PIRATA Northeast Extension 2008 Cruise Report

R/V *Antea*

Dakar, Senegal to Dakar, Senegal

Chief Scientist D. Zimmerman, NOAA/PMEL

Leg 1: October 8 - 18, 2008

0, 23°W; and 4°N, 23°W

Leg 2: October 22 - November 5, 2008

11.5°N, 23W; 20°N, 38°W; and 20.5°N, 23°W

Cruise report by R. Lumpkin, C.M. Alex and G. Rawson (NOAA/AOML) and D. Zimmerman (NOAA/PMEL)

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Moorings
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Hydrography, XBTs and drifters
Grant Rawson and Andy Stefanick (AOML)

Overview

The 2008 PIRATA Northeast Extension Cruise was designed to collect a suite of oceanographic and meteorological observations in the northeast Tropical Atlantic. Originally, this cruise was scheduled to be aboard the NOAA ship *Ronald H. Brown*, to depart from Uruguay in April 2008. This cruise would have included mooring servicing, a full hydrographic line along 23°W, meteorological observations including sonde launches, and a suite of other observations. However, this April cruise was canceled due to mechanical problems and safety concerns with the *Ronald Brown*. The PNE moorings ceased transmitting on April 27 (4°N, 23°W), May 31 (20.5°N, 23°W), June 15 (20°N, 38°W), and June 23 (11.5°N, 23°W), and the 0°, 23°W buoy transmitted only 20% good data starting in April, and ceased transmitting in September.

NOAA arranged a smaller-scale cruise by chartering the French R/V *Antea* in October 2008 through GENAVIR, the French organization that operates the *Antea*. This cruise focused upon servicing the PNE moorings and the French backbone mooring at 0, 23°W, and included five CTD casts at the mooring sites for data calibration. The *Antea* cruise consisted of two legs beginning and ending in Dakar, Senegal. Leg 1 began on October 8th and lasted 10 days, ending on October 18. During Leg 1, ATLAS moorings at 0, 23°W and 4°N, 23°W were serviced and CTD casts were conducted at these sites. Leg 2 began on October 21 and ended on November 5, also in and out of Dakar, Senegal. During Leg 2, CTD casts and ATLAS mooring servicing were conducted at 11.5°N, 23°W; 20°N, 38°W; and 20.5°N, 23°W.

Introduction

The Prediction and 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 10°W to 10°S, and northward along 38°W to 15°N. Given the widely varying dynamics of various sub-regions 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 one-year Southeast Extension pilot mooring (PI: M. Rouault) was deployed near 6°S, 8°E during the EGEE3/PIRATA FR15 cruise in June 2006.

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 in 2005. This PIRATA Northeast Extension (PNE) consists of four moorings (Fig. 1). Moored observations in these regions are expected to 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.

