Cruise Report
ACCE float deployment cruise
Leg 2

Preliminary
All material presented herein cannot be used or reproduced without the express consent of the author.

1 Cruise narrative

1.1 Highlights

1.1.1 Expedition

WOCE/ACCE (R/V SEWARD JOHNSON 97-03)

1.1.2 Expocode

31SJ9702/2

1.1.3 Chief Scientist

Molly O. Baringer
Atlantic Oceanographic and Meteorological Laboratory
National Oceanic and Atmospheric Administration
4301 Rickenbacker Causeway
Miami, FL 33149 USA
baringer@aoml.noaa.gov

1.1.4 Ship

R/V SEWARD JOHNSON, Captain J. V. Seiler

1.1.5 Ports of Call

Port of Spain, Trinidad

Fortaleza, Brazil

1.1.6 Cruise dates

25 June 1997 - 26 July 1997

1.2 Cruise summary

1.2.1 Cruise track

Fig. 1

1.2.2 Sampling

56 CTD/24-bottle rosette stations for a total of 90.5 hours of sampling; All stations included LADCP.

Water sampling through the water column for salinity and oxygen (Fig. 2).

Underway sampling programs are listed in section 3.9.

Listings of parameters measured at each station are given in the .SUM file.

1.2.3 Floats and XBTs deployed

10 PALACE floats along 6°N.

9 PALACE floats along the equator.

178 XBTs (resulting in 162 usable profiles).

Station Locations shown in Fig. 1. Identification numbers, locations and times are given in the .SUM file.

1.2.4 No mooring deployments

1.3 Principal Investigators

Molly O. Baringer	CTD-hydrography	AOML	baringer@aoml.noaa.gov
Silvia Garzoli	PALACE floats along 0 and 6S	AOML	garzoli@aoml.noaa.gov
Robert Molinari	PALACE floats along 0 and 6S	AOML	molinari@aoml.noaa.gov
Ray Schmitz	PALACE floats along 6N	WHOI	rschmitz@whoi.edu
Rik Wanninkhof	Underway pCO2	AOML	wanninkhof@aoml.noaa.gov
Doug Wilson	ADCP-LADCP	AOML	wilson@aoml.noaa.gov

Abbreviations and addresses for tables above and below:

NOAA/AOML: National Oceanic and Atmospheric Administration, Atlantic Oceanographic and Marine Laboratory, 4301 Rickenbacker Causeway, Miami, FL 33149

WHOI: Woods Hole Oceanographic Institution, Woods Hole, MA 02543

RSMAS: Rosenstiel School of Marine and Atmospheric Science, 4600 Rickenbacker Causeway, Miami, FL 33149

IOUSP: Instituto Oceanografico Da Universidade De Sao Paulo - IOUSP, Department De Oceanografia Fisica, Praca De Oceanografico, 191, Cidade Universitaria - Cep 05508–900, Sao Paulo, S.P., Brazil

WEIZMANN: Weizman Institute of Science, Department of Environmental Science, Rehovot 76000, Isreal

Liberia: Ministry of Lands, Mines and Energy, P.O. Box 10-9024, 1000 Monrovia-10, Liberia, Africa

1.4 Scientific Program and Methods

1.4.1 Narrative

R/V SEWARD JOHNSON departed Port of Spain, Trinidad for its second leg of cruise SJ9703 on June 23, 1997. This was the second leg of the SEWARD JOHNSON for this cruise number (called here ACCE2). The first leg (called here WIMP14) left from Fort Pierce, FL on June 9, 1997 and arrived into Port of Spain on June 21. This cruise was supported by the National Oceanic and Atmospheric Administration Office of Applied Research (OAR). There were almost no problems with the basic sampling program and the weather was excellent for the most part. The ship had some difficulty with its Mark IV winch controller, level winder and the oil cooling unit for one engine. Sampling was broken off for seven days to return to Barbados for engine repairs. However, the crew was excellent and Harbor Branch made every effort to complete the scientific goals of the cruise.

Stations were numbered consecutively from the beginning of the R/V SEWARD JOHNSON SJ97-03 work from Fort Pierce to Trinidad in WIMP14 with sampling along the Windward Islands (Wilson, chief scientist). The first station on ACCE/2 was numbered 60 and was a test station. Considerable problems were noted with the 11 of the 24 Niskin bottles leaking. After a complete overhall of the rosette and Niskin bottles, another test station, number 61 revealed no problems. The first complete station was 62. The last station was 115.

The cruise plan called for sampling northeastward from the 100m isobath off French Guiana along an historical STACS section (last sampled in 1989). The track was then to proceed eastward to the coast of Africa into Liberia, then down to the equator near 10W and back towards the west towards Brazil. The goals of the sampling were to deploy PALACE floats along 6N and the equator and to obtain an upper ocean section along 6N to estimate the flow of the warn water sphere flowing into the North Atlantic. Particular attention was to be paid to calibration of the PALACE floats. Station locations can be found in Fig. 1.

Most stations were to 2000 meters depth and included a rosette/CTD cast equipped with a lowered acoustic doppler current profiler (LADCP). Basic station spacing was 60 nm, closing to 40 nm west of 46W along 6N. Station spacing at the French Guiana and Liberian coasts was less than 30 nm and dictated by topography and previous STACS station locations.

Sampling was done with a 24-place Seabird pylon on a rosette frame with 10-liter bottles and a CTD (AOML CTD 1), LADCP and pinger. The CTD data stream consisted of elapsed time, pressure, two temperature sensors, two conductivity sensors, and two oxygen sensors through a majority of this cruise. LADCP data was logged internally and uploaded to a processing PC at the end of each cast. Water samples were collected for analyses of salt, and oxygen. Water sample depths for the basic physical oceanography program are shown in Fig. 2.

Station times for the CTD/rosette are shown in Table 4. A total of 90.5 hours of station time were completed. Wire speeds were up to 70 meters/minute for downcasts and upcasts; because of stops for bottle trips and slower speeds in the upper 100 meters, the average wire speed for all stations was 48-50 meters/minute. Slower wire speeds occurred initially due to difficulties with the winch controller. Throughout the cruise, the winch needed to be slowed so that a ships engineer could to manually adjust the level winder on the Mark IV at the end of each complete wrap (every 200-500 meters or so).

On all stations, Doug Wilson's RDI lowered acoustic doppler profilers (LADCP) was mounted inside the rosette frame. A broad band operating at 150kHz LADCP was used. A second hull mounted ADCP was also employed during the cruise. Underway shipboard ADCP data were logged. No substantial problems were encountered.

Underway measurements included pCO2 (Wanninkhof), and the various variables of the SEWARD JOHNSON's IMET system (surface water temperature and conductivity, oxygen, meteorological parameters, GPS navigation, ship's speed and heading) and TSG system (temperature and salinity). Bathymetry was recorded every 2 minutes from the SEWARD JOHNSON's CHIRP II system.

1.4.2 Bottle locations

Bottle positions follow WOCE sampling guidelines and are shown in Fig. 2.

1.4.3 Vertical sections

Potential temperature, salinity, oxygen, potential density and potential vorticity are distributed in Fig. 3, and 4 at the end of this report. XBT sections are given in Fig. 5 and LADCP sections are shown in Fig. 6.

1.5 Underway measurements

1.5.1 Navigation

- GPS. Bathymetry - PDR.

1.5.2 ADCP

- RDI vessel mounted 150kHz ADCP. See comments above.

1.5.3 Thermosalinograph and meteorological measurements

- using the IMET system and AOMLs thermosalinograph system.

1.5.4 XBTs deployed between CTD stations.

Identification numbers, locations and times are given in the .SUM file and Fig. 1. See comments above.

1.5.5 Meteorological observations:

Continuous measurements from the IMET system.

1.6 Major problems and goals not achieved

The underway XBT hand launching system installed by AOML in the stern of the ship resulted in the failure of some XBT probes when sea water leaked into an electrical junction box during moderate seas. The sea water leakage resulted in a small reduction of resistance in the lines which the SEAS system recognizes as warmer temperatures. The temperature profiles appeared normal and the slow increase in temperature between consecutive XBTs was not noted until after the amount of sea water present became so large that the hand launcher failed to detect new probes. The launching system was moved to the mid-beam starboard side of the ship and no other major problems were noted.

There were no problems resulting in major shortfalls in numbers, spacing, or coverage of the CTD and PALACE stations. There were no major problems with any of the basic analyses of salinity, oxygen and CO2/pCO2.

Some interruptions were encountered with the acquisition and storage of underway measurements due to computer network problems. Several eight hour gaps in coverage occurred.

1.7 Other incidents of note

One engine failed after CTD station 65. The ship continued to station 66 at a reduced speed of about 7 knots (made good) and attempted repairs. After determining the oil cooling system irreparable, the ship suspended operations at 13:45 GMT on 6/29 and headed for Barbados. A replacement part was promptly shipped and the engine fixed. After a long steam back to the cruise track, science operations resumed at 12:10 GMT on 7/6. The ships crew and Harbor Branch personnel made every effort to ensure continuity in the science program by adding 6 days to the cruise and the science program completed successfully (due largely to the fantastic speeds the ship made good throughout the remainder of the cruise).

Once engine repairs were complete, the Seward Johnson averaged 11.7 knots (helped by a surface current of as much as 1 knot). An excess of 12,700 nm were transversed.

2 Cruise Participants:

Molly Baringer	Chief scientist	NOAA/AOML	baringer@aoml.noaa.gov
David Bitterman	ET, PALACE	NOAA/AOML	bitterman@aoml.noaa.gov
Cecil Crosby	Programmer	RSMAS	ccrosby@rsmas.miami.edu
Don Cucchiara	Oxygens, deck	RSMAS	dcucchiara@rsmas.miami.edu
Chris Fleurant	CTD processing	NOAA/AOML	fleurant@aoml.noaa.gov
Eli Galanti	CTD watch	Weizmann Inst.	elul@beach.weizmann.ac.il
Julu M. Johnson	Observer/Sampler	Liberia	NA
Elcio Patti, Jr.	LADCP watch	IOUSP	elcio@vortex.io.usp.br
Ryan Smith	ADCP/LADCP	NOAA/AOML	rsmith@aoml.noaa.gov
Gregg Thomas	Salinity, deck	NOAA/AOML	thomas@aoml.noaa.gov

For addresses, see list following principal investigator table above.

3 Description of Measurement techniques and calibrations

3.1 Preliminary report on CTD calibrations

CTD data were collected with a Seabird 911 plus CTD (AOML CTD # 1 S/N 50619). This instrument provided pressure, temperature, conductivity and dissolved O2 channels, and additionally measured secondary temperature, conductivity and oxygen sensors as a calibration check.

Inlet ports for the sensor pairs including temperature, conductivity and oxygen are at the same depth, located approximately 6 inches apart. The secondary temperature sensor is used to calibrate the secondary conductivity and oxygen sensors.

Standard CTD maintenance procedures included soaking the conductivity and O2 sensors in distilled water between casts to maintain sensor stability, and protecting the CTD from exposure to direct sunlight or wind to maintain an equilibrated internal temperature.

The Seabird SBE 24-place pylon provided generally reliable operation and positive confirmation of all bottle trip attempts. The SEWARD JOHNSON's Seabird CTD acquisition PC, deck unit and external power supply were used.

3.1.1 Laboratory Calibration Procedures

Laboratory calibrations of the CTD pressure and temperature sensors were used to generate tables of corrections applied by the CTD data acquisition and processing software at sea.

Pressure calibrations were last performed on CTD # 1 (S/N 50619) at the Paroscientific, Inc Calibration Facility in Redmond, WA and Sea-Bird Electronics, Inc. at Bellevue WA, immediately prior to WIMP14. This pressure sensor is rated to drift less than 200 ppm or less per year (2.0 dbar for the 10,000 dbar sensor).

Temperature calibrations were last performed on both the primary Temperature sensor (SBE 3-02/F S/N 1609) and the secondary sensor (SBE 3-02/F S/N 1701) on April 15, 1997 at Sea-Bird Electronics, Inc. Accuracy of these calibrations is 1 mK, while the precision can be greater than 0.235 mK. Both sensors showed a similar small drift over the year proceeding this cruise (about 0.0005 C/yr). The primary sensor shows a possible slight secondary temperature response with largest residuals found near 15C.

Conductivity sensors (model SBE 4-02/O) were calibrated on April 15, 1997 at Sea-Bird Electronics, Bellevue WA. The primary conductivity sensor (S/N 1347) showed slightly larger drift than the secondary conductivity sensor (S/N 1346) over the one year period prior to this cruise (0.0009 vs 0.0002 psu/month).

Oxygen sensors were calibrated April 12, 1997 at SBE. For WIMP14 only the primary sensor (S/N 130353) was used. During ACCE2, a secondary oxygen sensor (S/N 130381) was added after station 68.

These calibration procedures will be repeated when the instrument is returned to AOML. Pre-cruise calibration sheets are attached in appendix B. At first inspection based on pre-cruise calibrations and sensor history, the secondary sensor pairs will most likely prove the most stable.

At the end of WIMP14, preliminary fits to conductivity and oxygen suggested an offset of -0.00124 and slope of 1.000254 for the primary conductivity sensor. The secondary conductivity sensor had an offset of -0.00127 and slope of 1.000379. The primary oxygen sensor oxygen current was fit with a bias of -0.002 and slope of 3.06. These calibration values were used for the entire ACCE2 leg.

3.1.2 Shipboard Calibration Procedures

ACCE2 is the second of 3 consecutive Atlantic Ocean legs for this CTD. Transfer standards and redundant sensors are being used as calibration checks, with the intent of shipping the instrument back for full recalibration only if significant changes are noted in pressure or temperature.

Redundant temperature, conductivity and oxygen sensors provided a transfer standard to monitor sensor health.

CTD conductivity and dissolved O2 were calibrated to in-situ check samples collected during each rosette cast.

Pressure and Temperature

The final pressure and temperature calibrations will be determined when CTD # 1 is returned to AOML.

Comparison of redundant temperature sensors are shown in Figure 9 and suggest a steady drift of 0.0009°C over the cruise.

Conductivity

Comparison of redundant conductivity sensors are shown in Figure 10 and suggest a steady drift of 0.0008 over the cruise.

The CTD rosette trip pressure and temperature were used with the bottle salinity to calculate a bottle conductivity. Differences between the bottle and CTD conductivities were then used to derive a conductivity correction as a linear function of conductivity.

Figures 12 summarize the residual differences between bottle and CTD salinities using only the precruise calibrations and the slope and offset correction determined from Leg 1. The CTD conductivity sensor appears to have drifted by about 0.0009 approximately linearly over the length of the cruise (as compared to bottle conductivities) The mean conductivity slope (XXX mmhos/cm) was found for all casts, as no significant linear trend or shifts were found. CTD conductivity offsets were determined for each cast from the deepest bottle conductivities.

The standard deviation from the mean residual in Figures 12, or (+-0.029 for all conductivities and (+-0.001 for conductivities deeper than 500 meters of repeatability of the bottle salinities (Autosal, operators and samplers). This limit agrees with station overlays of deep TS.

CTD Dissolved Oxygen

Comparison of redundant oxygen sensors are shown in Figure 11 and suggest a steady drift of 0.043 ml/L over the cruise. This figure is suggestive of clear calibration groupings.

3.1.3 CTD Data Acquisition, Processing and Control System

The CTD data acquisition, processing and control system consisted of the SEWARD JOHNSON's Seabird data acquisition PC and Deck unit, AOML's Seabird 9/11 (CTD #1), broad band LADCP, Seabird pylon and three acquisition and processing PCs. The PCs are equipped with Syquest disks, floppy drives and hard disks for data backups. Two other computer systems, a Digital Vaxstation and a Digital Unix Decstation 5000/200 both with 9 gig disks were networked to the data acquisition system, as well as to the rest of the networked computers aboard the SEWARD JOHNSON. These systems were available for real-time CTD data display as well as providing hydrographic data management and backup. The SEWARD JOHNSON's Lexmark 600 dpi printer and AOML's HP Laserjet 4p and color HP DeskJet 820 Cse provided hardcopy.

The CTD data acquisition, processing and control system was prepared by the console watch a few minutes before a deployment. A console operations log was maintained for each deployment, containing a record of every attempt to trip a bottle as well as any pertinent comments. The CTD and pylon power supplies were continually left on after station 71 to eliminate the transient pressure fluctuations inherent in the Seabird sensor during the first ten minutes of startup. After comp[letion of the operations log, verifying power to the Deckunit and stable readings recorded by the Seabird display, the operator would inform the deck watch to proceed.

Once the deck watch had deployed the rosette and informed the console operator that the rosette was at the surface (a formality, since the data acquisition system had already made it known), the console operator would wait for a confirmation that the Seabird pump units have turned on (typically one minute or less) and provided the winch operator with a target depth (wire-out) and lowering rate (normally 60 meters/minute for this package). The package would then begin its descent.

The console operator would examine the processed CTD data during descent via plot windows on the display. Additionally, the operator would decide where to trip bottles on the up-cast, noting this on the console log. The PDR was monitored to insure the bottom depth was known at all times.

The watch leader would assist the console operator when the package was 400 meters above the bottom, and verify the range to the bottom using the distance between the bottom reflection and pinger signal displayed on the PDR. The SEWARD JOHNSON on-screen CHIRP II displays allowed the watch leader to monitor the depth and safely approach to within 10 meters of the bottom.

