Atlantic Oceanographic & Meteorological Laboratory

National Oceanic & Atmospheric Administration

Physical Oceanography Division
4301 Rickenbacker Cswy
Miami, Florida 33149-1097

Phone: 305-361-4345
Fax: 305-361-4412

July 2018

Cruise Plan – AX10

Ship Name: ***M/V Global Leader***

Call Sign: **C6SU5**

IMO: **9237319**

Project Title: Ship Of Opportunity Program
High Density XBT Transect AX10

Beginning date: Departing Newark, NJ, July 3, 2018.

Ending date: Arriving Santo Domingo, Dominican Republic, July 8, 2018.

Scientific Ship Riders: Diego Ugaz and Patrick Halsall - NOAA AOML

If you encounter an issue that may cause the cruise to need to be canceled, or cause the cruise to fail, or are missing equipment, please contact the following people as soon as possible by phone or by what's app.
Zach Barton – 305-721-7100 (Phone and whatsapp)
Pedro Pena – 786-380-9192 (Phone only)
Ulises Rivero – 305-962-7446 (Phone and whatsapp)
Gustavo Goni – ***hereisgustavo (skype)***

Description of the Scientific Program

The volunteer ship, ***M/V Global Leader***, will be involved in a study of the upper ocean thermal structure of the subtropical North Atlantic Ocean within the context of the Ship Of Opportunity Program (*www.aoml.noaa.gov/phod/soop*). Repeat crossings through the center of the subtropical gyre, every 3 months, will be conducted with the intent of determining and monitoring the seasonal-to-interannual variability of the upper ocean. The upper ocean thermal structure obtained by the use of expendable temperature probes (XBTs) will be used to correlate the subtropical gyre intensity with atmospheric forcing as well as determining the heat transport. This particular transect along nominally 75^{0} W, designated as AX10, will be used in conjunction with the high resolution transect AX07 that transits from

Miami, Florida through the Straits of Gibraltar (Figure 1). Together, these two transects form a closed box off the eastern United States, which should allow us to make stronger statements about the effect of heat flux variability on atmospheric weather patterns.

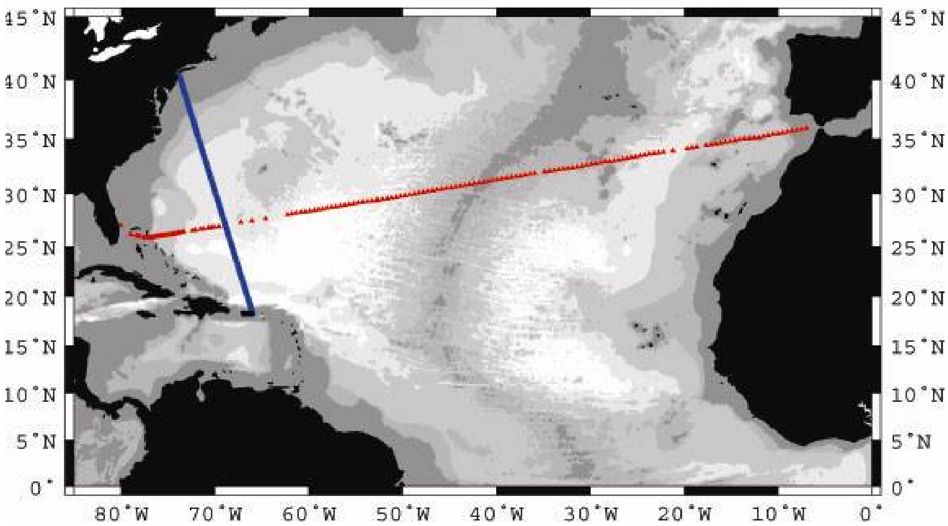

Figure 1. Projected station locations for the SOOP/XBT transect AX10 (blue circles) and the station locations from a sample track along AX07 (red triangles) taken aboard the M/V MITLA during Feb, 1995. Shading represents progressively deeper bottom contours of 3000, 4000, 5000, and 5500 m.

Implementation

Sampling along this section (designated AX10) began in 1996 (Figure 2) and meets the WOCE (World Ocean Circulation Experiment) criterion for high resolution deployment providing temperature profiles every 40 km in the open ocean and between 10-30 km near boundary currents down to a depth of about 800 m.

Sampling on this section should be of consistent horizontal spacing of XBT probes (see below) and a nearly repeating track line for each of the crossing in order to minimize the differences between sections and the possible aliasing of horizontal gradients in temperature into time changes of temperature.

