Preliminary Cruise Report
PIRATA Northeast Extension 2006 / AMMA / Sahara Dust Cruise
NOAA Ship *Ronald H. Brown*

Leg 1: May 27-June 18, 2006
San Juan, Puerto Rico to Recife, Brazil
Leg 2: June 22 - July 16, 2006
Recife, Brazil to Charleston, USA

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Note: this preliminary cruise report addresses only the hydrographic and mooring work associated with the AMMA/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 major revision after quality control and final calibration and should not be used without approval of the authors.

OVERVIEW: The 2006 AMMA/PIRATA Northeast Extension Cruise RB0605 was designed to collect a suite of oceanographic and meteorological observations in the northeast Tropical Atlantic, to deploy two new moorings as a northeast extension of the PIRATA array, and to service a PIRATA backbone mooring at 0º, 23ºW. The cruise track and northeast extension were planned 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 and equatorial waveguide. All scientific goals of RB0605 were achieved.

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 regions of the Tropical Atlantic, future extensions of the array had been anticipated by the PIRATA Science Steering Group.

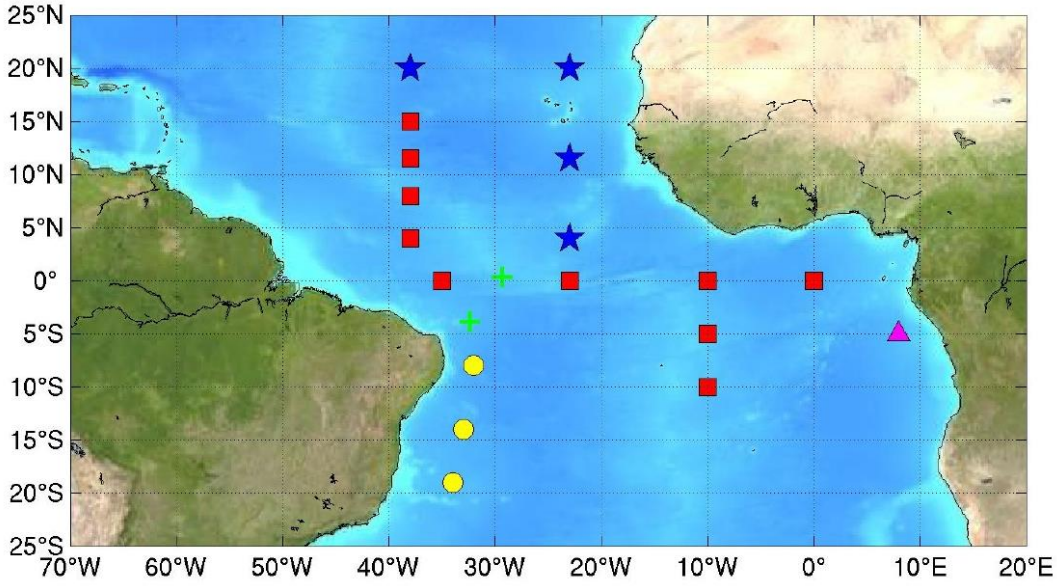

Fig. 1: The Tropical Atlantic, showing the PIRATA backbone (red squares), automatic meteorological stations (green +), southwest extension (yellow circles), southeast extension pilot site (magenta triangle), and the Northeast Extension (blue stars).

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 and were funded by NOAA for a Northeast Extension of the PIRATA array. This extension will consist of four moorings (Fig. 1), the first two deployed during this cruise and the next during 2007. Moored observations in these regions will improve our knowledge of (a) atmosphere-ocean heat exchanges and dynamics impacting the West African Monsoon (WAM) and the marine Intertropical Convergence Zone, (b) upper ocean dynamics affecting heat content and SST variability in the Tropical North Atlantic hotspot, (c) possible connections between SST patterns and North Atlantic climate regimes of variability, and (d) 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.

Due to commitments elsewhere, including in the Gulf of Guinea for EGEE3, the French were unable to service the backbone PIRATA mooring at 0º, 23ºW in the summer of 2006. Because the NOAA vessel Ronald H. Brown was scheduled to occupy the RB0605 hydrographic section down 23ºW, AOML and NOAA's Pacific Marine Environmental Laboratory (PMEL) offered to service the mooring during this cruise.

