PIRATA Northeast Extension 2007 / AEROESE III Cruise Report

NOAA Ship *Ronald H. Brown*
RB-07-03

May 2—29, 2007

Bridgetown, Barbados to Ft. Lauderdale, FL USA

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Hydrography:

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Grant Rawson (CIMAS, University of Miami/AOML)
Claude C. Lumpkin III, Sandy Snyder (volunteers)

Moorings:

Steve Kunze, Jeff Harmon (NOAA/PMEL)

Note: this preliminary cruise report addresses only the hydrographic and mooring work associated with the PIRATA Northeast Extension collaboration between AOML and PMEL. Input by other scientists aboard the cruise will be included in the final cruise report. All figures and results reported here are subject to revision after quality control and final calibration.

OVERVIEW: the 2007 PIRATA Northeast Extension Cruise RB-07-03 was designed to collect a suite of oceanographic and meteorological observations in the northeast Tropical Atlantic, and to complete the four-site Northeast Extension of the PIRATA array initiated with the deployment of two moorings during RB-06-05. The cruise track focuses upon collecting oceanographic and meteorological observations along 23ºW, a longitude cutting through the climatologically significant TNA (Tropical North Atlantic) region, including the southeast corner of the subtropical North Atlantic (a region of subduction for the subtropical cell circulation); the Guinea Dome and oxygen minimum shadow zone where the subtropical and tropical gyres meet, and the Tropical Atlantic current system. All scientific goals of RB-07-03 were achieved.

We thank the crew and officers of the Ronald H. Brown for their tireless work and input before and during the cruise. The deck crew recovered two moorings, deployed four, and conducted several small boat operations. Their efficiency and familiarity with mooring deployment operations was evident. We thank the Chief Survey Technician, Randy Ramey, for his continuous assistance and advice throughout the cruise – he always made himself available for Seabeam surveys, CTD operations, etc. We were extremely fortunate to have Electronics

Technician Jeff Hill aboard; as noted in the "order of operations", he fixed several pieces of equipment at key points during this cruise.

Introduction

PIRATA Northeast Extension (PNE)

The Pilot Research Moored Array in the Tropical Atlantic (PIRATA) is a three-party project involving Brazil, France and the United States that seeks to monitor the upper ocean and near surface atmosphere of the Tropical Atlantic via the deployment and maintenance of an array of moored buoys and automatic meteorological stations. The array consists of a backbone of ten moorings that run along the equator and extend southward along 10ºW to 10ºS, and northward along 38ºW to 15ºN. Given the widely varying dynamics of various subregions of the Tropical Atlantic, future extensions of the array had been anticipated by the PIRATA Science Steering Group to further the scientific scope of the observing system and improve weather and climate forecasts. In August 2005 a Southwest Extension of three moorings was added off the coast of Brazil (PIs: P. Nobre, E. Campos, P. Polito, O. Sato and J. Lorenzzetti). A Southeast Extension pilot mooring (PI: M. Rouault) was deployed near 6ºS, 8ºE during the EGEE3-PIRATA FR15 cruise in June 2006.

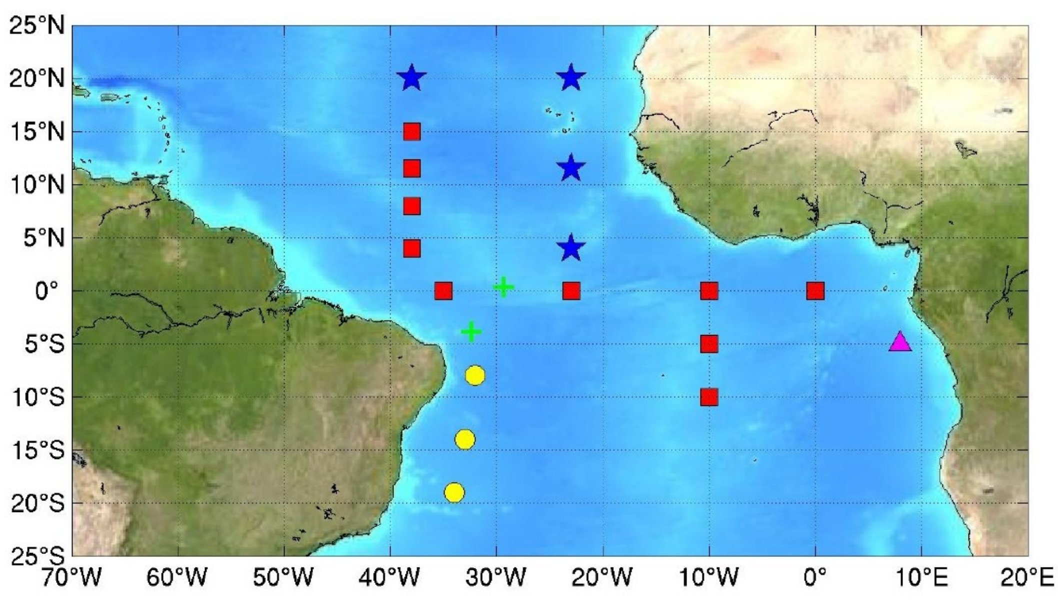

Fig. 1: The Tropical Atlantic, showing the PIRATA backbone (red squares), automatic meteorological stations (green +), southwest extension (yellow circles), southeast extension pilot site (magenta triangle), and the Northeast Extension (blue stars).

The northeastern and north central Tropical Atlantic is a region of strong climate variations from intraseasonal to decadal scales, with impacts upon rainfall rates and storms for the surrounding regions of Africa and the Americas. PIs R.Lumpkin, B. Molinari and M. McPhaden proposed a NOAA-funded Northeast Extension of the PIRATA array at the 2005 PIRATA meeting in Toulouse, France. This PIRATA Northeast Extension (PNE) consists of four moorings (Fig. 1) deployed during this cruise. Moored observations in these regions will improve our knowledge of atmosphere-ocean heat exchanges and dynamics impacting the West African Monsoon, marine Intertropical Convergence Zone, upper ocean dynamics affecting heat content and SST variability in the Tropical North Atlantic, possible connections between SST patterns and North Atlantic climate regimes of variability, and the development of atmospheric easterly waves into tropical cyclones. A better understanding of the processes driving SST anomalies in the TNA region will lead to better predictions of rainfall and other climate signals across a broad geographical domain at timescales from seasonal to decadal.

On February 12, 2007, the Brazilian PIRATA backbone mooring at 11.5°N, 38°W ceased transmitting precipitation data. By late March, it was clear that the problem was not a temporary data transmission issue. The CTD test cast for this cruise, initially planned at 8°N, 38°W, was relocated to this location to provide the added opportunity to replace the rain gauge, download data from the buoy, and conduct a Seabeam survey of the site.

<u>Order of operations:</u>

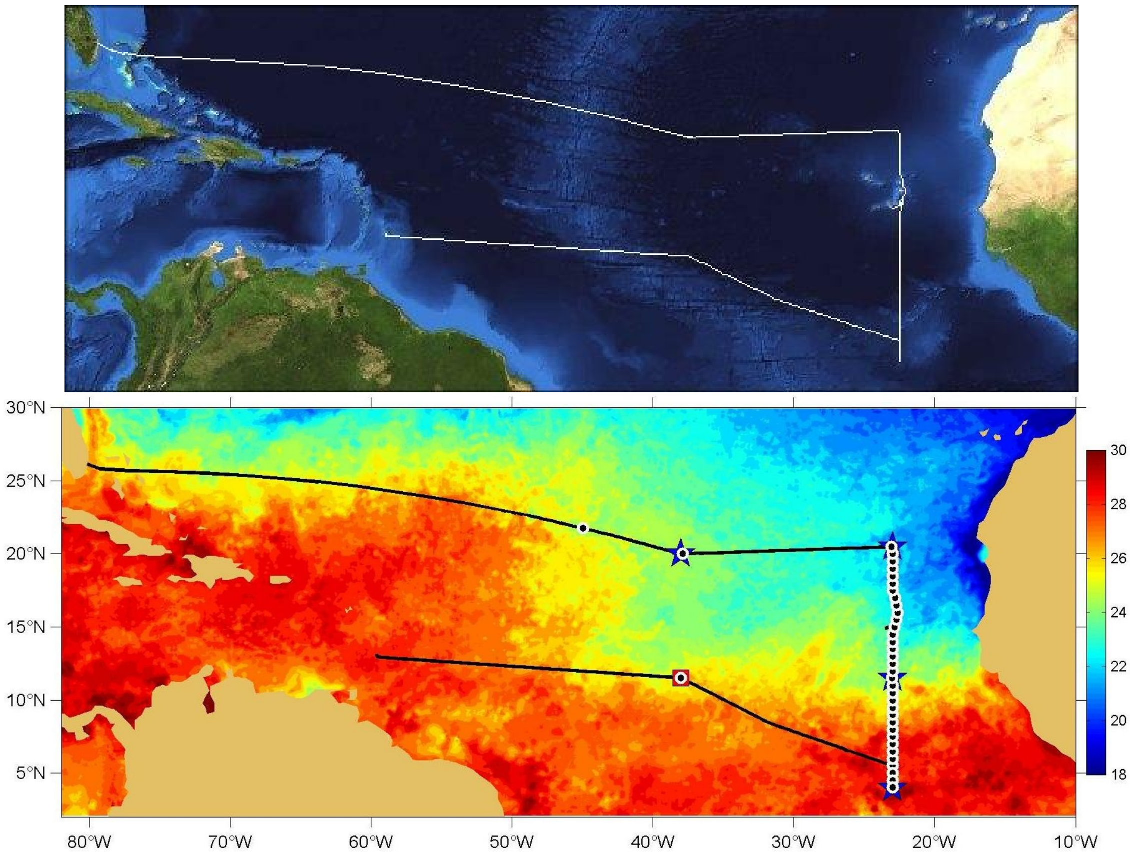

Fig. 2: cruise track of the R/V *Ronald H. Brown* during RB-07-03. Top: track superimposed on bathymetry, from the NOAA shiptracker web page. Bottom: track (black) with CTD stations (bullets), PNE deployment sites (blue stars) and the PIRATA backbone mooring at 11.5°N, 38°W (red square) superimposed. Background shading is SST (ºC) on 22 May 2007, from merged infrared and microwave satellite observations (Remote Sensing Systems).

