 1987	23 January 1988
3	106 through 170	Rio de Janeiro, Brazil	Abidjan, Ivory Coast
		29 January 1988	7 March 1988
4	171 through 235	Punta Arenas, Chile	Cape Town, South Africa
		7 December 1988	15 January 1989
5	236 through 308	Cape Town, South Africa	Montevideo, Uruguay
		23 January 1989	8 March 1989
HYDROS-4	309 through 379	Montevideo, Uruguay	Bridgetown, Barbados
		13 March 1989	19 April 1989

1. Introduction

The broad objectives of the South Atlantic Ventilation Experiment (SAVE) are to investigate the rates of ocean circulation, mixing, ventilation, inter-ocean exchange, and carbon, oxygen and nutrient cycling on an ocean basin scale. Transient and radioactive tracers are well suited for pursuing these objectives because they integrate over various spatial and temporal scales, providing strong constraints on time-averaged rates of circulation and mixing, and revealing pathways between the air/sea interface and the abyssal ocean that are not always discernible from traditional hydrographic and nutrient observations. The results should lead to a better understanding of the ocean's major role in the earth's climate, via its control of the global heat and carbon dioxide budgets.

The specific problems that will be addressed include:

1) Exchange of South Atlantic waters with the North Atlantic, Pacific, Antarctic and Indian Oceans,
2) Formation and spreading rates of intermediate waters,
3) Thermocline ventilation rates and locations,
4) Rates of biologically-mediated metabolic processes,
5) Diapycnic processes,
6) Origins of deep and bottom waters and their spreading routes and rates.

Underway/XBT Program

XBT casts were usually taken between CTD stations. Where the station spacing was 30nm, one XBT was taken and for greater spacing 2 XBTs were taken. The XBT casts were accompanied by water samples for dissolved oxygen, pCO_2, salinity and nutrients taken from the Melville's clean seawater line.

Bathymetry

Depth was measured continuously along the entire cruise track using a 12KHz 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.

2. Bottle Data Collection, Analyses and Processing

ODF CTD/rosette casts were carried out with a 36-bottle rosette sampler of ODF manufacture using a General Oceanics pylon. An ODF-modified NBIS Mark 3 CTD and a SeaTech transmissometer provided by Texas A&M University (TAMU) were mounted on the rosette frame. Seawater samples were collected in 10-liter PVC Niskin bottles mounted on the rosette frame. These bottles were numbered 1 through 36, if one of these 36 bottles needed servicing and repairs could not be accomplished by the next cast, the replacement bottle was numbered 71-78. Added CTD levels, no water samples, were assigned bottle numbers 95-99. Subsets of CTD data taken at the time of water sample collection (a 10 second average) were transmitted to the bottle data files immediately after each cast to provide pressure and temperature at the sampling depth, and to facilitate the examination and quality control of the bottle data as the laboratory analyses were completed.

After each rosette cast was brought on board, water samples were drawn in the following order: Freon, Helium-3, Oxygen, Oxygen-18, pCO_2. $\sum CO_2$, Tritium, Nutrients, Salinity and Suspended Particulate Matter. Other ancillary program samples were drawn after the core samples. The samples and the Niskin sampler they were drawn from were recorded on the Sample Log sheet. Comments regarding validity of the water sample (valve open, lanyard caught in lid, etc.) were also noted on the Sample Log sheets.

Table 1 is a tabulation of samples collected during all six legs [SAVE Legs 1 through 5 (STS/ODF, 1992) and HYDROS Leg 4 (STS/ODF, 1992)] unless otherwise noted and includes the Principal Investigators and their institutions. Samples collected on each station are tabulated in the Station and Cast Description.

Gerard casts were carried out with -270 liter stainless steel Gerard barrels on which were mounted 2-liter Niskin bottles with reversing thermometers. Samples for salinity, ^{14}C, ^{228}Ra, ^{39}Ar, and ^{85}Kr Were obtained from the Gerard barrels. The Gerard barrels were numbered 81 through 91 and the piggy-back Niskin were numbered 41 through 70. Surface samples taken from the ship's underway pump line were assigned a bottle number of 98 through 99. Salinity check samples were always drawn from the Niskin bottles for comparison with the Gerard barrel salinities to try to verify the integrity of the Gerard sample. Occasionally, barium and some of the samples normally taken from the rosette were also drawn from the Gerard-mounted Niskin bottle. These were also recorded on a Sample Log sheet.

The discrete hydrographic data were entered into the shipboard data system and processed as the analyses were completed. The bottle data were brought to a useable, though perhaps not final, state at sea. ODF data checking procedures included verification that the sample was assigned to the correct level. This was accomplished by checking the raw data sheets, which included the raw data value and the water sample bottle, versus the sample log sheets. Any comments regarding the water samples were investigated. The raw data computer files were also checked for entry errors. Investigation of data included comparison of bottle salinity and oxygen with CTD data, and review of data plots of the station profile alone and compared to nearby stations.

If a data value did not either agree satisfactorily with the CTD or with other nearby data, then analyst and sampling notes, plots, and nearby data were reviewed. If any problem was indicated the data value was flagged or deleted. (However, ODF preserves in its archives all bottle data values). The Bottle Data Processing Notes section includes comments regarding deletion of samples.

If it was determined that an entire 10 liter water sample was contaminated by leakage or other bottle or rosette malfunction, the level is reported with just the CTD data (pressure, temperature and salinity). This has been done to preserve the profile and accommodate investigators who prefer using bottle data files exclusively.

The number of the various types of samples:

Parameter	# Of Samples	Parameter	# Of Samples
discrete salinity	3179	pCO_2	845
discrete temp.	546	suspended part.	369
oxygen	2530	Keeling $C0_2$ Neodynium	20
nutrients	2517	Barium	280
CFMs	1592	^{14}C	187
Helium-3	346	Ra-228	237
Tritium	346	Kr-85	87
TCO_2	1040	Ar-39	13

2.1. Pressure and Temperatures

All pressures and temperatures for the Niskin bottle data tabulations on the rosette casts were extracted from the processed CTD data, usually those from the corrected 10-second average bottle trip files collected during the up cast (see CTD Data Collection, Analyses and Processing).

Gerard pressures and temperatures were calculated from Deep-Sea Reversing Thermometer (DSRT) readings. Each DSRT rack normally held 2 protected (temperature) thermometers and I unprotected (pressure) thermometer. Thermometers were read by two people, each attempting to read a precision equal to one tenth of the thermometer etching interval. Thus, a thermometer etched at 0.05 degree intervals would be read to the nearest 0.005 degrees. Each temperature value is therefore calculated from the average of four readings.

> IT SHOULD BE CLEARLY NOTED THAT THE TEMPERATURES PRODUCED AND PUBLISHED BY ODF IN THIS REPORT ARE BASED ON THE INTERNATIONAL PRACTICAL TEMPERATURE SCALE OF 1968, RATHER THAN THE CURRENTLY USED INTERNATIONAL TEMPERATURE SCALE OF 1990.
>
> (The expedition took place before 1 January 1990, the starting date for ITS-90).

2.2. Salinity

Salinity samples were drawn into ODF citrate salinity bottles which were rinsed three times before filling. Salinity was determined after sample equilibration to laboratory temperature, usually within about 8-36 hours of collection. Salinity has been calculated according to the equations of the Practical Salinity Scale of 1978 (UNESCO, 1981) from the conductivity ratio determined from bottle samples analyzed (minimum of two recorded analyses per sample bottle after flushing) with a Guildline Autosal Model 8400A salinometer standardized against Wormley P-108 standard seawater, with at least one fresh vial opened per cast, or from the corrected CTD conductivity, temperature, and pressure.

Accuracy estimates of bottle salinities run at sea are usually better than 0.002 psu relative to the specified batch of standard. Although laboratory precision of the Autosal can be as small as 0.0002 psu when running replicate samples under ideal conditions, at sea the expected precision is about 0.001 psu under normal conditions, with a stable lab temperature. Still, because a small droplet of fresh water, or the residue from a small evaporated droplet of seawater, can affect a bottle salinity in the third decimal place, and because the Autosal salinometer is sensitive to environmental fluctuations, salinities from bottle samples have a lower true precision under field conditions than in the laboratory. ODF typically deleted the Niskin bottle salinity from this report, and substituted the corrected CTD salinity, whenever there was any question regarding its validity (see Bottle Data Processing Notes).

2.3. Oxygen

Samples were collected for dissolved oxygen analyses soon after the rosette sampler was brought on board and after CFC and Helium were drawn. Nominal 100 ml volume iodine flasks were rinsed carefully with minimal agitation, then filled via a drawing tube, and allowed to overflow for at least 2 flask volumes. Reagents were added to fix the oxygen before stoppering. The flasks were shaken twice; immediately, and after 20 minutes, to assure thorough dispersion of the $Mn(OH)_2$ precipitate. The samples were analyzed within 4-36 hours.

Dissolved oxygen samples were titrated in the volume-calibrated iodine flasks with a l ml microburet, using the whole-bottle Winkler titration following the technique of Carpenter (1965). Standardizations were performed with 0.01N potassium iodate solutions prepared from pre-weighed potassium iodate crystals. Standards were run at the beginning of each session of analyses, which typically included from 1 to 3 stations. Several standards were made up and compared to assure that the results were reproducible, and to preclude basing the entire cruise on one standard, with the possibility of a weighing error. A correction (-0.014 ml/l) was made for the amount of oxygen added with the reagents. Combined reagent/seawater blanks were determined to account for oxidizing or reducing materials in the reagents, and for a nominal level of natural iodate (Brewer and Wong, 1974) or other oxidizers/reducers in the seawater.

The assay of the finest quality K103 available to ODF is 100%, ±0.05%, but the true limit in the quality of the bottle oxygen data lies in the practical limitations of the present sampling and analytical methodology, from the time the rosette bottle is closed through the calculation of oxygen concentration from titration data. Overall precision within a group of samples has been determined from replicates on numerous occasions, and for the system as employed on this expedition, one may expect ±0.1 to 0.2%. The overall accuracy of the data is estimated to be ±0.5%.

TABLE 1: Scientific Programs

Participating Institutions	Principal Investigators	Scientific Programs	Leg
STS/ODF	Mr. David Wirth	Salinity	ALL
		Oxygen	ALL
		Nitrate, Nitrite, Phosphate, Silicate	ALL
		CTD Profiles	ALL
LDGO	Dr. Wallace S. Broecker	Carbon-14	ALL
MIAMI	Dr. H. Göte Ostlund		
MIAMI	Dr. Zafer Top		
WHOI	Dr. William J. Jenkins	Helium-3	ALL
		Tritium	ALL
PRINCE	Dr. Jorge L. Sarmiento	Radium-228	ALL
PRINCE	Dr. Robert M. Key	Radium-226	ALL
SIO	Dr. Ray F. Weiss	Freon-11	ALL
LDGO	Dr. William M. Smethie, Jr.	Freon-12	ALL
LDGO	Dr. William M. Smethie, Jr.	Krypton-85	ALL
BERN	Dr. Heinz Loosli	Argon-39	ALL
LDGO	Dr. William M. Smethie, Jr.		
BERN	Dr. J. H. Oeschger		
LDGO	Dr. Taro Takahashi	Total CO_2	ALL
		pCO_2	
LDGO	Dr. Arnold Gordon	XBT Profiles	ALL
LDGO	Mr. Stanley Jacobs		
ANCILLARY PROGRAMS			
TAMU	Dr. Wifford Gardner	Suspended Particulate Matter	ALL
		Transmissometer	ALL
SIO	Dr. Charles D. Keeling	Total CO_2	ALL
SIO/GDC	Mr. Stuart M. Smith	Bathymetry	ALL
LDGO	Dr. James K. B. Bishop	Barium	ALL
SIO	Dr. Ray F. Weiss	Underway $pN_{2}0$, pCO_2, pCH_4	ALL
		Underway Surface Measurements	ALL
LDGO	Dr. Andrew McIntyre	Coccolith	1
URI	Dr. Michael Bender	Oxygen-18	2
LDGO	Dr. K. K. Liu	Nitrogen-15	2
UH	Dr. Chris Measures	Beryllium Isotopes	3
		Aluminum	3
CNES/GRGS	Dr. Catherine Jeandel	Neodymium	4 & 5
SIO	Dr. Martin Whelen	^{13}C, ^{14}C in methane (air samples)	5

Institution Codes:

BERN	Physics Institute of Bern, Switzerland
CNES/GRGS	Observatorie of Midi-pyrenees, Toulouse, France
LDGO	Lamont-Doherty Geological Observatory of Columbia University
MIAMI	University of Miami
PRINCE	Princeton University
SIO	Scripps Institution of Oceanography
SIO/GDC	Scripps Institution of Oceanography/Geological Data Center
STS/ODF	Shipboard Technical Support/Oceanographic Data Facility
TAMU	Texas A & M
UH	University of Hawaii
URI	University of Rhode Island
WHOI	Woods Hole Oceanographic Institution

Oxygens were converted from milliliters per liter to micromoles per kilogram using the equation:

$$O_2[\mu m/kg]=O_2[ml/l]/(.022392*(1.0+\text{sigma theta}/1000.0))$$

The potential density anomaly, sigma theta, is the potential density in kg/m3 referenced to pressure=0, from which 1000 has been subtracted.

2.4. Nutrients

Nutrients (phosphate, silicate, nitrate and nitrite) analyses, reported in micromoles/kilogram, were performed on a Technicon AutoAnalyzer®. The procedures used are described in Hager et al. (1972) and Atlas et al. (1971). Standardizations were performed with solutions prepared aboard ship from pre-weighed standards; these solutions were used as working standards before and after each cast (approximately 36 samples) to correct for instrumental drift during analyses. Sets of 4-6 different concentrations of shipboard standards were analyzed periodically to determine the linearity of colorimeter response and the resulting correction factors. Phosphate was analyzed using hydrazine reduction of phosphomolybdic acid as described by Bernhardt & Wilhelms (1967). Silicate was analyzed using stannous chloride reduction of silicomolybdic acid. Nitrite was analyzed using diazotization and coupling to form dye; nitrate was reduced by copperized cadmium and then analyzed as nitrite. These three analyses use the methods of Armstrong et al. (1967).

Sampling for nutrients followed that for the tracer gases, CFCs, He, Tritium, and dissolved oxygen. Samples were drawn into -45 cc high density polyethylene, narrow mouth, screw-capped bottles which were rinsed twice before filling. The samples may have been refrigerated at 2 to 6°C for a maximum of 15 hours.

Nutrients were converted from micromoles per liter to micromoles per kilogram by dividing by sample density calculated at an assumed laboratory temperature of 25°C.

3. CTD Data Collection, Analyses and Processing

Year-2 of SAVE (Legs 4 and 5) were processed with Hydros-4 therefore there may be references made to Hydros-4. 209 CTD casts were completed using a 36-bottle rosette sampling system; 64 casts were completed on Save Leg 4, 74 on Save Leg 5 one of which was a test and not reported in this report, and 71 casts on Hydros-4. STS/ODF CTDs #1 and #2, modified NBIS Mark III-B instruments, were both used during SAVE-4; CTD-1 was used exclusively on SAVE-5 and Hydros-4. The CTD data were initially processed into a filtered, half-second average time-series during the data acquisition. The pressure and PRT temperature channels were corrected using laboratory calibrations. The conductivity/salinity channels were calibrated to salinity check samples acquired on each cast. The CTD time-series data were then pressure-sequenced into 2-decibar pressure intervals, and the pressure series oxygen channel was corrected to match oxygen check samples acquired on each upcast.

3.1. CTD Laboratory Calibrations

3.1.1. Pressure Transducer Calibration

Each CTD pressure transducer was calibrated in a temperature-controlled bath by comparison with pressures generated by a Ruska Model 2400 piston gage. The mechanical hysteresis loading and unloading curves were measured both pre- and post-cruise at cold temperature (-1 to 0.5°C bath) to a maximum of 8830 psi, and at warm temperature (28-30°C bath) to a maximum of 2030 psi.

3.1.2. PRT Temperature Calibration

The CTD-1 and all CTD-2 PRT temperature sensors were calibrated in a temperature-controlled bath by comparison with temperatures calculated from the resistance of a Rosemount Model 162CE standard platinum thermometer, measured by a NBIS model ATB 1250 resistance bridge. The Rosemount standard PRT was checked periodically in water and diphenyl ether triple-point cells. Seven or more calibration temperatures, spaced across the range of 0 to 30°C, were measured both pre- and post-cruise. The CTD-2 primary PRT temperature transducer was replaced after SAVE-4, station 185, so the pre- and post-cruise calibrations for that temperature channel are not comparable.

3.2. CTD Data Processing

3.2.1. CTD Data Acquisition

Eight data channels (pressure, temperature, second temperature, conductivity, dissolved oxygen, transmissometer, altimeter and elapsed time) were acquired by CTD-2 at a data rate of 25 Hz. CTD-1 acquired seven channels, having only one temperature transducer. The FSK CTD signal was demodulated by an STS/ODF-designed deck unit and output to an RS-232 bus interface. An Integrated Solutions, Inc. (ISI) Optimum V computer served as the real-time data acquisition processor.