Bottles would be tripped and the console operator would wait for a trip confirmation signal sent to the SBE 11 deck unit. All tripping attempts were noted on the console log. The console operator would then direct the winch operator to the next bottle stop. The console operator was also responsible for generating the sample log for the cast.

After the last bottle was tripped, the console operator would direct the deck watch to bring the rosette on deck. Once on deck, the console operator would terminate the data acquisition and leave turned-on the CTD, pylon and acquisition computer. The acquired data was them backed up to the CTD Processing computer, and a Syquest disk.

3.1.4 CTD Data Processing

Seabird CTD processing software consists of many programs running under the Windows 95 operating system. The initial CTD processing program (SEASAVE) is used either in real-time or with existing raw data sets to:

- Convert raw CTD scans into scaled engineering units, and assign the data to logical channels;

- Filter specific channels according to specified filtering criteria;

- Apply sensor or instrument-specific response-correction models;

- Provide periodic averages of the channels corresponding to the output time-series interval; and

- Store the output time-series in a CTD-independent format.

Once the CTD data are reduced to a standard-format time-series, they can be manipulated in a number of various ways. Channels can be additionally filtered. The time-series can be split up into shorter time-series or pasted together to form longer time-series. A time-series can be transformed into a pressure-series, or a different interval time-series. Calibration corrections to the series are maintained in separate files and are applied whenever the data are accessed.

Seabird data acquisition software acquired and processed the CTD data in real-time, providing calibrated, processed data for interactive plotting and reporting during a cast. The 25 hz data from the CTD were filtered, response-corrected and averaged to a 2 hz time-series. Sensor correction and calibration models were applied to pressure, temperature, conductivity and O2. Rosette trip data were extracted from this time-series in response to trip initiation and confirmation signals. The calibrated 2 hz time-series data were stored on disk (as was the 25 hz raw data) and were available in real-time for reporting and graphical display. At the end of the cast, various consistency and calibration checks were performed, and a 1.0 db pressure-series of the entire-cast was generated and subsequently used for reports and plots.

CTD plots generated at the completion of deployment were checked for potential problems. The pairs of PRT temperature sensors, conductivity sensors and oxygen sensors were inter-calibrated and checked for sensor drift. The CTD conductivity sensors were monitored by comparing CTD values to check-sample conductivities and by deep TS comparisons with adjacent stations. The CTD dissolved O2 sensors were calibrated to check-sample data.

3.1.5 CTD References

Brown, N.L. and Morrison, G.K., WHOI/Brown conductivity, temperature and depth microprofiler, Woods Hole Oceanographic Institution Technical Report No. 78-23. Millard, R.C. Jr., CTD calibration and data processing techniques at WHOI using the practical salinity scale, Proc. Int. STD Conference and Workshop, La Jolla, Mar. Tech. Soc., 19pp. (1982). Owens, W.B. and Millard, R.C. Jr., A new algorithm for CTD oxygen calibration", Journ. of Am. Meteorological Soc., 15, 621 (1985).

3.2 Preliminary report on bottle sampling

At the end of each rosette deployment water samples were drawn from the bottles in the following order: Oxygen; Salinity.

The correspondence between individual sample containers and the rosette bottle from which the sample was drawn was recorded on the sample log for the cast. This log also included any comments or anomalous conditions noted about the rosette and bottles.

Normal sampling practice included opening the drain valve before opening the air vent on the bottle, indicating an air leak if water escaped. This observation together with other diagnostic comments (e.g., "lanyard caught in lid", "valve left open") that might later prove useful in determining sample integrity were routinely noted on the sample log.

Once individual samples had been drawn and properly prepared, they were distributed to their laboratory for analysis. Oxygen, and salinity analyses were performed on computer-assisted (PC) analytical equipment and then transferred to the data processing PC for centralized data analysis. The analyst for a specific property was responsible for delivering their results to the CTD data processor for inclusion in the cruise database.

3.2.1 Bottle Data Processing

The first stage of bottle data processing consisted of verifying and validating individual samples, and checking the sample log (the sample inventory) for consistency. At this stage, bottle tripping problems were usually resolved, sometimes resulting in changes to the pressure, temperature and other CTD properties associated with the bottle. Note that the rosette bottle number was the primary identification for all samples taken from the bottle, as well as for the CTD data associated with the bottle. As all CTD trips were retained (whether confirmed or not), resolving bottle tripping problems simply consisted of assigning the right rosette bottle number to the right CTD rosette trip.

Diagnostic comments from the sample log were then translated into preliminary WOCE quality codes, together with appropriate comments. Each code indicating a potential problem would be investigated. Table 5a lists the preliminary codes and the associated flag interpretation for Niskin problems.

The second stage of processing would begin once all the samples for a cast had been accounted for. All samples for bottles suspected of leaking were checked to see if the property was consistent with the profile for the cast, with adjacent stations and where applicable, with the CTD data. All comments from the analysts were examined and turned into appropriate water sample codes. Oxygen flask numbers were verified, as each flask is individually calibrated and significantly affects the calculated O2 concentration.

The third stage of processing would continue throughout the cruise (and indeed until the data set is considered "final"). Various property-property plots and vertical sections were examined for both consistency within a cast and consistency with adjacent stations. In conjunction with this process the analysts would review (and sometimes revise) their data as additional calibration or diagnostic results became available. Assignment of a WHP water sample code to an anomalous sample value was typically achieved through consensus. Quality code flags can be found in the complete bottle file.

WHP water bottle quality flags were assigned with the following additional interpretations:

3: An air leak large enough to produce an observable effect on a sample is identified by a code of 3 on the bottle and a code of 4 on the oxygen. (Small air leaks may have no observable effect, or may only affect gas samples.) 4: Bottles tripped at other than the intended depth were assigned a code of 4. There may be no problems with the associated water sample data.

WHP water sample quality flags were assigned using the following criteria:

1: The sample for this measurement was drawn from a bottle, but the results of the analysis were not (yet) received. 2: Acceptable measurement. 3: Questionable measurement. The data did not fit the station profile or adjacent station comparisons (or possibly CTD data comparisons). No notes from the analyst indicated a problem. The data could be correct, but are open to interpretation. 4: Bad measurement. Does not fit the station profile, adjacent stations or CTD data. There were analytical notes indicating a problem, but data values were reported. Sampling and analytical errors were also coded as 4. 5: Not reported. There should always be a reason associated with a code of 5, usually that the sample was lost, contaminated or rendered unusable. 9: The sample for this measurement was not drawn.

WHP water sample quality flags were assigned to the CTDSAL (CTD salinity) parameter as follows:

2: Acceptable measurement. 3: Questionable measurement. The data did not fit the

	Rosette Samples Stations 60-115							
	Reported	WHP Quality Flag						
	Levels	1	2	3	4	5	8	9
Salinity	1360	1	1242	62	35	0	0	20
Oxygen	1360	0	1341	3	3	0	0	13

Table 1: Frequency of WHP quality flag assignments. Note Oxygen values are incomplete, salinity contains a high number of questionable values that will be significantly reduced after reanalysis.

bottle data, or there was a CTD conductivity calibration shift during the cast. 4: Bad measurement. The CTD data were determined to be unusable for calculating a salinity. 8: The CTD salinity was derived from the CTD down cast, matched on an isopycnal surface.

WHP water sample quality flags were assigned to the CTDOXY (CTD oxygen) parameter as follows:

2: Acceptable measurement. 4: Bad measurement. The CTD data were determined to be unusable for calculating a dissolve oxygen concentration. 5: Not reported. The CTD data could not be reported. 9: Not sampled. No operational dissolved oxygen sensor was present on this cast.

Note that all CTDOXY values were derived from the down cast data, matched to the upcast along isopycnal surfaces.

Table B.2 shows the number of samples drawn and the number of times each WHP sample quality flag was assigned for each basic hydrographic property:

3.3 Preliminary report on discrete salinity measurements

Salinity samples were drawn into 200 ml Ocean Scientific bottles after 3 rinses, and were sealed with custom- made plastic insert thimbles and screw caps. This assembly provides very low container dissolution and sample evaporation. As loose inserts were found, they were replaced to ensure a continued airtight seal (no more than 6 were replaced). Salinity was determined after a box of samples had equilibrated to laboratory temperature, usually within 8-12 hours of collection.

Two Guildline Autosal Model 8400A salinometers (Number 1 and 5) located in a temperature-controlled laboratory were used to measure salinities. The salinometers contained interfaces for computer-aided measurement. A computer (PC) prompted the analyst for control functions (changing sample, flushing) while it made continuous measurements and logged results. The salinometer cell was first flushed four times then repeated until successive readings met software criteria for consistency, then three successive measurements were made and averaged for a final result.

The salinometer was standardized with IAPSO Standard Seawater (SSW) Batch #127 for stations 60-86, (K=0.99990, S=34.996) and Batch #129 for stations 87-115 (K=0.99996, S=34.998) either once every 48 samples or 48 hours, whichever is less. The program, ASAL1_3 requires an additional standard of 10-low Ocean Scientific water (batch 30L7, K=0.87332, S=30.071). The estimated accuracy of bottle salinities run at sea is usually better than 0.002 psu relative to the particular Standard Seawater batch used. PSS-78 salinity [UNES81] was then calculated for each sample from the measured conductivity ratios, and the results merged with the cruise database.

Salinometer 5 was used on stations for the entire cruise.

1341 salinity measurements were made and 54 vials of standard water were used (14 bad vials). The temperature stability of the laboratory used to make the measurements was good. The salinities were used to calibrate the CTD conductivity sensor.

3.3.1 Salinity reference

UNESCO, 1981. Background papers and supporting data on the Practical Salinity Scale, 1978 UNESCO Technical Papers in Marine Science, No. 37

3.4 Preliminary report on discrete oxygen measurements

Samples were collected for dissolved oxygen analyses soon after the rosette sampler was brought on board. Nominal 125 ml volume-calibrated iodine flasks were rinsed once with minimal agitation, then a 10 second inverted rinse with laminar flow from the drawing tube along the sides of the flask, then filled via a drawing tube, and allowed to overflow for at least 3 flask volumes. Reagents were added to fix the oxygen before stoppering. The flasks were shaken twice; immediately after drawing, and then again after 20 minutes(???))), to assure thorough dispersion of the MnO(OH)2 precipitate. The samples were analyzed within 4-36 hours of collection.

Dissolved oxygen analyses were performed with an automated oxygen titrator using photometric end-point detection based on the absorption of 365 nm wavelength ultra-violet light. Thiosulfate was dispensed by a Dosimat 665 buret driver fitted with a 1.0 ml buret. A whole-bottle modified-Winkler titration was used following the technique of Carpenter [Carp65] with modifications by Culberson et. al [Culb91], but with higher concentrations of potassium iodate standard (approximately 0.012N) and thiosulfate solution (50 gm/l) [Brew74]. Standard solutions prepared from pre-weighed potassium iodate crystals were run at the beginning of each session of analyses, which typically included from 1 to 3 stations. Several standards were made up during the cruise and compared to assure that the results were reproducible, and to preclude the possibility of a weighing error. Reagent/distilled water blanks were determined to account for oxidizing or reducing materials in the reagents. The auto-titrator generally performed very well.

The samples were titrated and the data logged by the PC control software. The data were then used to update the cruise database.

Blanks, and thiosulfate normalities corrected to 20 C, calculated from each standardization, were plotted versus time, and were reviewed for possible problems. New thiosulfate normalities were recalculated after the blanks had been smoothed. These normalities were then smoothed, and the oxygen data was recalculated.

Oxygen flasks were calibrated gravimetrically with degassed deionized water (DIW) to determine flask volumes. This is done once before using flasks for the first time and periodically thereafter when a suspect bottle volume is detected. All volumetric glassware used in preparing standards is calibrated as well as the 10ml Dosimat buret used to dispense standard Iodate solution.

Iodate standards are pre-weighed in AOML's chemistry department to a nominal weight of 0.44xx grams and exact normality calculated at sea. Potassium Iodate (KIO 3) is obtained is reported by the suppliers to be ¿ 99.4All other reagents are "reagent grade" and are tested for levels of oxidizing and reducing impurities prior to use.

1348 oxygen measurements were made. No major problems were encountered with the analyses. Differences between the primary oxygen sensor and the bottle samples are shown in Fig. 13. The oxygen data were used to calibrate the CTD dissolved O2 sensor.

3.4.1 Oxygen References

Carpenter, J. H., 1965. The Chesapeake Bay Institute technique for the Winkler dissolved oxygen method. Limnology and Oceanography, 1, 141-143.

Culberson, C. H. and Williams, R. T., fIet al.fR, Aug 1991. A comparison of methods for the determination of dissolved oxygen in seawater. WOCE Hydrographic Program Office, Report WHPO 91-2.

3.5 Preliminary report on lowered and vessel-mounted ADCP measurements

Molly Baringer and Ryan Smith (AOML)

All data are to be considered preliminary at this time.

Ocean velocity observations were taken on the ACCE Atlantic Float deployment cruise along 6°N and 0° using two acoustic Doppler current profiler (ADCP) systems and accurate navigation data. The two systems are the hull-mounted ADCP and a lowered ADCP mounted on the rosette with the CTD. The data were taken aboard the R/V SEWARD JOHNSON from June 25, 1997 to July 26, 1995 between Port of Spain, Trinidad and Fortaleza, Brazil. The purpose of the observations was to document the upper ocean horizontal velocity structure along the cruise track, and to measure vertical profiles of the horizontal velocity components at the individual hydrographic stations. The observations provide absolute velocity estimates including the ageostrophic component of the flow.

Figure 8 shows the cruise track and the near surface currents measured by the LADCP. Figure 7 show the LADCP velocities near the depths of the PALACE float deployments. Figure 6 shows the LADCP velocity along the 6°N and 0°N sections.

3.5.1 Hull-mounted ADCP

The hull-mounted ADCP unit was supplied by Harbor Branch Oceanographic Institute as standard equipment aboard the R/V SEWARD JOHNSON. The ADCP is a 150 kHz unit manufactured by RD Instruments. The instrument pings about once per second, and for most of the cruise the data were stored as 1.5-minute averages or ensembles. The user-exit program, ue4, receives and stores the ADCP data along with both the P-code navigation data from AOMLs Trimble receiver and the Ashtech GPS receiver, which accounts for pitch and roll. The P-code data are used as navigation for the ADCP processing. The ship's gyro- compass provides heading information for vector averaging the ADCP data over the ensembles. The user-exit program calculates and stores the heading offset based on the difference between the heading determination from the Ashtech receiver and from the ship gyro.

As setup parameters, we used a blanking interval of 4 meters, a vertical pulse length of 16 meters and a vertical bin size of 8 meters. Data collection during the cruise used four ping ensembles.

Data acquisition proceeded without incident until the end of the cruise. Shipboard data processing was limited due to software problems. Final editing and calibration of the ADCP data is not finished. This involves the usual editing of CTD wire interference and the determination of the actual transducer orientation. In addition, the CTD and underway temperature and salinity must be used to correct the speed of sound and check the ADCP thermistor and account for any possible offsets. Some problems arose with the Ashtech receiver's failure to swap satellites. This resulted in an occasional lose of pitch and roll measurements. Although the exact cause for this problem was never determined, manually cycling the Ashtech receiver through available satellites restored operation.

3.5.2 Lowered ADCP

The second ADCP system is the lowered ADCP (LADCP), which was mounted to the rosette system with the CTD. The LADCP yields vertical profiles of horizontal velocity components from near the ocean surface to near the bottom. The unit used is a broadband, self- contained, internally-logging 150 kHz system manufactured by RD Instruments. We use four ping ensembles. The data from the instrument was uploaded to a PC between casts.

The vertical shear of horizontal velocity was obtained from each four ping ensemble. These shear estimates were vertically binned and averaged for each cast. By combining the measured velocity of the ocean with respect to the instrument, the measured vertical shear, and accurate shipboard navigation at the start and end of the station, absolute velocity profiles are obtained (Fisher and Visbeck, 1993). Depth is obtained by integrating the vertical velocity component; a better estimate of the depth coordinate will be available after final processing of the data together with the CTD profile data. The shipboard processing results in vertical profiles of u and v velocity components, from a depth of 35 meters to the

Cast	Problems	Solutions
64	Unrealistic (u,v) at depth	not yet
68	Apparent v offset	not yet
70	Apparent v offset	not yet
71	Apparent u offset	not yet
72	End of cast problems	reprocessed ok
84	Processing error	not yet

Table 2: Tabulation of problem LADCP casts.

bottom of each station in 5 meter intervals. The meridional velocity in the 6°N section is shown in Figure 6a.

At the beginning of the cruise, a data/battery cable had a suspiciously bad connection that occasionally caused the LADCP to restart new casts when being plugged in. Several casts have a barotropic offset, that we believe was caused by the faulty cable. Casts with problems are listed in Table 2 (which were included in the contoured sections Fig. 6 but not included in the vector maps like Fig. 7).

3.5.3 Navigation

AOML installed a Trimble P-code receiver for navigation, with data coming in at once per second. We have stored this once per second data for the entire cruise.

The Ashtech receiver uses a four antennae array to measure position and attitude. The heading estimate was used with the gyro to provide a heading correction for the ADCP ensembles. The Ashtech data was stored by the ADCP user-exit program along with the ADCP data.

3.5.4 ADCP References

Fisher, J. and M. Visbeck, 1993; Deep velocity profiling with self-contained ADCPs; J. Atmos. Oceanic Technol., 10, 764-773.