The R/V *Ronald H. Brown* (RHB) departed from Bridgetown, Barbados on 2 May at 1430 local time, and proceeded to steam to the test cast site 11.5°N, 38°W. On the way to this site, we deployed two Argo floats (SOLO-type) and three surface drifters, and conducted an XBT test cast.

We arrived at 11.5ºN, 38ºW on May 7, and slowed on approach to conduct a Seabeam survey at the site of the Brazilian PIRATA mooring. Our CTD test cast was initiated at 0905 UTC. We immediately noted spuriously large conductivity and salinity values for both primary (~39.4 psu, sensor #1335) and secondary (~40.0 psu, #1374) sensors. These values were inconsistent with measurements from the PIRATA buoy and from the ship's TSG. Temperature and oxygen values were reasonable. The chief scientist aborted the first test cast at 0917 UTC. The package was recovered, coefficients for the sensors were checked, and the secondary conductivity sensor was swapped out (secondary sensor now #2980). A second test cast ("Cast 0B") was initiated at 0944 UTC. As before, both sensors measured large salinity values. The chief scientist elected to proceed with the cast in order to determine if the sensors were displaying an offset, but otherwise were working well. As the rosette descended, it was apparent that the conductivity sensors were measuring a reasonable salinity profile – halocline, salinity minimum at the level of Antarctic Intermediate Water, and increasing values toward the bottom of the 1500dbar cast. Temperature measurements for the two sensors agreed excellently; oxygen profiles agreed reasonably well. The anomalously large salinity values were later determined to be a result of using calibration coefficients dated prior to the most recent Seabird calibration. Once these coefficients were changes, the profile was reprocessed and the values matched water sample results to within 0.005 psu. All bottles fired successfully during the test cast. During the early descents of the test casts, five XBTs were dropped for comparison and XBT drop rate evaluation.

Throughout the cruise, we experimented with automatically generated CTD log sheets, set up by ship survey technician Randy Ramey. These sheets collected time, location, and CTD sensor data for highly accurate records that had in earlier cruises been hand written by the CTD console operator. These automated log sheets were a successful experiment throughout the cruise, and are recommended for future use.

After concluding the test cast, PMEL personnel launched on the RHIB to replace the broken rain gauge on the Brazilian PIRATA mooring. Upon inspection, they found that the watertight seal on the buoy's transmitter tophat had failed, necessitating removal of the mast and repair aboard the Brown (without this servicing, it was highly likely that the buoy would cease data transmission in short order). A second boat trip was needed to replace the data logger/transmitter assembly with a spare unit and reattach the anemometer atop the mast.

We proceeded to steam to the southernmost end of the 23°W line (4°N) while sampling water from the test cast; several bottles were leaking water, so we replaced all O-rings for all the Niskin bottles. Late in the day on 7 May, the conductivity sensor issues were resolved via e-mail communication with Carlos Fonseca (AOML). Newer coefficients, stored in a file with a different naming convention than earlier iterations, were available and necessary for the sensors; after recalculating the salinity profiles for the test cast, the values were quite reasonable and the two sensors agreed extremely well. A new set of coefficients was also available for the secondary oxygen sensor, and recalibration yielded almost identical values for the two profiles.

During the evening of May 8, extrapolations for our arrival at 4°N, 23°W produced an ETA of 1700—1800 local on 11 May. This was undesirable, as daytime small boat operations were necessary for the buoy recovery at that site. Deployment of a new mooring before recovery of the old one was not considered advisable, as significant separation between the two would be required and the ideal location for a mooring at the site was already occupied. Instead, the chief scientist decided to steam to 5.5°N, 23°W (ETA 1600—1700 local on 11 May) and conduct the CTD casts at 5.5°N, 5°N, 4.5°N and then 4°N. This would complete the southern 90 nautical miles of the 23°W section at approximately sunrise on 11 May, in time for the mooring recovery and redeployment at 4°N.

We completed CTD cast 4 (4°N, 23°W) at 0620 local time on May 11. Several modulo error counts were recorded during this cast, and difficulties were experienced firing the bottles on the upcast. As a consequence, the ship's ET (Jeff Hill) reterminated the CTD cable during the day. In the meantime, mooring recovery operations began upon completion of CTD#4. We had difficulty communicating with the mooring acoustic release using the ship's hydrophone, and resorted to lowering a hydrophone over the side of the ship. The mooring was released and brought to the ship via small boat operations, and recovered during the morning of the 11th. After a lunch break, the crew and PMEL personnel immediately proceeded with deployment of the replacement mooring. This operation went smoothly and efficiently, and was completed by 1600 local time. All sensors on the mooring were transmitting data upon our departure.

The RHB then steamed at ~13 kts to 6°N, 23°W, arriving at 0331 UTC on May 12 to resume the hydrographic line northward with CTD#5. Stations 6—16 were occupied from 6°30'N to 11.5°N. During this period, the RHB transitioned from the ITCZ to the dry, Saharan-dust-rich air coming off the African continent. On the night of May 12, a line was noted streaming from the bow of the ship on the starboard side. A brief stop was required immediately before station 13 to conduct a hull survey. The line was fishing longline, wedged between the ship's hull and sacrificial anode. This line was cut at the anode and the RHB proceeded to cast 13. We experienced extremely hazy conditions, resembling fog, on May 13—14 due to the dust storm.

We completed CTD#16, 11.5°N, 23°W, at 0654 local time on May 14 and proceeded to recover the PNE mooring at that location. Significant dust deposit was observed on the mooring sensors. The T/C sensor on the mooring at a depth of 40m, which had failed on deployment, was observed upon disassembly to have had a water leak and resulting corrosion. The replacement mooring, upgraded to full-flux capability, was deployed in the afternoon. During the fly-by at 1630 local, it was determined that the T/C sensor at 20m had failed. Rick Lumpkin and Steve Kunze investigated the possibility of dive operations to replace the 20m sensor, but only one NOAA certified diver was aboard the RHB for RB-07-03 (two are required for safety purposes). Thus, due to safety concerns this option was ruled out. Lifting the anchored, slack-line buoy onto the RHB deck to replace the sensor was quickly ruled out, as this would endanger the working sensors (including the current meter and temperature sensor at 13m, for which there was no backup sensor aboard). Chief scientist Rick Lumpkin decided that, as the mixed layer depth was 40—50m at this site (CTD#16), and the sensors at 40m and 13m were functioning, reasonable estimates of upper ocean heat content could conceivably be made in the absence of the 20m sensor. Furthermore, it was not warranted to stay on site for 12h to attempt a second turnaround, using the sole spare anchor and thus eliminating the ability to address potentially more serious problems with the new mooring deployments planned for 20.5°N, 23°W and 20°N, 38°W.

We occupied CTDs 17—24 on the evening of May 14 through the morning of May 16. During this period, Derrick Snowden and Claudia Schmid discovered that the AMVER SEAS software developed at AOML was not saving XBT data below the first significant spike, although it was displaying data below such a spike on the terminal. As a consequence, many of our XBT profiles, which displayed an easy-to-fix spike and thus hadn't been repeated, were truncated above much good data. We later determined that the data spikes were due to kinked wires near the base of the XBT hand launcher. We switched to using AOML's hand launcher, and ship ET Jeff Hill fixed the Brown's launcher (confirmed by an XBT drop with the ship's launcher on the afternoon of May 21).

On the evening of the 15th, the autosal "Dallas" stopped working while Claude C. Lumpkin was processing salts for cast 14. Jeff Hill determined that a fuse had blown in the autosal, despite the unit being plugged into a clean power outlet. Jeff replaced the fuse and we waited one hour for the autosal bath temperature to reequilibrate before Claude proceeded with processing the remainder of cast 14 through cast 18.

After completing CTD#24 (15°30'N, 23°W) at 0740 local time the RHB diverted to Praia on the island of Santiago in the Cape Verde group. Here a crewman was dropped off in the early afternoon using the Brown's small boat, so that he could return to the USA (necessitated by extenuating family circumstances). The RHB steamed to the site of CTD#25 through the afternoon of the 16th, arriving at 2200 local.

On May 17, Claude C. Lumpkin processed salts for casts 19—28 on the autosal "Dallas". Results were compared to sensor values on the night of May 17—18, with large discrepancies found between sample values and sensor values (on the order of 0.18 psu for salinity, when prior to the fuse blown the values had been within ~0.005 psu). These discrepancies were first seen for cast#14 values, e.g., immediately after the autosal had blown a fuse. No abrupt change in sensor values could be determined for this time period, and the primary and secondary sensors agreed well for post-cast#14 values. We decided that the autosal was suspect, and initiated duplicate salt sampling (starting with cast 31) for analysis at AOML. On 18 May, in order to assess Dallas' functionality, Rick Lumpkin processed a salt standard on the machine. The results were extremely close to the documented salinity of the standard (Dallas, average of 10 psu readings each: 34.99262, 34.99260, 34.99270, 34.99274, 34.99307, 34.99337. Documented standard: 34.9920). On the 20th, Grant Rawson began processing salts for which duplicates had been collected; manual comparison with values on the CTD log sheets showed that results were very close to sensor values, with offsets of ~0.005 psu (as seen before the blown fuse). Grant proceeded to process casts 29—33, and the results were clearly acceptable and reasonable. We concluded that Dallas was again functioning well and that a reequilibrium time on the order of 48 hours was needed for the autosal to recover after losing power.