Data acquisition consisted of storing all raw binary data on hard disk, then on magnetic cartridge tape, and generating a corrected and filtered half-second average time-series. Data calculated from this time series were reported and plotted during the cast. A 10-second average of the time-series data was calculated for each water sample collected during the data acquisition.

Generating the half-second time-series data set involved applying single-frame absolute value and gradient filters, then performing a two-pass 4,2 standard-deviation data rejection to all channels. During the acquisition, the pre-cruise laboratory calibration data were applied to pressure and temperature. Pressure, conductivity and oxygen were matched to the thermal response of the PRT temperature transducer. This lag time was determined using raw CTD data from the cruise. The conductivity and oxygen channels were corrected for thermal and pressure effects.

3.2.2. Pressure, Temperature and Conductivity/Salinity Corrections

A maximum of 36 salinity and oxygen check samples, plus 4 thermometric pressure and temperature measurements, were collected during each CTD cast. A 10-second average of the CTD time-series data was calculated for each trip time sample. The resulting data were then used to verify the pre- and post-cruise pressure and temperature calibrations, and to derive CTD conductivity/salinity and oxygen corrections.

3.2.2.1. CTD Pressure Corrections

3.2.2.1.1. CTD #2

The pre- and post-cruise pressure calibrations were compared. The warm/shallow calibration curve shifted by almost 3 decibars from pre- to post-cruise, and the cold/deep calibration curve shifted by 3.5 decibars. There were no notable slope differences between the two sets of calibrations. Offsets are adjusted automatically for each station as the CTD enters the water, so there were no significant differences between the two calibration results for CTD-2.

Since all CTD-2 casts were done during the first of the three Hydros legs, closer to the pre-cruise calibrations, no change was made to the shipboard CTD-2 pressure data, to which the pre-cruise pressure calibrations had already been applied. Thermometric pressures collected during the CTD-2 casts were minimal because of numerous lanyard hangups or other problems. The few acceptable check-pressure differences gave no indication of any problems with the CTD-2 calibrated pressures.

3.2.2.1.2. CTD #1

The laboratory calibration for CTD-1 at the end of Hydros-4 disclosed a pressure problem affecting all three Hydros (SAVE/Year-2) legs:

a. Although pre- and post-cruise pressure calibrations matched (to within 0.2 decibars) below 1190 decibars, the 0-decibar calibration point differed by 2.5 decibars (loading) and 3 decibars (unloading) between pre- and post-cruise.
b. There was a sudden 6-decibar jump in pressure response between the 1050- and 1190-decibar calibration points on the loading curve during the post-cruise calibration.
c. The jump does not appear in the unloading curve, but shallower than the 1400-decibar point, the post-cruise begins to deviate from the pre-cruise calibration to a maximum of 3 decibars at the 0-decibar calibration point.
d. The post-cruise pressure calibration was repeated, giving similar results.

The pre-cruise calibrations were re-checked, and a smaller/shallower indication of the same problem could be seen on the cold loading curve at 365 decibars. CTD-1 downcasts from all three legs of the cruise were checked for sudden pressure shifts between 800 and 1600 decibars.

The CTD-1 half-second time-series downcasts were checked for a ratio of pressure difference to time difference ("r") greater than 2.5 (equivalent to a winch speed of 150 m/min). For each station with a sudden pressure shift visible on Pressure vs. Time plots, there was exactly one area where "r" was between 4 and 13. All but six of the jumps occurred between 1000 and 1550 decibars, where the temperature ranged from about 2.5 to 4°C. The other six jumps, between 900 and 1000 decibars, occurred during casts at the beginning of SAVE-4 and at the end of Hydros-4 All detectable rapid changes in pressure occurred in 0.6 to 1.5 seconds and were 1.5 to 10.2 decibars in magnitude.

95 out of 192 CTD-1 casts were affected by a pressure jump as described above. There were problems on many sequential casts, then no detectable problem for many more casts in a row. The pressure at which the jump occurred, and the magnitude of the jump, seemed to be random: there was no apparent correlation to water temperature or elapsed time from the cruise start.

A "baseline" pressure correction curve was generated by averaging the pre- and post-cruise calibration curves for each of the shallow/warm and deep/cold data sets, then removing the 500- to 1500-decibar distortion of the post-cruise calibrations by using the shape of the more typical pre-cruise curve. This averaged out the surface differences and maintained the deep consistency in the calibrations. This average correction curve was used for all casts in which no pressure problem was detected.

Customized pressure corrections were generated for problem casts, as identified by areas of r greater than 3.5. The "baseline" curve described in the previous paragraph was used as the starting point for each cast. The "average" curve was used from the surface to 365 decibars and from the post-"jump" pressure to the bottom. The correction for the beginning pressure of the jump was the post-jump correction value plus the jump size, minus the real pressure change occurring in that time. A straight-line correction was used between 365 decibars down and the beginning pressure of the jump on the cold curve.

The average upcast calibration curves were retained for each cast unless the last corrected in-water surface pressure of an upcast was less than -0.6 decibars. In these cases, the upcast correction curve was adjusted by 0 at 365 decibars to a maximum of +1.5 decibars at the surface, which allowed the curve to resemble the shape of the pre-cruise curve in cases where the end-pressure warranted it.

The corrections applied were intended to correct the distorted pressures to within 2 decibars to maintain the WOCE CTD salinity standards. It should be noted that other problems may still exist, but are not detectable at this time. CTD-1 pressure data above 1600 decibars should not be considered accurate to better than 2 decibars, while deeper data should be within more typical error ranges.

Thermometric pressures collected during the casts were compared with CTD-1 corrected pressure data. Any differences between the two sets of pressures appeared to be rack-dependent.

3.2.2.2. CTD Temperature Corrections

3.2.2.2.1. CTD #2

CTD-2 had two PRTs. PRT-1 was the main temperature sensor and began drifting during station 177, seven stations into SAVE-4. The drifting increased by stations 183-185, where it was finally isolated as a temperature problem rather than a conductivity problem. PRT-2 was a secondary temperature sensor installed to provide a check for the primary PRT; it was used as the primary PRT for stations 177-185 and 210. PRT-2 was not located as near to the conductivity sensor as PRT-1 and therefore generated noisier CTD salinity data, as it was measuring slightly different water and could not be matched properly to the conductivity sensor response. CTD-2 was used for all stations from 171-185, plus 210 and 218: CTD-2 was re-installed at these last two stations to test the new PRT-1 sensor, to ensure that CTD-2 could be used as a backup if CTD-1 failed later in the expedition.

The pre- and post-cruise laboratory temperature transducer calibrations for PRT-1 were not comparable because a new sensor was installed during SAVE-4 PRT-1a and PRT-2 data from the pre-cruise laboratory calibration and from shipboard casts were compared to see if the relative difference between them changed. There was good agreement between these two CTD-2 PRTs, the differences being consistent at calibration, within a given station, and from station to station. No shift in either sensor occurred until station 176, when the difference increased by .002. Since PRT- la began shifting noticeably in the same direction during station 177, an additional +.002 temperature offset was applied to station 176 data, assuming some change may have begun at that time.

A new sensor (PRT-1b) was installed in CTD-2 after station 185. The CTD was used/tested during station 210, where PRT-1b also displayed a drifting problem. CTD-2 was worked on again, then tested at station 218:

PRT-1b functioned normally and was used as the CTD-1 primary PRT for that cast. PRT-1b and PRT-2 differences from station 218 and the post-cruise calibration were compared. The post-cruise difference was an average -.022 compared to the station 218 difference. PRT-2 shifted by -.013 from pre-cruise to post-cruise laboratory calibrations, which points to a -.035 shift in PRT-1b between station 218 and the post-cruise calibration. Two deep thermometric temperatures from station 218 also support this shift. The post-cruise PRT-1b laboratory calibration curve, with an additional -.035 offset, was applied to station 218 CTD temperature data.

A comparison of the pre- and post-cruise laboratory CTD-2/PRT-2 temperature transducer calibrations showed an average -.013°C shift for PRT-2. There was also a small slope difference between the two PRT-2 calibrations. Since CTD-2 was used mostly at the beginning of the expedition and there is no evidence to show that PRT-2 shifted by the last cast it was used for, the pre-cruise PRT-2 laboratory temperature calibration was applied to stations 177-185 and 210 CTD data.

The few thermometric temperature differences available for comparison with CTD-2 data support the temperature corrections used. Additional verification of the temperature corrections was obtained by comparing bottle salinity differences vs. CTD values generated from corrected pressure and temperature, plus raw conductivity. There were no sudden shifts in preliminary salinity differences on casts where a different primary PRT was used or when temperature corrections were offset from the laboratory calibrations.

3.2.2.2.2. CTD #1

CTD-1 had a single temperature sensor and was used for stations 186 through 379, except stations 210 and 218. A comparison of the pre- and post-cruise laboratory CTD-1 PRT temperature transducer calibrations showed a shift varying from -.001°C at cold temperatures to -.0017 at warm temperatures. An average of the two laboratory calibrations was applied to the CTD-1 temperature data.

Thermometric temperature data from the cruise were compared to the calibrated CTD-1 temperature data. Any offsets in the differences tended to correlate with thermometer rack number, no shifts in CTD-1 temperature data could be detected over the course of the cruise.

3.2.2.3. CTD Conductivity Corrections

3.2.2.3.1. CTD #2

Check-sample conductivities were calculated from the bottle salinities using CTD-2 pressures and temperatures. The differences between sample and CTD conductivities at all pressures were fit to CTD conductivity using a linear least-squares fit. A conductivity correction slope was not warranted at that time.

Conductivity differences were then calculated: offsets were determined for each cast and fit to station number. Preliminary offsets were applied to stations 171 through 175 individually, based on conductivity differences at pressures below 100 decibars. Stations 176-185 conductivity differences below 1000 decibars were re-fit, and smoothed offsets were applied to those casts. Stations 210 and 218 conductivity offsets were determined individually based on differences below 1000 decibars. The offsets were manually adjusted to account for discontinuous shifts in the conductivity transducer response, or to insure a consistent deep θS relationship from station to station.

After applying the conductivity offsets, the need for a conductivity slope as a function of conductivity was reevaluated: no slope was required.

3.2.2.3.2. CTD #1

Check-sample conductivities were calculated from the bottle salinities using CTD pressures and temperatures. The differences between sample and CTD-1 conductivities at all pressures were fit to CTD conductivity using a linear least-squares fit. Values greater than 2 standard deviations from the fit were rejected. The resulting conductivity correction slope was applied to each CTD-1 cast.

Conductivity differences were calculated for each cast after applying the preliminary conductivity slope correction. Residual conductivity offsets were then computed for each cast and fit to station number. Smoothed offsets were determined in three groups: stations 186-189 (first-order fit), stations 190-202 (0-order/same offset for all casts) and stations 203-379 (0-order/same offset for all casts). The resulting smoothed offsets were then applied to the data, then conductivity slope as a function of conductivity was re-checked: no change was warranted. Some offsets were manually adjusted to account for discontinuous shifts in the conductivity transducer response, or to insure a consistent deep θS relationship from station to station.

It was noted that stations 190-202 had numerous casts of inconsistent bottle data values caused by a scum buildup in the Autosal cell. Adding to this problem were CTD-1 conductivity offsetting problems caused by sensor fouling on stations 192 and 202. The Autosal was thoroughly cleaned and checked before station 200 deep salts were run, and the CTD conductivity sensor was thoroughly cleaned both before and after station 202. No effect on conductivity values was noted after opening up CTD-1 two separate times to repair the non-functioning multiplexer channel (after stations 192 and 255).

3.2.2.3.3. Bottle vs. CTD Conductivity Statistical Summary

The Hydros (SAVE/Year-2) calibrated bottle-minus-CTD conductivity differences yield the following statistical results:

cruise leg	pressure range(dbars)	mean conductivity difference (bottle-CTD mmho/cm)	standard deviation	#values in mean
SAVE-4	all pressures	-.00076	.00578	1944
	allp (4,2rej)	-.00039	.00227	1805
	press < 1500	-.00113	.00769	991
	press > 1500	-.00034	.00238	952
SAVE-5	all pressures	-.00011	.00400	2311
	allp (4,2rej)	-.00012	.00137	2176
	press < 1500	-.00002	.00552	1174
	press > 1500	-.00021	.00104	1137

"4,2rei" means a 4,2 standard-deviation rejection filter was applied to the differences before generating the results.

3.2.3. CTD Dissolved Oxygen Data

3.2.3.1. CTD Oxygen Corrections

Dissolved oxygen data were acquired using a Sensormedics dissolved oxygen sensor. During the three legs of the cruise, three oxygen sensors were used. The original sensor on CTD #2 was used for stations 171 through 183, then failed during station 184. A replacement sensor did not work on stations 185 and 210, then functioned normally on station 218 following various repairs. The CTD #1 oxygen sensor was used for all other CTD casts except station 279, where a new sensor faded; the original sensor was re-installed.

CTD raw oxygen currents were extracted from the downcast pressure-series data (upcast for station 202) at isopycnals corresponding to the upcast check-samples. The differences between CTD and check-sample dissolved oxygens were used to generate coefficients for the sensor model on a station-by-station basis. Bottle oxygen values were weighted as needed to optimize the fitting of CTD oxygen to discrete bottle samples.

3.2.3.2. Bottle vs. CTD Oxygen Statistical Summary

After the CTD oxygen fitting was completed, the upcast bottle values were compared to the corrected CTD oxygen values. The bottle-minus-CTD oxygen differences resulted in the statistics below:

cruise leg	pressure range(dbars)	mean oxygen difference (bottle-CTD ml/1)	standard deviation	#values in mean
SAVE-4	all pressures	-.0009	.0813	1883
	allp (4,2rej)	+.0001	.0391	1740
	press < 1500	-.0044	.1095	963
	press > 1500	+.0027	.0312	920
SAVE-5	all pressures	-.0032	.0780	2361
	allp (4,2rej)	+.0003	.0382	2193
	press < 1500	-.0071	.1036	1196
	press > 1500	+.0009	.0356	1165

* 4,2 standard deviation data rejection

3.2.4. Additional Processing

A software filter was used on a third of the casts to remove larger conductivity or temperature spiking problems. Additionally, oxygen spikes were filtered out of nearly half of the casts. Pressure did not require filtering 0.35% of the time-series data were affected by the filter. Two-thirds of the spiking problems were concentrated in the CTD-2/PRT-2 casts, where the distance between the secondary PRT and the conductivity sensor resulted in poor signal match-up in high-gradient areas, and station 202, with its fouled-sensor problem. After filtering, the downcast (upcast for station 202) portion of each time-series was pressure-sequenced into 2-decibar pressure intervals. A ship-roll. filter was applied to each cast to disallow pressure reversals.

The remaining density inversions in high-gradient regions cannot be accounted for by a mis-match of pressure, temperature and conductivity sensor response. Detailed examination of the raw data shows significant mixing occurring in these areas because of ship roll. The ship-roll filter resulted in a reduction in the amount and size of density inversions.

3.3. General Comments/Problems

There were 212 CTD rosette casts: three of these (station 178 casts 2 and 3, plus station 328 cast 1) were aborted because of various computer problems, but another CTD cast was done immediately afterward at the same locations. There is one pressure-sequenced CTD data set, to near the ocean floor, for each of 209 stations. The data reported is all from downcasts, excepting station 202, which is an upcast. The effect of the initial sensor fouling on station 202's downcast was not possible to filter out, while the upcast problems were mostly resolvable.

The 0-decibar level of some casts was extrapolated using a quadratic fit through the next three deeper levels. Recorded surface values were rejected only when it appeared that the drift was caused by sensors adjusting to the in-water transition; if there were any question that the that the surface values might be real, the original data was reported.

Several shipboard time-series data sets had areas of missing or noisy data. These casts were recovered by redigitizing the raw signal from analog tape. A total of 9 data levels were interpolated in 8 casts: the pressures for these interpolated data frames are listed in the CTD Processing Notes as well as other shipboard or processing comments regarding individual casts.

During conductivity data calibrations it was noticed that there was an apparent +.002 conductivity offset in the deep data for some stations. This apparent offset appeared in both the downcasts and upcasts for the affected stations. A similar phenomenon has been noticed before in this and other CTDs where the raw conductivity value crosses from 32.768 to 32.767. On some stations, a -.002 shift back appears yet deeper, where the raw conductivity value crosses back over to 32.767 from the other direction. This is a problem specific to certain instruments, and currently there is no correction. It is most noticeable in Atlantic Ocean data because this particular conductivity crossover" value typically occurs in deep water, where salinity is stable over many hundreds of meters.