3.6 Preliminary report on PALACE floats

Dave Bitterman and Molly Baringer (AOML)

The Profiling Autonomous LAgrangian Current Explorer (PALACE) floats are used to provide information on both the current circulation at a predetermined depth and the temperature structure in the upper layers of the ocean. The floats are designed to float on the surface for 24 hours and then submerge to a depth of 1000 decibars and remain there for 240 hours (10 days). They then rise to the surface and measure the water temperature approximately every 10 decibars to obtain a temperature profile. While on the surface the data is transmitted to the Service ARGOS satellite system. From the Doppler frequency shift of the transmitted signal as it is received by the satellite, the geographical position of the float can be computed. This cycle, 24 hours on the surface and 10 days at depth, is then repeated for the life of the float. Barring a failure of any components, the floats have sufficient battery capacity to operate for over two years.

The floats have an aluminum hull, approximately 6" in diameter by 60" long, with an antenna for data transmission to the satellite system. The antenna and a temperature probe are mounted on the top end of the float and a pressure sensor is ported to the ocean near the bottom end cap. A damper plate is attached near the top end to stabilize the float in the surface wave field.

To control the buoyancy of the float, a small amount of oil is contained within the float. When the float is submerged, all of this oil is kept entirely within the hull. When it is time to rise to the surface, the oil is pumped into an external rubber bladder which expands. Since the weight of the float does not change but its volume increases when the bladder expands, the float becomes more buoyant and floats to the surface. Similarly, when the float is on the surface and it is time to submerge, the oil is withdrawn from the bladder into the hull of the float and the buoyancy decreases. Oil is pumped into the bladder by a small high pressure electric pump. When the float is built, the air pressure in the hull is evacuated to about a 0.5 atmosphere vacuum. By opening a valve, the oil is then sucked out of the external bladder into the hull when it is time to submerge.

The depth to which the float submerges is controlled by very carefully ballasting it when it is built. Typically the weight of the float is about 25000 grams and must be accurate to within a few grams. A one gram error results in a depth error of about 19 meters.

Deployment procedures typically include removing the PALACE floats from the shipping crates and inspecting for damage, starting the self test several hours before deployment (2-7 hours for the WHOI PALACE, and 5-12 hours for the AOML PALACE) and installing

Deployment Number	S/N	Argos ID #	Lat	Lon	Date	GMT	CTD cast	Nominal depth, m
11	29	09336	0° N	11° W	07/18/97	17:47	107	1004
12	28	09335	0° N	15° W	07/19/97	14:55	108	998
13	37	12274	0° N	19° W	07/20/97	10:19	109	1007
14	36	12273	0° N	23° W	07/21/97	06:28	110	1003
15	20	09333	0° N	26° 9' W	07/22/97	01:19	111	997
16	21	09334	0° N	32° 43' W	07/23/97	10:41	112	1005
17	32	09339	0° N	35° W	07/23/97	23:04	113	1008
18	36L	09332	0° N	38° W	07/24/97	14:32	114	1008
19	34	09336	0° 46' N	39° 59' W	07/25/97	02:21	115	1005

Table 3: Tabulation of AOML PALACE float deployments. Floats are ballasted to be neutrally buoyant at a density of 1032.078 kg m^{-3}. Nominal depths are based on density from the closest CTD cast (preliminary data).

the stability disk. Once the self test has been successfully completed the PALACE float is deployed by lowering off the stern of the ship while the ship steams slowly (1-2 knots).

AOML PALACE were equipped to begin ARGOS transmissions within 2 hours from start up. For these floats a further test of the transmission system was performed by allowing the PALACE to cycle through one complete start up (6 hours) prior to deployment. The PALACE was then reset at least 2 hours before deployment. This allowed shore based personnel at AOML to verify ARGOS transmissions were being received. A typical delay of about eight hours occurred from the time the PALACE float was first initialized to a confirmed position received at AOML via Argos.

The PALACE floats deployed along 6°N included a conductivity sensor and were ballasted for approximately 800 meters. Ray Schmitt (WHOI) can supply the operational details. The floats along the equator (AOML) included only a temperature sensor, except for the float deployed at 38°W, which also included a salinity sensor. The AOML floats have been ballasted to rest at a density of 1032.078 kg m^{-3}, which is approximately 1000 meters at these latitudes (see Table 3 for exact depth based on preliminary CTD data). For some indication of the expected movement of these floats, Figure 7 shows the velocity at 800 and 1000 meters as determined from 30 meter centered averages of LADCP velocity.

3.7 Preliminary report on XBT deployments

XBT profiles were deployed throughout the cruise at 30-60 nm spacing to augment the sampling between CTD stations. XBT locations are shown in Fig. 1. Deployment procedures include noting the time, location, depth and Therosalinograph and engine intake temperatures. Data is acquired on an AOML supplied Seas PC running Seas4 software. Once the position information is logged, the Seas4 software initializes the MK12 board and a new XBT probe is loaded into the hand launcher. The Seas4 software then begins acquiring data and the XBT is deployed. XBT data was periodically transferred to the processing computers for analysis and backup.

As noted above, the underway XBT hand launching system installed by AOML in the stern of the ship resulted in the failure of some XBT probes when sea water leaked into an electrical junction box during moderate seas which resulted in an apparently uniform offset in the recorded temperature. Approximately 12 XBT profiles were affected (although an exact number is difficult to estimate given the gradual onset of the problem). We will attempt a post cruise adjustment of these profiles using the recorded thermosalinograph and intake temperatures, as well as adjacent CTD stations. A total of 178 XBTs were deployed resulting in 162 apparently good profiles (including these offset profiles noted above). This represents about a 9% failure rate, higher than desired (probably due to the removal of the launcher from the stern of the ship). The junction box was patched, died out and readied for use on Leg 3 of this cruise.

3.8 Preliminary report on bathymetry measurements

The SEWARD JOHNSON's Chirp II Model LSP 661 by Datasonics was used along the 6^0N and the equator both for recording depths and for use with the pinger on the CTD/rosette. Pinging was suspended during the transit into Barbados to undergo engine repair. Depths were recorded every 2 minutes, entered on the SEWARD JOHNSON SJserver computer, and merged with navigation acquired from the ship's Magnavox MX GPS system via RS-232 (Check this), logged at 2 minute intervals. The merged navigation and bathymetry file provides a time series of underway position, course, speed and bathymetry data. These data were used for all station positions, PDR depths, and for bathymetry on vertical sections [Cart80].

3.8.1 Bathymetry Reference

Carter, D. J. T., Wormley, Godalming, Surrey. GU8 5UB. U.K., 1980. Computerized Version of Echo-sounding Correction Tables (Third Edition). Marine Information and Advisory Service, Institute of Oceanographic Sciences.

3.9 Preliminary report on underway IMET measurements

The following IMET sensors were installed and in use during ACCE2.

Type	Model
Air temperature	IMET Alden 7030-A and ORG-715 (ScTi)
Barometric Pressure	(AIR)
Precipitation	ORG-715 (ScTi)
Relative Humidity	IMET (Alden 7030-A)
Sea Surface Temperature	Seabird
Short Wave Radiation	Eppley PSP
Wind Speed and Direction	Bendix
Wind Speed and Direction	Bendix

Data: The data were logged to ASCII text files, one containing ship navigational information, and the other containing meteorological information. Molly Baringer (AOML) has complete copies of this data.

Known problems:

Humidity Sensor - An unknown (???) problem occurred that resulted in the temporary loss of humidity readings for a short period.

Network problems - Resulting in the halting of collection on the SEWARD JOHNSON's centralized computer, Popeye. Data storage was suspended during the following periods:

Depth recording - Occasionally the CHIRP II system would loose the automated lock on the bottom (due to an increase in the time variable gain). The depths thus recorded are unrealistically shallow. At this time there is no known way to correct or flag these bad values. Other segments of data were lost when the output to the CIDS was turned off (the default configuration). This would occur inadvertently whenever the computer systems we rebooted.

4 Figures

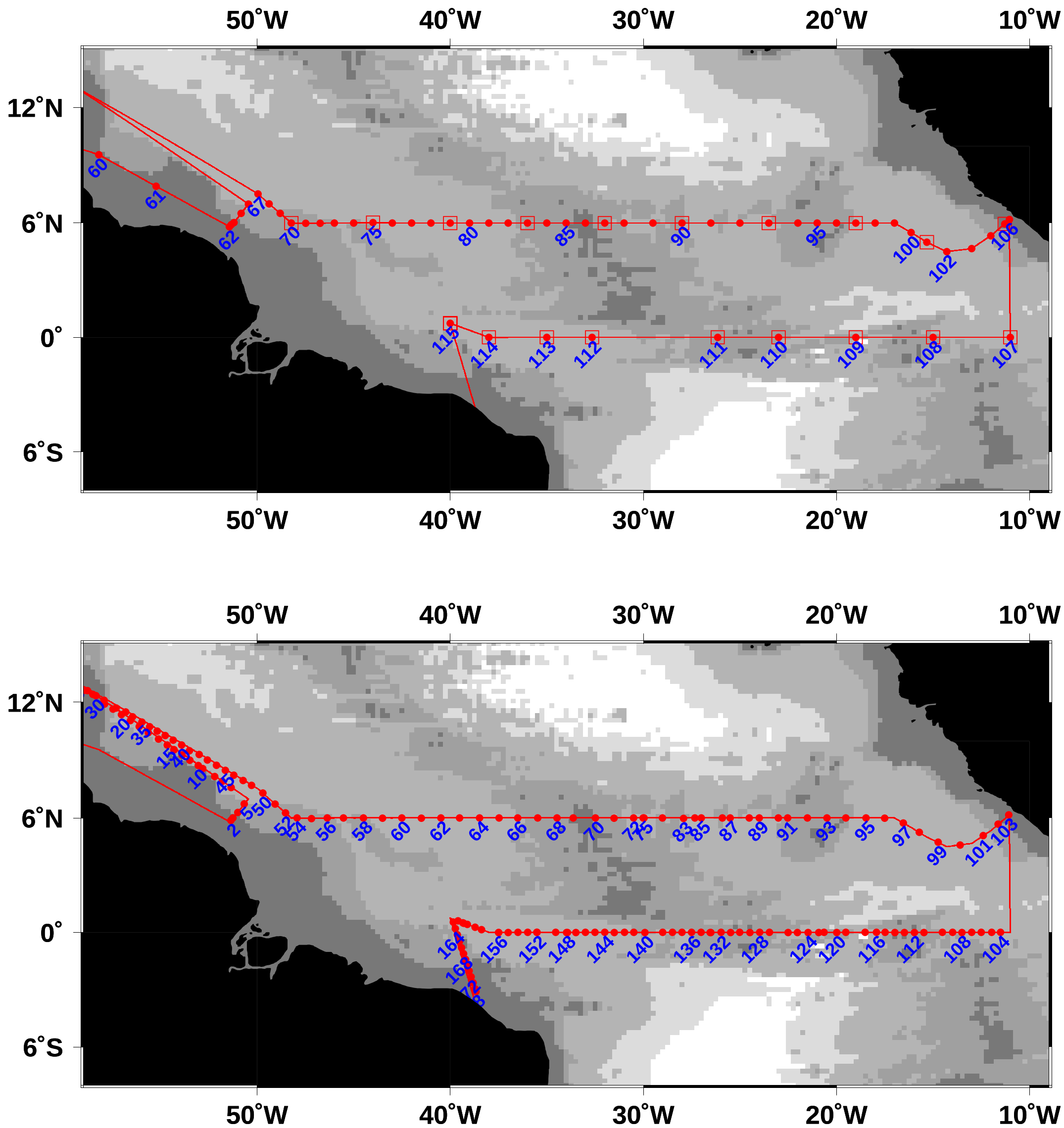


Figure 1: Station positions. Top: shows CTD station locations and selected numbers (round symbols) and PALACE float deployment locations (large square symbols). Topography is taken from ETOPO5 and shaded at 3000, 4000, 5000 and 5500 meter intervals increasingly lighter.

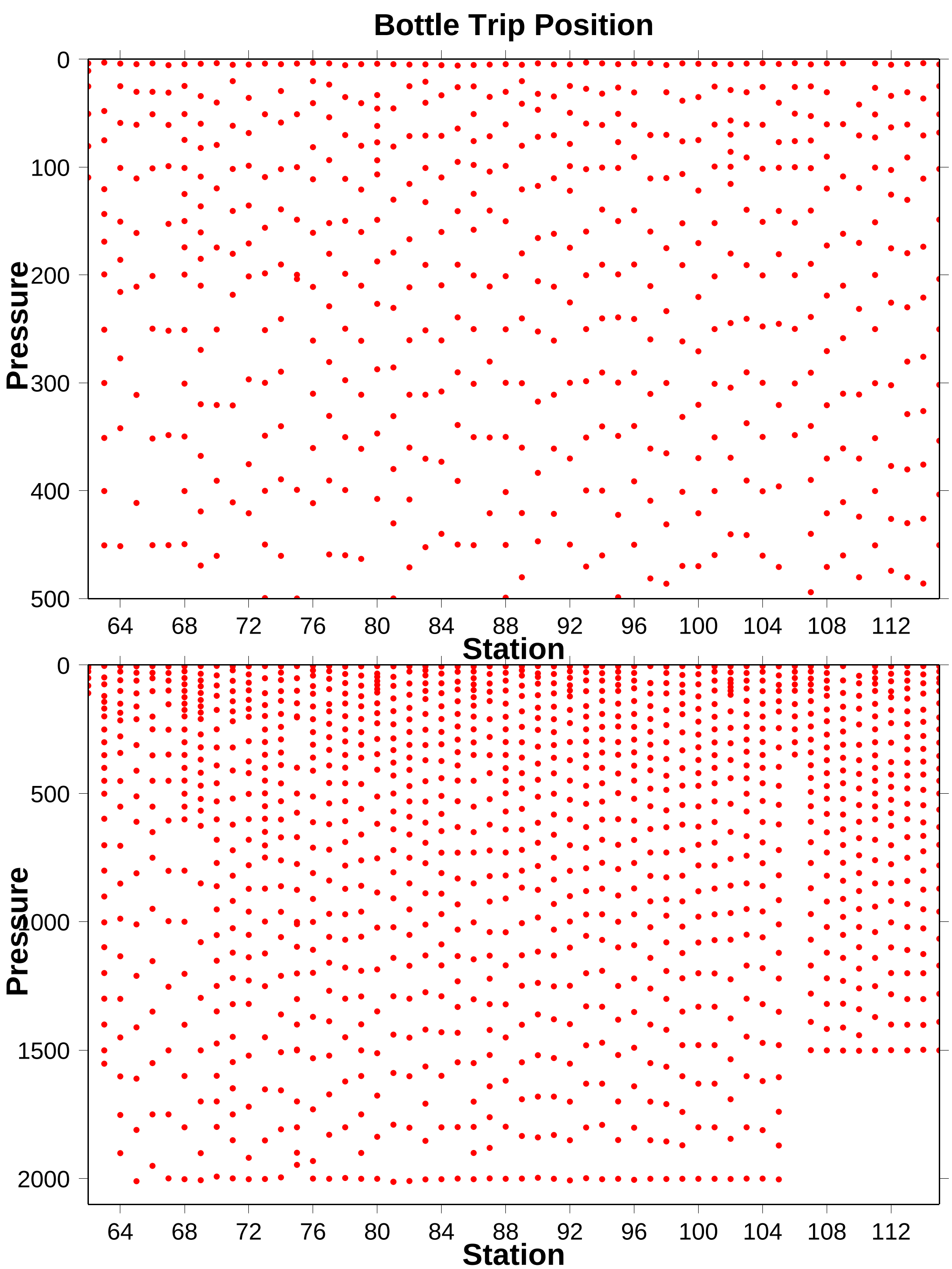


Figure 2: Bottle positions as a function of station number. Typical WOCE criterion for bottle sample spacing was used with staggered spacing to provide better contouring accuracy.

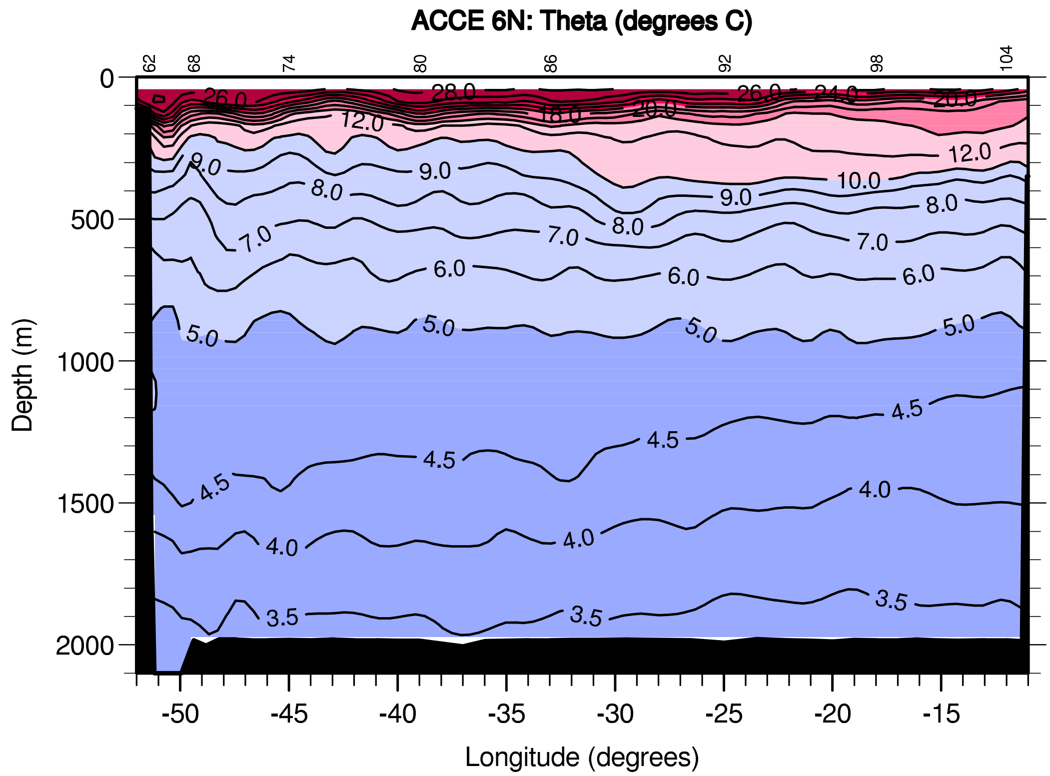


Figure 3a: Potential temperature section along 6°N from the primary temperature sensor.