Operations:

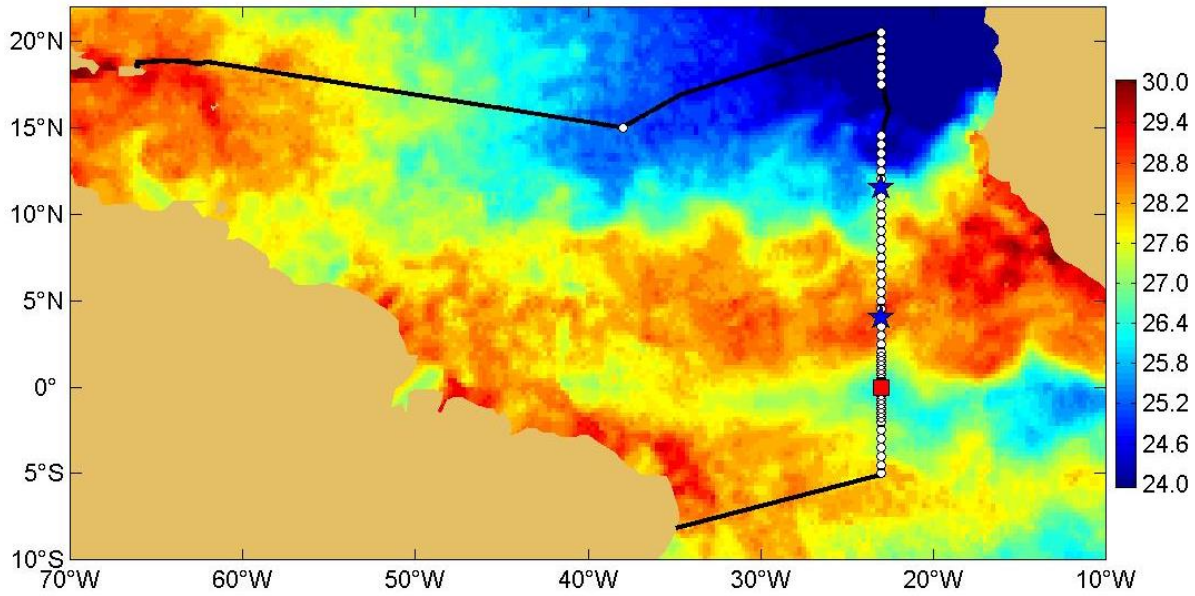

Fig. 2: cruise track of the R/V Ronald H. Brown during leg 1 (black), with CTD stations (white bullets), PNE deployment sites (blue stars), and the PIRATA backbone servicing site (red square). Background shading is SST (ºC) on 13 June 2006, from merged TMI/AMSRE microwave satellite observations (Remote Sensing Systems).