CTD casts 16—33 were conducted on May 16—18. The RHB then steamed to 20.5°N, 23°W to begin deployment of the new PIRATA Northeast Extension mooring. As a Seabeam survey had been conducted the previous year and an exact location site chosen, we were able to quickly commence with deployment upon our arrival in the late afternoon of May 18. The deployment was a complete success, with all sensors reporting during the flyby. As the anchor was settling, CTD#34 was conducted.

The RHB steamed to 20°N, 38°W, site of the final new PNE mooring, from May 19 to the afternoon of May 22. We commenced a Seabeam survey of this new site as we approached, slowing to ~8 kts at a distance of 6—7 nautical miles from the nominal site. This site is ~400 nautical miles east of the Mid-Atlantic Ridge, in the abyssal plain of the Cape Verde Basin. Upon approach, the Seabeam system revealed extremely rugged bathymetry. Early in the survey, shortly before entering the 5 nautical mile box of the formal survey, Steve Kunze identified a sub-optimal spot; it was relatively flat, but was only 0.5x1.5 nm in size and was immediately west of an extremely steep cliff. The survey was conducted to 5 nm west of the nominal site, then 6 nm north, then back across a 10 nm-long swath slightly overlapping the previous swath. No more ideal site was located after this extensive survey, so the Brown steamed back to the first target site, conducted the drift test, and commenced mooring deployment late in the evening of the 22nd. CTD cast#35 was conducted while the anchor settled. The final position of the mooring was exactly where we had desired, in the center of the relatively small target area. Before leaving the site, Steve Kunze determined that the data stream from the current meter was a repeated error code. With no replacement current meter aboard, and with the possibility that the existing current meter could reset and commence collecting data, Steve advised that recovery and redeployment for the one nonfunctional sensor was not merited.

An additional CTD cast was conducted in the morning of May 23, at 21°46.4'N, 044°58.2'W over the Mid-Atlantic Ridge, in order to wash/lubricate the CTD wire. This cast (#36) was taken to a bottom depth of 1827 dbar in the region where salinity maximum water is formed, allowing the AOML group to conduct simultaneous XBT drops for drop-rate calibration and to collect 12 additional water samples for sensor calibration. Upon conclusion of this cast, the RHB commenced the weeklong steam back to Ft. Lauderdale via a great circle route to the Northwest Providence Channel.

On the morning of May 21, the RHB briefly lost power. Underway data collection was interrupted but quickly resumed. The air conditioning of the autsal room, with the water samples for casts 34—36, was not restarted until the evening of May 22. These salt samples were processed on May 25 by Rick Lumpkin and Grant Rawson, and indicated that the Autosal "Dallas" was functioning properly.

Shortly before noon local time on May 24, the shipboard ADCP system ceased operating. Survey technician Randy Ramey and ET Jeff Hill attempted to fix the system through the afternoon and evening, and verified that there was no obvious software problem via communications with Lisa Beal (UM/RSMAS). Upon further examination of the data, Hill and Ramey determined that the sADCP system began degrading on May 23. Further diagnostics (examining resistance on pins of cable from transducer, before it is connected to the deck unit) and communications with RDI suggest that the problem is associated with the transducer, and Jeff Hill is exploring possible routes to fix the problem as rapidly as possible for the remainder of the 2007 campaign season.

The RHB arrived at Ft. Lauderdale, FL on the evening of May 29, over a full day earlier than planned due to an impressive 13.0 knots *mean* speed over the period May 24—28, and due to the lack of any significant problems impacting CTD or mooring operations timing during RB-07-03.

Recommendation for the future:

- The XBT software (AMVER SEAS) should never display data that is not being archived. This counter-intuitive choice caused us to believe we had good profile data below a near-surface “spike” in the data, but the deeper data was not being recorded – despite being displayed. Had we known that the deeper observations were being discarded, we could have deployed a second XBT in such circumstances. A superior solution would be to save this data separately from the data intended for GTS transmission, for recovery and post-processing.
- NOAA should add a new desktop PC in the Brown’s computer lab beside the CTD acquisition computer, dedicated to automated spreadsheets for CTD logging and for a charting/navigation package that can be used to facilitate underway monitoring and planning of cruises (e.g., testing alternative scenarios and generating intermediate waypoint time-to-go information, without having to formally run waypoints through the ship’s navigation system on the bridge). Automated CTD log sheets were a successful experiment during this cruise, run on a non-dedicated AOML desktop PC; these log sheets eliminated errors that can be caused by a number of sources in hand-written log sheets, with greater accuracy to capture values at bottle firing depths, etc. Such log sheets proved invaluable when assessing autosal performance during this cruise.
- If outages of the autosal occur it seems advisable to give it a couple of days to equilibrate. The same seems advisable if the temperature in the autosal room becomes unstable (due to a power outage, for example). In addition, a permanent temperature sensor should be placed in the Autosal room and linked to the SCS system, to verify that samples have been equilibrated to the appropriate room temperature for at least eight hours before processing.

Oceanographic data collected on this cruise:

1. ATLAS moorings of the Pilot Array in the Tropical Atlantic (PIRATA) were deployed at two new sites and redeployed at two existing sites. These moorings compose the PIRATA Northeast Extension (PNE), a US contribution to PIRATA. A Brazilian PIRATA backbone mooring at 11.5º, 38ºW was serviced by replacing a broken rain gauge, and repairing the transmitter mast. The moorings are relaying real-time data including air temperature, relative humidity, wind speed and direction, rain rate, shortwave and longwave radiation, barometric pressure, sea surface temperature, subsurface currents at ~10m depth, and subsurface temperature and salinity at multiple points through the upper 500m of the water column.
2. Conductivity-Temperature-Depth (CTD) data were collected at 37 casts, including a test cast at 11.5ºN, 38ºW, and 34 casts on a meridional section from 4ºN, 23ºW to 20º30'N, 23ºW. All casts except #36 were conducted to a pressure of 1500dbar, or the bottom (if shallower). Cast #36 was conducted to 1827 dbar. On all casts water samples were taken at various depths to calibrate salinity and oxygen sensors.
3. Nine ARGO floats were deployed to measure temperature and salinity profiles and currents at 1000m depth, as part of the 3000 float global array.
4. 17 satellite-tracked surface drifters were deployed to measure sea surface temperature and mixed layer currents, as part of the 1250 drifter global array.
5. 122 expendable bathythermographs (XBTs) were launched to measure temperature profiles of the upper ocean. Several of these launches were conducted at the same time as five of the CTD casts, in order to calibrate/validate the drop rate equation that converts XBT temperature as a function of time to temperature as a function of depth.
6. Shipboard measurements collected by RHB equipment. Current measurements collected from the beginning of the cruise through 23 May using a 75 kHz Ocean Surveyor hull-mounted Acoustic Doppler Current Profiler (SADCP); heading data for the SADCP was provided by the MAHRS system, with data from the ship's gyro for comparison. Meteorological and ocean surface information were collected by the ship's IMET and TSG sensors. Bathymetry was sampled by the Seabeam 2112 (12 kHz) swath bathymetric sonar system sampling

On this cruise, XBT temperature profiles and CTD temperature/salinity profiles were transmitted in near-real time via the Global Telecommunication System

(GTS) for model calibration and validation. Although XBT data is commonly transmitted on the GTS from Voluntary Observation Ships, the RHB is the first ship to have CTD data transmitted in near-real time for weather and climate prediction (this was initiated in the 2006 PNE/AMMA cruise).

1. ATLAS moorings (text by S. Kunze)

12N38W (nominally 11.5N)

This site was not originally part of the cruise itinerary but was later added to the schedule for a rain gauge repair. Time wise, it was not considered a major diversion from the original track line while in route to 4N23W. The site is located in the western portion of the PIRATA array that the Brazilians routinely service. A Seabeam survey was conducted on arrival to compliment the bathymetry map that the Brazilians had created for the area.

The rain gauge on the mooring had been flagged as indicating a high percent time of rainfall without accumulation. When the RHIB approached the buoy to conduct the repair the anemometer mast was observed to be rocking rather severely on its mount. Addressing this was futile as its mounting screws appeared seized and wouldn't move. The tube was then replaced as well as the rain gauge. The problem rain gauge was found to be in good physical condition. The mooring was dusty and fresh water was poured over the dome of the radiation sensor. In addressing the mast problem while back onboard we found the screws had been installed with a thread locking compound. This doesn't explain the loose fitting mast and it can only be assumed that it was improperly mounted to begin with. There was no evidence that the mooring had been visited prior to our arrival. Fortunately the piston seal at the base of the mast maintained integrity and no water intrusion was found in the tube.