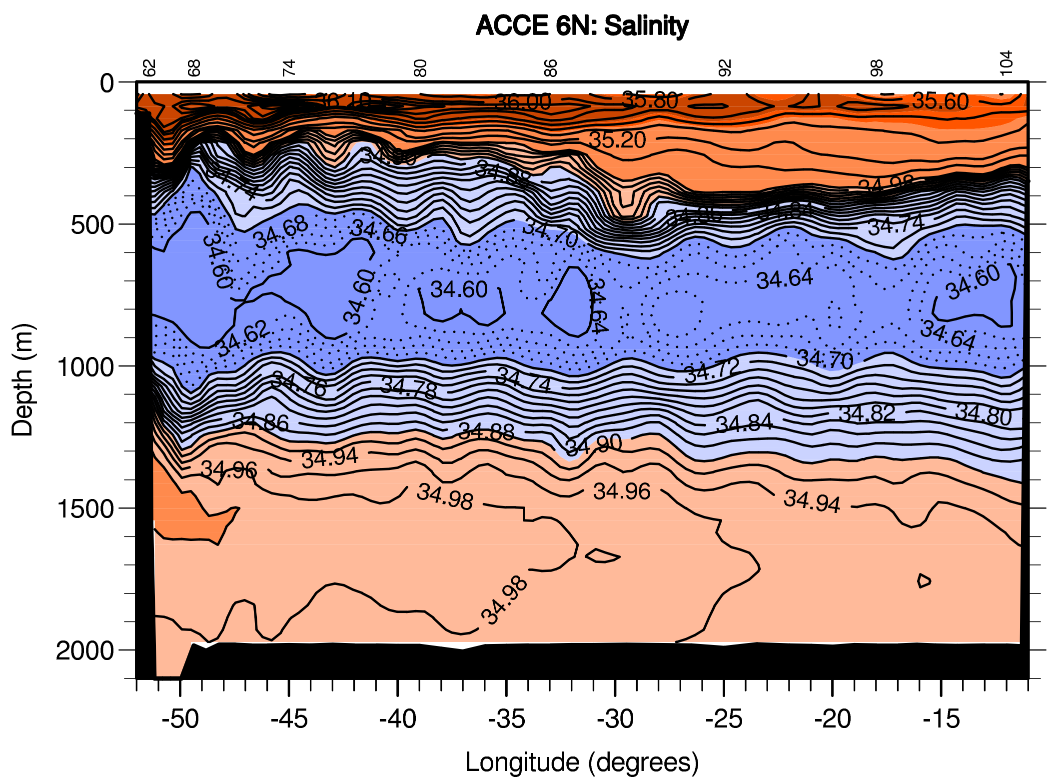


Figure 3b: Salinity section along 6°N from the primary sensors.

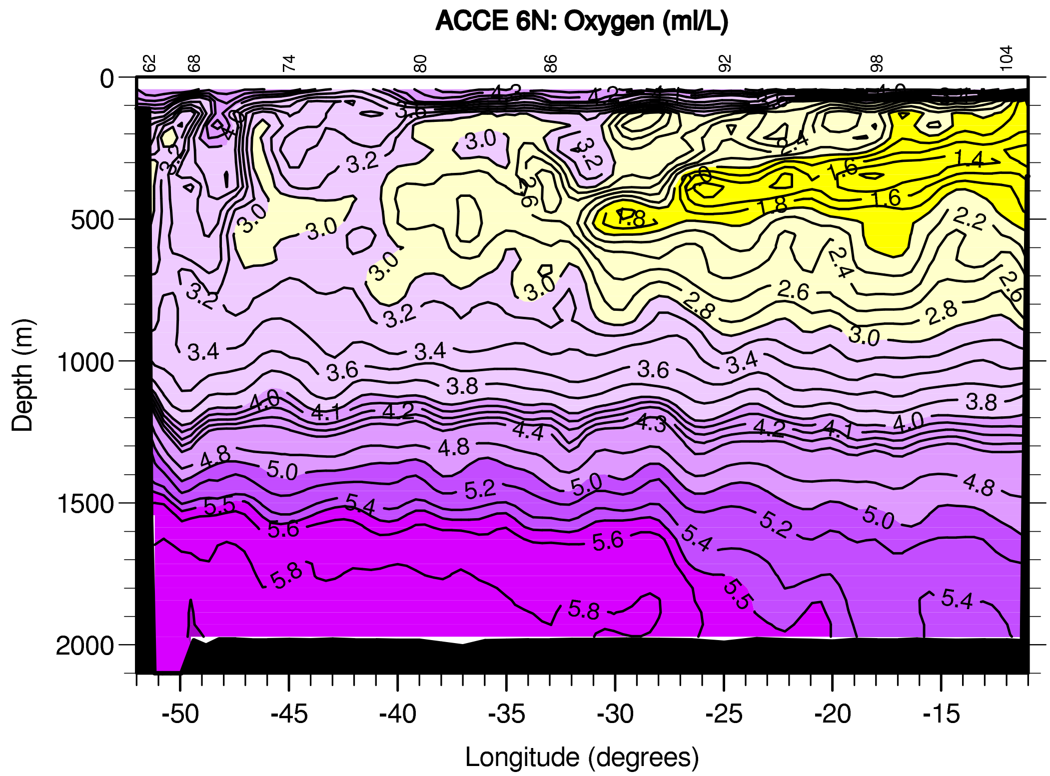


Figure 3c: Uncalibrated Oxygen section along 6^{o}N from the primary sensors.

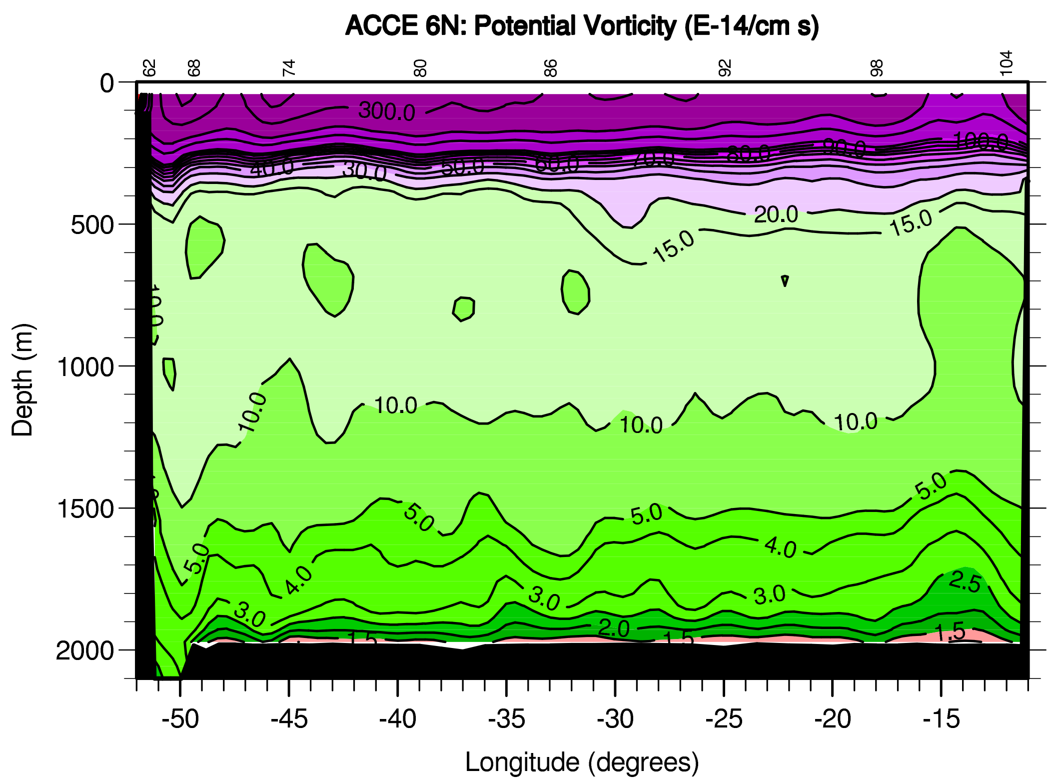


Figure 3d: Planetary potential vorticity along 6^{o}N based on primary sensors.

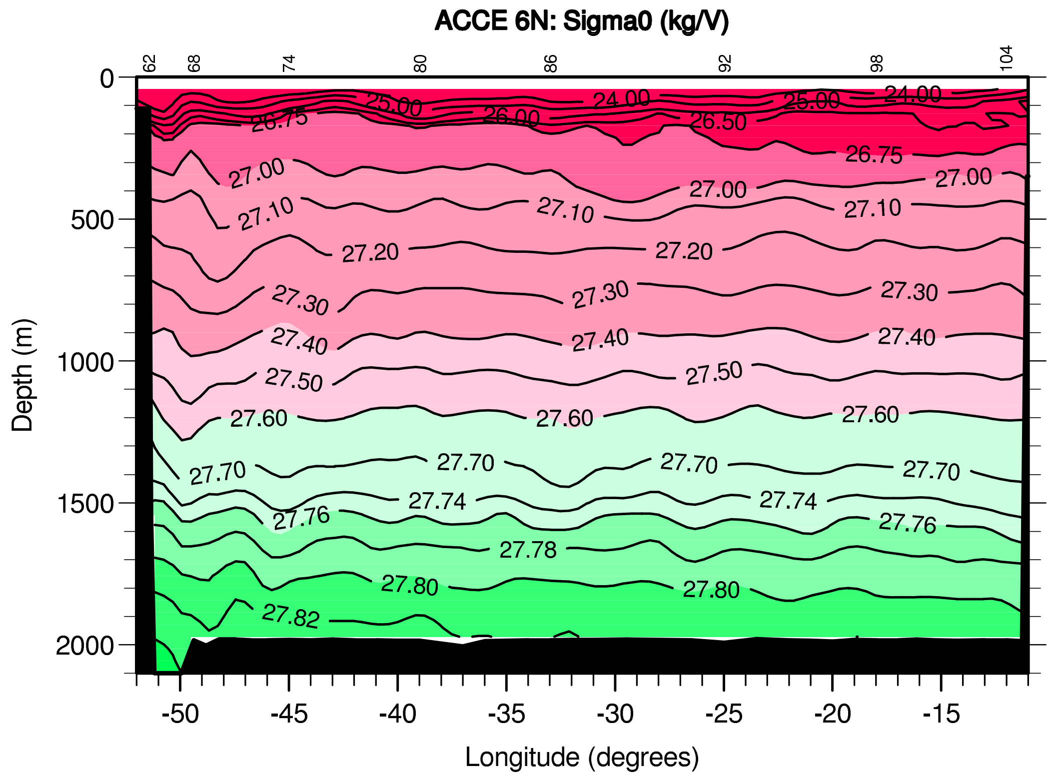


Figure 3e: Potential density referenced to the sea surface along 6°N from the primary sensors.

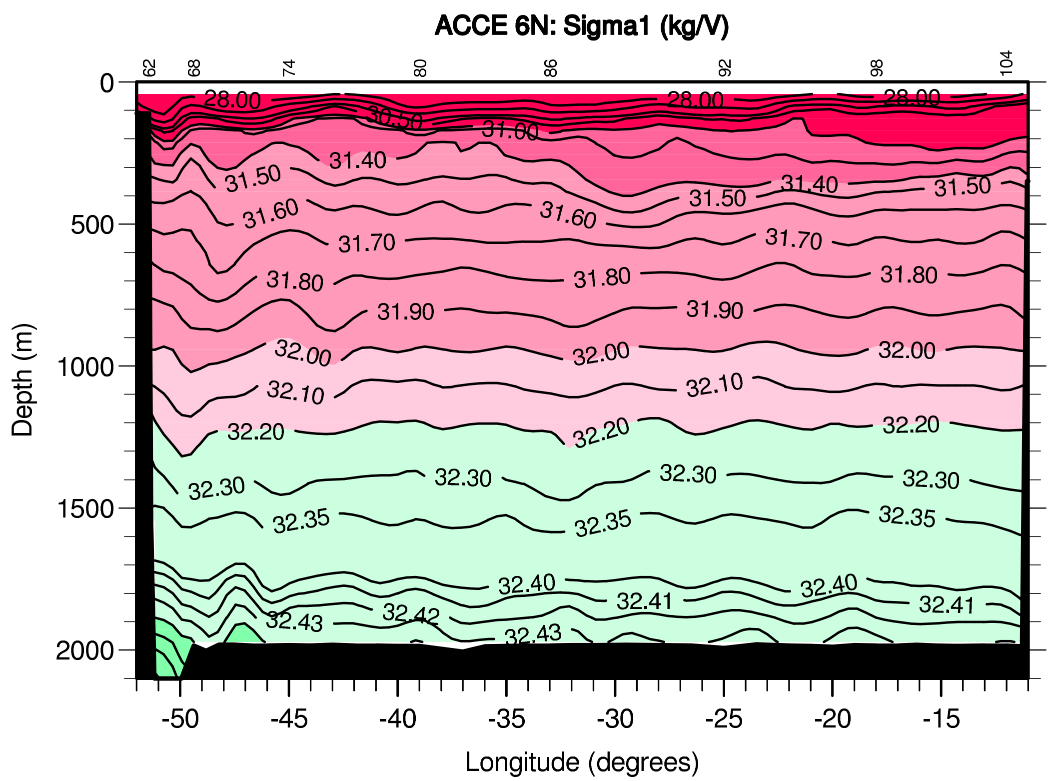


Figure 3f: Potential density referenced to 1000 meters along 6°N from the primary sensors.

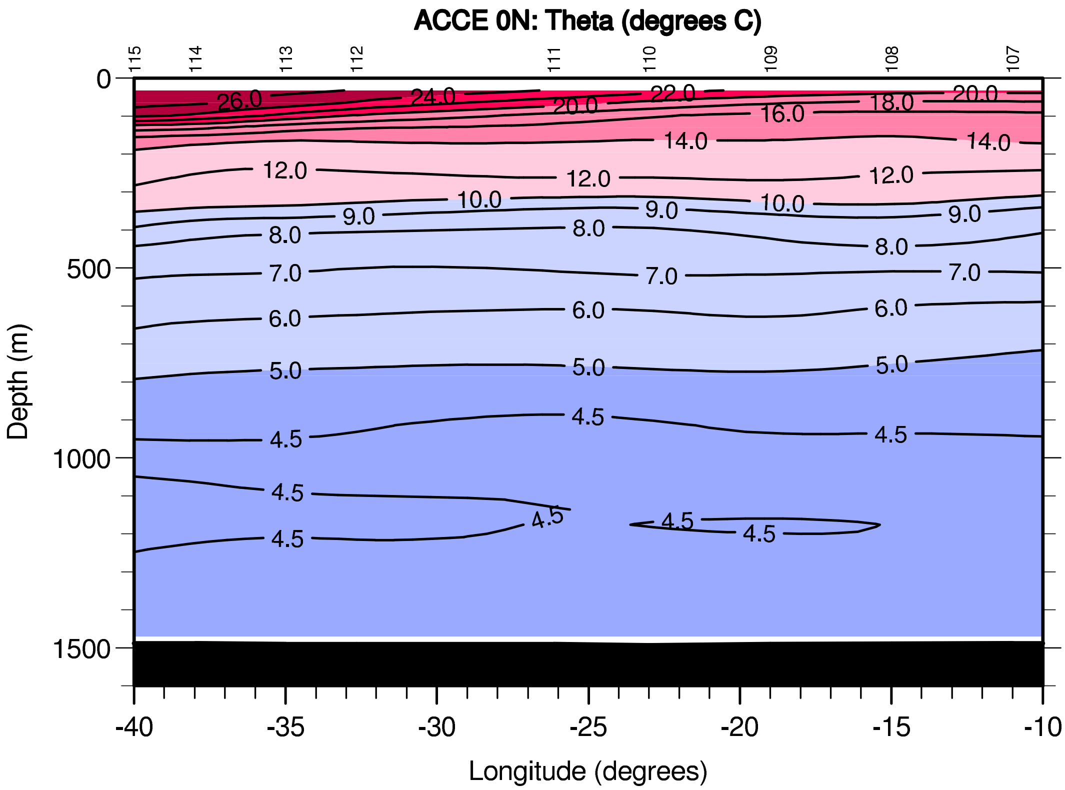


Figure 4a: Potential temperature section along the Equator from the primary temperature sensor.