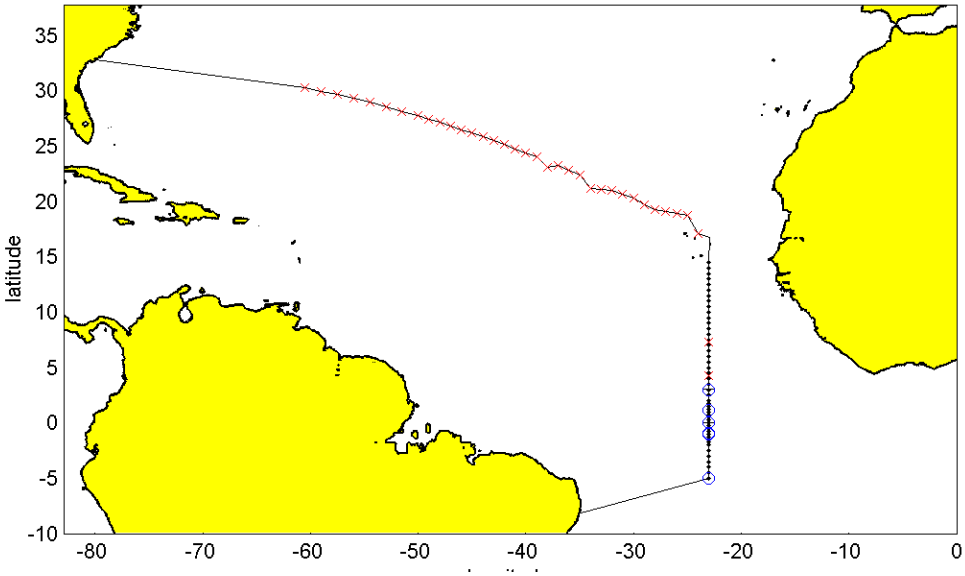

Fig. 3: cruise track of the R/V Ronald H. Brown during leg 2 (black), with CTD stations (black bullets), drifter deployments (blue circles), float deployments (black plusses) and XBT profiles (red crosses).

Oceanographic data collected on this cruise:

1. ATLAS moorings of the Pilot Array in the Tropical Atlantic (PIRATA) were deployed at two new sites. These were the first two moorings of the PIRATA Northeast Extension (PNE), a US contribution to PIRATA. A French PIRATA backbone mooring at 0º, 23ºW was recovered and redeployed. 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 57 casts during leg 1, including a test cast at 15ºN, 38ºW and 56 casts on a meridional section from 20º30'N, 23ºW to 5ºS, 23ºW. During leg 2, the 23ºW section was repeated in the opposite direction (from 5ºS to 14º30'N) with 48 casts. All casts were conducted to a pressure of 1500dbar, or the bottom (if shallower). On all casts water samples were taken at various depths to calibrate salinity and oxygen sensors. The Temperature-Salinity structure along 23ºW from the CTD casts from leg 1 is shown in Fig. 4. Strong T-S anomalies at the northern two casts may be associated with an intrusion of high-oxygen Mediterranean Water north of the Cape Verde islands. The nearly linear T-S relationship at intermediate densities is the signature of Central Water. The salinity sections collected during the two legs show some significant differences in the mixed layer (Fig. 5), for example the freshening around 4ºS that can be seen clearly in Fig. 6. Other differences include changes in the thickness of the mixed layer, especially south of the equator as well as changes within the mixed layer close to the equator.