4N23W

PM598A Recovery - This mooring had been flagged for indicating a high percent time of rainfall without accumulation, intermittent SSC, intermittent 12 meter current meter data, and intermittent TC at 10 meters. The mooring was transmitting on arrival and observations indicated no data from the current meter or the 10 meter TC. The SSC was working and the rain gauge gave no obvious abnormal indication. After the buoy was brought up on deck the anemometer was broken off by the working line. Winds compared well with the ship pre-recovery. There was a minor crack in the head of the SSC and one of its anti-foulants was missing. The 60 meter TC was also missing one anti-foulant. Two modules had broken mounts. The current meter required external power to retrieve the data which subsequently indicated that it logged up until 11/15/2006 corresponding to about the time that it was flagged. The 10 meter TC had dead batteries. A fresh battery was installed, the memory pointer was reset, the counter was set to 425 records, and data was acquired.

12N23W (nominally 11.5N)
PM595A Recovery - From the day it was deployed the 40 meter TC had failed. Both the SST/C and 12 meter current meter were later flagged as becoming intermittent. This mooring was also transmitting on arrival. The SST/C was working but the current meter and 40 meter TC were not. The buoy was covered heavily with dust and the radiation sensor had been partially rinsed by a zealous crew member before we could stop him. Half of the dome was untouched and a photo of the sensor was taken. It was later cleaned completely before it was packed up. The current meter required external power to retrieve data with internal logging ending on 5/3/2007, right before it was flagged. The TC module had suffered a slight amount of water intrusion and would not communicate properly with a new battery installed. During recovery of the subsurface section the SST/C was found to be missing one anti-foulant and there was shark bite to the core of the nilspin immediately above the 140 meter module.


PM595A SWR #33720

PM674 Deployment – The 20 meter TC module failed on deployment. A request was made to the command for a dive operation to replace it but there was only one qualified NOAA diver onboard and the regulations require two. The mooring design was upgraded and the location is now a flux site.

21N23W (nominally 20.5N)
PM676 Deployment – This is a new site. It had been surveyed previously on last years AMMA cruise. Further mapping was conducted for mooring operations and the chosen location was to the east of the Newport processed bathymetry map. Current Seabeam data should be reprocessed and a new map drawn up centering on the general area that the mooring was deployed at. Ideally, this is at about 20 29.00N, 23 04.00W.

20N38W
PM679 Deployment – This was the second of the two new mooring locations. A survey had to be conducted to determine a suitable location. The bottom topography was very rugged and choices for mooring locations were few. A small, somewhat flat plateau was decided and acted upon. A few alternate locations in valleys to the northwest were considered but steep inclines adjacent to those could become a factor for future deployments depending on the ships set up.
12 meter current meter communications failed after the anchor drop as indicated by a hexadecimal error code of 7F.

2. Conductivity-Temperature-Depth (CTD) casts

We conducted 37 CTD casts, including a test cast at 11.5ºN, 38ºW (Fig. 2). One cast, #7 at 6º59.95'N, 22º59.99'W, was conducted above a bathymetric feature associated with the Sierra Leone Rise where the bottom depth was 1481m; this cast was conducted to 1474 dbar, 15m above the bottom according to the altimeter on the CTD package. For casts 0—20, 23 Niskin bottles were used to collect water samples, with two bottles fired at each of 12 target depths (one at the depth of bottle 13; no Niskin bottle was attached to the frame at position 14, normally reserved for the LADCP). Oxygen and salinity were sampled from 12 of these bottles for sensor calibration. Starting with cast 16, salinity was only sampled from 6 bottles due to the close bottle/sensor values determined from autosal runs to that point. After cast#20, we removed the even-numbered Niskin bottles, leaving 12 bottles on the package. On casts 21—30, we sampled salt and oxygen from every other bottle (six samples per cast). On casts 31—32, we sampled salt from seven bottles; cast 33, 10 bottles; casts 34—36, all 12 bottles. On casts 33—36, we sampled oxygen from all 12 bottles.

CTD processing was performed using Seabird software and Matlab routines developed by Carlos Fonseca, with modifications by Derrick Snowden and Rick Lumpkin.

No communication problems between the CTD console and the package were experienced except for cast#4. On this cast, the modulo error count reached 4 by the first 100 m on descent. Bottle 1 failed to fire after three attempts with the Seasave software. It was manually fired from the deck unit, which had the red "confirm" light go on – and then not go off. Further attempts to fire bottles from the software resulted in an error message "all bottles already fired", forcing all bottle firings to be done from the deck unit on the upcast. Ship ET Jeff Hill reterminated the CTD after this cast, and all cable connections were cleaned and resealed. No subsequent problems with communication were encountered. On cast#11, an incorrect configuration file had been loaded into Seasave after rebooting the CTD acquisition computer; the CTD was recovered after initial deployment, this problem was identified and fixed, and the cast was resumed.

Cast#2 was noteworthy for the large anomalies seen in the primary conductivity and oxygen sensors on the downcast, and extremely large anomalies in the secondary oxygen sensor during the upcast, from 1500dbar to ~1000dbar. The probable cause of these anomalies was a temporary blockage of water through the sensors; we flushed the sensors several times with fresh DI water after this cast, and did not see anomalies in cast#3.

CTD casts are tabulated in Table 1, and preliminary sections are shown at the end of this preliminary cruise report.

Cast #	***Date***	***Start time (UTC)***	***Latitude***	***Longitude***
0	7-May-07	0944	11.4947N	38.0345W
1	10-May-07	1652	5.4998N	23.0008W
2	10-May-07	2123	5.011N	23W

3	11-May-07	0027	4.507N	22.9992W
4	11-May-07	0655	4.0427N	22.9678W
5	12-May-07	0326	5.9908N	22.9998W
6	12-May-07	0081	6.4852N	22.9998W
7	12-May-07	1234	6.9997N	22.9995W
8	12-May-07	1712	7.4987N	22.9998W
9	12-May-07	2145	7.9982N	22.9997W
10	13-May-07	0251	8.4987N	22.9992W
11	13-May-07	0740	8.9997N	23W
12	13-May-07	1159	9.4933N	22.9998W
13	13-May-07	1811	9.994N	22.9952W
14	13-May-07	2237	10.4895N	22.9998W
15	14-May-07	0320	11.0017N	22.9997W
16	14-May-07	0743	11.4947N	23.0097W
17	14-May-07	2138	11.9983N	22.9998W
18	15-May-07	0226	12.499N	23.0002W
19	15-May-07	0654	12.9953N	23.0002W
20	15-May-07	1145	13.5N	23.0003W
21	15-May-07	0171	13.9982N	23.0002W
22	15-May-07	2219	14.4997N	23W
23	16-May-07	0355	14.9993N	22.8668W
24	16-May-07	0830	15.5002N	22.7323W
25	16-May-07	2341	15.9745N	22.6128W
26	17-May-07	0443	16.4997N	22.7333W
27	17-May-07	0944	16.9978N	22.8163W
28	17-May-07	1442	17.4923N	22.9972W
29	17-May-07	1931	17.9847N	22.9998W
30	18-May-07	0022	18.4863N	23.0003W
31	18-May-07	0512	18.9985N	22.9998W
32	18-May-07	0954	19.4998N	23.0002W
33	18-May-07	1438	19.9972N	23.0013W
34	18-May-07	2315	20.4738N	23.0673W
35	22-May-07	0121	20.0118N	37.8698W
36	23-May-07	1156	21.7702N	44.9582W

Table 1: locations and times of CTD casts.

The Temperature-Salinity structure along 23ºW from the CTD casts is shown in Fig. 3. The upper portion of the curves shows the gradient of surface water salinity from the fresh ITCZ region and the tropical gyre to the salty subduction region of the southern subtropical gyre. The nearly linear T-S relationship at intermediate densities is the signature of Central Water, while Antarctic Intermediate Water is indicated by the salinity minimum at 5—7°C, σ_θ=27.4.

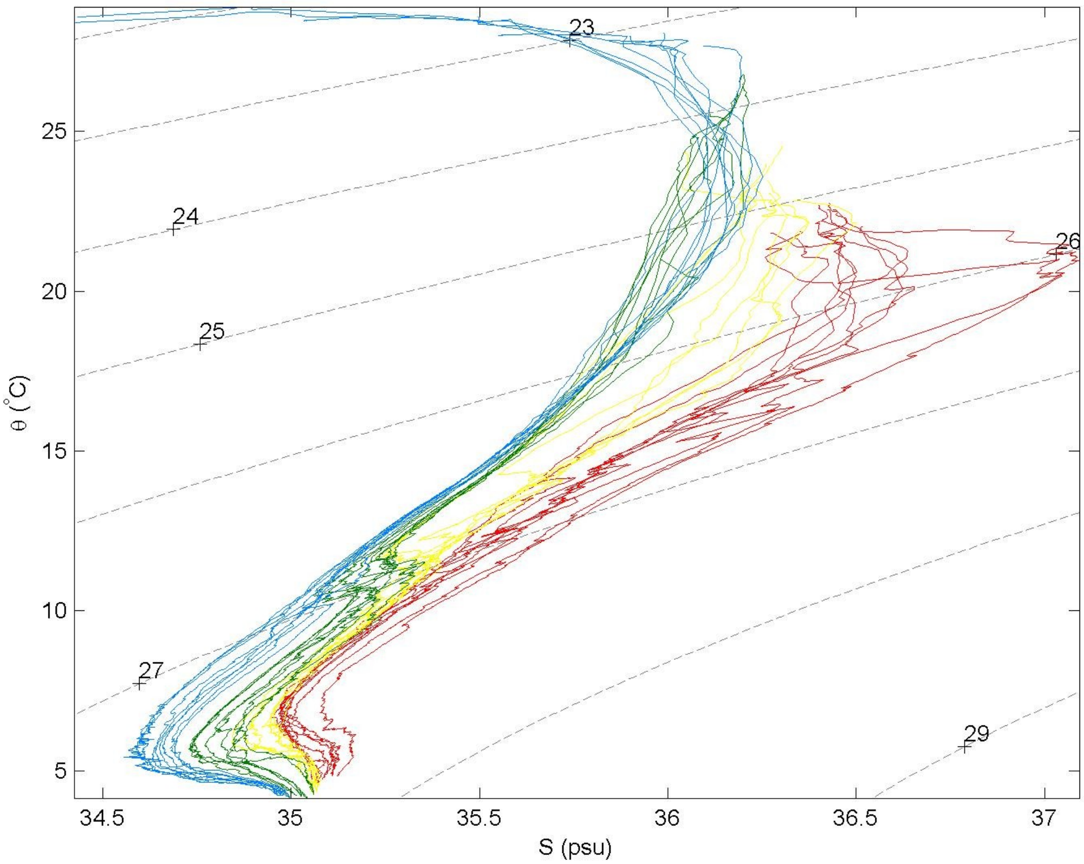

Fig. 3: salinity vs. potential temperature along the 23ºW section. Colors indicate latitude band: 16—20.5ºN (red), 12—16ºN (yellow), 8—12ºN (green) and 4—8ºN (blue). Dashed contours are values of constant potential density σ_θ.