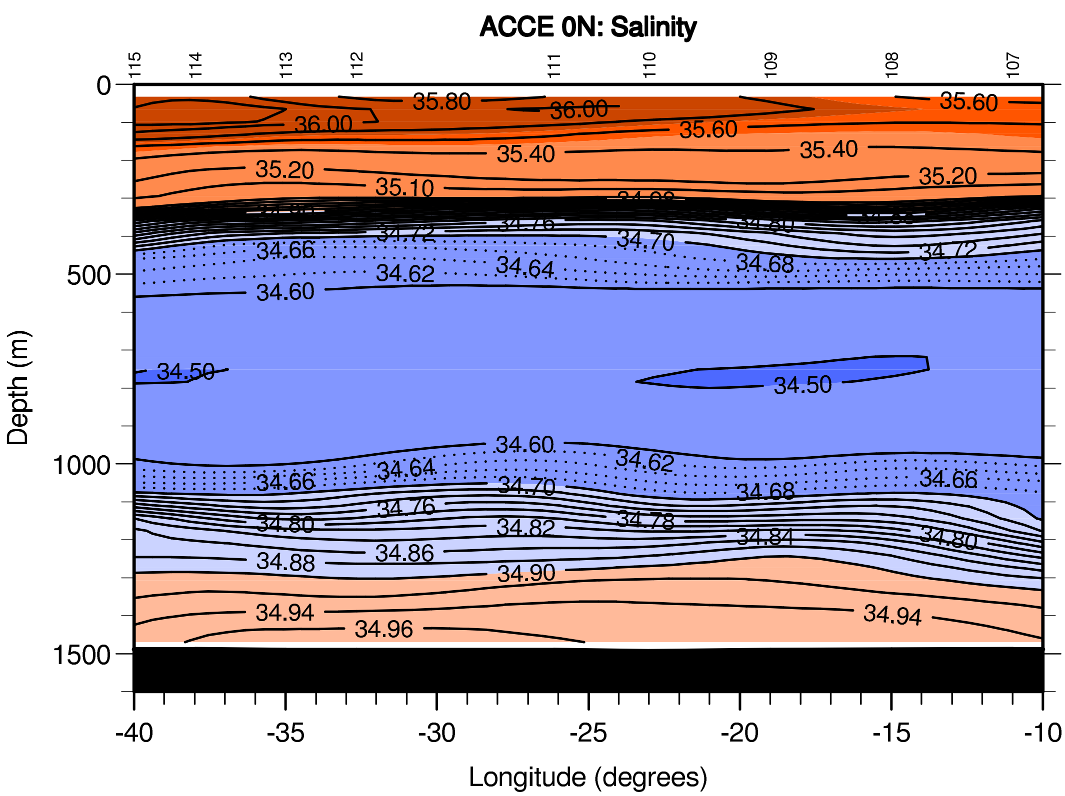


Figure 4b: Salinity section along the Equator from the primary sensors.

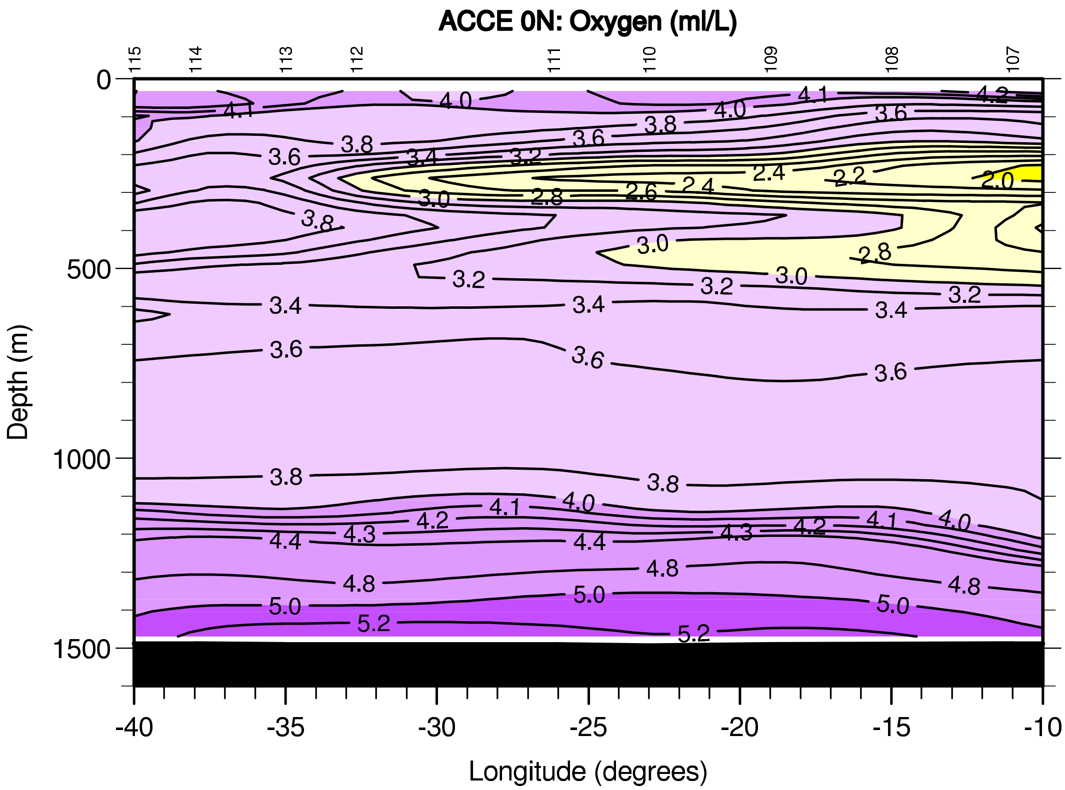


Figure 4c: Uncalibrated Oxygen section along the Equator from the primary sensors.

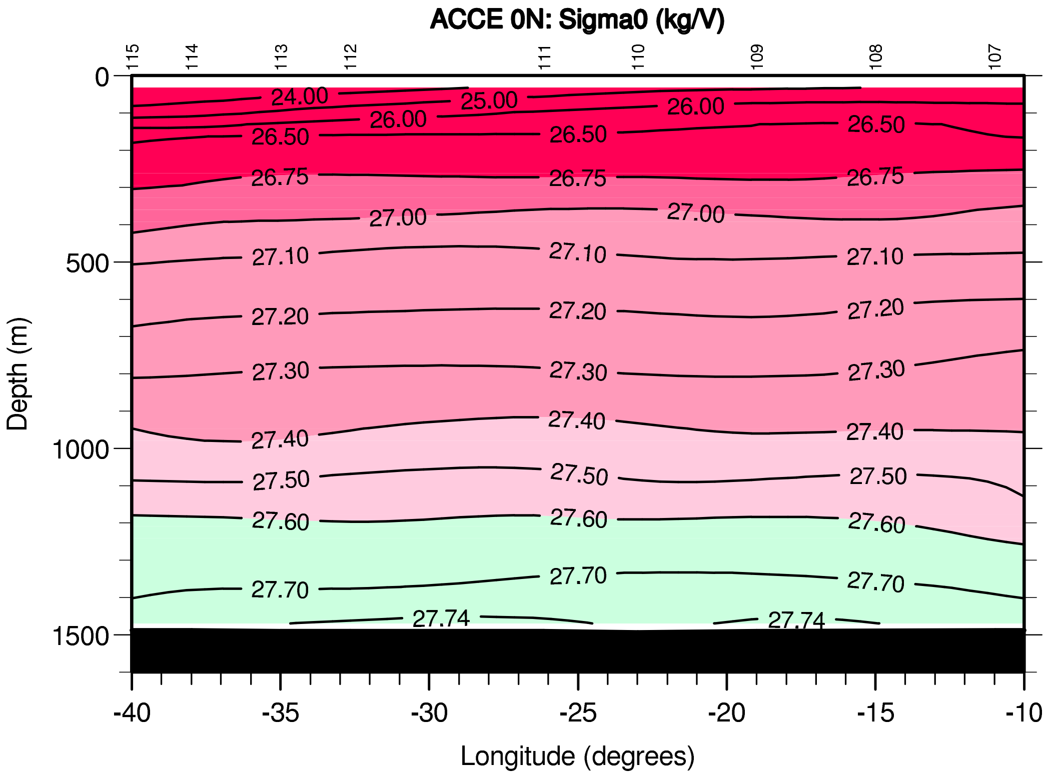


Figure 4d: Potential density referenced to the sea surface along the Equator from the primary sensors.

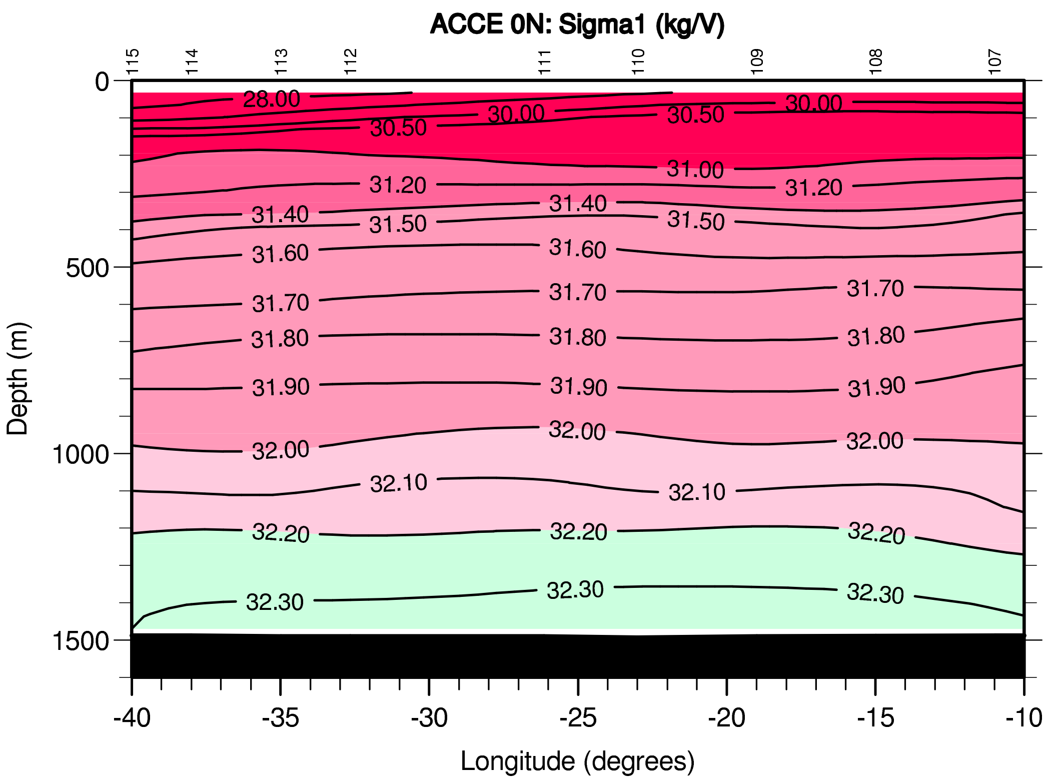


Figure 4e: Potential density referenced to 1000 meters along the Equator from the primary sensors.

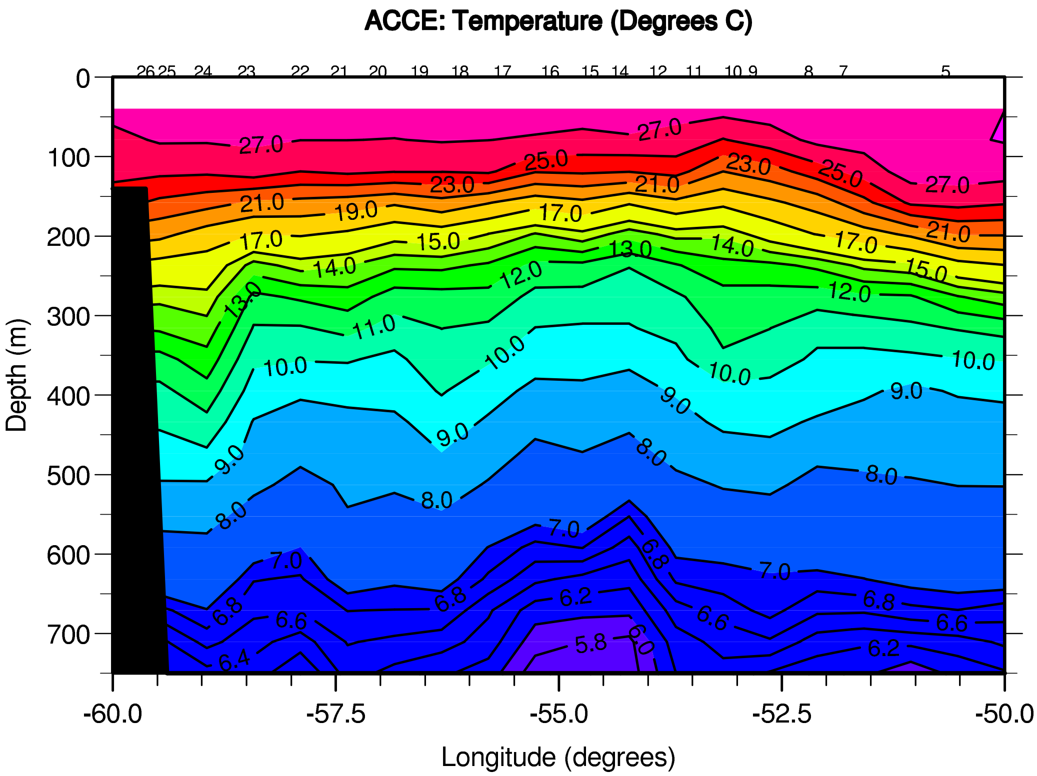


Figure 5a: XBT Temperature Section from 6°N section into Barbados.

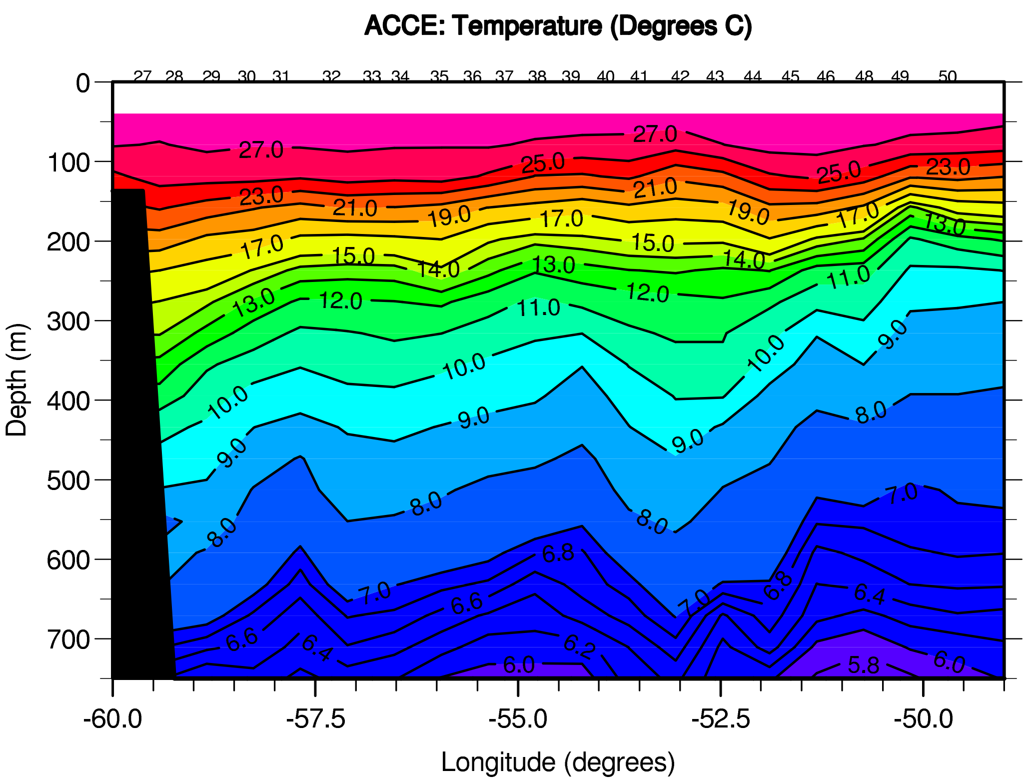


Figure 5b: XBT Temperature Section from Barbados to 6°N.