The CTD oxygen sensor often requires several seconds in the water before being wet enough to respond properly; this is manifested as low or high CTD oxygen values at the start of some casts. Flow-dependence problems occur when the lowering rate varies, or when the CTD is stopped, as at the cast bottom or bottle trips, where depletion of oxygen at the sensor causes lower oxygen readings. CTD downcast oxygen data are usually smoother than upcast data because of the more constant lowering rate. Station 202, the only upcast, demonstrates the typical oxygen depletion effect at each bottle stop. Any delays or stops during the downcasts that may have similarly affected the CTD oxygen data are documented in the CTD Processing Notes.

There were various winch, wire or rosette problems throughout the cruise. These resulted in occasional stops, pauses or yoyos during casts. Only those problems that may have affected the data continuity have been noted. As mentioned above, these changes in the lowering rate can affect oxygen in particular.

4. DATA TABLES AND PLOTS

4.1. Station and Cast Description

Latitudes and longitudes were read from the ship's navigation system. The time (GMT) is the beginning of the CTD up cast or the time the messenger was sent for the Gerard casts. The bottom depth was read from the PGR, and corrected according to Carter Tables (Carter, 1980). The value (in meters) in the column "DAB" (Distance above bottom) was obtained from the PGR, unless the "Comments" column reports altimeter, as was the ocean depth. Note that the maximum sampling depth for the Rosette casts is calculated from the corrected CTD data since the deepest bottle may not have been closed at the deepest CTD sampling point. If less than 36 bottles were sampled for the Rosette casts or 9 barrels for the Gerard casts, the number of samples taken are reported in the comments. The complementary programs are reported in the "Samples" column.

4.2. Tabular Data, CTD, Rosette and Gerard

Station numbers are consecutive from the beginning to end of the cruise, without interruption. Cast numbers are consecutive at each station, including aborted casts. Meteorological data were collected by the ship's officers and were copied from the Melville's Bridge Log. If more than one CTD cast were done on a station, the deepest cast is reported.

The headings in both the CTD data and ROSETTE and GERARD bottle data have been abbreviated to PRESS, TEMP, and O_2 for pressure (decibars), temperature (degrees Celsius), and oxygen which is reported in both (milliliters per liter) and (micromoles per kilogram). In the CTD data listings, specific volume anomaly (centiliters/ton) was abbreviated SVA and calculated according to Millero et al. (1980) and Fofonoff et al. (1983), Sound Velocity (meters per second) to SVEL, (Chen and Millero, 1977), Dynamic Height (dynamic meters) to DYN HT, (Sverdrup et al., 1942), Vaisla Frequency (cycles per hour) to VAIS FREQ which uses a subroutine by Bob Millard modified by Lynne Talley to incorporate Gaussian weighting after the formulation of Breck Owens and N. P. Fofonoff. In the bottle data listings, the headings have been abbreviated to SAW NUM and SALT for Sample Number and Salinity (Practical Salinity Units), AOU, PO_4, NO_3, SiO_3, and NO_2 for apparent oxygen utilization, phosphate, nitrate, silicate, and nitrite (micromoles/kilogram), respectively. Density anomalies in sigma-notation follow the usual practice; e.g. sigma-theta (or sigma-0) is the potential density in kg/m3 referenced to pressure=O, from which 1000 has been subtracted. Potential temperature, 0, (degrees Celsius) has been calculated according to Fofonoff (1977) and Bryden (1973) and depth (meters) by Saunders (1981) and Mantyla (1982-1983).

Throughout the bottle data report alphabetic characters may be found in the tabular data. These characters have the following meaning:

D	A salinity value, normally from a bottle sample, has been taken from CTD records.
G	Data value appears to be high or low as compared with the station profile, however as compared with CTD trace the sample appears good.
H	A pressure or temperature value, normally from CTD records, has been taken from reversing thermometers.
L	The sample bottle appears to have leaked. This usually refers to Gerard barrels or the piggy-back Niskin and indicates that the samples may be contaminated.
P	The sampler either pre or post-tripped. This usually refers to Gerard barrels and indicates that the samples may be contaminated.
U	A data value is suspect, although no obvious reason has been found.

Comments and investigation of these values are reported in the appropriate leg's Bottle Data Processing Notes section. Surface samples from the ship's underway pump line were assigned a separate cast number and reported in the data table under the heading GERARD. This was not the caw on Leg 4, these samples may have the rosette data cast number. These surface samples are distinguished by an "H" footnote on the pressure and reported in the GERARD section.

4.3. Station Plots

The hydrographic station plots provide a visualization of the data that is not possible from listings. The first few overlay plots represent the entire leg. Then for each station, the upper plots on the even numbered pages are CTD data, the lower two plots are bottle data. The odd numbered pages are single station representation of potential temperature vs. oxygen, phosphate, nitrate and silicate.

5. Acknowledgements

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CTD Processing Notes

Station	Cast	Remarks
236	1	ODF-CTD #1 with TAMU transmissometer #100-D
237	1	CTD #1
238	1	CTD #1
239	1	CTD #1
240	1	CTD #1
241	1	CTD #1
242	1	CTD #1
243	3	CTD #1; -.002 psu salinity offset 3748-3980 dbars
244	1	CTD #1
245	1	CTD #1
246	1	CTD #1
247	1	CTD #1; winch problem/stop at 4090 dbars down
248	1	CTD #1; only 11 oxygen samples: added bottles from stations 247/249 for CTD oxygen fitting
249	1	CTD #1
250	1	CTD #1
251	1	CTD #1; 7-minute delay in cast at 2945 dbars down
252	2	CTD #1
253	1	CTD #1; 7-minute delay in cast at 2750 dbars down
254	1	CTD #1; new end termination
255	1	CTD #1; transmissometer cleaned before cast; multiplexed channels (transmissometer altimeter, elapsed-time, trip-confirm) not working: replaced 3 chips in CTD after cast; rosette hit bottom; found 2 kinks in wire
256	1	CTD #1; new end termination, pylon leads crossed: 12 bottles open, no bottle data 510-2500 dbars; CTD oxygen fitting used bottle data from this cast only
257	1	CTD #1; pylon leads switched back
258	1	CTD #1
259	2	CTD #1; pylon problems, top 10 bottles not closed; CTD oxygen fitting used cast 3/Gerard bottle oxygens for top 500 dbars
260	1	CTD #1; 1370-dbar data level interpolated
261	1	CTD #1
262	1	CTD #1
263	1	CTD #1; new end termination
264	1	CTD #1; 1202-dbar data level interpolated
265	1	CTD #1
266	1	CTD #1
267	1	CTD #1
268	1	CTD #1; new end termination following CTD cable repair
269	1	CTD #1; yoyo 3655 dbars back to 3645 dbars on downcast
270	1	CTD #1; -.004 psu salinity dropout 3524-3556 dbars, then residual -.001 psu offset 3556-4906 dbars
271	2	CTD #1; 8-minute delays in cast at 1180 + 1280 dbars, down
272	1	CTD #1; new end termination following CTD flag block replacement; 15-minute delay in cast at 11-15 dbars down
273	1	CTD #1; CTD wire rubbing on cheeks of flag block

CTD Processing Notes (continued)

Station	Cast	Remarks
274	1	CTD #1
275	1	CTD #1
276	1	CTD #1
277	1	CTD #1
278	1	CTD #1
279	1	CTD #1; new CTD oxygen sensor installed/failed: no CTD oxygen data this cast
280	1	CTD #1; original CTD oxygen sensor re-installed
281	1	CTD#1
282	1	CTD #1; 3-/7-minute delays in cast at 1785/1850 dbars, down
283	1	CTD #1
284	1	CTD #1
285	1	CTD #1
286	1	CTD #1
287	1	CTD #1
288	1	CTD #1
289	1	CTD #1
290	1	CTD #1
291	2	CTD #1
292	1	CTD #1
293	1	CTD #1
294	1	CTD #1
295	1	CTD #1
296	1	CTD #1; yoyo 5125 dbars back to 5114 dbars on downcast; rinsed CTD connector cables after cast
297	1	CTD #1
298	2	CTD #1
299	1	CTD #1
300	1	CTD #1
301	1	CTD #1
302	2	CTD #1
303	1	CTD #1
304	1	CTD #1
305	1	CTD #1
306	1	CTD #1; 36-hour delay for engine repairs en route to station
307	1	CTD #1
308	1	CTD #1

Bottle Data Processing Notes

Remarks for deleted or missing samples and footnoted data from SAVE Leg 5. Uncertainty of data (footnoted data) results in values that may not fit the station profile, but are within the accuracy of the measurement. Investigation of data may include comparison of bottle salinity and oxygen with CTD data, comparison of Niskin/Gerard salinity, review of data plots of station profile and adjoining stations, rereading of charts (i.e., nutrients). CTD data is reported instead of bottle salinity when comments refer to deleted salinity samples or missing for various reasons. Oxygen and nutrient values are referred to in ml/l and µm/l, respectively. On Gerard casts, if there is a comment regarding the Niskin bottle the corresponding Gerard barrel number follows the Niskin number (i.e., 153/183 is Niskin 53 and Gerard 83).

Station 236

104	Nutrients: NO$_2$-"Bubbly" Junk in water. Analyst having trouble with NO$_2$, this sample @41db was affected.
108	Nutrients: NO$_2$-"Bubbly" Junk in water. NO$_2$ missing-had no readable peak @187db.
133	ΔS .004 low at 4618db. Calc ok. CTD trace smooth. No notes. Same value as sample 135. Probably bad draw or run. Delete hydro salt (34.727).

Station 237

1all	Salinity: general comment: Autosal drifting - Reruns indicate drift not linear and rerun values too ragged to use. Delete bottle salinities.

Station 240

101	Sample Log: Missing salts and nuts. No salts or nutrients drawn @1db.
132	Hydro O$_2$ @3401db .1 high compared to CTDO. Calc ok. No notes. Delete bottle oxygen (5.66).

Station 241

260/287	Sample Log: Bottom leaker. Bad spring. No other water samples from Niskin#60. Niskin-Gerard S=.014 at 776db. Delete bottle salinity (34.272).

Station 242

124	ΔS .058 low at 2100db. Calc ok. Same value as 123 salt at 1900db. Apparent dupe draw or run. Delete bottle salinity (34.757).
126	ΔS .026 low at 2500db. Calc ok. Same value as 125 salt at 2300db. Apparent dupe draw or run. Delete bottle salinity (34.847).
127	ΔS .017 low at 2700db. Calc ok. Normal CTD gradient. Apparent bad draw or run. Delete bottle salinity (34.869).
134	Salinity: "Dirty bottle" ΔS .019 high at 3949db. Calc ok. Same value as 133 at 3801db. Apparent dupe draw or run. Delete bottle salinity (34.813).

Station 243

192	Sample Log: Fork jumped wire, rest of cast did not trip. Untripped barrels sent down again as cast 2.
260	Sample Log: Bottom leaker. Niskin-Gerard S=.021 low at 2997db. Delete Niskin bottle salinity (34.865).
309	Sample Log: Helium drawn between freon; vent leaks. Oxygen:" stopper 797 switched with flask 798. Deleted discrete O$_2$ until flask 798 recalibrated with stopper 797. Flasks 798 & 797 broken on station 248 when O$_2$ box 9 fell apart, recalibration could not be performed, Delete bottle oxygen (5.33) @300db.

Station 243 (continued)
310 Delete O_2 until flask 797 recalibrated with stopper 798. Deleted discrete O_2 until flask 797 recalibrated with stopper 798. Flasks 755 & 756 broken on station 248 when O_2 box 9 fell apart, recalibration could not be performed. Delete bottle oxygen (5.47) @349db.
451/481 Temperature: Thermometer Rack#5 did not flip. No temperature @524db.
454 Sample Log: Didn't close. No salinity @948db. Barium drawn from Gerard.

Station 244
121 Sample Log: O_2 flask 756, lid 755. Oxygen: "stoppers switched again" Deleted discrete O_2 until flask 756 recalibrated with stopper 755. Flasks 755 & 756 broken on station 248 when O_2 box 9 fell apart, re calibration could not be performed. Delete bottle oxygen (4.35) @1394db.
122 Sample Log: O_2 flask 755, lid 756. Deleted discrete O_2 until flask 755 recalibrated with stopper 756. Flasks 755 & 756 broken on station 248 when O_2 box 9 fell apart, recalibration could not be performed. Delete bottle oxygen (4.20) @1498db.

Station 246
120 PO_4 missing @1298db. Original and rerun peaks both bad.
132 Sample Log: Missing drain. No water samples @3400db.

Station 248
101 Sample Log: Drain fell apart on opening. Assume means disk came off spigot. Oxygen flasks broken, no oxygen samples @2db.
102 Oxygen flasks broken, no oxygen samples @25db.
103 Oxygen flasks broken, no oxygen samples @54db.
104 Sample Log: Spigot opened while bringing aboard. No gases sampled @77db. Oxygen flasks broken, no oxygen samples @77db.
105 Oxygen flasks broken, no oxygen samples @98db.
106 Oxygen flasks broken, no oxygen samples @152db.
112 Sample Log: Retake helium. Oxygen flasks broken, no oxygen samples @499db.
114 Sample Log: Bottom leaker. ΔS .000 at 697db. Oxygen flasks broken, no oxygen samples.
116 Oxygen flasks broken, no oxygen samples @894db.
118 Oxygen flasks broken, no oxygen samples @1096db.
120 Oxygen flasks broken, no oxygen samples @1293db.
121 Oxygen flasks broken, no oxygen samples @1293db.
122 Oxygen flasks broken, no oxygen samples @1496db.
123 Oxygen flasks broken, no oxygen samples @1596db.
125 Oxygen flasks broken, no oxygen samples @1897db.
126 Oxygen flasks broken, no oxygen samples @2099db.
127 Oxygen flasks broken, no oxygen samples @2300db.
128 Oxygen flasks broken, no oxygen samples @2498db.
129 Oxygen flasks broken, no oxygen samples @2701db.
131 Oxygen flasks broken, no oxygen samples @3099db.
132 Oxygen flasks broken, no oxygen samples @3299db.
133 Oxygen flasks broken, no oxygen samples @3498db.
134 Oxygen flasks broken, no oxygen samples @3702db.
135 Oxygen flasks broken, no oxygen samples @3899db.
136 Sample Log: Retake helium. Oxygen flasks broken, no oxygen samples @3989db.

Station 249

101-136 Delete all bottle salinities; problem with temperature in salinity lab.

Station 250

104 Sample Log: Drain broken, probably broken on pinger. No water samples @100db.

Station 251

111 ΔS .183 high at 378db. Calc ok. Normal gradient. No notes. Salt value .007 lower than 110 salt value which could indicate possible dupe draw. Other water samples ok. Delete bottle salinity (34.973).

171 Sample Log: Bottom endcap open. No water samples 49db.

Station 252

160 Sample Log: Empty. No salt sample for Gerard 89 check @4352db. Gerard 89 salt agrees with rosette salts and rest of Cast 1 salts.

222 ΔS .051 at 1651db. Calc ok. Normal gradient, no notes. No apparent reason for large difference here. Other water samples ok (02 min). Delete bottle salinity (34.538).

3all Niskin salinities were not drawn. No explanation given, must just have been sampling oversight.

Station 253

116 Nutrients high @897db, same values as 117, assume dupe draw. Delete nutrients (PO_4=2.08, NO_2=0.00, NO_3=31.4, S103=32.1).

130 Discrete O_2 appears .1 low at 3196db. Agrees with CTDO, conductivity and temperature feature this level. Footnote "G" indicating sample appears low, but verifies with CTD trace.

136 ΔS .162 low at 4322db. Calc ok. Salt bottle #PP47 on Sample Log & #4277 on Salinity Data Sheet. Assume mixup with sample bottles. Delete bottle salinity (34.843).

256 Sample Log: Hung up, no sample. Gerard 86 salt @802db agrees with other salts this level so Gerard ok.

260 Niskin-Gerard S=.023 at 826db. Calc ok. Gerard 89 salt agrees with other salts this level so assume Niskin leaked and Gerard sample ok. No other samples from Niskin 60. Delete Niskin bottle salinity (34.247).

Station 254

101 Nutrients: Evidently too much junk in water to resolve peaks on NO_2. No NO_2 @6db.

136 Discrete O_2 about .1 high at 4368db. CTDO increasing at bottom but not this much. Only 2 other stations have unexplained high O_2 for Niskin #36. Possibly drawer forgot to flush pickling syringes. Delete bottle oxygen (5.16).

Station 256

108 ΔS .012 low at 3897db. Calc ok. Normal gradient. Same value as sample 109. Assume dupe draw. Delete bottle salinity (34.681).