Order of operations

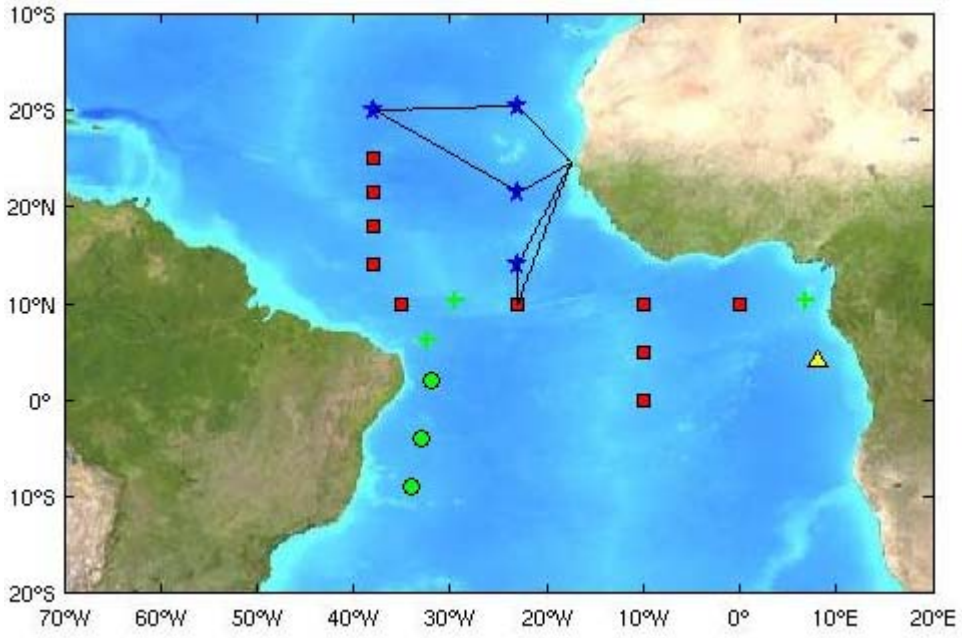

Fig. 1: The Tropical Atlantic showing the PIRATA array and PNE08 *Antea* ship tracks: PIRATA backbone (red squares), automatic meteorological stations (green +), southwest extension (green circles), southeast extension pilot site (yellow triangle), and the Northeast Extension (blue stars).

Due to a delay in delivery (a missed transfer from Hamburg to Dakar), AOML equipment did not arrive in time to join the cruise for Leg 1. This shipment included sample bottles for salinities and oxygens, XBTs, and drifting buoys. This equipment arrived in Dakar in time for Leg 2 of the cruise.

The R/V *Antea* departed from Dakar, Senegal on 8 October at 1145 UTC, and proceeded to the PIRATA backbone mooring at 0°, 23°W. Shortly after departure from Dakar, AOML technician Andy Stefanick became ill from presumed food poisoning, and was treated for nausea and dehydration by the ship's medical technician during Leg 1. Stefanick left the ship at the end of Leg 1, after which Grant Rawson was solely responsible for the hydrography and XBT/drifter deployments.

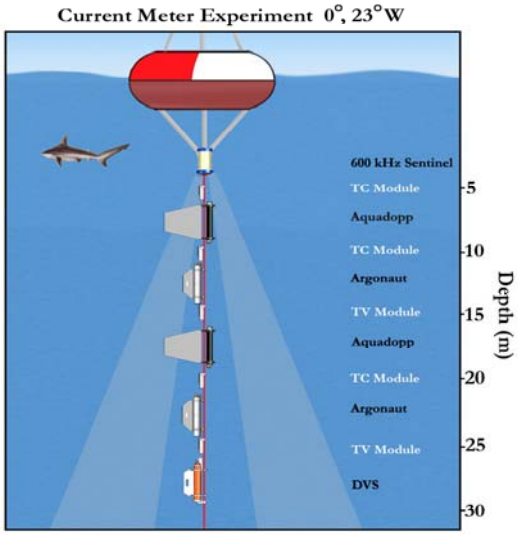

Fig 2.

The ship arrived at 0°, 23°W at 2000 UTC on 12 October. A Brazilian fishing boat, the *Marlin Azul* from Natal, Brazil, was found tied up to the buoy. The boat at first refused to cast off their mooring line and move clear, saying that they were still fishing on it. Finally, the *Antea* hailed the boat and told them that the buoy belonged to the ship and to please move clear. They then complied, staying on site within a couple of miles. The buoy itself was missing the wind sensor, the rain gauge top was broken off, the radiation mast was bent over with shortwave radiation glass broken, and multiple lines were tied off on the buoy. Upon recovery, it was discovered that fishing gear was fouled on the 10m module and 12m Sontek single point acoustic current meter, and the tower ring was broken.

Several different current meters were deployed at 0°-23°W (see diagram/figure 2) as a comparison test between 2 upward-looking Sontek Argonauts, 2 downward-looking Nortek Aquadopps, and one upward-looking RDI DVS (Doppler Volume Sampler). In addition, a 600KHz RDI Sentinel ADCP was deployed at 2m, mounted in a special can that was installed in a yoke mounted on the bottom of the bridle. Beams 1 & 3 of the Sentinel were oriented towards the nilspin wire, splitting it equally on each side of the wire.

As noted above, the tower recovered at 0°, 23°W (Tower 4-2-91, PM680) had been damaged by a fishing boat. It was repaired by the French Engineers aboard the *Antea* and redeployed at 4°N, 23°W, PM780. The tower ring was completely broken from one of its welds, so the French made a brace out of aluminum plate to hold the break together, then bolted it on with stainless bolts and plastic isolators. One of the mast pads was also bent, and was pounded back straight with a sledgehammer.