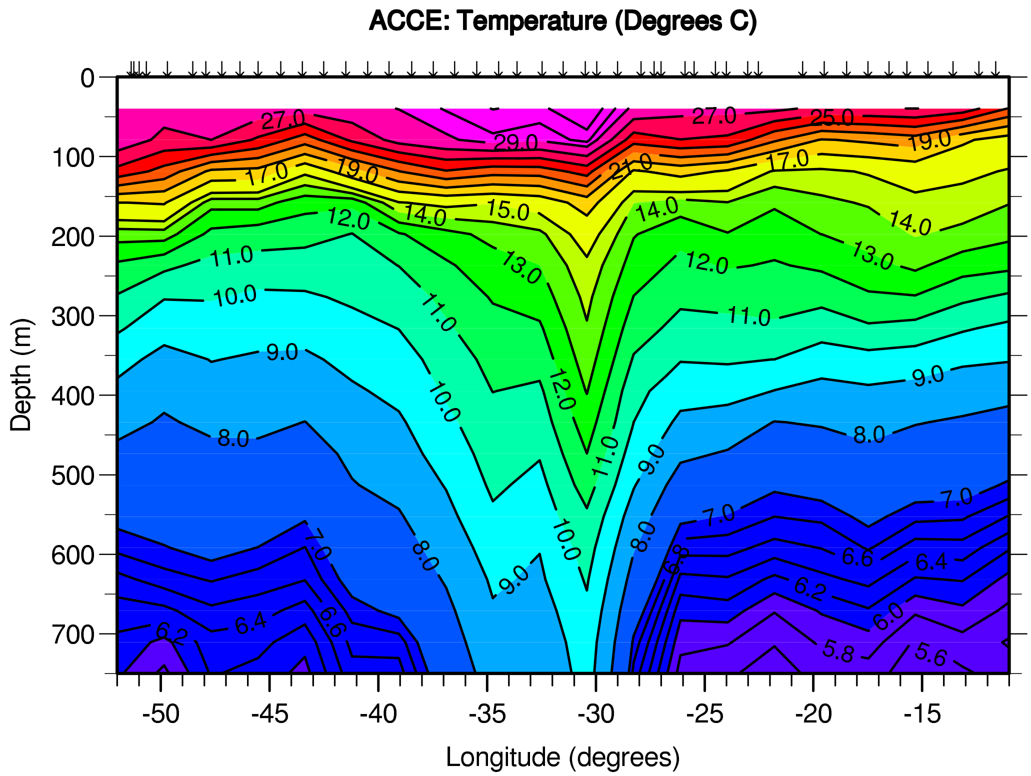


Figure 5c: XBT Temperature Section along 6°N. A malfunction of the hand launching system resulted in a gradual offset of temperatures from about 38 to 28° W.

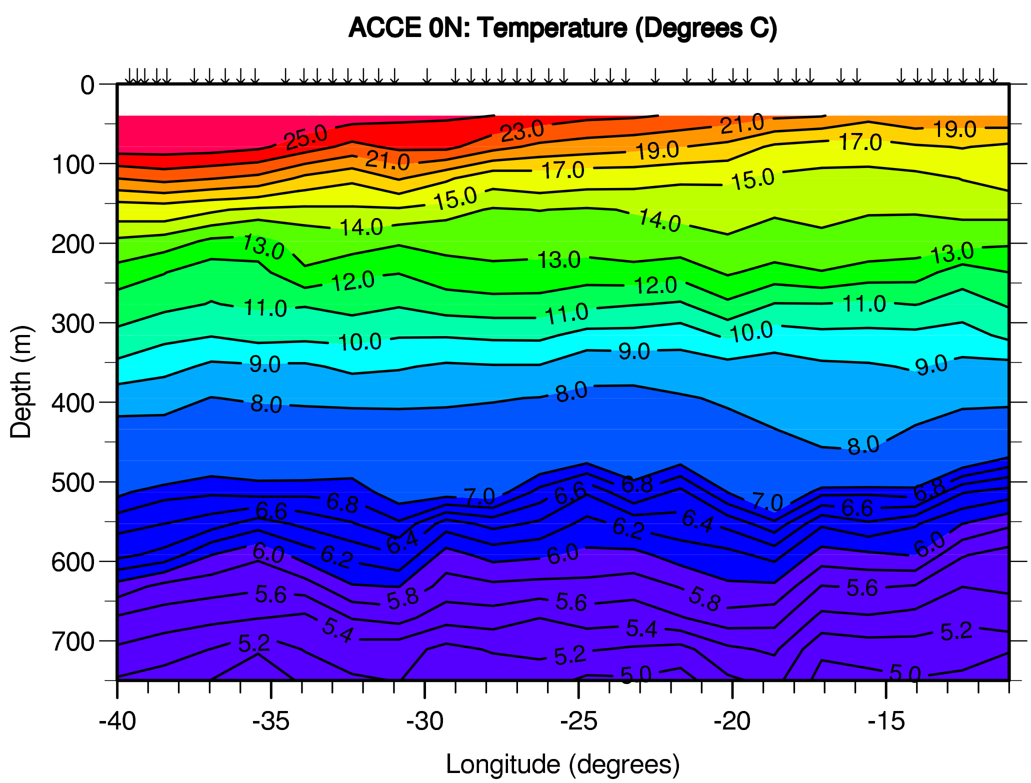


Figure 5d: XBT Temperature Section along the Equator.

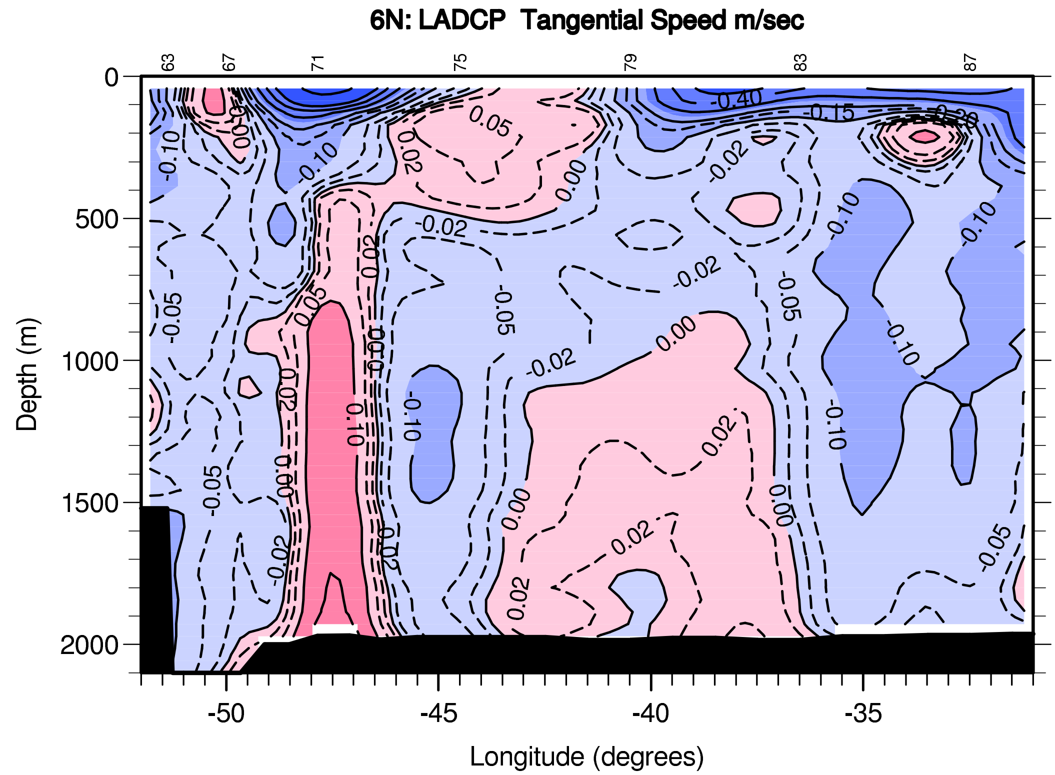


Figure 6a: LADCP velocity tangential to section along 6°N (contours in m/s).

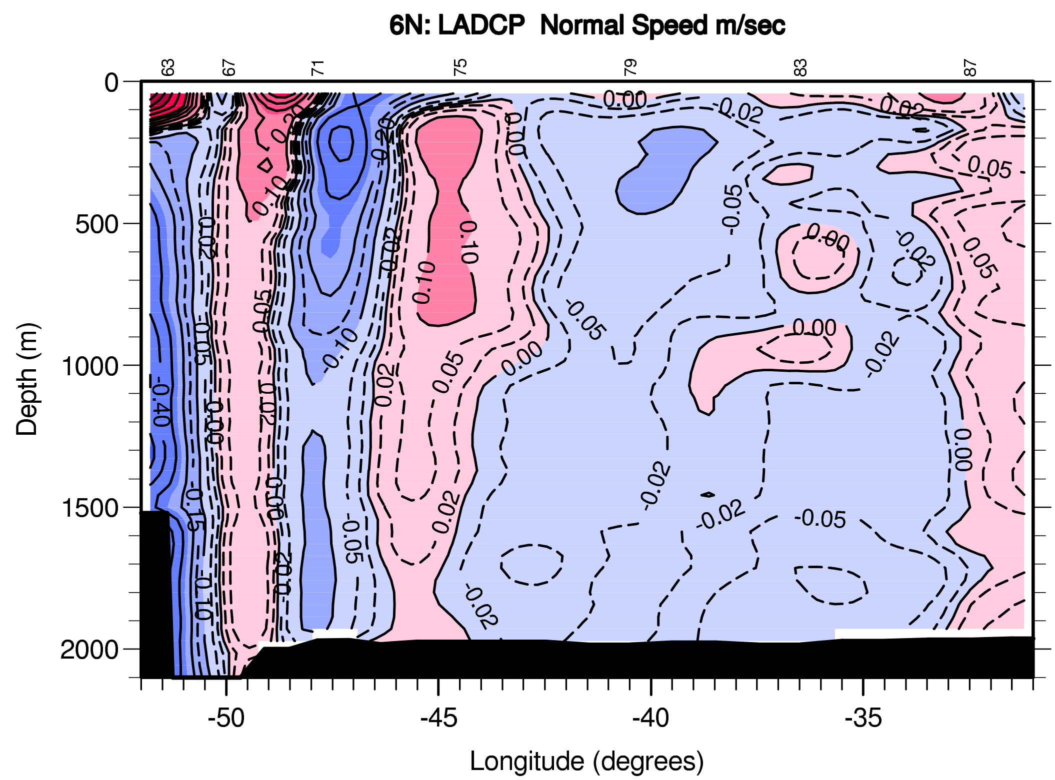


Figure 6b: LADCP velocity normal to section along 6°N (contours in m/s).

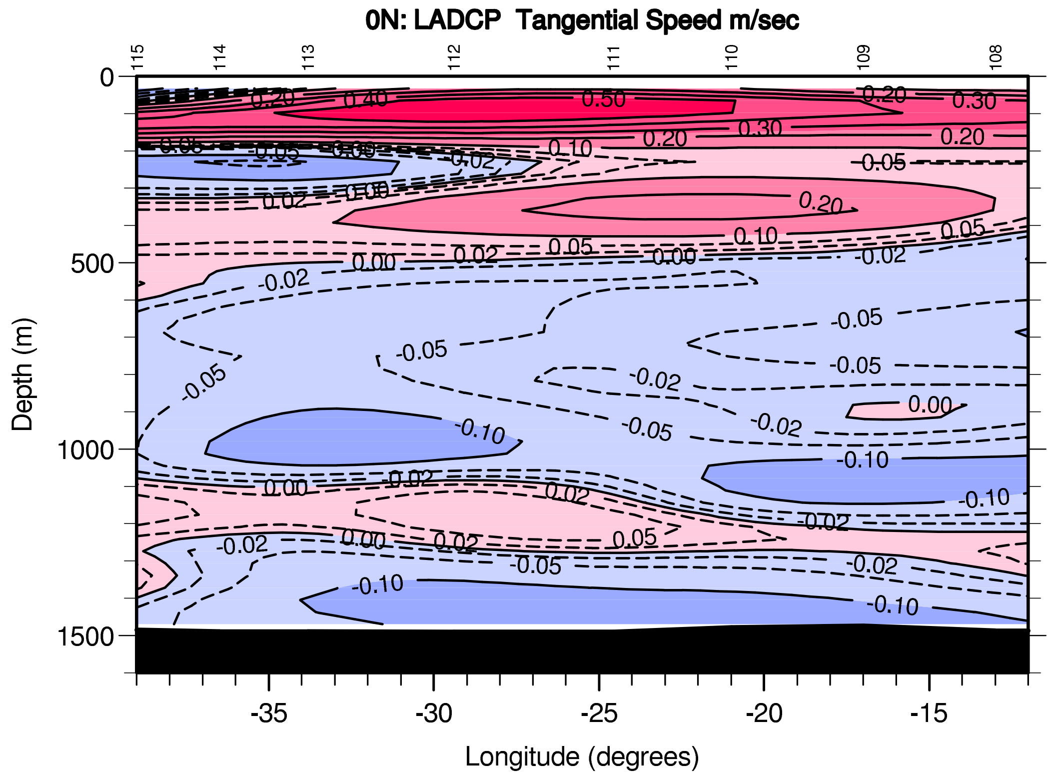


Figure 6c: LADCP velocity tangential to section along the equator (contours in m/s).

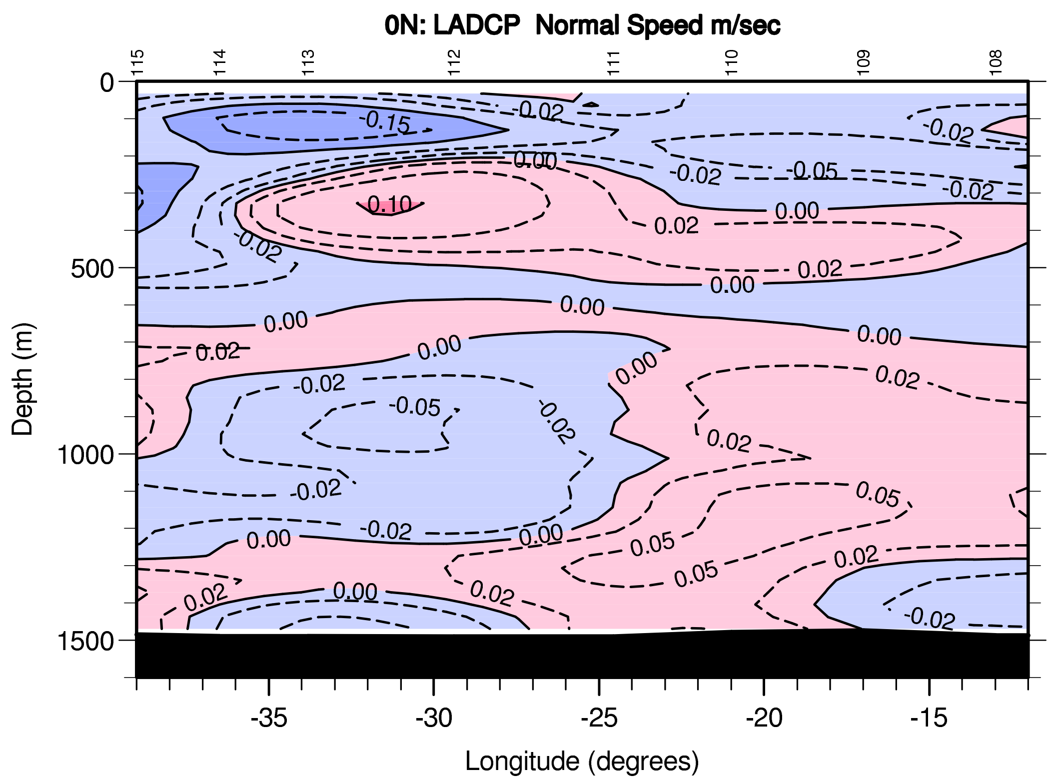


Figure 6d: LADCP velocity normal to section along the equator (contours in m/s).

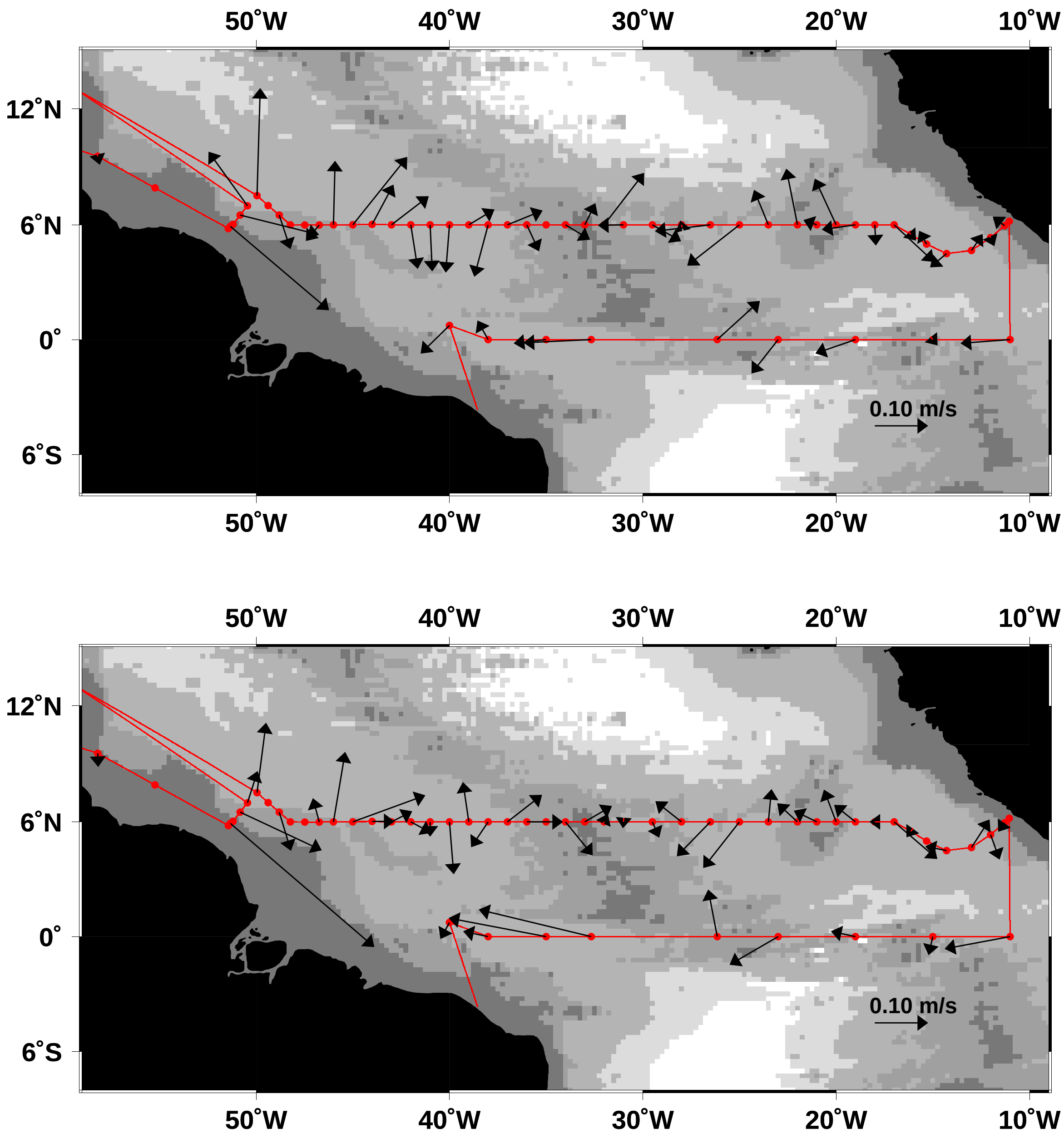


Figure 7: LADCP velocity at 800 and 1000 meters depth, the nominal depths for the PALACE floats deployed on 6°N and the equator respectively.