124 No O_2 drawn @10db, Keeling CO_2 sample.

Station 259

181/152 Sample Log: Too shallow. Pre-tripped at 1631db vs. 3800db intended depth. Niskin-Gerard S=.008 due poor flush Cast not repeated due bad weather. Samples drawn & analyzed. Suggested footnote: "Pre-trip, depth uncertain by +/- 50 meters." "P"

182/153 Sample Log: Too shallow, leaking but vent is tight. Pre-tripped at 2127db vs. 4200db intended depth. Niskin-Gerard S=.024 due poor flush and probable Gerard leak. Unable to open Gerard 82 lid after this cast. Cast not repeated due bad weather. Samples drawn & analyzed. Suggested footnote: "Pre-trip, depth uncertain by +/- 100 meters." "P"

183/154 Sample Log: Too shallow. Pre-tripped at 2489db vs. intended depth of 4440db. Niskin-Gerard S=.009 due poor flush. Cast not repeated due bad weather. Samples drawn & analyzed except no Argon this station. Suggested footnote: "Pre-trip, depth uncertain by +/- 50 meters." "P"

185 Sample Log: Did not trip and no messenger on top. It did drop its messenger. No water samples. Cast not repeated due bad weather.

186 Sample Log: Tripped at the surface. No water samples drawn. Cast not repeated due bad weather.

187 Tripped at the surface per DSRTs. No water samples drawn. Cast not repeated due bad weather.

188 Tripped at the surface per DSRTs. No water samples drawn. Cast not repeated due bad weather.

189 Tripped at the surface per DSRTs. No water samples drawn. Cast not repeated due bad weather.

151 Delete low PO_4 (2.09 kg, 2.14 1) @3371db.

201 Sample Log: Did not trip. Bad Pylon

202 Sample Log: Did not trip. Bad Pylon

203 Sample Log: Did not trip. Bad Pylon

204 Sample Log: Did not trip. Bad Pylon

205 Sample Log: Did not trip. Bad Pylon

206 Sample Log: Did not trip. Bad Pylon. No water samples @178db.

207 Sample Log: Did not trip. Bad Pylon. No water samples @248db.

208 Sample Log: Did not trip. Bad Pylon. No water samples @299db.

209 Sample Log: Did not trip. Bad Pylon. No water samples @371db.

210 Sample Log: Did not trip. Bad Pylon. No water samples @427db.

211 No salt drawn @522db per sample log. Other water samples ok. No notes. Forgotten? All three (silicate, phosphate and nitrate) do not fit at all with the vertical section and are pretty clearly erroneous. - L. Talley 920409 Bottle appears to have tripped at ~300db, Delete all water samples (O_2=5.91, PO_4=1.77, NO_2=0.01, NO_3=25.9, SiO_3=13.3).

212 No salt drawn @623db per sample log. Other water samples ok. No notes. Forgotten?

215 ΔS .075 low @988db. Calc ok. Same value as 214. Assume dupe draw. Delete bottle salinity (34.266).

216 ΔS .016 high at 1096db. All water samples appear to be from about 100db. No notes. Assume bad trip or bad leak. Delete all water samples (S=34.441, O_2=5.16, PO_4=1.00, NO_2=0.08, NO_3=12.3, SiO_3=12.8).

222 L. Talley indicated PO_4 high. Investigation of the data shows good comparison with CTDO2 even though bottle oxygen appears low. Silicate appears high, but only fits lower in the water column. NO_3 appears high, also fits lower in the water column. Salinity agrees with CTD .003 so both salinity and oxygen show that something is different here, and appears to be real. ODF has suggested that the samples be footnoted either "U" for uncertain or "G" for good and verified by other data parameters. Foot note PO_4 "U" for uncertain.

Station 259 (continued)

228 Salinity: "loose top" ΔS .004 high at 3112db. Delete bottle salinity (34.741).

234 Sample Log: Lanyard bung up. No water samples @4298db.

356 Niskin-Gerard S=.312 at 421db. Calc ok. No notes. 356 water samples appear to be surface water. Gerard 86 salt agrees with CTD salt this level so Gerard sample good. Delete all Niskin water samples (S=34.526, O_2=5.91, PO_4=0.78, NO_2=0.09, NO_3=9.0, SiO_3=2.9).

360 Sample Log: Leaked. Details not noted. Salinity: "jumpy" Niskin-Gerard S=-.007 at 1325db. Calc ok. Normal gradient small leak in Niskin 60 likely and Gerard 89 looks ok. Freon & barium. also drawn from Niskin. Suggested footnote: "Sample Log note and .007 difference between Niskin and Gerard salts indicate slight leak in Niskin sample 360." "L"

Station 260

102 No discrete O_2 @7db, Keeling CO_2 samples.

171 Sample Log: Did not fire. No further explanation. No notes Conops or Deck Log. No water samples @79db.

116 Sample Log: Lanyard hung on frame during recovery, lifted top stopper. Discrete O_2 @1059db about .12 high compared to CTDO. No freon or helium. drawn this sample. Salt & nutrients ok. Delete bottle oxygen (4.62).

128 PO_4 @3200db low. Footnote PO_4 "U" uncertain.

129 PO_4 @3402db low. Footnote PO_4 "U" uncertain.

130 PO_4 .05 low at 3599db. Calc ok, peaks fair. Air in PO_4 line before 130 and after 136. Footnote PO_4 "U" uncertain.

131 PO_4 .04 low at 3799db. Calc ok, peaks fair. Air in PO_4 fine before 130 and after 136. Footnote PO_4 "U" uncertain.

132 PO_4 .04 low at 3999db. Calc ok, peaks fair. Air in PO_4 line before 130 and after 136. Footnote PO_4 "U" uncertain.

133 PO_4 .03 low at 4198db. Calc ok, peaks fair. Air in PO_4 line before 130 and after 136. Footnote PO_4 "U" uncertain.

134 PO_4 .03 low at 4349db. Calc ok, peaks fair. Air in PO_4 line before 130 and after 136. Footnote PO_4 "U" uncertain.

135 PO_4 .02 low at 4499db. Calc ok, peaks fair. Air in PO_4 line before 130 and after 136. Footnote PO_4 "U" uncertain.

136 PO_4 .04 low at 4550db. Calc ok, peaks fair. Air in PO_4 line before 130 and after 136. Footnote PO_4 "U" uncertain.

Station 263

106 Salinity: "Lost" No reason given. No hydro salt 249db.

Station 265

131 ΔS .006 high at 4402db. Calc ok. Smooth CTD gradient. Probable bad draw or run. Delete bottle salinity (34.680).

Station 266

111 Salinity: "may leak a little" ΔS .004 high at 601db. Same salt bottle used subsequent station with no problem. Delete bottle salinity (34.224).

171 Sample Log: Lanyard hung, no sample. No water samples @98db.

Station 267

101 Oxygen: "broken flask, no sample" No oxygen sample @4db.

125 O2 .04 high at 3199db compared to CTDO. Calc ok. Possibly drawn from Niskin 26?. Delete bottle oxygen (4.84).

127 Sample Log: Vent leaks. ΔS .001 low at 3600db. Other water samples also ok. NO_3 @3600db 1.0 higher than adjacent stations. Rerun (between 130 & 131) was used which was definitely higher than original, poorer, peak. All subsequent NO_3 values also higher than adjacent stations. Footnote high NO_3 as uncertain "U".

128 NO_3 @3802db about 1.0 higher than adjacent stations. Peak not perfect but definitely high. Footnote high NO_3 as uncertain "U".

129 NO_3 @4004db about 1.0 higher than adjacent stations. Peak not perfect but definitely high. Footnote high NO_3 as uncertain "U".

130 NO_3 @4200db about 1.0 higher than adjacent stations. Peak not perfect but definitely high. Footnote high NO_3 as uncertain "U".

131 NO_3 @4399db about 1.0 higher than adjacent stations. Peak not perfect but definitely high. Footnote high NO_3 as uncertain "U".

132 NO_3 @4596db about 1.0 higher than adjacent stations. Peak not perfect but definitely high. Footnote high NO_3 as uncertain "U".

133 NO_3 @4802db about 1.0 higher than adjacent stations. Peak not perfect but definitely high. Footnote high NO_3 as uncertain "U".

134 NO_3 @5000db about 1.0 higher than adjacent stations. Peak not perfect but definitely high. Footnote high NO_3 as uncertain "U".

135 NO_3 @5198db about 1.0 higher than adjacent stations. Peak not perfect but definitely high. Footnote high NO_3 as uncertain "U".

136 NO_3 @5253db about 1.0 higher than adjacent stations. Peak not perfect but definitely high. Footnote high NO_3 as uncertain "U".

Station 268

117 Sample Log: Valve pushed in. ΔS .071 low at 1498db. Calc ok. Other water samples also indicate leak. Delete all water samples (S=34.684, O_2=4.31, PO_4=2.22, NO_2=0.00, NO_3=32.8, SiO_3=81.1).

127 NO_3 high @3401 db, footnote "U".

128 NO_3 high @3608db, footnote "U".

129 NO_3 high @3802db, footnote "U".

130 NO_3 high @4001db, footnote "U".

136 Oxygen: "Forgot to write down value, lost" No oxygen data @5146db.

Station 270

136 Sample Log: Tritium drawn after nuts. O_2 .4 high at 5638db compared to CTDO and adjacent stations. Calc ok. Assume draw or titration. Delete bottle oxygen (6.01).

Station	**271**
1all	No temperatures, forgot to read DSRTs before next Gerard cast. Calculating barrel depths based on corrected wire length, pinger distance from bottom, and corrected bottom depth gives good agreement between Gerard salts and rosette salts.
211	No nutrients @605db per nutrient data sheet. Ok per sample log. Assume not drawn.
217	O_2 .4 high compared to CTDO at 1658db. Calc ok. Delete bottle oxygen (4.83).
223	O_2 .04 high compared to CTDO at 2796db. Calc ok. Delete bottle oxygen (4.88).
228	ΔS .005 high at 3799db. Calc ok. Smooth CTD gradient. Note on salt data sheet indicates possible salt crystal contamination. Delete bottle salinity (34.677).
3all	Sample Log: Cast aborted, double pinging after two barrels. No samples.
451/487	DSRTs indicate post-trip; TP 1505db vs. intended depth of 2900m. Delete Niskin and Gerard level. Post trip. See 451.
452/488	Sample Log: Rigged wrong, didn't close. No Niskin salts or temp. DSRTs on barrels above & below indicate post-trip. Delete Niskin and Gerard level. Post-trip. See 452.
453/489	DSRTs indicate post-trip; TP 1746db vs. intended depth of 3800m. Delete Niskin and Gerard level. Post trip. See 453.
456	Sample Log: Rigged wrong, didn't close. No Salt for Gerard check @2366db. See 486. Gerard 86 salt agrees with rosette salt this level. Gerard sample ok.
459/485	Sample Log: Rigged wrong, did not close. No salt for Gerard check @2O27db. See 485. Gerard 85 salt is .005 higher than rosette salt this level. Gerard sample probably ok.
553/589	DSRTs indicate pre or post-trip; TP 1337db vs. 3600m intended depth. Niskin-Gerard S=.014 indicating poor flush. Delete Niskin and Gerard level. Post?-trip. See 553.

Station	**272**
113	Salinity: "top loose, leaks" ΔS .005 high at 801db. Normal CTD gradient. Delete bottle salinity (34.663).
134	ΔS .005 high at 4753db. Calc ok. Same value as 132. Possible dupe draw. Delete bottle salinity (34.659).
171	Sample Log: Smashed drain. No water samples @148db.

Station	**273**
113	Sample Log: No sample, end caps lost. No water samples @801db.
131	Sample Log: 6 pCO_2 samples, nothing else. No water samples @4000db.

Station	**274**
132	NO_3 1.5 high @4200db. Poor peak but high. Rerun after standards had worse peak. Delete nitrate (36.2).

Station	**275**
122	Sample Log: Bottom end cap hung up. No sample @1803db.
135	O_2 .12 high @3938db. Calc ok. CTDO shows smooth gradient. Delete bottle oxygen (5.40).

Station	**279**
120	Keeling & LDGO CO_2 only. No hydro S, O_2 or nutrients @4db.

Station	**280**
125	PCO_2 only. No other water samples @903db.

Station 281

101 No Salt, O_2 or nutrients @4db, Keeling CO_2.

106 No Salt, O_2 or nutrients @200db, Keeling CO_2.

108 No Salt, O_2 or nutrients @247db, Keeling CO_2.

111 No Salt, O_2 or nutrients @347db, Keeling CO_2.

114 No Salt, O_2 or nutrients @499db, Keeling CO_2.

116 No Salt, O_2 or nutrients @597db, Keeling CO_2.

118 No Salt, O_2 or nutrients @748db, Keeling CO_2.

120 No Salt, O_2 or nutrients @998db, Keeling CO_2.

123 No Salt, O_2 or nutrients @1497db, Keeling CO_2.

126 No Salt, O_2 or nutrients @1999db, Keeling CO_2.

129 No Salt, O_2 or nutrients @2484db, Keeling CO_2.

132 No Salt, O_2 or nutrients @3010db, Keeling CO_2.

135 No Salt, O_2 or nutrients @3628db, Keeling CO_2.

136 SiO3 6. too high. Delete SiO3 (140.6). NO_2.03 high, not sure what caused this. Footnote NO_2 "U" for uncertain.

171 No Salt, O_2 or nutrients @126db, Keeling CO_2.

Station 282

115 All water samples appear to be from about 2000db vs. 5 db when tripped. Top lanyard found broken on recovery per Deck Log. Delete all water samples ($S=34.709$, $O_2=4.67$, $PO_4=2.18$, $NO_2=0.00$, $NO_3=33.9$, $SiO_3=119.1$).

129 ΔS .004 high at 14OOdb. Calc ok. CTD trace smooth and indicates sal max closer to 1500db. No notes. No apparent problems with other water samples. Delete bottle salinity (34.720).

Station 283

135 Sample Log: Lid not closed. 5m above 136. Suspended particles checked on sample log. Deck Log note: "top of Niskin 35 did not close completely slightly askew." No other samples drawn @1714db so sample integrity unknown.

Station 284

131 Discrete O_2 .2 high at 1297db. Calc ok. CTDO down & up traces show min not max this level. O_2 values similar to 132 value so possibly drawn from Niskin32 in error. Delete bottle oxygen (4.39).

287 Sample Log: Went down without washer on valve arm. Assume means no o-ring on valve cap. Niskin Gerard S=.003 at 889db. Probable slight leak. Suggested footnote: "No o-ring on valve cap. Probable slight leak." "L"

Station 286

110 Sample Log: Air leak. ΔS .000 at 551db. Other water samples also ok.

122 Discrete O_2 .1 high. Calc ok. No notes. CTDO shows feature this level both down & up but only about 1/2 as high. Nutrients & salt also have feature but salt is proportional to CTD down & up traces. Suggest: FOOTNOTE "U"

Station 287

112	Sample Log: Air leak, sample leaked out on deck. No water samples drawn @801db.
113	ΔS .014 high at 948db. Calc ok. High gradient. Nutrients ok (NO_3 & PO_4 max). O_2 problem apparently unrelated is described below. O_2 value appears about .07 high at 948db compared to CTDO down & up traces. Oxygen analyst indicated sample was over-titrated, but sample does not give good results. Delete bottle oxygen (4.00).
259	Sample Log: No salts drawn. Sampling error @5203db, they should have been. Freon & barium were drawn. Gerard (#289) salt agrees well with CTD salt trace.
260	Sample Log: No salts drawn. Sampling error @5380db, they should have been. Freon & barium were drawn. Gerard (290) salt agrees well with CTD salt trace.
353	Salinity: "top loose" Niskin-Gerard S=.009 at 208db. Gerard salt looks ok. Delete Niskin salinity (34.147).

Station 291

160	Niskin-Gerard S=.005 at 5449db. Calc ok. No notes. Gerard (190) salt agrees with CTD and other Argon cast salts this level. No other samples taken Niskin 160. Delete Niskin salinity (34.671).

Station 292

130	SIL 1.6 higher than 131 SIL tripped at same level (4198db). 131 value in better agreement with adjacent values and 130 has poor peak. Delete silicate value (129.3).

Station 293

116	Sample Log: Hung up. No water samples @1502db.

Station 294

121	ΔS .018 low at 2198db. Calc ok. Same value as 120 salt so possible dupe draw. CTDs noisy but not this much. O_2 & PO_4 look ok. NO_3 1.0 high and SIL 2.0 high. NO_3 peak poor, SIL peak ok. Calc ok. Delete bottle salinity (34.773).
136	Discrete O_2 @5242db .33 ml/L high compared to adjacent samples and CTDO traces. Calc ok. Assume bad draw or titration. Deleted bottle oxygen (5.51).
257/288	Thermometer: Lanyard hang-up, therms did not reverse. No temperature @4716db. Sample Log: Lid not completely closed. Niskin-Gerard S= -.001 at 4699db. Gerard sample ok.
259/289	Sample Log: Air leak. Salinity: "Perhaps drawn quite late" Niskin-Gerard S= -.002 but both DSRTs and salinities indicate Niskin and Gerard tripped at about 2550db instead of 5080db as intended. Probably post-tripped. See 290. Suggested footnote: "Post-trip, poor flush.".
260/290	Sample Log: Air leak. Salinity: "Perhaps drawn quite late" Niskin-Gerard S=.008 at 5241db. Gerard salt agrees with rosette & CTD salts. Assume Niskin leaked. Freon & barium also drawn from Niskin. Delete Niskin salinity (34.673). Gerard samples looks good.
360/392	Niskin salt low at 1476db indicating leak. No notes but same Niskin leaked last cast. Barium also drawn from Niskin #60. Delete bottle salinity (34.596). Sample Log: Air leak. Niskin-Gerard S= -.013 at 1476db. Gerard salt agrees with rosette & CTD salts. Assume Gerard ok.