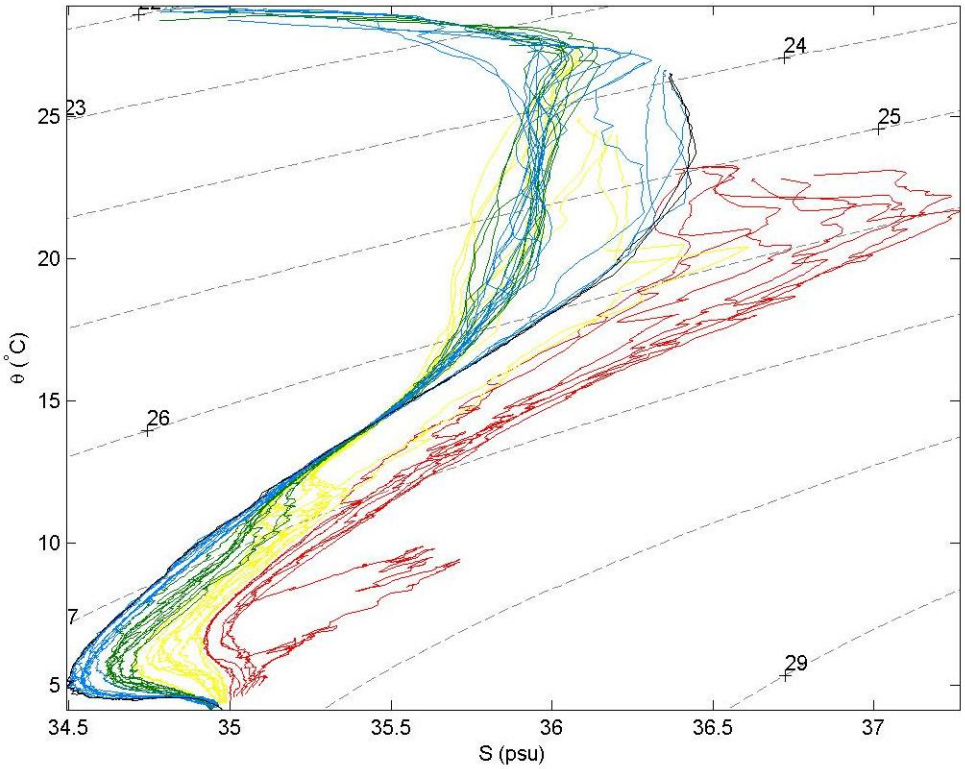

Fig. 4: salinity vs. potential temperature along the 23ºW section. Colors indicate latitude band: 15—20ºN (red), 10—15ºN (yellow), 5—10ºN (green), 0—5ºN (blue) and 5ºS—0 (black). Contours are sigma-theta values of constant potential density.

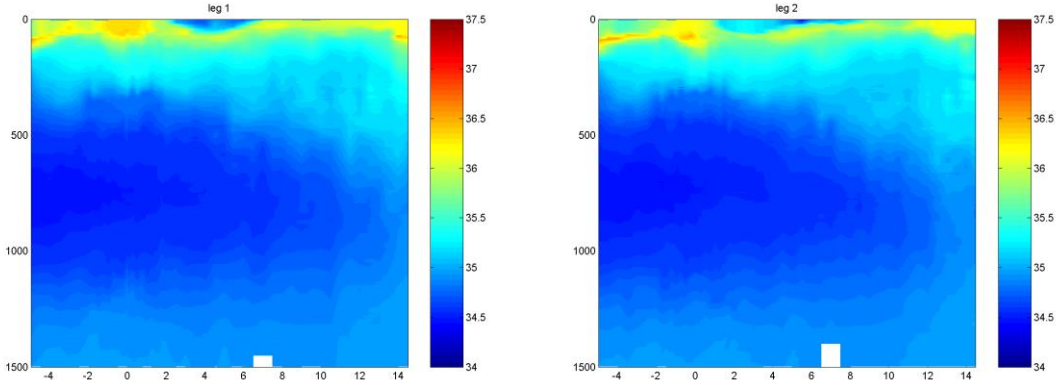

Fig. 5: sections of salinity along 23ºW collected during leg 1 (left) and leg 2 (right).