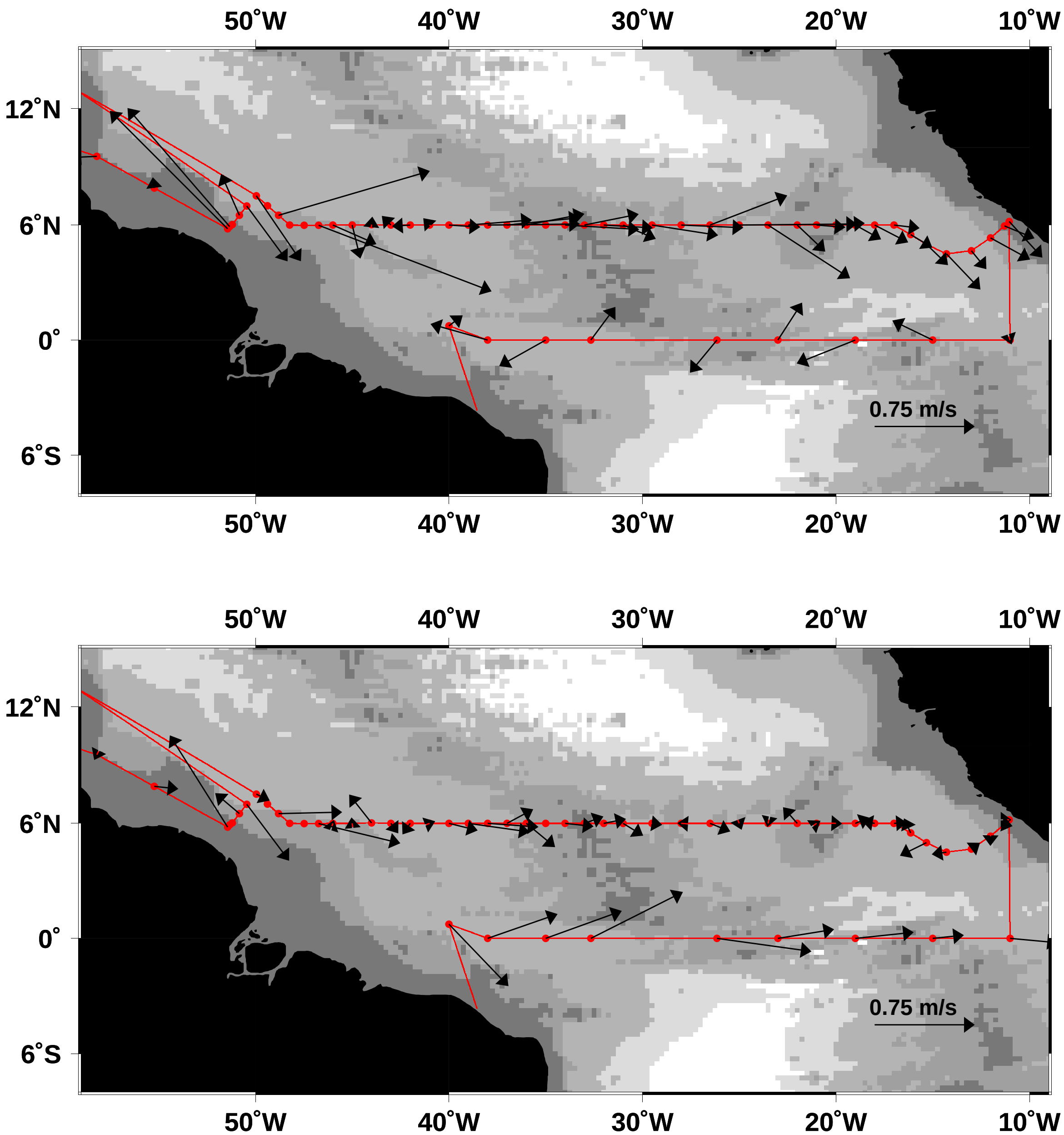
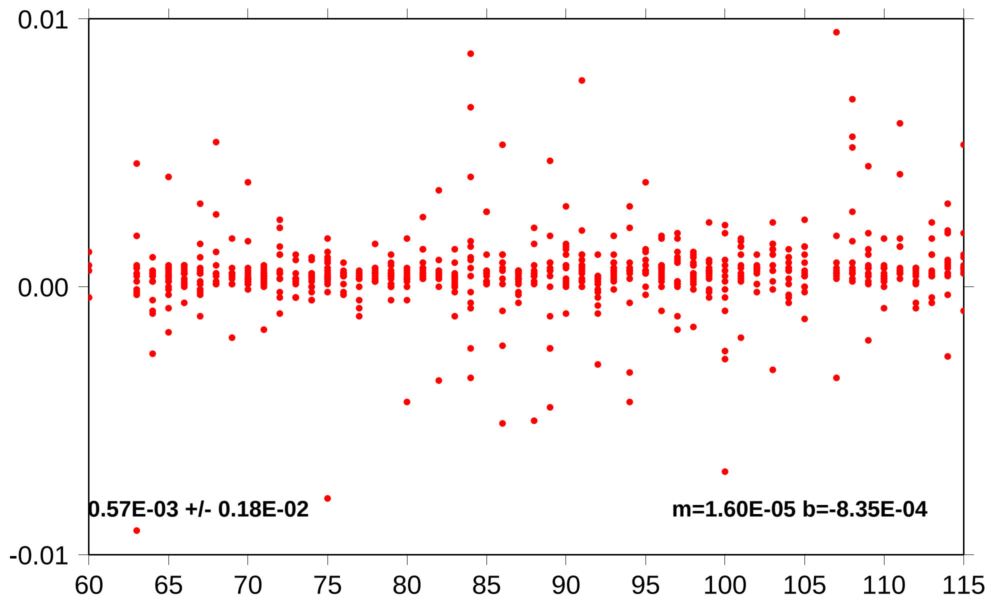


Figure 8: LADCP velocity at 0 and 100 meters depth.



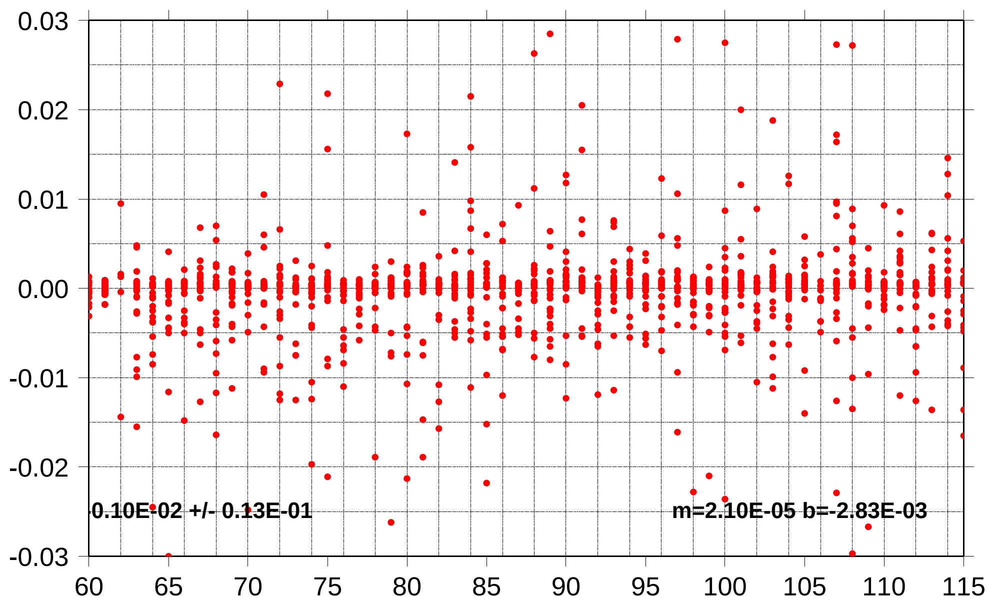


Figure 9: Differences between primary and secondary temperature sensors at each bottle depth. The mean slope, m and offset, b are given in the lower left corner. The mean and standard deviation are given in the lower right corner.

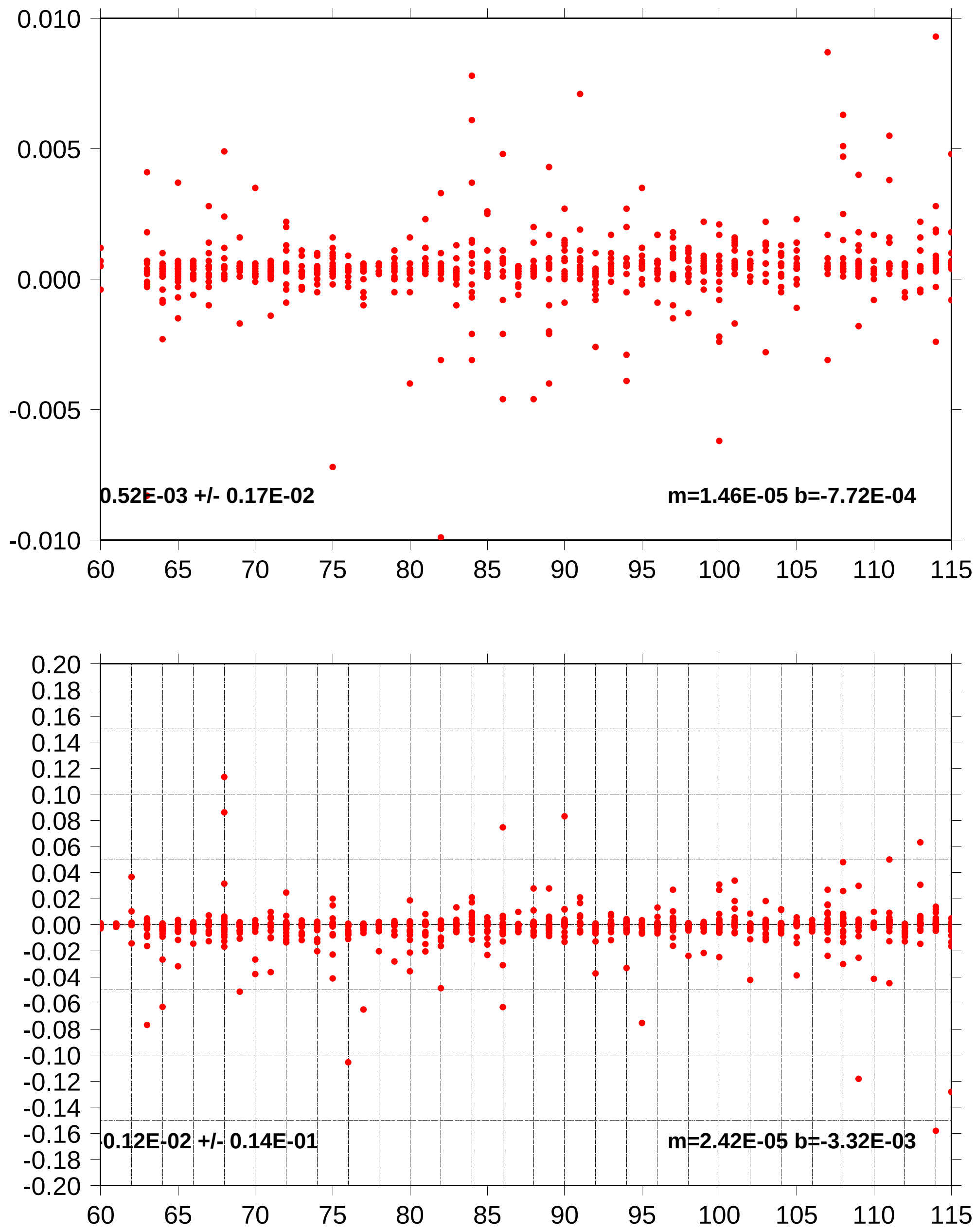
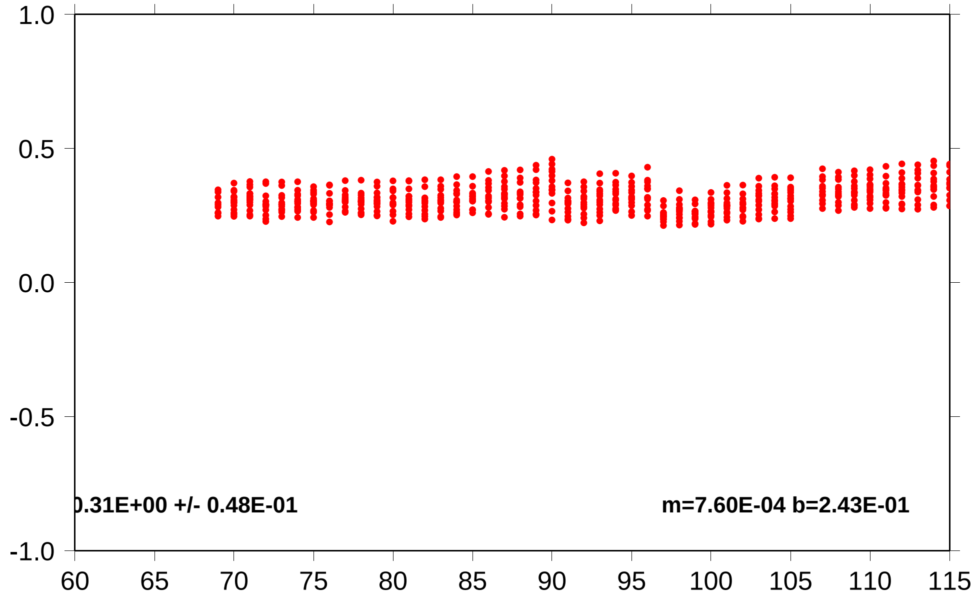


Figure 10: Differences between primary and secondary conductivity sensors at each bottle depth. The mean slope, m and offset, b are given in the lower left corner. The mean and standard deviation are given in the lower right corner.



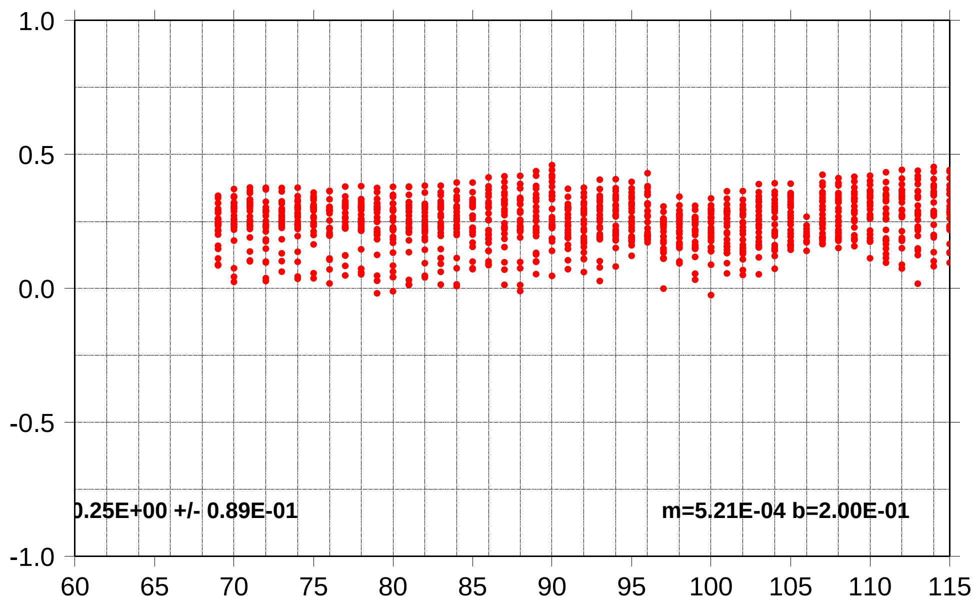


Figure 11: Differences between primary and secondary oxygen sensors at each bottle depth (in ml/L). The mean slope, m and offset, b are given in the lower left corner. The mean and standard deviation are given in the lower right corner.