The CTD cast was completed and all work at 0°, 23°W was finished at ~1230 UTC on Oct 13. The *Antea* then departed for 4°N, 23°W, arriving at ~1345 UTC Oct 14. The existing mooring there was recovered. Fishing gear was found fouled on the 300m and 500m modules, and there were deep cuts in the nilspin jacket at 180m. While deploying the replacement ATLAS system, the *Antea*'s crane ram was not able to lift the anchor over the side due to its leaking hydraulic oil. The crew instead used the cable from their deep sea winch to push and slide the anchor over the side. The anchor was dropped prematurely due to tension built as the ship was towing the buoy to the intended deployment site. After deployment, a CTD cast at this site was completed, and the ship left the site to return to Dakar at ~2145 UTC Oct 14. The *Antea* arrived at Dakar at 0630 UTC, October 18 to complete Leg 1.

Leg 2 departure was delayed by 40 hours because of a medical emergency with a crewman. The ship left Dakar and commenced Leg 2 at 0030 UTC on Oct 22, and steamed for 11.5°N, 23°W. Later that

day, a “Notice to Mariners” report from Dakar was issued stating that a “white and rusty” colored steel buoy, marked with a “1”, was seen adrift about 60nm south of Dakar. Zimmerman requested the Captain to contact the Dakar Agency “MRCC” for any updates of its position, as it could have been an ATLAS buoy. Unfortunately, no additional sightings were reported. The buoy was too far south for the *Antea* to search, and impossible to locate without updated position information.

The *Antea* arrived at the last transmitted position (since going off the air on 24 June 2008) of the 11.5°N, 23°W buoy at about 6:30pm (an hour before sunset) on Oct 23, but did not find the buoy on radar or see it visually. The ship then went to the original deployment position, 1 nm away, but found nothing there either. PMEL personnel put the transducer over the side and got good ranges of 5430m (in a depth of 5086m) from the mooring’s release. Zimmerman put the deck set in horizontal range mode and got 1968m, putting the release 1.1nm away. The ship then moved approximately another 0.5nm towards the last transmitted position and got a range of 5150m (in a depth of 5084m), putting the release at a horizontal distance of 964m, only 0.5 nm away. The ship continued to search the area until after dark, but did not see anything on radar and did not find the buoy on the surface, so the mooring was presumed lost. The release did not have a tilt sensor to verify it was horizontal on the bottom. The replacement mooring was deployed, with an Aanderaa Seaguard current meter (on loan from Aanderaa) included at 7.5m, mounted on the wire with a large fin and clamps with 18 bolts. This current meter was originally scheduled to be deployed on the 0-23W current meter test mooring, but it did not arrive in Dakar in time to make the Leg 1 sailing date. After the mooring was deployed, a CTD cast was conducted. The ship left the site at ~0145 UTC on Oct 24.

The *Antea* arrived at 20°N, 38°W on Oct 28 at 1430 UTC. The existing buoy was recovered, missing the wind sensor tail and the Sontek fin. The buoy itself was damaged, with cracks in the toroid. The replacement system was deployed, a CTD cast was conducted, and the ship left the site at 0500 UTC Oct 29.

The *Antea* arrived at 20.5°N, 23°W at 1800 UTC on Nov 2. The wind mast was found bent over, presumably hit by a fishing boat. The mast was bent over enough to expose the opening of the tophat to the weather. The mooring was recovered. When the tube’s case was opened, moisture was found inside and corrosion was seen on the I/O connectors, battery connector, and on some of the motherboard ICs. The tube would not communicate, so its memory flash card was removed and hand-carried back to PMEL. The Telonics transmitter was removed and packed in the air shipment. The tube was dried out, new desiccants were installed, and it was shipped back to Seattle in the PMEL container. After mooring operations were completed, a CTD cast was conducted. The *Antea* left 20.5°N, 23°W at 0600 UTC Nov 3.

The ship arrived back in Dakar to conclude Leg 2 at 1200 UTC on November 5. There was a slight delay in delivery of the 40-foot containers for unloading the NOAA equipment. A recovered buoy, spare anchor, and some nylon were left on board for the French to use during their 2009 PIRATA cruise.

Oceanographic data collected on this cruise

1. ATLAS moorings

Mooring turnarounds were conducted at the four PNE sites and at 0°, 23°W.

2. Conductivity-Temperature-Depth (CTD) casts

CTD data were collected at the five mooring sites, to a depth of 1500m. All casts were done with the French IRD CTD system to calibrate the sensors at the mooring sites. All casts were done after the anchor drop of the replacement mooring. The two French Autosal units were offloaded from the ship in Cotonou, Benin after the previous French PIRATA cruise, due to miscommunication between French

and US scientists. As a consequence, it was not possible to get salinity checks done during the cruise. Preserved samples were collected and shipped to the US for post-cruise calibration.