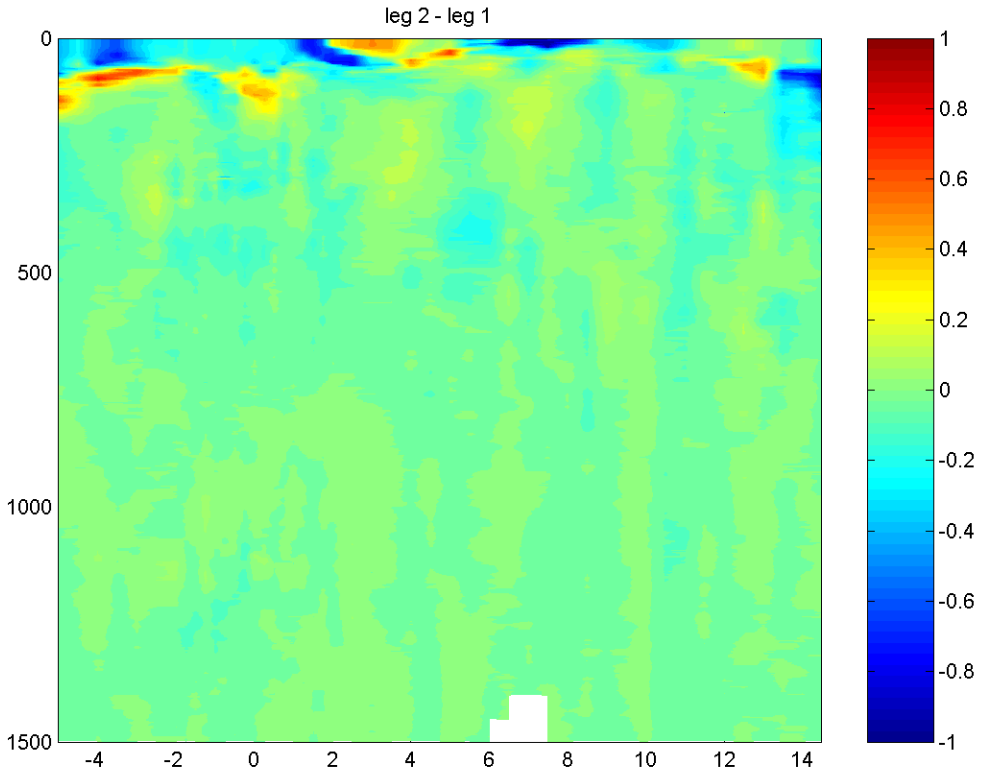

Fig. 6: sections showing the change of salinity between the time of leg 1 and the time of leg 2 along 23ºW.

3. Lowered Acoustic Doppler Current Profiler (LADCP) data were collected at all CTD casts with two 300 kHz workhorse LADCPs. The LADCP system measured the structure of the tropical and subtropical gyre down 23ºW, including an anticyclonic eddy centered at ~13.5ºN (Fig. 7). Major tropical currents are robust features in these data; abbreviations in Fig. 7 indicate the central branch of the South Equatorial Current (cSEC), Equatorial Undercurrent (EUC), northern branch of the South Equatorial Current (nSEC), North Equatorial Countercurrent (NECC), South Equatorial Countercurrent (SECC), North and South Intermediate Countercurrents (NICC and SICC) and the Equatorial Intermediate Current (EIC). The strongest current encountered during the cruise was the EUC, peaking at over 77 cm/s.