Station 295

112 Sample Log: Hung up/no sample. No water samples @849db.

Station 296

133 ΔS .004 low at 4797db. Calc ok. Normal CTD gradient. Same value as 134, possible dupe draw. Delete bottle salinity (34.667).

Station 297

130 ΔS .006 high at 3898db. Calc ok. Normal CTD gradient. Possible salt crystal from cap got into sample. Nutrients ok. Delete bottle salinity (34.708).

Station 298

154/185 Sample Log: Didn't trip. No water @3022db. Gerard (185) salt agrees with CTD salt.

157/188 Sample Log: Didn't trip. No water @4515db. Gerard (188) salt agrees with CTD salt.

Station 300

131 ΔS .004 high at 3899db. Calc ok. Normal gradient. No notes. Other water samples ok. Deleted bottle salinity (34.700).

Station 302

210 ΔS .051 high at 473db. Calc ok. Normal gradient. No notes or explanation Other water samples ok (02 min). Delete bottle salinity (34.880).

235 PO_4 .42 high at 4550db. Calc & peak ok. Assume contamination problem. Delete phosphate (2.78).

236 ΔS .002 to .003 high at 4643db. Steady increase in each Autosal run indicating possible salt crystal contamination from bottle cap. Delete bottle salinity (34.671).

Station 303

113 Sample Log: Drained for salts. No salinity sample @651db.

115 Sample Log: Empty for salts. No hydro S @803db.

117 Sample Log: Low for salts. ΔS .002 high at 1002db. Hydro O_2 low at 1003db per CTDO calibration. Calc ok, no notes. This is Keeling CO_2 bottle so bottle half empty when O_2 drawn. O_2 .22 lower than Niskin 16 tripped at same level. Delete bottle oxygen (5.19).

124 Sample Log: Empty for salts, barely sampled nuts. No bottle salinity @2110db.

131 Sample Log: Freon drawn after TCO_2. Does not effect samples @3551db. ΔS .008 high at 3550db. Calc ok. Small spike in raw CTD S trace this level but block averaged data has smooth normal gradient. No notes. Delete bottle salinity (34.785).

Station 304

134 ΔS .080 high at 3696db. Calc ok. All water samples appear to be from about 3475db. Delete all water samples (S=34.779, O_2=5.19, PO_4=2.00, NO_2=0.00, NO_3=28.8, SiO_3=86.1)

Station 305

113 Oxygen @10OOdb is low. Appears to have drawn from bottle 14. Delete oxygen (5.33).

171 Sample Log: Sample cock sheared off during recovery, sample lost. No water samples @129db.

Station 306

119 Oxygen data sheet "bubble - large variety" O_2 .2 high @1954db. Same value as 120. Smooth CTDO trace. Delete bottle oxygen (4.75).

453 Salinity data sheet: "Junk in water" Niskin-Gerard S=.006 at 5049db. Calc ok. Niskin is high and Gerard (88) agrees with CTD, rosette and other samples this Argon cast. No other sample drawn this Niskin. Delete Niskin salinity (34.676).

457 Niskin-Gerard S=.011 at 4862db. Calc ok. Niskin is high and Gerard (83) agrees with CTD, rosette and other samples this cast. Freon and Barium also drawn this Niskin. Niskin salt is similar to 454 salt which was the adjacent bottle in the rack. Possibly 457 was mis-drawn and the other samples are ok. No notes. Delete Niskin salinity (34.681).

459 Sample Log: Empty - didn't trip. No Niskin salt or hydro T & P at 5025db. Gerard salt (485) agrees with CTD, rosette and other samples this Argon cast.

Station 307

128 Sample Log: Thermometer lanyard caught in bottle top. Sample discarded. Nutrients & salinity run; both indicate severe leak@3301db. Delete all water samples (S=34.893, O_2=1.35, PO_4=1.35, NO_2=0.01, NO_3=19.3, SiO_3=37.4).

186 Sample Log: Not latched, water squirting out of lid on recovery. Niskin-Gerard S=-.007. Niskin sample (56) agrees with other samples this level and Gerard salt is high. After cast found wrong size air vent plug had been used. (New {WHOI} barrels have slightly different diameter hole in lid for air vent plug than the old (yellow- hooded) barrels.) Sample Log indicates Argon and radium 228 may have been taken from Gerard. Leave bad Gerard salt in report to indicate problem, footnote "U".

Station 308

106 ΔS .258 low at 199db. Calc ok. Same value at 107 salt. Other water samples ok. Assume 106 salt drawn from Niskin 7. Delete bottle salinity (34.626).

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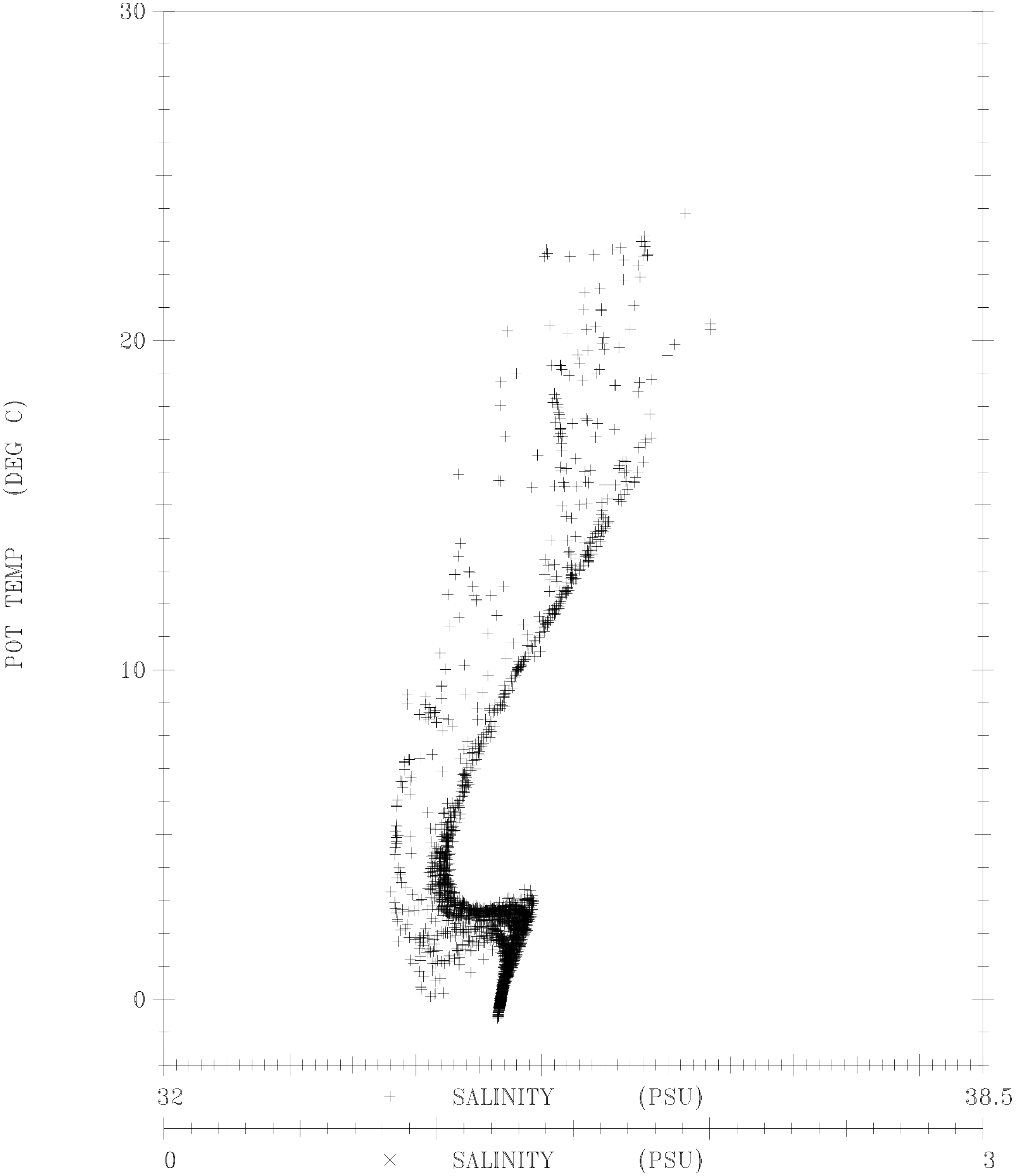

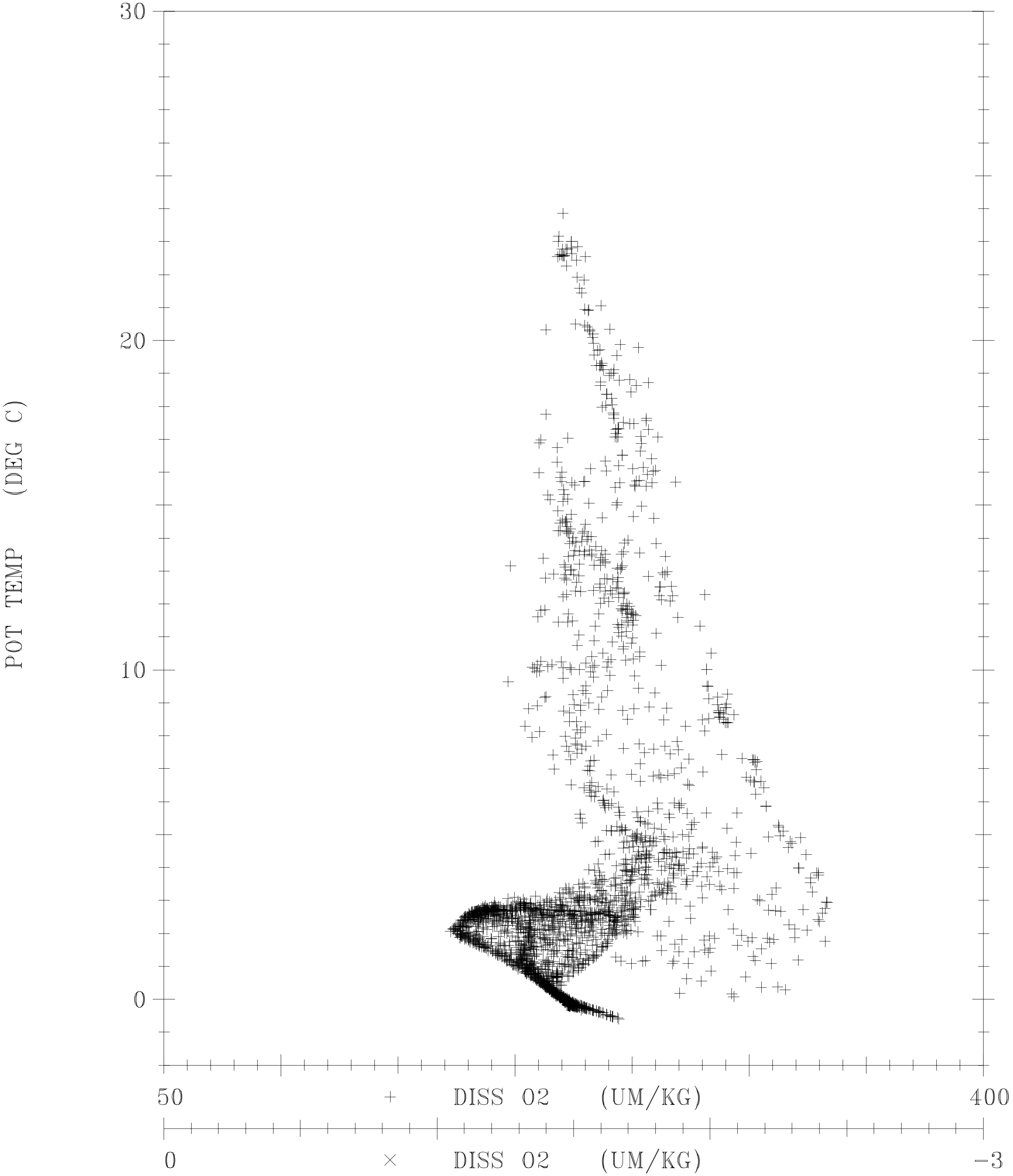
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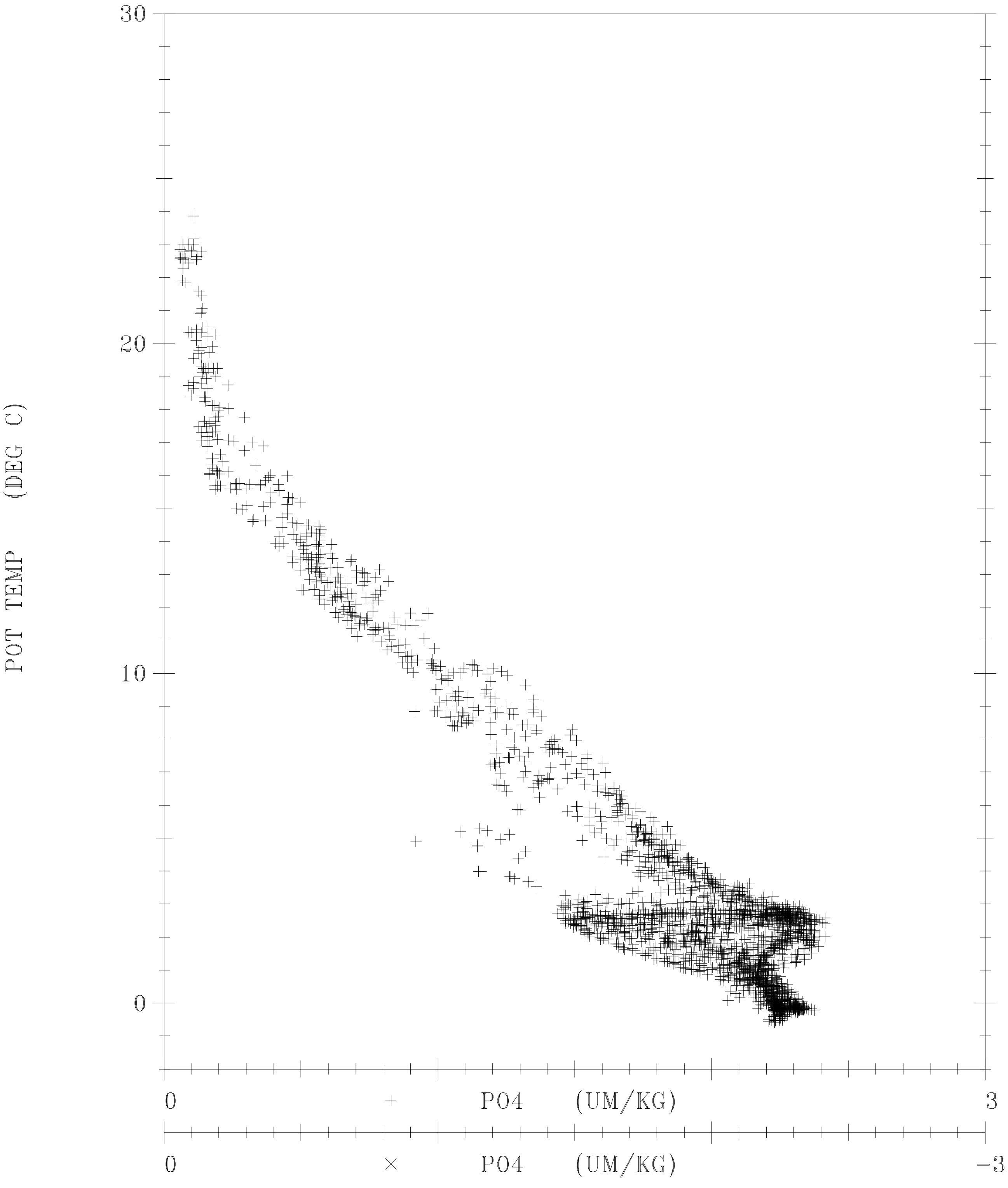
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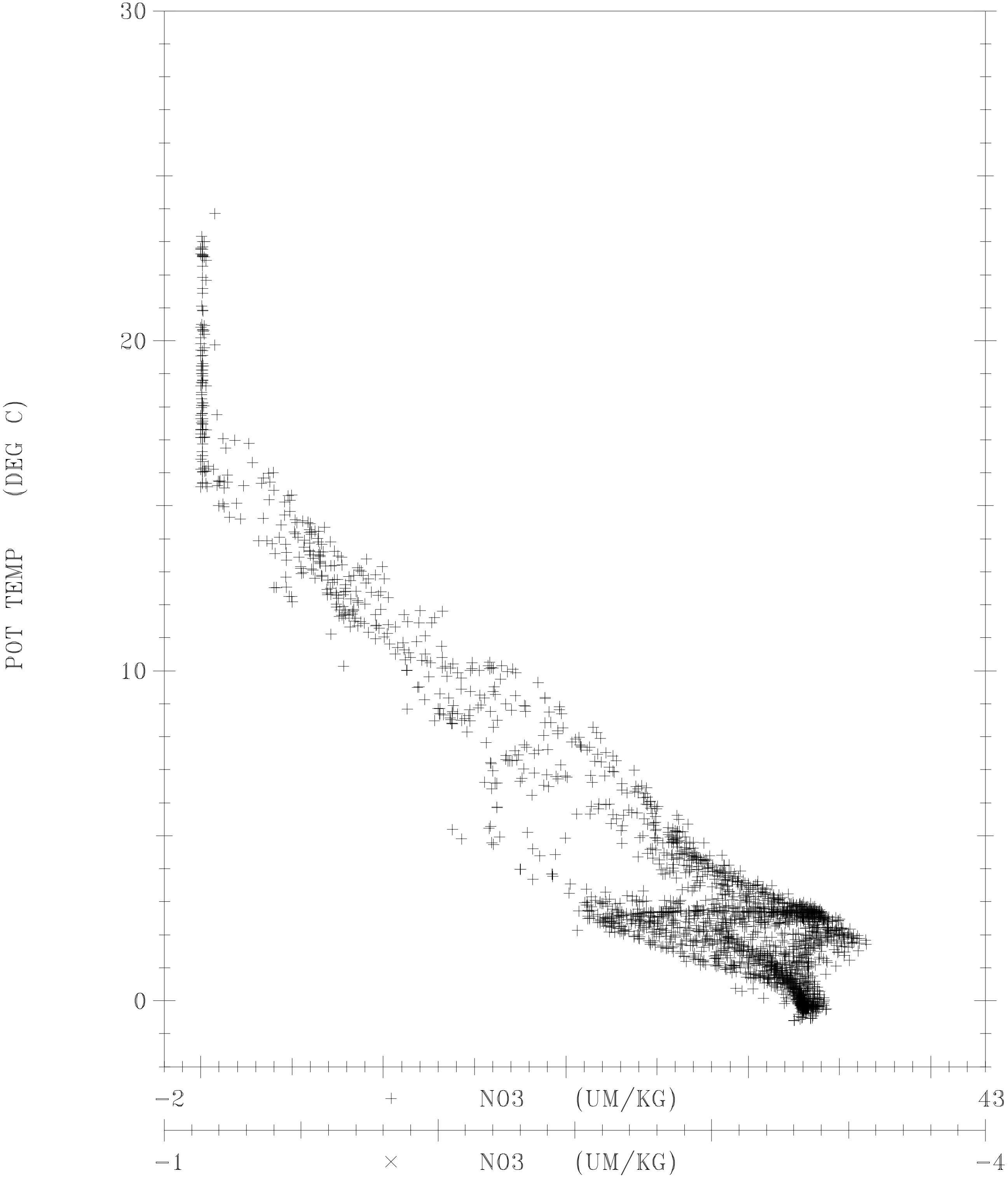
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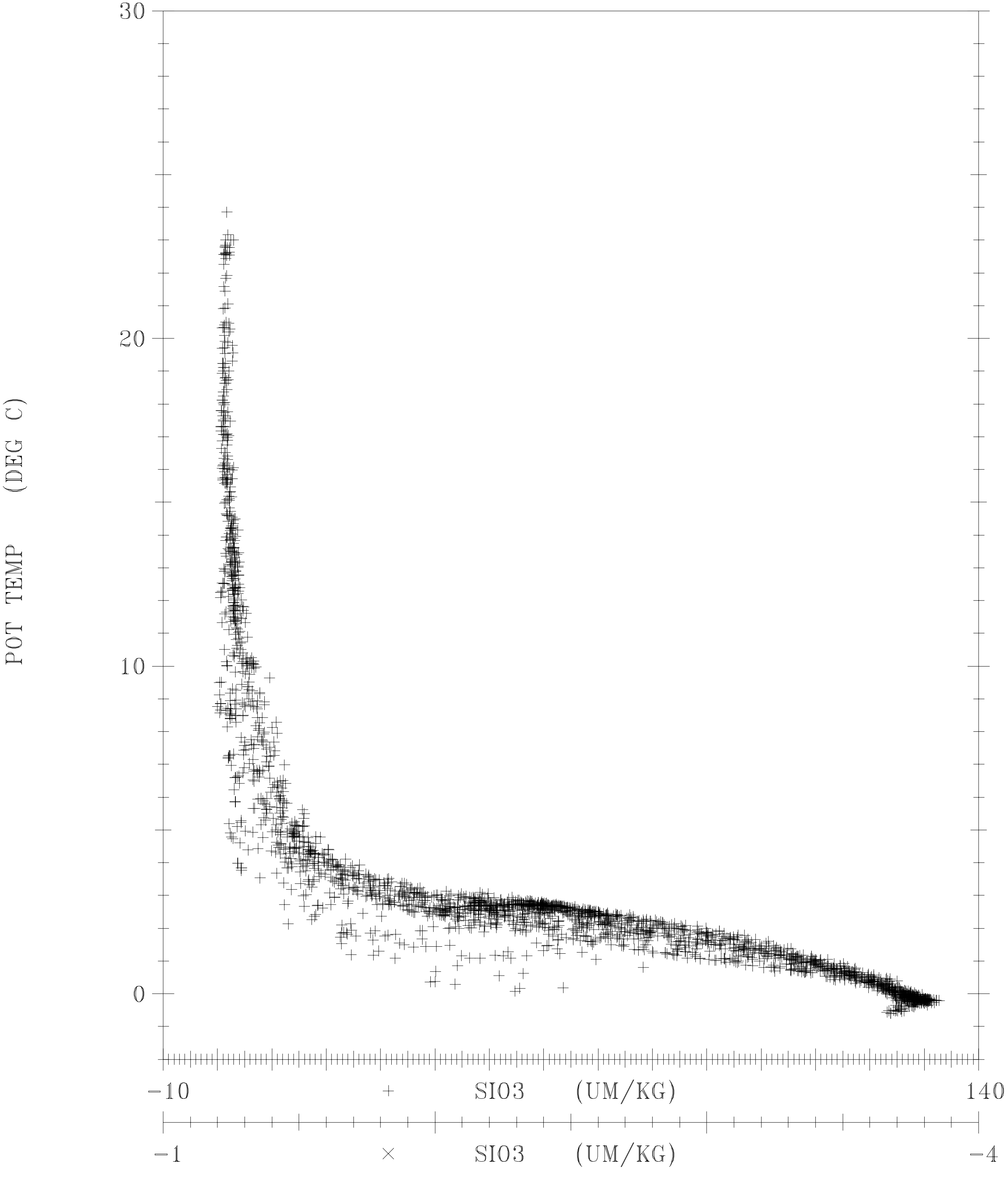
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S.A.V.E. RADIOCARBON
SOUTH ATLANTIC VENTILATION EXPERIMENT