Oxygen samples were also taken, but only on Leg 2, since the AOML shipment with the oxygen sample bottles had not arrived in time for Leg 1 sailing. The CTD cable had to be re-terminated for the final cast at 20.5°N-23°W.

3. Drifters: 14 satellite-tracked surface drifters were deployed to measure sea surface temperature and mixed layer currents, as part of the 1250-drifter global array.

4. XBTs: 47 expendable bathythermographs were launched during Leg 2 to measure temperature profiles of the upper ocean to a depth of about 900m.

5. Shipboard measurements collected by *Antea* equipment: thermosalinograph (TSG), shipboard acoustic Doppler Current Profiler (sADCP), wind speed, wind direction, atmospheric pressure, and relative humidity.

1. ATLAS moorings (from PMEL report authored by D. Zimmerman)

Summary of Mooring Operations:

Site	Mooring ID #	Operation
0-23W	PM680A / PM779A	REC / DEP, Leg 1
4N-23W	PM672A / PM780A	REC / DEP, Leg 1
11.5N-23W	PM674A / PM784A	NO Recovery (LOST at SEA) / DEP, Leg 2
20N-38W	PM679A / PM787A	REC / DEP, Leg 2
20.5N-23W	PM676A / PM788A	REC / DEP, Leg 2

Table 1.

Fishing and Vandalism:

0-23W	PM680A	Brazilian fishing boat, Marlin Azul from Natal, found tied up to the buoy. Wind sensor gone, rain gauge top broken off, rad mast bent over with SW rad glass broken, multiple lines tied off on buoy. Fishing gear fouled on 10m module and 12m sontek. Tower ring broken.
4N-23W	PM672A	Fishing gear found fouled on 300m & 500m modules. Deep cuts in nilspin jacket at 180m.
11.5N-23W	PM674A	Entire Mooring LOST at SEA. Found release on bottom.
20N-38W	PM679A	Wind Sensor tail broken off. Sontek fin broken off. Buoy damaged, cracks in toroid.
20.5N-23W	PM676A	Wind Sensor gone. Wind mast bent over. Rain top broken off. Rad shield bent with blue paint marks. Fishing gear found at various depths. A small fishing boat was seen on site after we finished operations.

Table 2.

Recovered, failed or damaged:

TYPE	S/N	SITE	ID	DESCRIPTION
Rain	1170	0-23W	PM680	Funnel top broken off
SW Radiation	32406	0-23W	PM680	Glass domes broken, mast found bent over 50-60 degs.
Sontek	D374	0-23W	PM680	Fin broken off
ATRH	104892	4N-23W	PM672	Shield bent during recovery, pigtail cable stretched tight
Sontek	D520	4N-23W	PM672	Fin broken off
Buoy Tower	4-2-91	0-23W	PM680	Tower ring broken, mast pad bent, both repaired onboard.
Wind	37596	20N-38W	PM679	Tail broken off
Sontek	371	20N-38W	PM679	Fin broken off
Buoy Toriod	D-7-06	20N-38W	PM679	Buoy damaged by fishing, cracks in toroid above waterline, mostly gel coating affected. Had to redeploy this buoy at 20.5N-23W, PM788 since it was the only one onboard to use.
Rain	1098	20.5N-23W	PM676	Funnel top broken off, housing cracked.
SW Rad	32672	20.5N-23W	PM676	Shield bent.
Tube	514	20.5N-23W	PM676	Wind mast found bent over, exposing tophat opening to weather. No comms. Found moisture inside tube case and motherboard chips & connectors corroded.

Table 3.

Individual sensors lost at sea:

TYPE	S/N	SITE	ID
Wind	11673	0-23W	PM680
TC Module	14296	0-23W	PM680
TV Module	14117	0-23W	PM680
TC Module	14055	0-23W	PM680
TC Module	14257	0-23W	PM680
T Module	14212	0-23W	PM680
TC Module	12320	4N-23W	PM672
Wind	38154	20.5N-23W	PM676

Table 4.