3. Floats and Drifters

Nine floats and seventeen drifters were deployed during the cruise, as shown in Fig. 5a and compiled in Table 2. The floats were Argo WHOI-SOLO, designed to sink to a parking depth of 1000m, stay there for 10 days following currents at that depth, then profile temperature and conductivity of the upper ocean, from the parking depth to 200 dbar, for satellite transmission and real-time dissemination.

The drifters were mini-Surface Velocity Program satellite-tracked drifting buoys, drogued at 15m to follow mixed layer currents. All included a thermistor on the surface buoy for SST. One drifter also had a barometer. Their data are transmitted in real time via the Argos system onto the Global Telecommunication System. One of the 17 drifters failed on deployment; the others are all successfully relaying data at a median temporal resolution of 1.68 hours (set by the multi-satellite Argos constellation).

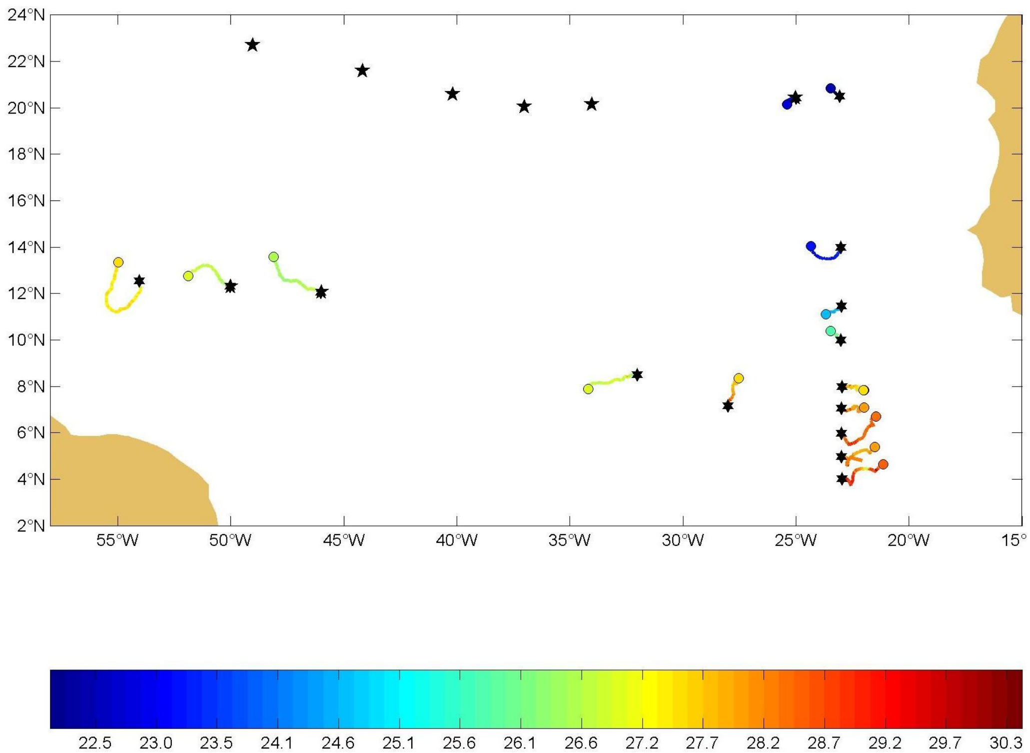

Fig. 4: location of Argo float deployments (black stars) and surface drifter positions (colored bullets) as of 26 May 2007. The positions and trajectories of the drifters are colored according to their SST measurements (°C).

	ID number	Date	Time (UTC)	Latitude	Longitude	Notes (floats: start date/time)

ARGO floats

	ID number	Date	Time (UTC)	Latitude	Longitude	Notes
1	721/71546	4-May	2012	12º 18.15' N	50º 0' W	woke 2120Z 3 May
2	722/71547	5-May	1634	12º 2.92' N	46º 0' W	woke 2120Z 3 May
3	713/4050	19-May	0957	20º 25.95' N	25º 01.62' W	inflated 1st try 0939Z 19 May Iridium*
4	717/71542	20-May	2250	20º 7.951' N	34º 01.822' W	inflated 1st try 1859 20 May*
5	719/71544	21-May	1157	20º 2.032' N	37º 01.114' W	inflated 1st try 0750 21 May
6	715/71540	22-May	1929	20º 34.73' N	40º 11.823' W	inflated 1st try approx. 0320 22 May*
7	718/71543	23-May	0821	21º 35.35' N	44º 09.715' W	inflated 1st try 0020 23 May
8	725/71550	24-May	0739	22º 40.74' N	49º 01.355' W	inflated 1st try 2226 23 May
9	727/71552	25-May	0029	23º 25.4' N	52º 55.9' W	inflated 1st try 2015 24 May

***Note: float made loud noise at reset: float #s 713, 717, 715 (5 times)**

Drifters

	ID number	Date	Time (UTC)	Latitude	Longitude	Notes
1	62914	3-May	2357	12º 34.09' N	54º 1.337' W	bottom depth 4712m
2	62889	4-May	2014	12º 18.13' N	49º 59.623' W	deployed with float 721/71546
3	62897	5-May	1634	12º 2.52' N	46º 0' W	deployed with float 722/71547
4	62898	8-May	2056	08º 32.32' N	32º 0' W	depth 4945m #62898
5	62905	9-May	1627	07º 10.49' N	28º 0' W	
6	62913	10-May	2302	04º 58.88' N	22º 59.597' W	
7	62882	11-May	1808	04º 03.49' N	22º 59.01' W	
8	63885	12-May	0446	05º 59.93' N	22º 59.93' W	
9	62895	12-May	1445	07º 05.391' N	23º 00.00' W	
10	62891	12-May	2343	08º 00.398' N	22º 59.977' W	launched pair w/ 62901
11	62901	12-May	2343	08º 00.398' N	22º 59.977' W	
12	62884	13-May	1935	09º 59.96' N	22º 59.985' W	
13	62875	14-May	1823	11º 28.72' N	22º 59.657' W	*Failed on deployment*
14	72184	14-May	1823	11º 28.722' N	22º 59.657' W	barometer drifter
15	62892	15-May	1816	14º 00.305' N	22º 59.965' W	
16	71112	19-May	0121	20º 29.61' N	23º 03.995' W	
17	62878	19-May	0954	20º 25.99' N	25º 00.439' W	

Table 2: float (top) and drifter (bottom) deployments.

4. eXpendable Bathythermograph (XBT) casts

A total of 122 XBTs were dropped during the cruise (Fig. 6 and Table 3). These measured temperature to depths of up to 900m. During the period May 14—16, XBT profiles began exhibiting spikes (anomalous temperature values) due to a kinked wire near the handle of the ship's hand launcher. These profiles were good above and below the spikes, and we believed that reasonable profiles could be recovered with additional processing. However, Derrick Snowden and Claudia Schmid discovered on 16 May that the AMVER SEAS software developed at AOML was not saving XBT data below the first significant spike, despite the fact that it was displaying data below such a spike on the terminal. As a consequence, many of our XBT profiles, which displayed an easy-to-fix spike and thus hadn't been repeated, were truncated above much good data. The spiking problem was fixed by switching to AOML's hand launcher, and ship ET Jeff Hill fixed the ship's launcher (confirmed by an XBT drop with the ship's launcher on the afternoon of May 21).

An additional problem was encountered when Derrick Snowden swapped Mk.21 interface units for the XBT computer (donated to the RHB by AOML on last year's PNE cruise) on May 16. The PC did not recognize the interface, and re-using the original interface did not fix the problem. During several rounds of communications with Carrie Wolfe, Derrick attempted modifications for the PC's drivers, then restored the system to an earlier state, but was unable to solve the problem. We bypassed this problem by conducting subsequent launches (from 17 May on) using the Sippican Mk.21 software on an alternative laptop computer, and are returning the XBT desktop to AOML for further diagnostics.