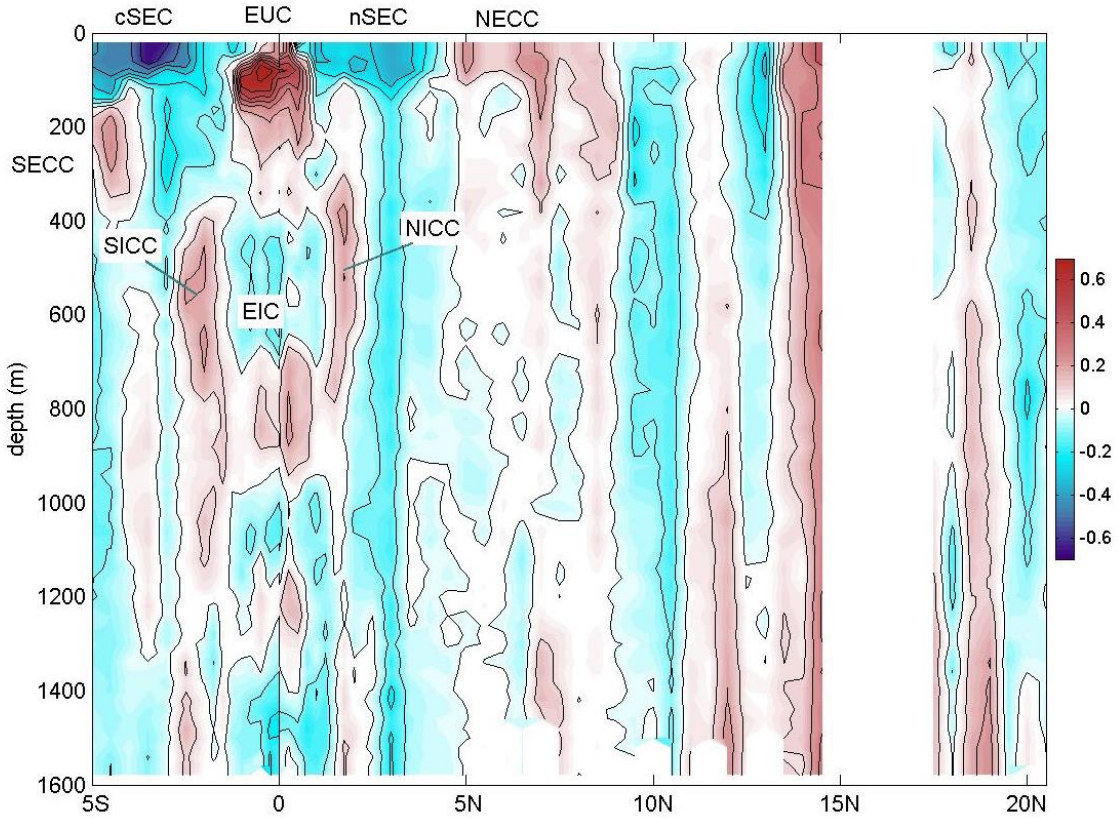

Fig. 7: zonal currents (m/s; red=eastward, blue=westward) measured by the LADCP system down 23ºW. Major currents are labeled.

4. 13 Argo floats were deployed during leg 1 and two during leg 2 to measure temperature and salinity profiles from the sea surface to 2000m and currents at 2000m depth, as part of the 3000 float global array. The floats were Argo WHOI-SOLO units, designed to sink to a parking depth of 2000m, stay there for 10 days following currents at that depth, then rise to the surface while profiling temperature and conductivity for transmission to Argos satellites.
5. 12 satellite-tracked surface drifters were deployed during leg 1 and nine during leg 2 to measure sea surface temperature and mixed layer currents, as part of the 1250 drifter global array. 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. Their data are transmitted in real time via the Argos system.
6. 69 expendable bathythermographs (XBTs) were launched during leg 1 and 36 during leg 2 to measure temperature profiles of the upper ocean (Fig. 8).

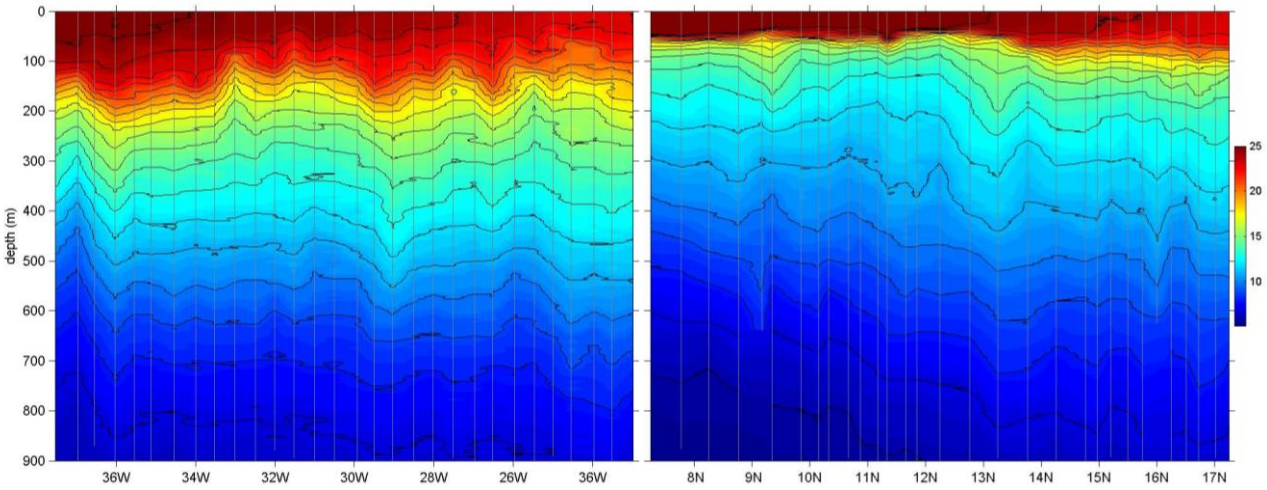

Fig. 8: temperature sections (ºC) from XBT deployments. Left: almost zonal section from 37º32'W to 22º59'W, 10—20ºN. Right: meridional section from 17º15'N to 7º15'N, ~23ºW.

7. Near surface current data were collected throughout the cruise 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.

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.