PM674A, 11.5N-23W ENTIRE MOORING LOST AT SEA:
Tube 656, ATRH 58341, Rain 1234, SW 32430, LW 32894, Baro 101761, Wind 70624, Sontek 370, SSC13024, TC13780, TC13779, TV13914, TC13126, TC13129, TC13776, TC13777, T12790, TC13778
T12791, T12792, TP13303, TP13304, plus 8242 Release 14971.

11.5N-23W
PM674A, LOST at SEA.

11.5N-23W
PM784, Aanderaa Current Meter Deployed: An Aanderaa Seaguard current meter was deployed at

7.5m, mounted on the wire with a large fin and clamps with 18 bolts. It was originally scheduled to be deployed on the 0-23W current meter test mooring, but did not arrive in Dakar in time to make the Leg 1 sailing date. This current meter is a test loaner from Aanderaa.

20.5N-23W
PM676 TUBE 514 Damage: The wind mast of Tube 514 was found bent over, probably hit by a fishing boat. The mast was bent over enough to where the opening of the tophat was exposed to the weather. When Tube 514's case was opened up, moisture was found inside, and corrosion was seen on the I/O connectors, battery connector, and on some of the motherboard ICs. The tube would not communicate, so its memory flash card was removed and hand-carried back. Steve dumped the entire contents of the card back at PMEL. Also note, that Tube 514 was not air shipped back. Steve had me remove the Telonics transmitter, which was packed in the air shipment. The tube was dried out, new desiccants were installed, and it was shipped back in the container.

Oxygen sensors: Oxygen sensors belonging to IFM-GEOMAR (primary contact: Peter Brandt) were deployed at 300m and 500m depth, at 4°N, 23°W and at 11.5°N, 23°W.

2. Conductivity-Temperature-Depth (CTD) casts

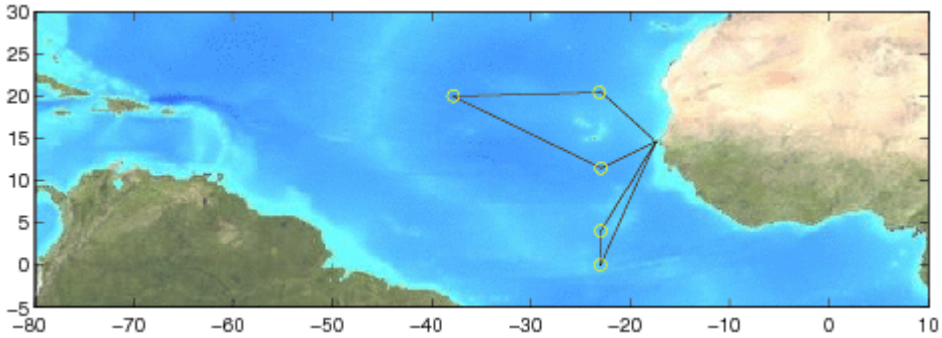

Fig 3: CTD locations

CTD data were collected at 5 casts: 0°, 23°W; 4°N, 23°W; 11.5°N, 23°W; 20°N, 38°W and 20.5°N, 23°W. No CTD processing was performed during the cruise. Salinity and oxygen samples were shipped to the United States for post-cruise calibration. Due to many communications errors after the cast at 20°N, 38°W, the CTD wire was re-terminated.

Cast #	Date (UTC)	Start time	Latitude	Longitude	# Sample bottles
1	10/13/08	01:20	00 00.443 N	23 01.153 W	6
2	10/14/08	18:32	04 04.511 N	23 00.274 W	2*
3	10/24/08	00:30	11 29.275 N	22 58.968 W	7**
4	10/28/08	21:13	20 03.191 N	37 51.115 W	7***
5	11/02/08	22:43	20 27.967 N	23 08.472 W	7

Table 5: CTD. * rosette did not fire after second bottle, at 717 dbar. ** Bottle 3, 4 comm error message *** wrong con file used; couldn't fire bottles from computer; used deck unit. Many error messages.

3. Drifters

14 satellite-tracked surface drifters of NOAA's Global Drifter Program were deployed during Leg 2 to measure sea surface temperature and mixed layer currents, as part of the 1250 drifter global array (Fig. 4 and Table 6). Eight of the drifters were launched in four pairs.