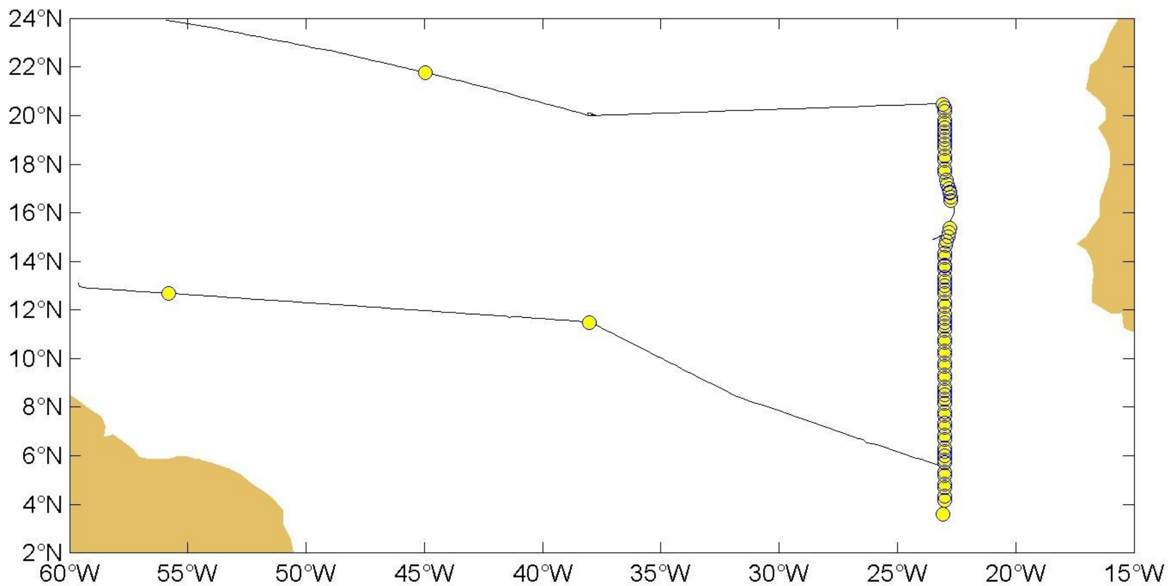

Fig. 5: location of XBT deployments (bullets) superimposed on ship track (black).

XBT file name	***date***	***latitude***	***longitude***
X070503N01	03/05/2007 15:25 GMT	12.685	-55.795
X070507N01	07/05/2007 09:14 GMT	11.495	-38.035
X070507N02	07/05/2007 09:55 GMT	11.495	-38.035
X070507N03	07/05/2007 10:00 GMT	11.495	-38.035
X070507N04	07/05/2007 10:04 GMT	11.495	-38.035
X070507N05	07/05/2007 10:08 GMT	11.495	-38.035
X070510N01	10/05/2007 19:25 GMT	5.335	-23
X070510N02	10/05/2007 20:22 GMT	5.18	-23
X070511N01	11/05/2007 00:02 GMT	4.841	-23
X070511N02	11/05/2007 01:04 GMT	4.682	-23
X070511N03	11/05/2007 04:49 GMT	4.324	-22.996
X070511N04	11/05/2007 05:55 GMT	4.158	-22.993
X070512N01	12/05/2007 02:10 GMT	5.712	-22.998
X070512N02	12/05/2007 02:45 GMT	5.832	-22.999
X070512N03	12/05/2007 03:42 GMT	5.999	-22.999
X070512N04	12/05/2007 03:46 GMT	5.999	-22.999
X070512N05	12/05/2007 03:50 GMT	5.999	-22.999
X070512N06	12/05/2007 03:53 GMT	5.999	-22.999
X070512N07	12/05/2007 06:02 GMT	6.164	-23
X070512N08	12/05/2007 07:08 GMT	6.333	-23
X070512N09	12/05/2007 10:37 GMT	6.669	-23
X070512N10	12/05/2007 11:38 GMT	6.837	-23
X070512N11	12/05/2007 15:24 GMT	7.182	-23
X070512N12	12/05/2007 16:20 GMT	7.343	-23
X070512N13	12/05/2007 19:37 GMT	7.66	-23
X070512N14	12/05/2007 20:36 GMT	7.816	-23
X070513N01	13/05/2007 00:48 GMT	8.167	-23
X070513N02	13/05/2007 01:49 GMT	8.332	-23
X070513N03	13/05/2007 02:59 GMT	8.499	-22.999
X070513N04	13/05/2007 03:02 GMT	8.499	-22.999
X070513N05	13/05/2007 03:04 GMT	8.499	-22.999
X070513N06	13/05/2007 03:07 GMT	8.499	-22.999
X070513N07	13/05/2007 03:11 GMT	8.499	-22.999
X070513N08	13/05/2007 05:23 GMT	8.675	-23
X070513N09	13/05/2007 06:19 GMT	8.831	-23
X070513N10	13/05/2007 10:14 GMT	9.179	-23
X070513N11	13/05/2007 11:08 GMT	9.331	-23
X070513N12	13/05/2007 14:49 GMT	9.665	-23

X070513N13	13/05/2007 15:48 GMT	9.832	-23
X070513N14	13/05/2007 20:42 GMT	10.164	-23
X070513N15	13/05/2007 21:41 GMT	10.325	-23
X070514N01	14/05/2007 01:18 GMT	10.667	-23
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X070514N03	14/05/2007 05:47 GMT	11.175	-23
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X070514N05	14/05/2007 07:53 GMT	11.495	-23.01
X070514N06	14/05/2007 07:56 GMT	11.495	-23.01
X070514N07	14/05/2007 07:59 GMT	11.495	-23.01
X070514N08	14/05/2007 08:02 GMT	11.495	-23.01
X070514N09	14/05/2007 19:37 GMT	11.659	-23
X070514N10	14/05/2007 20:38 GMT	11.828	-23
X070514N11	14/05/2007 20:40 GMT	11.833	-23
X070515N01	15/05/2007 00:21 GMT	12.168	-23
X070515N02	15/05/2007 01:29 GMT	12.345	-23
X070515N03	15/05/2007 04:54 GMT	12.669	-23
X070515N04	15/05/2007 05:55 GMT	12.829	-23
X070515N05	15/05/2007 07:14 GMT	12.999	-23
X070515N06	15/05/2007 07:17 GMT	12.999	-23
X070515N07	15/05/2007 07:18 GMT	12.999	-23
X070515N08	15/05/2007 09:38 GMT	13.18	-23
X070515N09	15/05/2007 10:47 GMT	13.357	-23
X070515N10	15/05/2007 14:24 GMT	13.656	-23
X070515N11	15/05/2007 14:37 GMT	13.672	-22.995
X070515N12	15/05/2007 15:50 GMT	13.83	-23
X070515N13	15/05/2007 15:53 GMT	13.838	-23
X070515N14	15/05/2007 19:34 GMT	14.163	-23
X070515N15	15/05/2007 20:51 GMT	14.327	-23
X070515N16	15/05/2007 20:54 GMT	14.333	-23
X070516N01	16/05/2007 00:53 GMT	14.662	-22.957
X070516N02	16/05/2007 00:59 GMT	14.673	-22.954
X070516N03	16/05/2007 02:25 GMT	14.829	-22.912
X070516N04	16/05/2007 04:04 GMT	14.999	-22.867
X070516N05	16/05/2007 04:06 GMT	14.999	-22.867
X070516N06	16/05/2007 04:10 GMT	14.999	-22.867
X070516N07	16/05/2007 04:13 GMT	14.999	-22.867
X070516N08	16/05/2007 04:14 GMT	14.999	-22.867
X070516N09	16/05/2007 04:16 GMT	14.999	-22.867
X070516N10	16/05/2007 06:49 GMT	15.182	-22.818
X070516N11	16/05/2007 06:51 GMT	15.189	-22.816

X070516N12	16/05/2007 07:51 GMT	15.375	-22.767
TD_00011	17/05/2007 04:59 GMT	16.49967	-22.7333
TD_00012	17/05/2007 05:03 GMT	16.49967	-22.7333
TD_00013	17/05/2007 05:07 GMT	16.49967	-22.7333
TD_00014	17/05/2007 07:13 GMT	16.64817	-22.758
TD_00015	17/05/2007 08:38 GMT	16.8355	-22.7883
TD_00017	17/05/2007 08:45 GMT	16.8505	-22.7917
TD_00019	17/05/2007 10:03 GMT	16.99917	-22.817
TD_00020	17/05/2007 10:06 GMT	16.99917	-22.817
TD_00021	17/05/2007 10:09 GMT	16.99917	-22.817
TD_00022	17/05/2007 10:13 GMT	16.99917	-22.817
TD_00023	17/05/2007 12:26 GMT	17.17533	-22.8803
TD_00024	17/05/2007 13:35 GMT	17.33517	-22.9395
TD_00025	17/05/2007 17:15 GMT	17.662	-22.9998
TD_00026	17/05/2007 18:25 GMT	17.82483	-22.9998
TD_00027	17/05/2007 22:14 GMT	18.15917	-22.9982
TD_00028	17/05/2007 23:21 GMT	18.32383	-22.9998
TD_00029	18/05/2007 02:55 GMT	18.66	-22.9998
TD_00030	18/05/2007 04:06 GMT	18.82833	-22.9998
TD_00031	18/05/2007 05:29 GMT	18.99983	-23.0002
TD_00032	18/05/2007 05:32 GMT	18.99983	-23.0002
TD_00033	18/05/2007 05:35 GMT	18.99983	-23.0002
TD_00034	18/05/2007 05:38 GMT	18.99983	-23.0002
TD_00035	18/05/2007 07:41 GMT	19.15767	-22.9998
TD_00036	18/05/2007 08:50 GMT	19.3255	-22.9998
TD_00037	18/05/2007 10:14 GMT	19.49967	-22.9998
TD_00038	18/05/2007 10:18 GMT	19.49967	-22.9998
TD_00039	18/05/2007 10:21 GMT	19.49967	-22.9998
TD_00040	18/05/2007 10:24 GMT	19.49967	-22.9998
TD_00041	18/05/2007 12:31 GMT	19.66633	-22.9998
TD_00042	18/05/2007 13:34 GMT	19.83333	-22.9998
TD_00043	18/05/2007 17:13 GMT	20.17417	-22.9998
TD_00044	18/05/2007 18:15 GMT	20.3265	-22.9998
TD_00046	18/05/2007 23:37 GMT	20.47267	-23.0678
TD_00048	18/05/2007 23:40 GMT	20.47267	-23.0678
TD_00050	18/05/2007 23:43 GMT	20.47267	-23.0678
TD_00051	18/05/2007 23:47 GMT	20.47267	-23.0678
TD_00052	21/05/2007 15:37 GMT	3.5945	-23.0678
TD_00053	23/05/2007 12:21 GMT	21.77267	-44.9705
TD_00054	23/05/2007 12:24 GMT	21.77267	-44.9705
TD_00055	23/05/2007 12:27 GMT	21.77267	-44.9705

TD_00056	23/05/2007 12:30 GMT	21.77267	-44.9705
TD_00057	23/05/2007 12:33 GMT	21.77267	-44.9705

Table 3: XBT deployments.