1987-1989

TRITIUM LABORATORY
DATA REPORT # 18
by
H. Göte Östlund and Charlene Grall

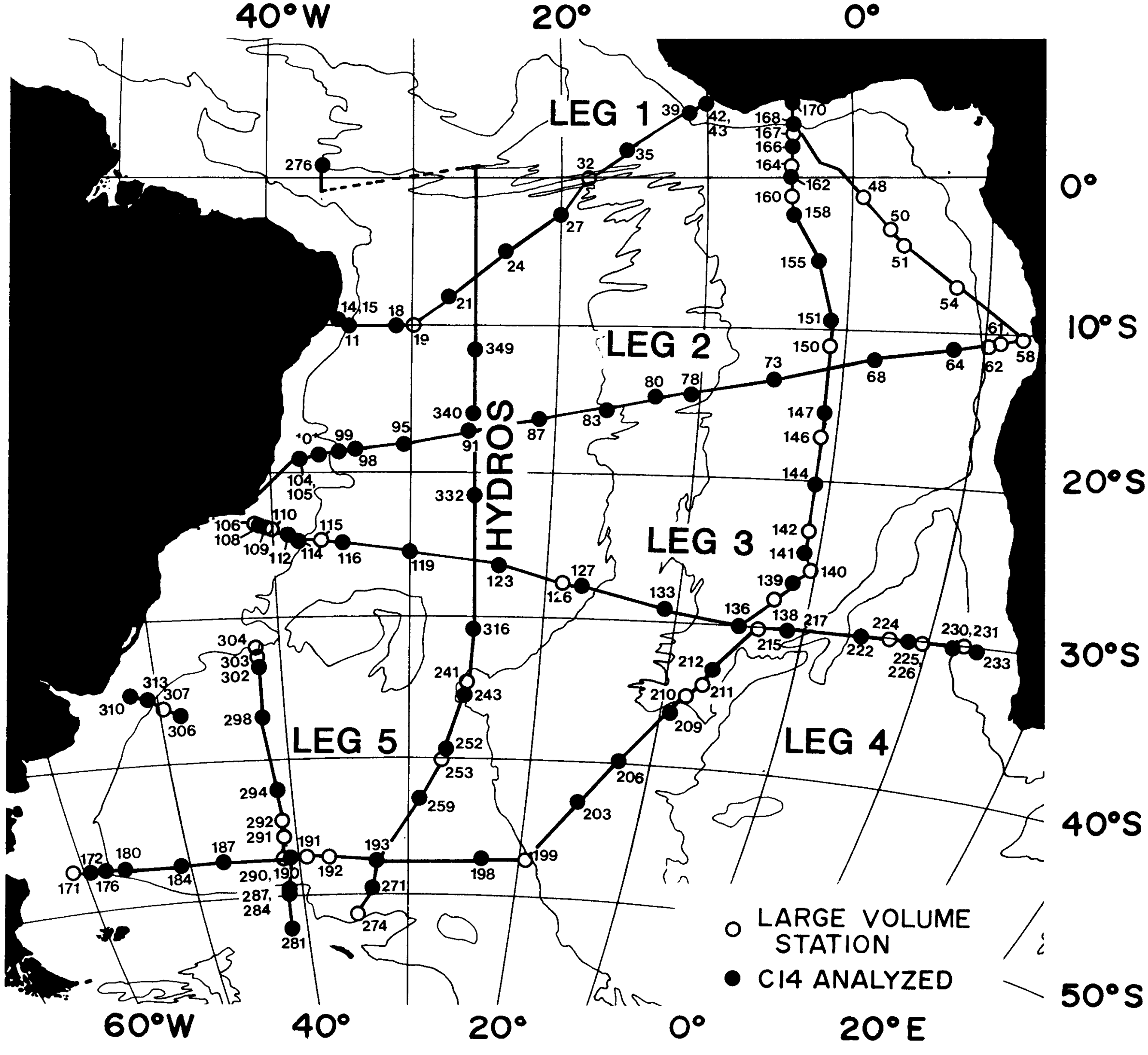
This report constitutes the Final Report for the following grant:
NSF OCE-86-13329 September 1992

TRITIUM LABORATORY DATA REPORTS

- #1 TRITIUM IN THE TROPOSPHERE AND SURFACE WATER OF NORTH ATLANTIC OCEAN 1964-70, H.G. Östlund, R.D. Stearns, and R. Brescher. July 1971.
- #11 ANTARCTIC TRITIUM 1977-1979, A.S. Mason and H.G. Östlund. November 1981.
- #12 GEOSECS TRITIUM, Atlantic Ocean 1972-73, Pacific Ocean 1973-74, Indian Ocean 1977-78, Station 347 Revisits, H.G. Östlund and R. Brescher. December 1982.
- #13 NAGS TRITIUM, North Atlantic Gyre Studies and Associated Projects, H.G. Östlund. June 1984.
- #14 ATMOSPHERIC TRITIUM 1968-1984, H.G. Östlund and A.S. Mason. April 1985.
- #15 EQUATORIAL PACIFIC TRITIUM, H.G. Östlund, C. Grall, and R.E. Brescher. April 1986.
- #16 TTO NORTH AND TROPICAL ATLANTIC TRITIUM AND RADIOCARBON, H.G. Östlund and C. Grall. February 1987.
- #17 INDIGO 1985-1987, INDIAN OCEAN RADIOCARBON. H.G. Östlund and C. Grall. April 1988.
- #18 S.A.V.E. RADIOCARBON, South Atlantic Ventilation Experiment, 1987- 1989. H.G. Östlund and C. Grall. November 1992. **THIS REPORT.**

NOTE: Data Report #s 2,3,4,5,6,7,8,9,10 have been superseded by #s 12,13 and 14. The measurement results of #12 are also available in Vol. 7 of the GEOSECS ATLAS.

SAVE 1987 - 1989



PREFACE

This report presents all the radiocarbon measurements produced from the six S.A.V.E Cruises 1987-1989. The following informal Data Releases include all measurement results previously reported. Additional quality control has slightly changed some earlier data which are hereby superseded.

#89-05 S.A.V.E. Radiocarbon Results, Legs 1 and 2.

#89-38 S.A.V.E. Radiocarbon Results, Legs 2 and 3.

#90-32 S.A.V.E. Radiocarbon Results, Legs 4,5 and HYDROS Leg 4.

#91-56 S.A.V.E. Radiocarbon Results, Legs 3,4,5 and HYDROS Leg 4.

The data in this report are hereby in the public domain to, be used by anyone. Conventional reference is appreciated.

Copies of this Data Report, or any other Tritium Laboratory Data Report, may be obtained by addressing the Tritium Laboratory, RSMAS, University of Miami, 4600 Rickenbacker Causeway, Miami, Florida 33149, U.S.A.

A 5-1/4" floppy disk, containing all radiocarbon data in this report in addition to some hydrographic data, in ASCII format, is available upon request. We hope that this data set will be used extensively in many modeling studies in the years to come.

ACKNOWLEDGMENTS

The measurement of all the radiocarbon samples and the production of this report were carried out under National Science Foundation Grant NSF-OCE-86-13329. We are very grateful for their long term support. We also thank the technical staff of the Ocean Data Facility at Scripps Institution of Oceanography for the radiocarbon sample collection and shipboard extraction. We sincerely appreciate the efforts of the chief scientist to include as many sample collections as they did especially after the untimely loss of the Gerard barrels on the first cruise of this project. M. Stuiver and T. Saling at Quaternary Research Office, University of Washington, made the numerous and excellent ^{13}C measurements which is hereby gratefully acknowledged.

TABLE OF CONTENTS

S.A.V.E. RADIOCARBON SOUTH ATLANTIC VENTILATION EXPERIMENT, 1987-1989

I. INTRODUCTION

The project called Transient Tracers in the Ocean, TTO was initiated it 1980 with the intent to study the Atlantic Ocean. The North Atlantic Study (NAS) and Tropical Atlantic Study (TAS) scientific cruises continued only as far south as 10°S. The South Atlantic Ventilation Experiment (SAVE) expeditions traversed as far south as 53°S and east to Africa. Through the use of various tracers, the program investigated circulation, mixing and ventilation of the South Atlantic Ocean. Radiocarbon (^{14}C) is considered an important tracer to study because it helps provide information on rates of internal oceanic mixing as well as the rate of gas exchange between ocean surface and atmosphere. The coverage of ^{14}C measurements from SAVE is much denser than that of its predecessor, GEOSECS, and can provide a much better base upon which future CO_2 studies can build. It also provides a view at the evolution of bomb ^{14}C distribution over the last decade since GEOSECS, as several GEOSECS stations were reoccupied during SAVE.

II. CRUISE DESCRIPTIONS

The SAVE expedition consisted of two cruises subdivided into six legs.

A. Year 1

The first leg aboard the R/V Knorr, began 23 November 1987 from Recife, Brazil. The Knorr crossed the Atlantic Ocean on a northeasterly course and arrived into Abidjan, Ivory Coast on 13 December 1987. A total of 121 radiocarbon samples was collected from ten large volume stations. During a deep Gerard cast on station 32, all barrels were lost when the winch cable snapped. Two spare Gerard barrels were used during the remainder of Leg 1, which limited sample collection to the upper 1000m of depth.

The Knorr departed Abidjan on 18 December 1987, heading southwest and arrived in Rio de Janeiro, Brazil on 23 January 1988. During Leg 2, 163 ^{14}C samples were collected from 21 large volume stations. With the exceptions of stations 95 and 99, where deep samples were collected from the core of the Antarctic Bottom Water and North Atlantic Deep Water, maximum sample depth was 1000m.

On Leg 3, once again armed with full complement of Gerard barrels, the expedition set out on 28 January 1988, traveled southeast to about O°W then heading north back to Abidjan. Before the cruise ended on 7 March 1988, 349 radiocarbon samples were taken at 30 large volume stations.

B. Year 2

The second year of SAVE began with departure of the R/V Melville from Punta Arenas, Chile on 7 December 1988. She crossed the South Atlantic Ocean along 47°S to 20°W, headed northeast to 30°S before steaming due east to Capetown, South Africa, arriving on 15 January 1989. During Leg 4, 299 radiocarbon samples were collected from 27 large volume stations.