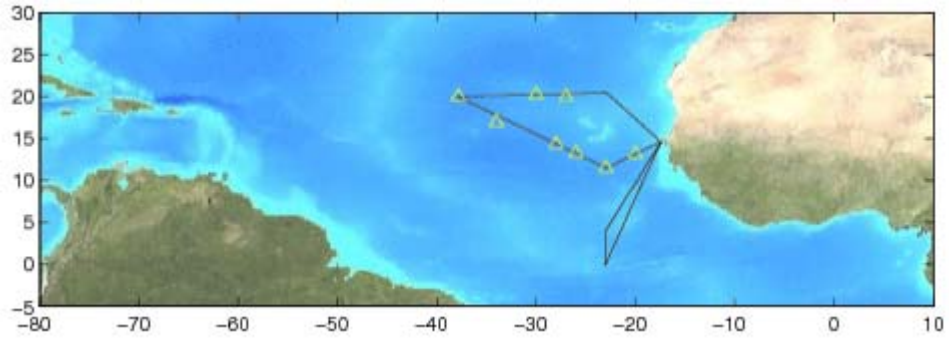

Fig. 4: Drifter deployment locations.

Drifter deployments

Deploy #	Drifter PTT ID#	Date	Time	Latitude	Longitude
1	79308	10/22/08	1951	13°10.512	19°59.858
2	79268	10/24/08	0140	11°29.95	22°59.49
3	79318				
4	79299	10/25/08	0032	13°14.93	26°00.52
5	79269	10/25/08	1551	14°21.83	28°00.13
6	79303	10/27/08	1045	17°47.66	34°00.16
7	79262	10/28/08	2256	20°00.85	37°52.00
8	79270	10/31/08	1834	20°14.52	29°59.91
9	79275				
10	79267	11/01/08	1528	20°19.90	26°59.83
11	79316	11/02/08	2350	20°28.23	23°06.70
12	79307				
13	79317	11/04/08	1159	17° 21.79	20°00.19
14	79261				

Table 6: Drifter deployments. Pair deployments are indicated by a single date/time/lat/lon entry.

4. eXpendable BathyThermographs (XBTs)

47 XBTs were deployed during Leg 2 (Fig. 5 and Table 7). Temperatures were measured to a depth of 900m.

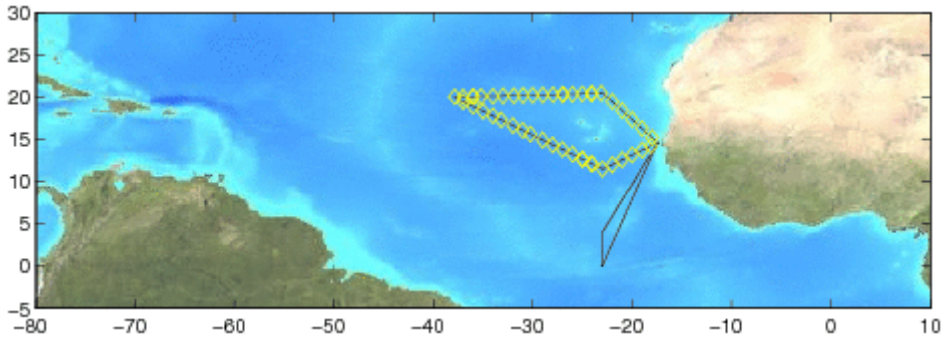

Fig. 5: Location of XBT deployments (red diamonds) superimposed on ship track (black).

Several of these launches were conducted at the same location as the three CTD casts of Leg 2, 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.

Filename	Date	Time	Lat	Lon
X081022N01	10/22/2008	05:07	14.259	18.112
X081022N02	10/22/2008	12:04	13.739	19.001
X081022N03	10/22/2008	19:54	13.171	20.004
X081023N01	10/23/2008	03:38	12.596	21.013
X081023N02	10/23/2008	11:13	12.006	22.001
X081024N01	10/24/2008	00:52	11.492	22.985
X081024N02	10/24/2008	09:19	12.092	24.001
X081024N03	10/24/2008	10:16	12.160	24.125
X081024N04	10/24/2008	16:53	12.665	24.999
X081024N05	10/24/2008	17:01	12.674	25.015
X081025N01	10/25/2008	00:28	13.244	26.000
X081025N02	10/25/2008	07:46	13.819	27.003
X081025N03	10/25/2008	15:51	14.364	28.002
X081025N04	10/25/2008	22:57	14.940	29.002
X081026N01	10/26/2008	07:49	15.650	30.242
X081026N02	10/26/2008	13:21	16.089	31.002
X081026N03	10/26/2008	20:21	16.655	32.001
X081027N01	10/27/2008	04:55	17.325	33.175
X081027N02	10/27/2008	10:45	17.794	34.003
X081027N03	10/27/2008	18:03	18.359	35.002
X081028N01	10/28/2008	01:19	18.922	36.002
X081028N02	10/28/2008	08:29	19.491	37.015
X081028N03	10/28/2008	21:29	20.054	37.855
X081029N01	10/29/2008	10:58	20.038	37.000
X081029N02	10/29/2008	18:29	20.069	36.000
X081029N03	10/29/2008	18:35	20.070	35.987
X081030N01	10/30/2008	00:45	20.090	35.188
X081030N02	10/30/2008	10:59	20.110	33.994
X081030N03	10/30/2008	19:43	20.149	32.991
X081031N01	10/31/2008	04:19	20.184	31.920
X081031N02	10/31/2008	11:43	20.220	30.970