5. Ship IMET observations

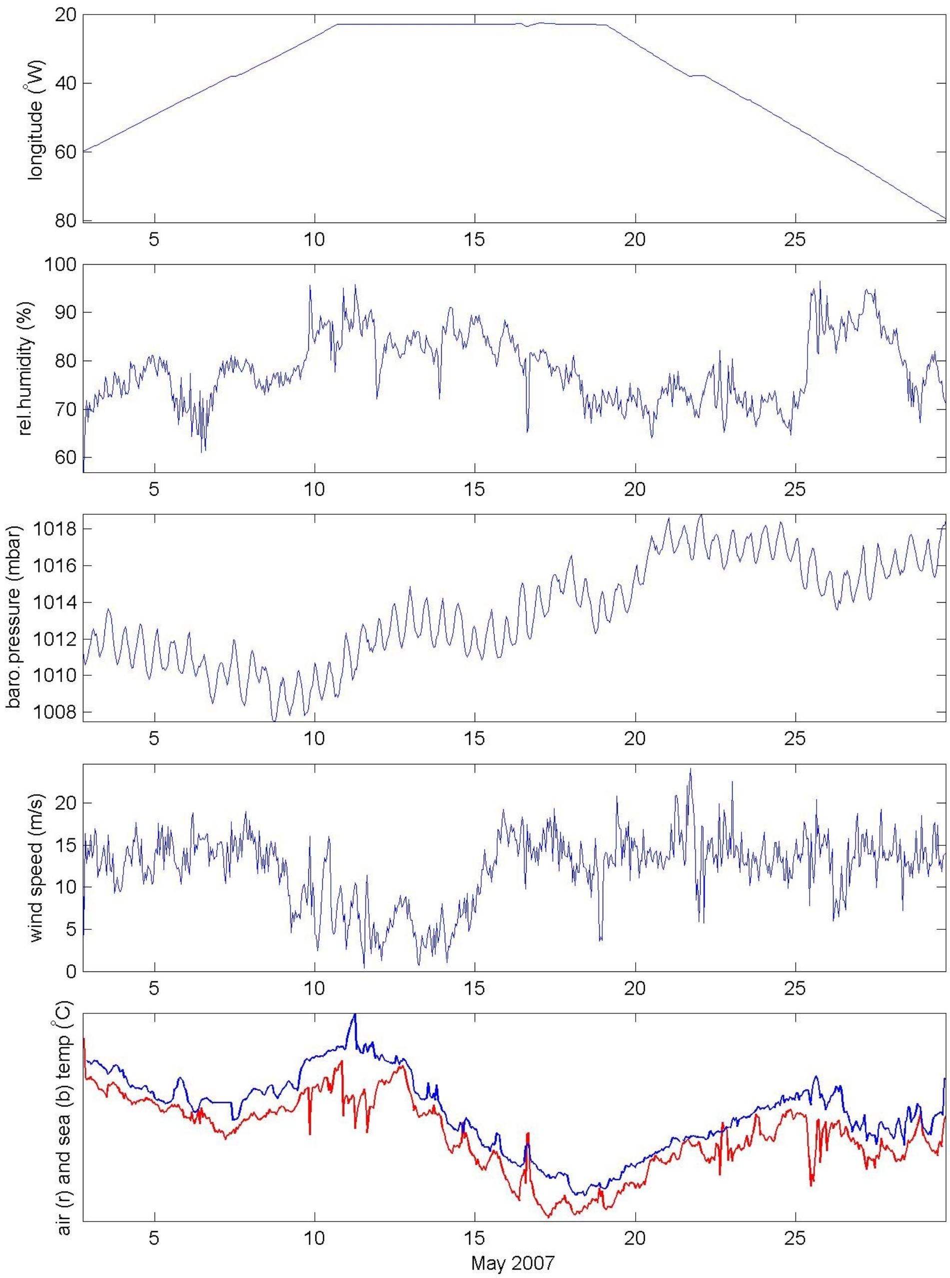

Figure 6: ship data during RB-07-03.

Shipboard IMET data are invaluable for calibration and validation of the ATLAS buoy observations. Time series of winds, relative humidity and air/sea temperature (Fig. 6) from the RHB IMET system clearly indicate the ship's passage through the ITCZ and a low pressure system west of the Bahama islands.

Preliminary property sections

Preliminary sections of 23°W, from 4°N to 20.5°N, include CTD casts along the eastern edge of the Cape Verde plateau. The salinity and oxygen fields have undergone preliminary calibration with the bottle measurements. Standard deviations for salinity and oxygen samples vs. post-calibration sensor profiles were 2.7×10^{-3} psu and 0.17 ml/l.

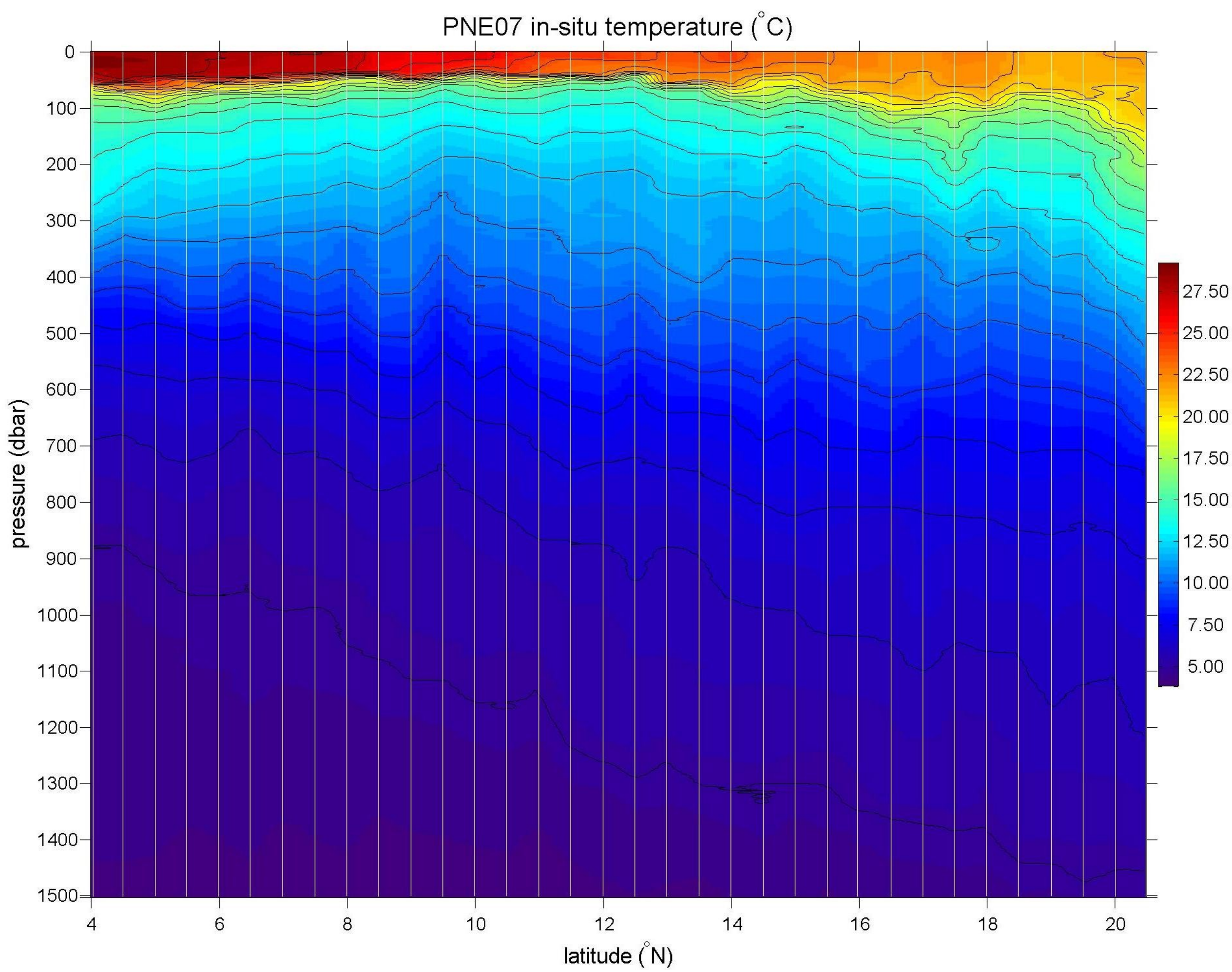

Fig. 7: temperature (ºC) vs. depth at 23ºW. White vertical lines indicate the position of CTD casts.