Leg 5 cruise departed Capetown on 23 January 1989. The cruise track consisted of two meridional sections: the first traversing from 24°W south to South Georgia Island; the second section going north along 41°W. A small northwest portion of the track heading toward Montevideo, Uruguay ended on March 8, 1989. A total of 173 ^{14}C samples was taken on 20 stations.

The remainder of the cruise was a meridional section called HYDROS, Leg 4, which ran north from SAVE station 237 to the equator along 25°W. During this leg, 107 radiocarbon samples were collected from eight stations. The program ended 19 April 1989. The table below summarizes the sample collection and measurement.

Cruise Leg	**# Radiocarbon Samples**	
	Collected	**Measured**
SAVE 1	121	117
SAVE 2	163	111
SAVE 3	349	296
SAVE 4	299	256
SAVE 5	173	159
HYDROS 4	107	100
TOTAL	1,212	1,039

C. Samples Still Available for Analysis

Although most of the samples collected during SAVE have been analyzed, 139 samples are still unmeasured and are archived at our laboratory. Stations not yet analyzed are presented as tables located in the last section of this report, starting on page 72. We hope that the sample selection by various investigators and us has covered the major and relevant ocean features explored during the two years of SAVE. In the event that some questions remain that could be answered with additional analyses, we intend to store the remaining samples for a few more years.

III. TECHNICAL PROCEDURES

A. Sampling

Water samples were collected on board ship using 270 liter stainless steel Gerard barrels. Shipboard extraction of CO_2 was performed by acidifying 200 liters of seawater with 50ml of 95% sulfuric acid, and bubbling through an inert CO_2-free gas. The released CO_2 was then stripped from the carrier gas and re-dissolved into a 450ml bottle of 4N sodium hydroxide (NaOH). The sample bottles were then shipped to the Tritium Laboratory for measurement. Resulting yield under favorable conditions, was about 9 lit-atm of CO_2 or 95 - 98% of the total dissolved CO_2 in the sample.

B. Preparation of Sampling Gas

In the laboratory, CO_2 was released from the NaOH solution by adding phosphoric acid. Nitrogen gas, the carrier, transferred CO_2 and any other evolved gases to collection traps maintained at -196°C by liquid nitrogen. After pumping on the solid CO_2, this gas was then passed through a purification system consisting of a series of cold traps to remove water vapor, and two copper-silver ovens to remove gaseous electronegative impurities, mainly chlorine and oxygen. Remaining impurities were removed by pumping on condensed CO_2 at a temperature of -196°C. It is our experience that yields are about 99.7% of the total CO_2 contained in the NaOH solution. Occasionally, yields were less than optimal for counting in the large radiocarbon counters. These samples were saved when possible by counting in a smaller counter for twice the length of time required for a normal size sample.

At this point, a small aliquot of purified gas was removed for massspectrometric $\delta^{13}C$ analysis. The remaining gas was stored in a stainless steel high pressure cylinder for 14 to 21 days before counting to allow any radon to decay (half-life is 4 days). The radon apparently originated from the phosphoric acid, and occasionally from the glass of the NaOH bottles.

Below follows a description of our standard ^{14}C measurement technique and special modification for this project.

C. Counting

We have four 2.5 liter and one 1 liter low-level gas proportional counting tubes for ^{14}C, using CO_2 gas samples. The counters are shielded by 2.5 cm of selected lead, a ring of anti-coincidence Geiger counters, 10cm of paraffin wax, boric acid and/or borated polyethylene, and at least 20 cm of iron, plus the walls and ceiling of the building. The counter is filled with the sample to a working pressure of 45 psi. The proper operating voltage, dependent on temperature and pressure in the counter, is adjusted to produce the most efficient and stable ^{14}C detection. This is done by an external radioactive source, usually 60- CO. Gas amplification is continually monitored by the distribution of meson counts in selected energy channels. The occurrence of radon is monitored in a separate channel with each counter. Each sample is counted for at least two separate periods of about 20 hours each, in different counters, with an interim waiting time of at least 7 days. Inconsistency between the two counts prompts an additional measurement in a third counter. For the short samples in this series, two counters were temporarily standardized to work at low pressure. These samples were counted for a total of 4 to 6 days.

D. Background and Standards

Background count rates, typically 3.5 cpm, are determined weekly by measuring ^{14}C-free CO_2 gas. The standard material for ^{14}C measurements is the NBS oxalic acid standard, RM49 and SRM4990C, for radiocarbon dating. The CO_2 prepared from this standard is counted for two days every week in each counter, to determine counting efficiency; typical count rate for an ocean surface sample is 43 cpm above background.

E. Update

Periodically, usually every five weeks, all measurements in all counters for the preceding time period are recomputed, statistical tests are applied, and results scrutinized for flaw in quality of sample counts and stability of efficiency and background. This includes all measurements of standards, unknown and backgrounds. Only after this step is the measurement result considered final. Contribution from minute quantities of CO_2 in the original NaOH solutions is measured for each batch of NaOH and appropriate corrections have been applied.

IV. NOTES ON SCALES

The measurement results in the ratio, r, between the measured specific activity of the sample CO_2 and that Of CO_2 prepared from the NBS standard. The activity value of the standard is corrected to a hypothetical $\delta^{13}C$ value of -19‰ and age-corrected from today back to AD1950, all according to international agreement. $\Delta^{14}C$ is the deviation, in ‰ (per mil), from unity, of the activity ratio, isotope- corrected to a sample $\delta^{13}C$ value of -25‰ Normally there is very little (± 0.3‰) isotope separation in our preparation procedure. Within these limits, our $\delta^{13}C$ values represent the state of isotope fractionation of the original seawater CO_2. According to this convention, each of our reported $\Delta^{14}C$ values is, however, normalized to the delta value it would have if its $\delta^{13}C$ changed to -25 ‰, noting that the change is equal to twice the change in $_{13}C$. Note that the mass of $_{14}C$ is always proportional to the r-value, not to $\Delta^{14}C$ (See Appendix 1).

Dr. Minze Stuiver at the Quaternary Lab, University of Washington measured the $\delta^{13}C$ values for this project by precision mass- spectrometry.

For further explanation of these features, and information on standards, cf. preface to each issue of Radiocarbon, and papers by Broecker and Olson (1), Stuiver and Robinson (2) and by Stuiver and Polach (3). Also refer to Appendix.

V. ACCURACY AND ERRORS

Errors for $\delta^{14}C$ are not listed in the tables. For a normal size sample the errors are 3.0 to 3.5 ‰ for precision and 3.5 to 4.0 ‰ for accuracy, including all conceivable uncertainties. The small samples, due to the very long counting times should be about as good.

VI. HYDROGRAPHIC DATA

The hydrographic data were supplied by the Ocean Data Facility (ODF), Scripps Institution of Oceanography. Total CO_2 data were supplied by Taro Takahashi, Lamont Doherty Geological Observatory at Columbia University. They are presented in µmol/kg.

We calculated potential temperature from in situ temperature, pressure, and salinity by the equations of Bryden (4). The density (sigma-theta) values were calculated according to the International one-atmosphere equation of state of seawater according to Millero and Poisson (5), which generates absolute densities in units of kg/m3. For serious use of the hydrographic, data, please refer to the Scripps Institution of Oceanography SAVE Data Reports; S.I.0. Reference 92-9, 92-10 and 92-12. For total CO_2 data please contact Taro Takahashi.

VII. COMMENTS TO FIGURES AND TABLES

A. Sections

Radiocarbon is expressed as $\Delta^{14}C$ ‰ The horizontal scale distance is given in kilometers with accompanying latitudes or longitudes. The vertical depth scale is in meters. Dots indicate measured samples. Due to scant data coverage in several areas, some subjectivity enters in drawing the isopleths.

B. Profiles

Radiocarbon is plotted as $\Delta^{14}C$ ‰ versus depth in meters. The bottom depth is marked by a horizontal line when it falls inside graph limits. Occasionally, some of the data were not reliable and are designated by "++" or small letters. Explanations are found in the tables of data.

C. Tables

Positions are stated in degrees and minutes. SMPL# is the cast and Niskin bottle number. GER represents the cast and Gerard barrel number. DC14 is $\Delta^{14}C$ ‰ and dC13 is $\delta^{13}C$ ‰. TCO_2 is total dissolved carbonate in µmol/kg. All collected sample's are presented in the tables. Those samples marked with an asterisk, * are still available for analysis.

VIII. REFERENCES

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Stuiver, M. , and W.S. Robinson, 1974. University of Washington GEOSECS North Atlantic carbon-14 results. Earth Planet, Sci. Lett., 23, 87-90.

Stuiver, M. , and H.A. Polach, 1977. Discussion reporting of 14C data. Radiocarbon, 19, (3), 355-363.

Bryden, H.L., 1973. New polynomials for thermal expansion, adiabatic temperature gradient and potential temperature of sea water. Deep-Sea Res., 20, 401-408.

Millero, F.J. and A. Poisson, 1981. International one-atmosphere equation of state of seawater. Deep-Sea Res., 28, (6A), 625-629.

APPENDIX (Revised August 15, 1992)

On the meaning and use of $\delta\ ^{14}C$ and $\Delta^{14}C$ in Oceanography

by

H. Göte Östlund

Tritium Laboratory, RSMAS, University of Miami

Summary OOPS! Don't use $\delta\ ^{14}C$ for calculating quantity of ^{14}C.

Argument δ

Beta counting of ^{14}C produces results in form of count rates, which can be converted to the relative specific activity r of the sample defined by

$$r = A_{sx} / A_{st} = I_{sx} / I_{st} \qquad (1)$$

where A_{st} is the adjusted specific activity of the NBS oxalic acid ^{14}C standard, 13.56 dpm/g of carbon, and A_{sx} is the specific activity of the sample in dpm/g. By applying the decay rate of ^{14}C this ratio can also be expressed in isotope $^{14}C/C_{tot}$-abundance ratios I, where I_{st} is 1.176 - 10-12. Often a 'per mil deviation', δ -^{14}C is calculated according to

$$\delta\ ^{14}C = 1000 \cdot (r - 1) \qquad (2)$$

See Remark.

Assuming that isotope fractionation is negligible during sample preparation, the r-value (and thereby the $\delta\ ^{14}C$) is the proper parameter to use for computing the absolute, true quantity of ^{14}C as number of atoms or moles. Thus the amount of ^{14}C in moles, in a kg of seawater or air is

$$\sum {}^{14}C = 1.176 - 10^{-12} \cdot r \cdot \sum C \qquad (3)$$

where SIGMA-C is the absolute assay of carbon in moles/kg. Mass inventories of ^{14}C, as well as macroscopic mixing and transports by currents and turbulent diffusion call for the use of Eq 3. If there is fractionation during collection and processing of a sample, the true, original r-value can be calculated from the sample r-value if $\delta\ ^{13}C$ data are available for both. By experience the standard ship-board CO_2 extraction from seawater and laboratory processing cause isotope shifts that are less than 0.5 ‰ and thus insignificant.

Argument Δ:

By (an unfortunate) convention environmental ^{14}C data are usually expressed as $\Delta^{14}C$ or R according to

$$\Delta^{14}C = \delta\ ^{14}C - 2\ (\delta\ ^{13}C + 25) \cdot (1 + 0.001\delta\ ^{14}C) \qquad (4)$$

$$R = 1 + 0.\ 001.\Delta^{14}C \qquad (5)$$

These equations describe what the $^{14}C/C_{tot}$ isotope ratio would be if a hypothetical chemical fractionation process brings the $\delta\,^{13}C$ value from its actual value to -25 per mil.

The use of the $\Delta^{14}C$ and R is a carry-over from the radiocarbon dating procedures, where isotope fractionation in the biological cycle necessitates this correction to allow calculation of best 'radiocarbon age' of a sample, most often organic material. The $\delta^{13}C$ reference value -25 was originally chosen as standard value, being typical for terrestrial wood, first used for ^{14}C standard material.

In geochemical considerations, conversion to $\Delta^{14}C$ is needed for calculations of "mummy" ages and for the proper handling of chemical equilibria, rate of chemical reactions and phase transfers. Examples:

Mummy age = (-ln R) / λ years before AD 1950.

where λ is ^{14}C decay rate in years^{-1}

In air-sea exchange of $^{14}CO_2$, assume P_{air} and P_{dia} are partial pressures of atmospheric and dissolved CO_2 and R_{air} and R_{dis} the isotope adjusted R-values according to Eq. 5, then there should be chemical equilibrium (no net transport) of $^{14}CO_2$ if

$$P_{air}\,R_{air} = P_{dis}\,R_{dis}$$

CONCLUSION:

The r-values ($\delta\,^{14}C$) are needed for use in the calculation of mass of ^{14}C. If only $\Delta^{14}C$ values are available, this is accomplished by solving for r in the equations 5,4 and 2 above and putting the value into Eq 3. With some approximation:

Oceanic dissolved CO_2	$\delta\,^{13}C =$ 0.0	r =1.050 R
Atmospheric CO_2	$\delta\,^{3}C =$ - 8.5	r =1.033 R
Wood (cellulose)	$\delta\,^{13}C =$ -25.	r =1.000 R

The factors in column 3, above express the errors obtained in ^{14}C inventories if $\Delta^{14}C$, or R, is used instead of $\delta\,^{14}C$, or r.

When one compares ^{14}C in various parts of the ocean, a systematic error of 5% may be insignificant. Also measured transfer coefficients have larger uncertainties than 5%. However, include a production term for ^{14}C (cosmic, industrial), or the atmospheric inventory, and there is cause for concern.

REMARK

In the exhaustive, maybe exhausting, paper by Stuiver and Polach (1977) $\delta^{14}C$ is indeed defined accurately and properly, with age corrections of standard material activity to AD 1950, and for the time elapsed between collection and measurement of the unknown sample. It is the first equation (un-numbered) on pg. 361 in that paper. The activity and isotope ratio values of the NBS oxalic acid standard are listed in several papers, among them one by Stuiver et al, (1981), viz pg. 208. The inventory equation on that page should use $\delta\,^{14}C$, not $\Delta^{14}C$.

POSTSCRIPT:

This error was pointed out in a recent paper by Bard et al, (1988), and is discussed by Östlund and Rooth (1990), as well as by Lassey (1989). In this pioneering paper on global ^{14}C, Craig (1957), correctly used the unadjusted r-values, and so did Kuc (1986 and 1987) on atmospheric ^{14}C inventories. Most often, however, $\Delta^{14}C$ is erroneously used for absolute quantities of ^{14}C.

First presented at the Modeling Workshop, Seattle, WA - August, 1989

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Bard, E., M. Arnold, H.G. Östlund, P. Maurice, P. Monfray and J-C Duplessy. Penetration of bomb radiocarbon in the tropical Indian Ocean measured by means of accelerator mass spectrometry, Earth and Planet. Sci. Lett., 87, 379-389, 1988, viz pg. 380.

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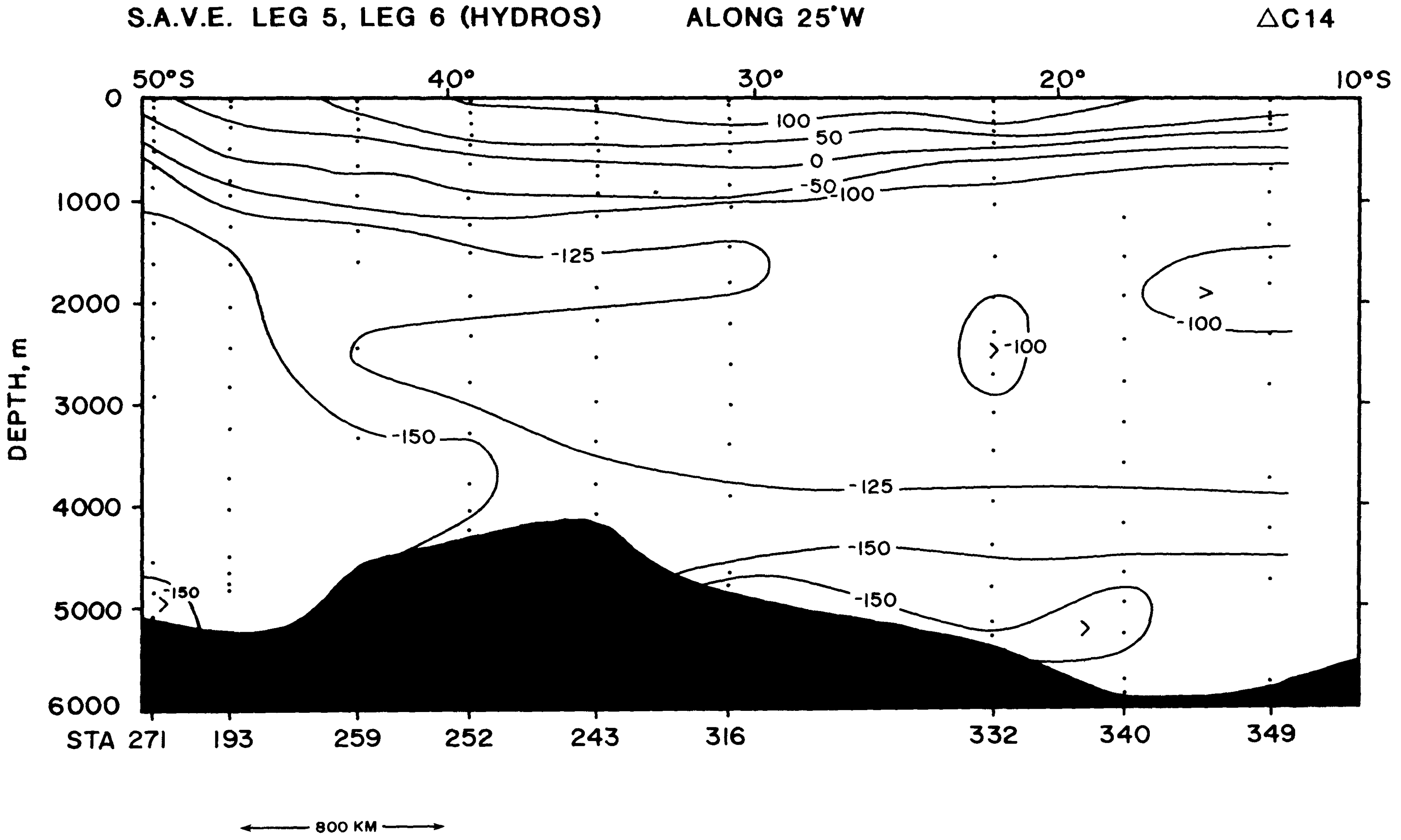
Östlund, H.G. and C.G.H. Rooth. The North Atlantic tritium and radiocarbon transients, 1972-1983. J. Geophys. Res., 95, 20,147-20,165, 1990.