X081031N03	10/31/2008	18:34	20.242	29.998
X081101N01	11/01/2008	01:36	20.272	28.998
X081101N02	11/01/2008	08:43	20.303	27.971
X081101N03	11/01/2008	15:28	20.332	26.997
X081101N04	11/01/2008	15:45	20.333	26.954
X081101N05	11/01/2008	22:04	20.360	26.006
X081102N01	11/02/2008	04:42	20.390	25.004
X081102N02	11/02/2008	11:01	20.431	24.079
X081102N03	11/02/2008	11:07	20.431	24.065
X081102N04	11/02/2008	22:59	20.468	23.107
X081103N01	11/03/2008	16:16	19.502	22.009
X081104N01	11/04/2008	02:01	18.437	21.010
X081104N02	11/04/2008	11:59	17.363	20.003
X081104N03	11/04/2008	22:03	16.293	19.004
X081105N01	11/05/2008	07:40	15.213	18.003

Table 7: XBT deployments.

5. Shipboard measurements collected by R/V *Antea* equipment

Data collected by the Antea include: shipboard Acoustic Doppler Current Profiler (sADCP), continuous near-surface thermosalinograph (TSG), wind speed and direction, atmospheric pressure, and relative humidity.

The TSG data suffered from a clogged conductivity cell on 21 October (during Leg 2), which was repaired by cleaning the filter and cell. However, the conductivity data was extremely noisy for several days thereafter, and the cell and filter were cleaned again on 27 October. A preliminary look at the TSG near-surface salinity distribution (Fig. 7) after removing the resulting spuriously low values reveals the minimum associated with the ITCZ and the maximum of the North Atlantic subtropical gyre.

6. Preliminary data plots

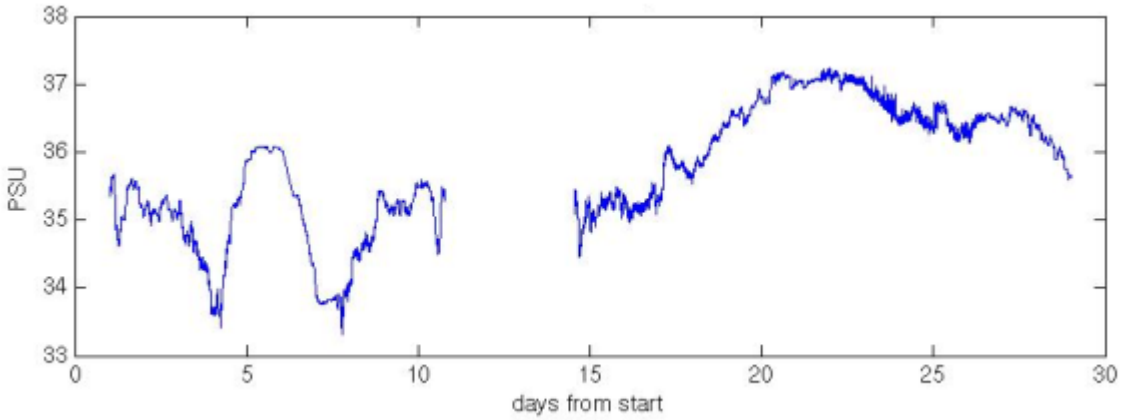

Fig. 6: Filtered TSG salinity time series.