Temperature vs. pressure along the 23ºW section is shown in Fig. 7. Surface features include the warm, thick subtropical gyre and warmer, shallow tropical surface water layer. At depths of 100—400 dbar, rapidly shoaling isotherms from 14ºN to 11ºN may be associated with the cyclonic Guinea Dome (Siedler *et al.*, 1992).

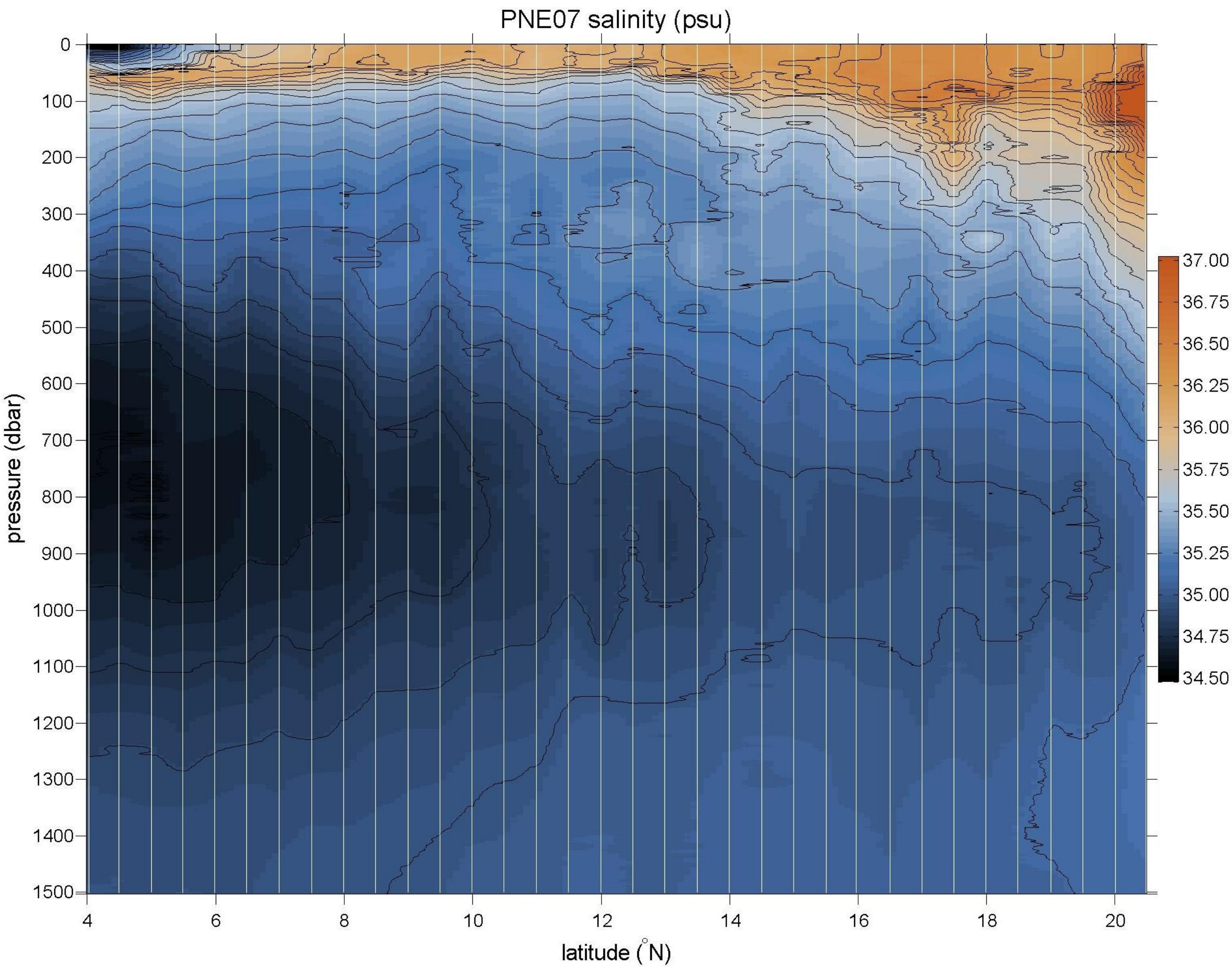

Fig. 8: salinity (psu) vs. depth at 23ºW. White vertical lines indicate the position of CTD casts.

Salinity vs. pressure (Fig. 8) shows the increased salinity of the subtropical waters to the north, in the region where increased evaporation-minus-precipitation drives subduction and the production of Salinity Maximum Water (SMW), a subtropical mode water. Tropical SMW is seen beneath the surface, where low salinity is caused by the precipitation associated with the Intertropical convergence zone. At 500—1000 dbar, the signature of northward-spreading fresh Antarctic Intermediate Water dominates the section.

Oxygen vs. pressure along 23ºW is shown in Fig. 9. The oxygen minimum water at 400—500 dbar dominates the section. This water is in the stagnant shadow zone of the North Atlantic, not participating in the ventilated thermocline circulation of the subtopical gyre (e.g., Luyten and Stommel, 1986). The abrupt increase in oxygen values north of 14ºN marks the Cape Verde Frontal Zone, which also marks the boundary between North Atlantic and South Atlantic Central Water (Stramma *et al*., 2005).

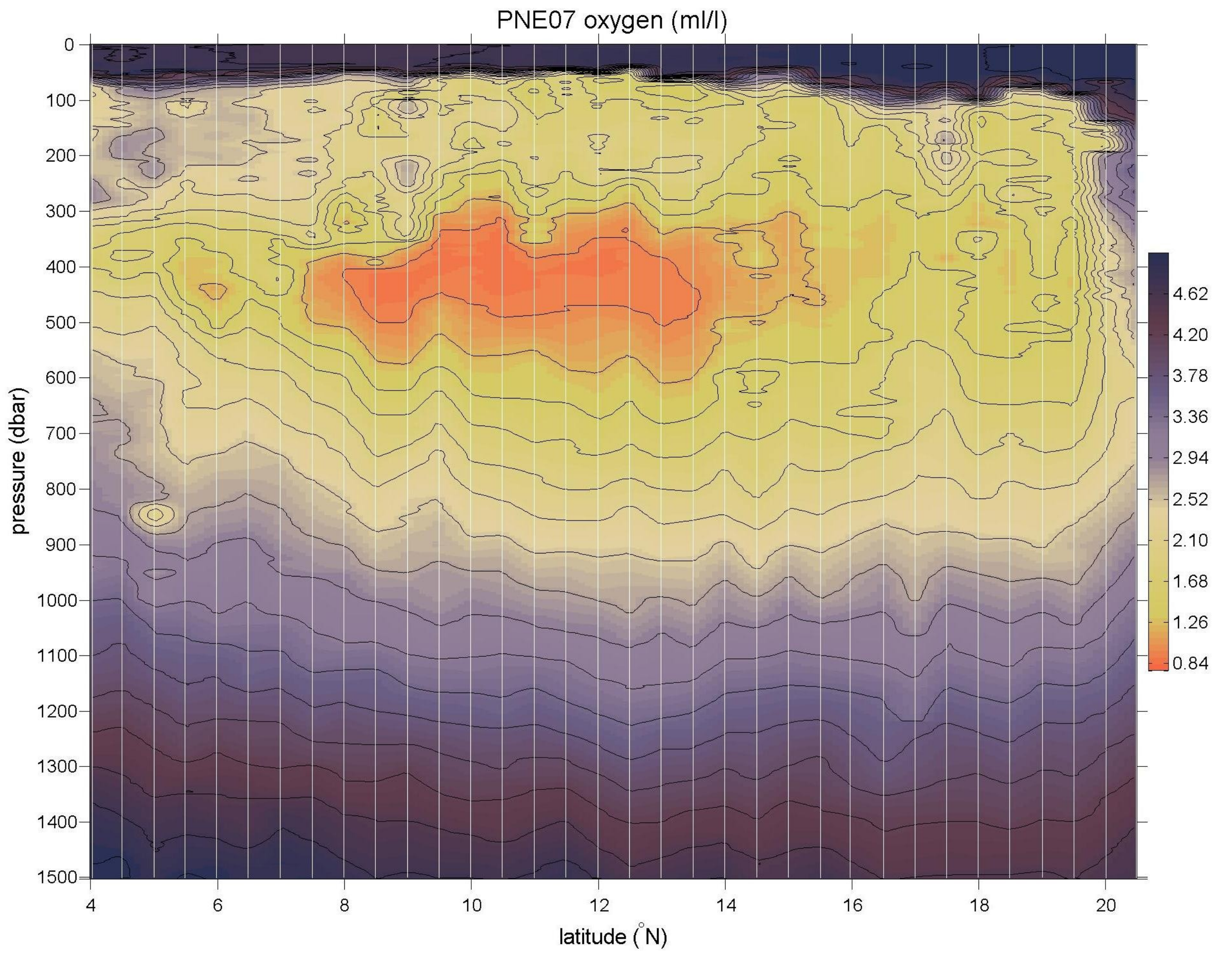

Fig. 9: oxygen (mL/L) vs. depth at 23ºW. White vertical lines indicate the position of CTD casts.

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Stramma, L., S. Huttl and J. Schafstall, 2005: Water masses and currents in the upper tropical northeast Atlantic off northwest Africa. *J. Geophys. Res*., **110**, C12006, doi:10.1029/2005JC002939.