Stuiver, M. and H.A. Polach. Discussion Reporting of ^{14}C Data, Radiocarbon, 19, 355-363, 1977.

Stuiver, M., H.G. Östlund and T.A. McConnaughey. GEOSECS Atlantic and Pacific ^{14}C Distribution in Carbon Cycle Modeling, Wiley and Sons, 1981, edited by Bert Bolin.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40°
30°
20°
10°S
DEPTH, m
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1000
2000
3000
4000
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6000
100
50
0
-50
-100
-125
-150
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-150
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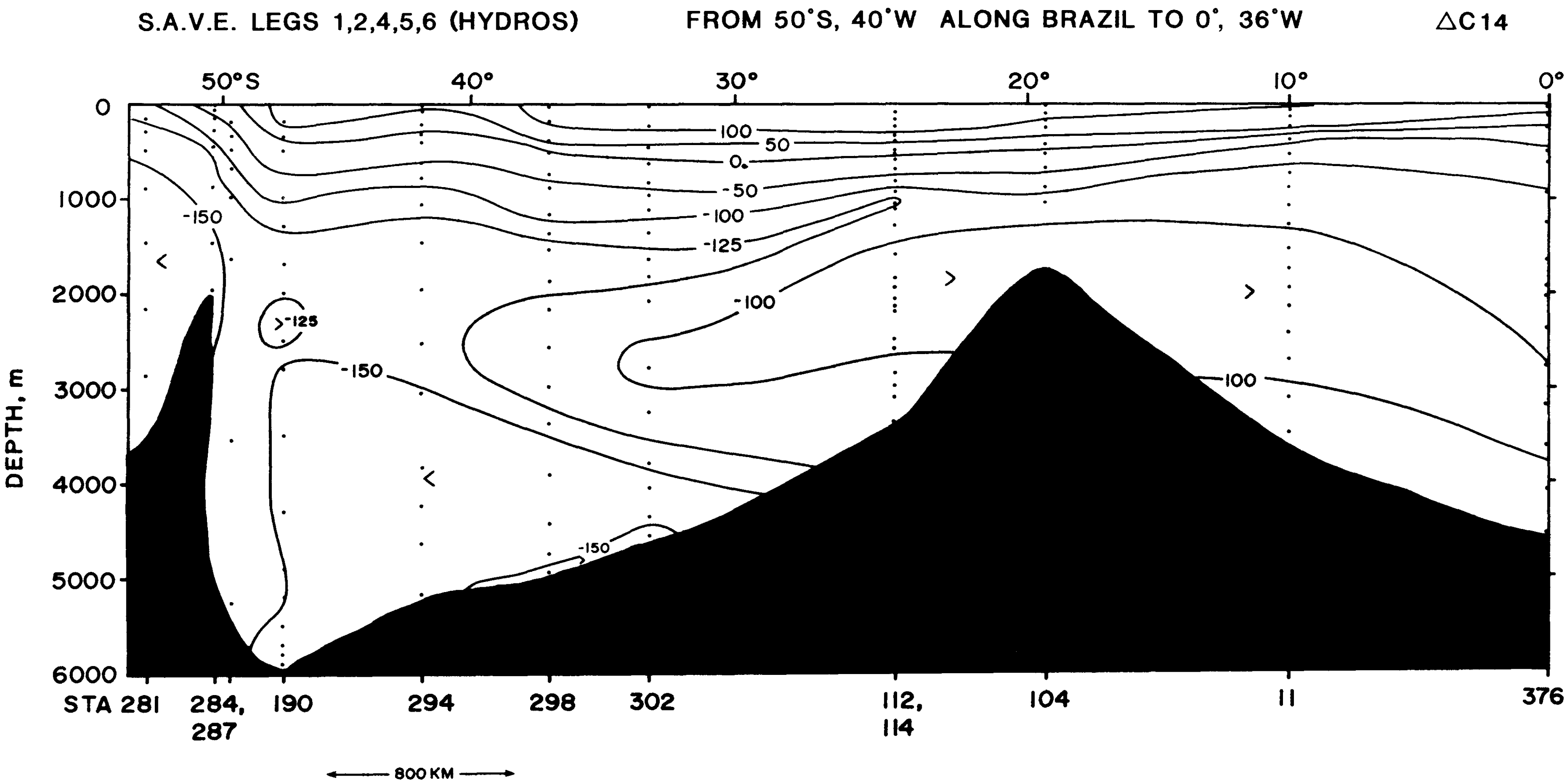
259
252
243
316
332
340
349
800 KM


S.A.V.E. LEGS 1,2,4,5,6 (HYDROS)
FROM 50°S, 40°W ALONG BRAZIL TO 0°, 36°W
△C14
50°S
40°
30°
20°
10°
0°
0
1000
2000
3000
4000
5000
6000
DEPTH, m
100
50
0
-50
-100
-125
-150
>-125
-150
-100
-100
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>
STA 281
284,
287
190
294
298
302
112,
114
104
11
376
800 KM

CCHDO-WHPO Data Processing Notes

Date	Contact	Data Type	Data Status Summary
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01/11/99	Smethie	CTD/BTL	Data are public
04/16/99	Jenkins	He/Tr	Projected Submission Date; 1999.09.15
	disk crash/must reprocess		
06/03/99	Diggs	CTD	CTD data are still with the PI.
06/04/99	Smethie	CTD	data avail. at ODF/SIO
06/07/99	Smethie	CTD	Data are Public
	I thought you had all the SAVE and you certainly have my permission to obtain the CTD data. It is my understanding as you indicate in your e-mail that it is public		
03/07/00	Talley	CTD/BTL	Data are Public; ctd data should be on website
05/31/00	Huynh	DOC	Website Updated; pdf, txt versions online
06/16/00	Talley	CTD	Submitted; not woce formatted
07/07/00	Anderson	CTD/SUM	Data Reformatted
	Reformatted .sum file. Reformatted CTD files, added correct headers. Used 2 for all QUALT codes. Station 279 did not have oxygen, so used quality flag of 9.		
07/10/00	Bartolacci	SUM	Website Updated; updated file online
	I have replaced the current sumfile with the newly reformatted sumfile (by S Anderson) and updated all table references		
07/10/00	Bartolacci	CTD	Website Updated; reformatted file online
	I have linked the newly reformatted CTD file (reformatted by S. Anderson) and updated all table references.		
12/11/00	Uribe	DOC	Submitted
	File contained here is a CRUISE SUMMARY and NOT sumfile. Documentation is online. Files were found in incoming directory under whp_reports. This directory was zipped, files were separated and placed under proper cruise. All of them are sum files. Received 1997 August 15th.		
04/03/01	Diggs	CFCs	Submitted
	CFC data submitted by Peter Salameh @ SIO. Placed files in data/onetime/ atlantic/a16/ onetime		

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1. Generated new SUMMARY file from final SIO/ODF data. Now has Uncorrected as well as Corrected Bottom Depths, corrected EVENT CODEs, NAV, Height ABOVE BOTTOM, WIRE OUT, MAX PRESS, NO. OF BOTTLES, complete parameter numbers from Sample Log Sheets and COMMENTS from ODF Station and Cast Description. Neodynium was not included since it does not have a parameter number. Particulates were not included since the documentation does not say whether they were parameter number 40 or 41 (or both).
2. Generated new SEA file from final SIO/ODF data. Now has BTLNBRs, complete CTDSAL and more decimal places in data. ODF did not include CTDOXY with bottle data in pre-woce cruises so it is not available for this report. Oxygen is included with the CTD data.
3. Merged final CFC data received from Peter Salameh April 3, 2001 /usr/export/html-public/data/onetime/atlantic/a16/original/ A16_SAVE_CFC/save5.txt into the new SEA file, replacing the shipboard CFCs in the ODF data</td></tr>
<tr><td>04/16/01</td><td>Muus</td><td>CFCs</td><td>Reformatted by WHPO</td></tr>
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We do not have any of the the actual large volume data (c14, argon-39, krypton, radium 228 & 226). The new files included them in the .SUM parameters but do not have any headers in the .SEA files.
Successfully ran sumchk and wocecvt.
Please let me know if you have any questions or need further clarification.</td></tr>
<tr><td>06/20/01</td><td>Uribe</td><td>BTL</td><td>Website Updated; Exchange File Online</td></tr>
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CTD exchange files were put online.</td></tr>
<tr><td>08/02/01</td><td>Key</td><td>DELC14</td><td>Website Updated; PI names corrected</td></tr>
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<tr><td>08/27/01</td><td>Swift</td><td>He/Tr</td><td>Data Request; HE/TR data requested by J Swift</td></tr>
<tr><td></td><td colspan="3">WHPO records indicate he/tr data not yet submitted. Request for earliest possible submission sent to Bill Jenkins.</td></tr>
<tr><td>09/17/01</td><td>Diggs</td><td>BTL/SUM</td><td>Website Updated: excange file, new SUM Y BTL files</td></tr>
<tr><td></td><td colspan="3">Replaced both the SUM and BOTTLE files online with the ones with CFC values (Muus 20010416). Also placed LVS file online, produced EXCHANGE file and placed on website. EXCHANGE file veried w/ JOA v3.0.</td></tr>
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Date	Contact	Data Type	Data Status Summary
11/12/01	Key	BTL/SUM	BTL and SUM submitted, see note:
	I uploaded the SAVE+HYDROS LV files today using your form. Note that a bottle number of "99" is a surface sample obtained without using a Gerard barrel. The file I sent does NOT have the piggyback niskin bottles. The only way I have that information is in a merged ascii file with "everything". This merged file does not have flags and is closer to the original files sent out by ODF + merged data I recieved from individual investigators. I have attached a copy of this file "just in case". The attached file is in an shortened format, but your guys won't have any trouble doing a reformat.		
11/19/01	Key	BTL	Large Volume submitted by Bob Key, not DQE'd
	This is information regarding line: SAVE 1-5; HYDROS-4 ExpoCode: Cruise Date: 1987/11/23 - 1989/04/19 From: KEY, ROBERT Email address: key@princeton.edu Institution: PRINCETON Country: USA The file: SAVE.dat - 209411 bytes has been saved as: 20011112.075818_KEY_SAVE†1_5;†HYDROS_4_SAVE.dat in the directory: 20011112.075818_KEY_SAVE†1_5;†HYDROS_4 The data disposition is: Public The bottle file has the following parameters: CTDPRS, REVTMP, SALNTY, OXYGEN, SILCAT, NITRAT, NITRIT, PHSPHT, C14, C14ERR, TCARBN, ALKALI The file format is:Comma Separated Values The archive type is: NONE - Individual File The data type(s) is: Summary (navigation) Bottle Data (hyd) The file contains these water sample identifiers: Cast Number (CASTNO) Station Number (STATNO) Bottle Number (BTLNBR) KEY, ROBERT would like the following action(s) taken on the data: Place Data Online Any additional notes are: WOCE flags have been assigned and are included, however, the QC was NOT thorough, especially with respect to routine hydro data.		
12/06/01	Key	DELC14	Data QC'd to WOCE standards
	The primary ref. for the SAVE/HYDROS C14 data is: S.A.V.E. Radiocarbon South Atlantic Ventilation Experiment 1987-1989 Tritium Laboratory Data Report No. 18 H. gote Ostlund and C. Grall Univ. OF Miami Rosenstiel School of Marine and Atmospheric Science Miami, FL 33149 Sept. 1992 84pp I will try to do a more complete QC of SAVE by the end of the year, but this should only amount to a footnote saying that the data have been QCed to WOCE standards.		

<table>
<tr><th>Date</th><th>Contact</th><th>Data Type</th><th>Data Status Summary</th></tr>
<tr><td>12/20/01</td><td>Uribe</td><td>CTD</td><td>Website Updated; Exchange file online</td></tr>
<tr><td></td><td colspan="3">CTD has been converted to exchange using the new code and put online.</td></tr>
<tr><td>12/20/01</td><td>Hajrasuliha</td><td>CTD</td><td>Data consistency check done</td></tr>
<tr><td>07/10/02</td><td>Huynh</td><td>DOC</td><td>Website Update; PDF & TXT cruise reports online</td></tr>
<tr><td>03/20/03</td><td>Kozyr</td><td>TCO2/PCO2</td><td>Submitted</td></tr>
<tr><td></td><td colspan="3">I noticed that the carbon data for A16S (R/V MELVILLE CR SAVE-5/HYDROS-3 WHP-ID A16S 23 JAN 1989 - 8 MAR 1989 20010417WHPOSIODM) are missing in WHPO bottle data file. I have put the data file with TCO2 and pCO2 (and pCO2TMP) values into WHPO ftp area.</td></tr>
<tr><td>04/16/03</td><td>Anderson</td><td>TCO2/PCO2</td><td>Website Updated Data merged into online BTL file</td></tr>
<tr><td></td><td colspan="3">Merged carbon data into online file. Made new exchange file, put files online.
Notes on a16s carbon merging:
April 16, 2003
A. Kozyr noted that the carbon data for a16s was not in the online file. See e-mail below. Since the file he sent only had station number and bottle number to use for merging, I retrieved the a16s carbon data from his web site.
• Merged TCARBN, PCO2, and PCO2TMP into the online file 20010412WHPOSIODM.
• Copied QUALT1 flags to QUALT2 flags.
• Changed the missing data code for TCARBN and PCO2 from -999.9 to -9.0 and for PCO2TMP from -999.90 to -9.00.
• Made new exchange file, and put files online.
Sarilee Anderson

On March 20, 2003 Alex Kozyr wrote:
I noticed that the carbon data for A16S (R/V MELVILLE CR SAVE-5/HYDROS-3 WHP-ID A16S 23 JAN 1989 - 8 MAR 1989 20010417WHPOSIODM) are missing in WHPO bottle data file. I have put the data file with TCO2 and pCO2 (and pCO2TMP) values into WHPO ftp area.
Also, could you check a05hy.txt file (EXPOCODE 29HE06_1 WHP-ID A05 DATES 072092-081792 20020821WHPOSIOSA), it has wrong CFCs flags. Please, let me know when you fix these problems.</td></tr>
<tr><td>09/28/04</td><td>Kappa</td><td>DOC</td><td>PDF and Text Cruise reports expanded and updated</td></tr>
<tr><td></td><td colspan="3">Additions to both versions (PDF and Text):
Final ODF-SIO Data Report which includes:
• Bottle Data Collection, Analyses and Processing
Salinity, Oxygen, Nutrients
• CTD Data Collection, Analyses and Processing
• References
• CTD Processing Notes
• Bottle Data Processing Notes
• List of Participants
Radiocarbon report by H. Göte Östlund and Charlene Grall
CCHDO-WHPO cruise summary page (page 1)
These CCHDO-WHPO Data Processing Notes
(more)</td></tr>
</table>

Date	Contact	Data Type	Data Status Summary
09/28/04	Kappa	DOC	PDF and Text Cruise reports expanded and updated **(continued)**
	Changes to PDF version only: Added standard "WOCE" outline (page 2) with links to text locations Updated CCHDO-WHPO station plot with improved clarity Added station track from author's original report Added scatter plots (nutrients) Added figures for radiocarbon report		