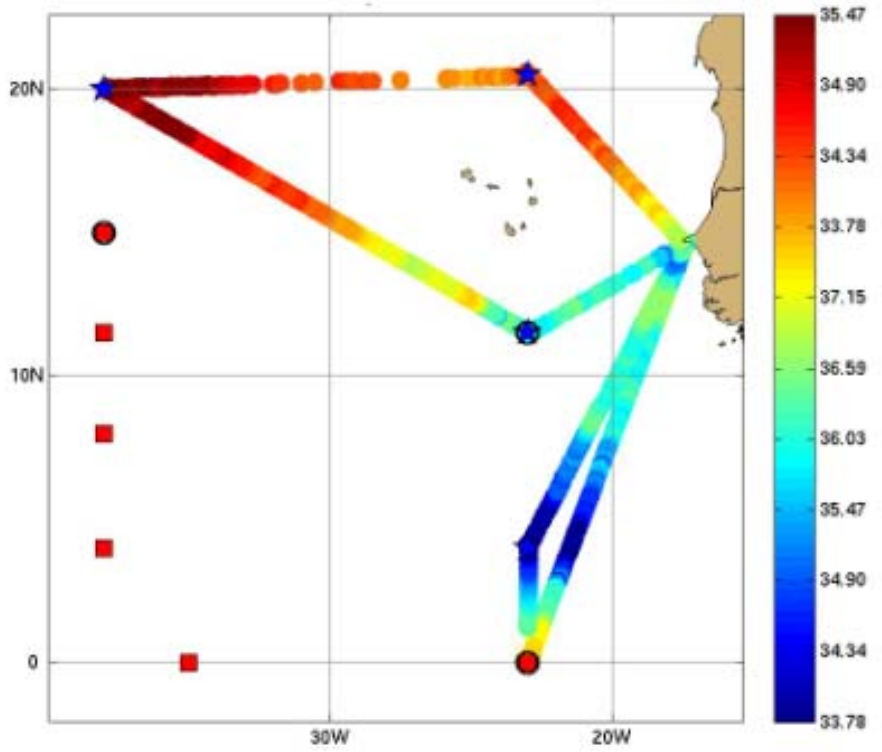

Fig. 7: Salinity (psu) from TSG.

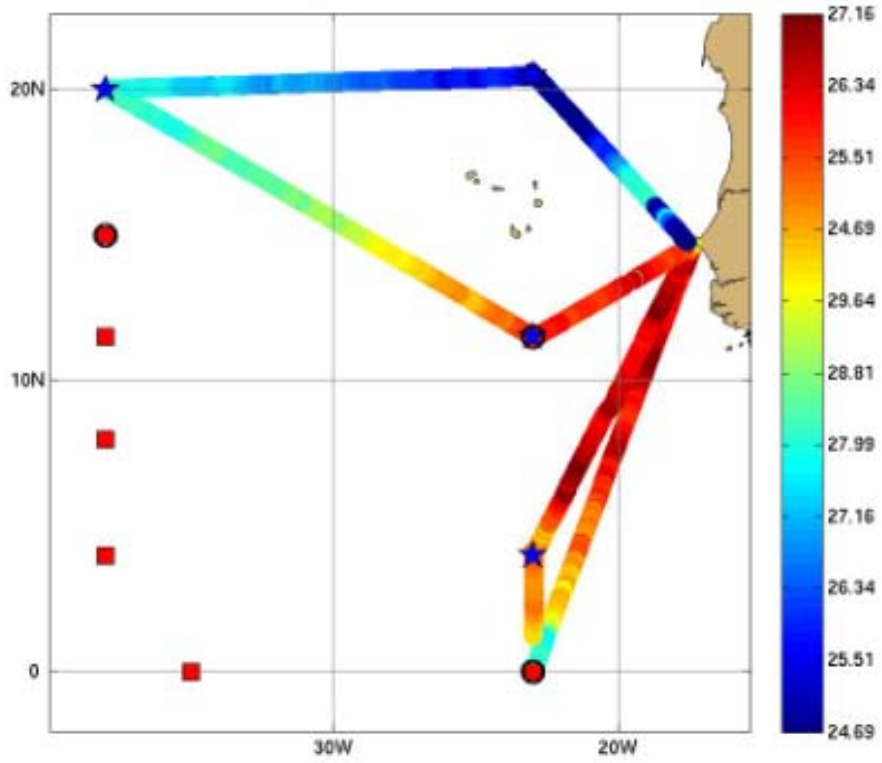

Fig. 8: Temperature (°C) from TSG.