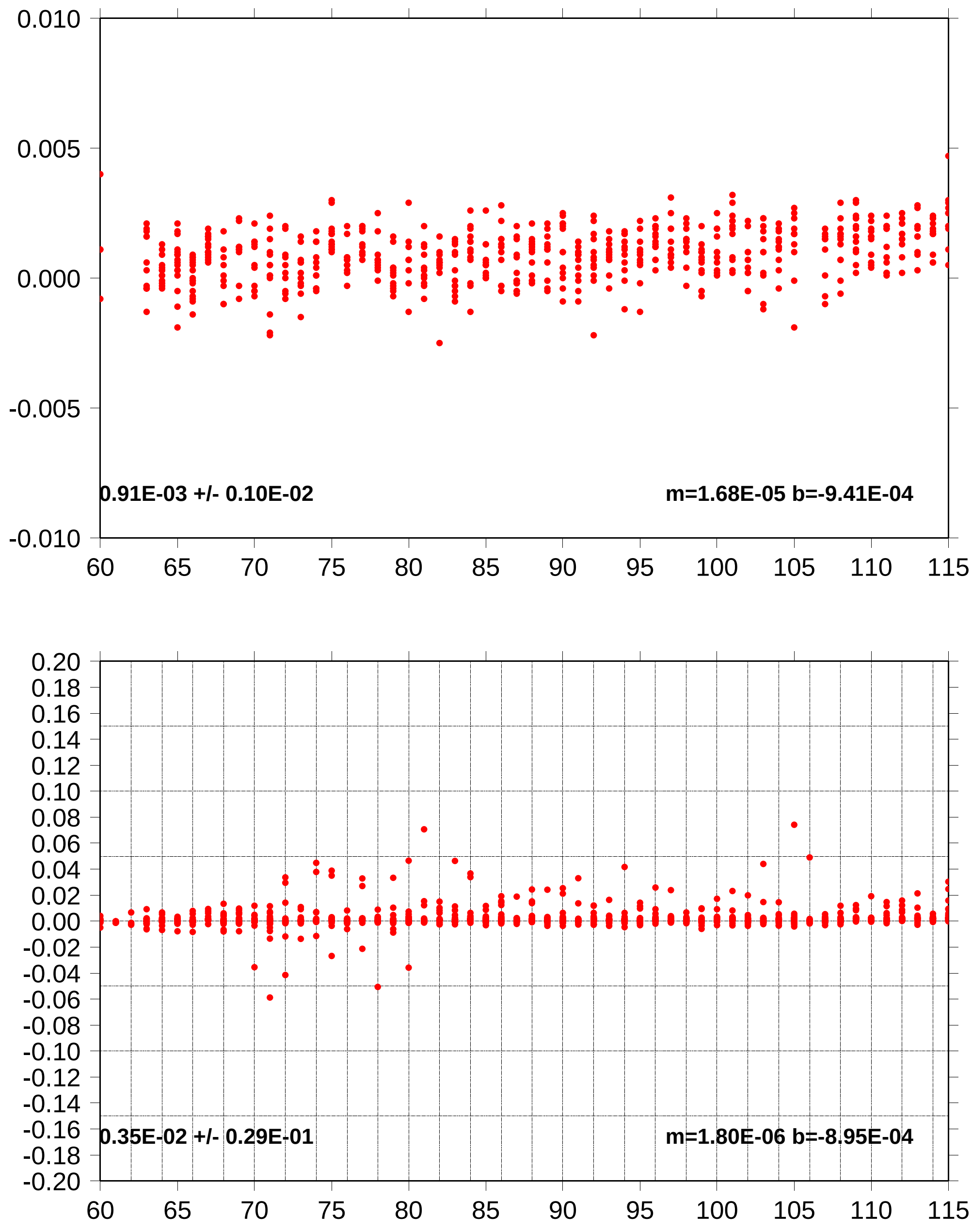


Figure 12: Differences between bottle conductivity and primary CTD conductivity as a function of station number. The mean slope, m and offset, b are given in the lower left corner. The mean and standard deviation are given in the lower right corner.

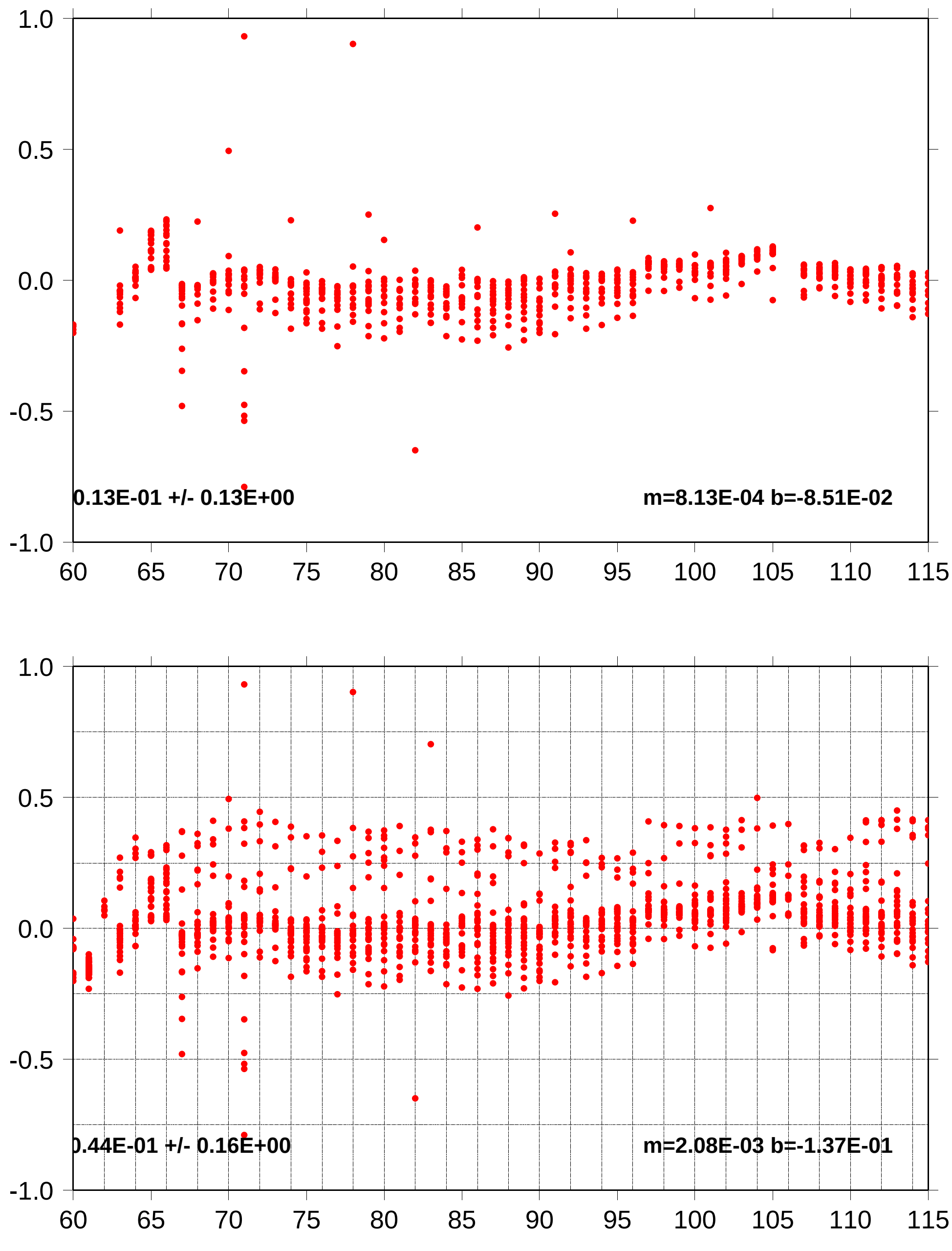


Figure 13: Differences between bottle oxygen and primary CTD oxygen as a function of station number (in ml/l). The mean slope, m and offset, b are given in the lower left corner. The mean and standard deviation are given in the lower right corner.

sta.	lat degmi	long degmi	cum (km)	depth (m)	extra time	ctd time	sta. time	wire speed	steam time	Ship speed	total hours
-9	10 38n	61 35w	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60	9 33n	58 12w	389	1007	0.2	0.9	1.1	36.6	26.6	7.9	27.8
61	7 55n	55 14w	762	457	0.2	0.5	0.7	31.5	18.8	10.7	47.3
62	5 48n	51 26w	1243	107	0.3	0.4	0.7	8.9	25.4	10.2	73.4
63	5 55n	51 20w	1260	1602	0.3	1.6	1.9	32.7	0.8	11.2	76.1
64	6 1n	51 12w	1278	3398	0.4	2.6	3.0	42.7	1.1	8.8	80.2
65	6 30n	50 50w	1345	3737	0.2	3.1	3.3	40.4	3.0	12.1	86.5
66	6 59n	50 27w	1413	4120	0.2	2.7	2.9	51.5	5.6	6.6	95.0
-9	13 5n	59 29w	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
67	7 31n	49 57w	1212	4371	0.3	3.2	3.5	45.8	60.1	10.9	63.5
68	7 0n	49 23w	1296	2016	0.2	1.4	1.6	47.4	4.0	11.4	69.1
69	6 30n	48 48w	1381	2139	0.3	1.6	1.9	43.2	3.6	12.9	74.6
70	6 0n	48 14w	1464	2091	0.5	1.5	1.9	47.5	3.5	12.8	80.0
71	5 59n	47 29w	1546	2214	0.3	1.7	2.0	43.0	3.3	13.6	85.2
72	5 59n	46 44w	1628	2112	0.2	1.4	1.6	49.1	3.7	11.9	90.6
73	6 0n	46 0w	1709	2025	0.1	1.6	1.8	41.3	3.8	11.6	96.1
74	6 0n	45 0w	1819	2158	0.2	1.6	1.8	45.9	5.4	11.0	103.2
75	6 1n	44 0w	1929	2110	0.2	1.4	1.6	49.1	5.5	10.8	110.3
76	6 0n	43 0w	2039	2175	0.1	1.4	1.5	53.0	5.2	11.4	117.0
77	6 0n	42 0w	2149	2000	0.2	1.4	1.5	48.8	4.9	12.1	123.4
78	6 0n	41 0w	2259	2040	0.1	1.3	1.5	51.0	5.1	11.6	130.0
79	6 0n	40 0w	2369	2082	0.1	1.3	1.4	52.7	4.9	12.1	136.3
80	6 0n	39 0w	2479	2023	0.1	1.3	1.4	53.9	5.1	11.5	142.8
81	6 0n	38 0w	2589	2041	0.2	1.3	1.5	53.0	5.0	11.8	149.3
82	6 0n	37 0w	2699	2267	0.1	1.5	1.6	50.4	4.9	12.1	155.8
83	6 0n	36 0w	2809	2116	0.2	1.3	1.5	54.3	5.0	12.0	162.3
84	6 0n	35 0w	2919	1999	0.2	1.3	1.5	49.4	5.1	11.6	168.9
85	6 0n	34 0w	3029	2080	0.2	1.3	1.5	53.3	5.1	11.7	175.4
86	6 0n	33 0w	3139	2008	0.2	1.4	1.5	49.6	5.0	11.8	182.0
87	6 0n	32 0w	3249	2157	0.1	1.3	1.4	53.9	5.6	10.6	189.1
88	6 0n	31 0w	3359	2131	0.2	1.3	1.5	56.8	5.5	10.9	196.0
89	6 0n	29 30w	3524	1996	0.2	1.4	1.5	48.1	8.1	11.0	205.6
90	6 0n	28 0w	3689	2151	0.2	1.4	1.6	50.6	8.0	11.2	215.3
91	6 0n	26 30w	3854	2143	0.1	1.3	1.4	54.9	7.6	11.7	224.3
92	6 0n	25 0w	4019	2173	0.1	1.3	1.5	54.3	7.1	12.6	232.9
93	6 0n	23 30w	4184	2064	0.2	1.3	1.5	51.6	7.2	12.4	241.6
94	6 0n	22 0w	4349	2006	0.1	1.4	1.5	48.3	7.9	11.3	250.9
95	6 0n	21 0w	4459	2026	0.2	1.3	1.5	52.6	5.0	11.9	257.4
96	6 0n	20 0w	4569	2076	0.1	1.3	1.5	51.9	4.9	12.2	263.8
97	6 0n	19 0w	4679	2030	0.1	1.2	1.3	55.6	4.8	12.4	269.9
98	6 0n	18 0w	4789	2055	0.1	1.4	1.5	48.4	5.0	11.9	276.4
99	6 0n	17 0w	4899	2086	0.1	1.3	1.4	53.5	4.8	12.2	282.8
100	5 30n	16 8w	5009	2005	0.1	1.4	1.5	48.9	5.1	11.8	289.3

sta.	lat degmi	long degmi	cum (km)	depth (m)	extra time	ctd time	sta. time	wire speed	steam time	Ship speed	total hours
101	5 0n	15 19w	5115	2023	0.2	1.2	1.4	57.0	5.2	11.0	295.9
102	4 30n	14 17w	5242	2030	0.2	1.3	1.4	54.1	5.7	12.0	303.0
103	4 40n	13 0w	5385	2003	0.2	1.4	1.6	48.9	6.6	11.6	311.2
104	5 20n	12 1w	5516	2094	0.2	1.2	1.4	56.6	5.9	11.9	318.5
105	5 57n	11 17w	5622	2017	0.2	1.4	1.6	48.0	4.8	11.8	324.9
106	6 11n	11 3w	5658	365	0.2	0.4	0.6	30.4	1.7	11.2	327.2
107	0 0n	11 0w	6345	1506	0.8	1.0	1.9	49.4	33.1	11.2	362.2
108	0 0n	15 0w	6789	1512	0.3	1.0	1.3	48.8	19.5	12.3	383.0
109	0 0n	19 0w	7233	1500	0.2	1.0	1.2	48.4	18.2	13.2	402.4
110	0 0n	23 0w	7677	1544	0.2	1.2	1.3	43.5	18.8	12.7	422.6
111	0 0n	26 9w	8027	1526	0.2	0.9	1.1	53.5	17.7	10.6	441.4
112	0 0n	32 40w	8751	1556	1.1	1.1	2.1	48.6	31.2	12.5	474.7
113	0 0n	35 0w	9010	1525	0.2	1.0	1.2	53.5	11.3	12.4	487.2
114	0 0n	38 0w	9343	1543	0.2	1.1	1.3	49.0	14.1	12.7	502.6
115	0 45n	40 0w	9580	1706	0.2	1.1	1.3	50.9	10.5	12.2	514.4
-9	3 41s	38 28w	100101	0	0.0	0.0	0.0	0.0	27.6	10.2	543.5

Niskin	Cast															
#	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
1	1	1	1	1	1	1	1	1	1	1	1	4	1	1	2	1
2	1	1		1	1	1	1	1	1	1	1	1	3	1	1	1
3	1	1		1	1	1	2	1	1	1	1	2	1	1	1	1
4	2	1		1	1	1	1	1	1	1	1	1	1	1	1	1
5	2	1	1	1	1	1	1	1	1	1	4	1	1	1	1	1
6	2	1		1	1	1	1	1	1	1	2	1	1	1	1	1
7	1	1		1	1	1	1	1	1	2	4	1	1	1	1	1
8	3	1		1	1	1	1	1	1	1	1	1	1	1	1	1
9	2	5	1	1	1	1	1	1	1	1	1	3	3	3	1	3
10	2	3		1	1	1	2	2	2	2	1	1	1	1	1	1
11	2	1		1	1	1	1	1	1	1	1	1	1	1	5	1
12	1	1		1	1	1	1	1	1	2	1	1	1	1	2	1
13	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1		1	1	1	1	7	1	1	1	3	1	1	1	1
19	4	1		1	1	1	2	1	1	1	1	1	1	1	1	1
20	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1
23	2	1		1	1	1	1	1	1	1	1	1	1	1	1	1
24	2	1		1	1	1	1	1	1	1	1	1	1	1	1	1

Table 5a:

1 Good Bottle - No problems noted
2 Suspect value - Bottle leaked on deck (O-ring, end cap)
3 Suspect value - Bottle leaked after venting
4 No sample - Bottle did not close (rosette or lanyard)
5 No sample - Sample lost on deck due to excessive leaking
6 Sample drawn - but lost during analysis due to software
7 Sample drawn - but lost due to broken bottle during analysis
8 No Sample - unknown reason

Niskin	Cast														
	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
1	1	2	1	1	2	1	5	1	1	1	1	2	1	1	1
2	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1
3	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	4	1	1	1	1	1
6	1	1	3	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	3	2	1	1	1	2	3	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	3	1	1	1	1	1	2	2	3	2	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	3	1	1	3	1	1	3	3	2	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	5	1	1	1	1	1
15	1	1	1	7	3	1	1	3	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1
17	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1
18	1	3	1	1	1	2	5	3	2	1	1	1	1	3	1
19	1	1	1	1	1	1	1	1	1	1	1	4	2	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1
22	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Niskin	Cast														
	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105
1	1	1	1	1	3	1	1	1	1	3	1	1	1	1	1
2	2	3	1	1	1	1	1	1	1	1	1	1	1	1	3
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	8	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	4	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1
12	1	1	3	1	1	1	1	1	1	3	1	1	1	1	1
13	1	1	1	1	3	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	3	1	1	3
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	6	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1	1	4	4	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	2	1	3	1	3	1	1	1	2	1	1	1	3	1	3
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Niskin	Cast		
	106	107	108
1	1	1	3
2	1	3	1
3	1	1	1
4	1	1	1
5	1	1	1
6	1	1	1
7	1	1	1
8	1	1	1
9	1	1	1
10	1	1	1
11		1	1
12		1	1
13		1	1
14		1	1
15		1	1
16		1	1
17		1	1
18		1	1
19		1	4
20		1	1
21		3	3
22		1	1
23		1	1
24		1	1