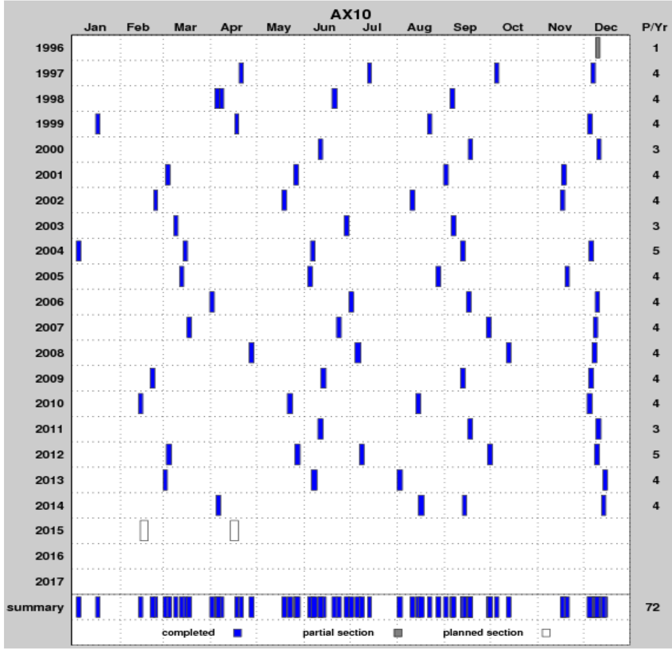

Figure 2: Table of section occupations since the program began in 1994.

<u>XBT Deployment Plan</u>

The overall plan for the sampling assuming previous ship tracks and speeds is as follows:

PLEASE NOTE: IT IS THE RESPONSIBILITY OF THE RIDER TO ENTER THE SHIP'S IMO NUMBER AND CALL SIGN INTO THE AMVERSEAS METADATA SETUP. This information is included in the first page of this Cruise Plan.

AX10 proposed drop locations

~~**1- From Ambrose Tower, 40°27'N, 73°49'W to near 35 N:** deployments every 15 km (625 km) Approximately 42 XBTs.~~

~~**Note:** this sampling should continue **until** you first see the Gulf Stream. The northern edge of the Gulf Stream can be estimated by looking at the **<u>15°C isotherm at</u> <u>150-200 m</u>.** As soon as you see this temperature at this depth, start shooting every 10 km until the Gulf Stream is completely crossed. The southern edge of the Gulf Stream is reached when the **15°C isotherm is at 600 m deep.** Once you cross this isotherm, the gulf stream has been completely crossed.~~

~~2 – From 35 N to approximately 20N, high density deployments every 30 km (1722 km) Approximately 70 XBTs.~~

~~3 – From 20 N to **18°40'N** Deployments every 15 km. Approximately 12 XBTs.~~

~~4 - After **18°40' N** XBT locations will be as follows: **18°40' N, 18°35' N, 18°30' N, 18°29.4' N and 18°28.8' N.**~~

The time interval between XBT deployments is a function of ship speed. **Use Table 1 below to determine the time interval between consecutive deployments.** If the ship changes its speed it will be necessary to adjust the launch times. If the planned cruise track deviates significantly from the outline above and the alternate deployment plan is used, please notify Shenfu Dong at 305-361-4372.

Dominican Republic Plan: (Reverse the directions and all will be fine.

1. From **Port of Departure,** to the exit of the passage, roughly **18.5° N 68° W** :
   Set up and test XBT launcher as desired. No planned sampling.
2. From **18.5°N, 68°W** until **20°N** (170 Km), Deployments every 15 km. Approximately 12 XBTs.
3. From **20°N** until **35° N,** high density deployments every 30 km (1722 km) Approximately 70 XBTs
4. From near **35°N** until **Ambrose Tower, 40°27'N, 73°49'W,** deployments every 15 km (625 km) Approximately 42 XBTs. **Note:** this sampling should continue **until** you first see the Gulf Stream. The southern edge of the Gulf Stream is reached when the **15°C isotherm is at 600 m deep.** As soon as you see this temperature at this depth, start shooting every 10 km until the Gulf Stream is completely crossed. The northern edge of the Gulf Stream can be estimated by looking at the **<u>15°C isotherm at</u> <u>150-200 m</u>.** Once you cross this isotherm, the gulf stream has been completely crossed.

XBT Drop rate						
Ship Speed (knots)	Desired Sampling Space					
	10 km	**15 km**	**20 km**	**30 km**	**40 km**	**50 km**
10	32 min	48 min	1 h 04 min	1 hr 37 min	2 hr 09 min	2 hr 42 min
11	29 min	43 min	58 min	1 hr 28 min	1 hr 57 min	2 hr 27 min
12	27 min	40 min	54 min	1 hr 21 min	1 hr 47 min	2 hr 15 min
13	25 min	37 min	50 min	1 hr 15 min	1 hr 39 min	2 hr 04 min
14	23 min	34 min	46 min	1 hr 10 min	1 hr 32 min	1 hr 55 min
15	22 min	33 min	44 min	1 hr 05 min	1 hr 26 min	1 hr 48 min
16	20 min	30 min	40 min	1 hr 00 min	1 hr 20 min	1 hr 41 min
17	19 min	29 min	38 min	57 min	1 hr 16 min	1 hr 35 min
18	18 min	27 min	36 min	54 min	1 hr 11 min	1 hr 30 min
19	17 min	25 min	34 min	51 min	1 hr 08 min	1 hr 25 min
20	16 min	24 min	32 min	48 min	1 hr 04 min	1 hr 20 min
21	15 min	22 min	30 min	46 min	1 hr 01 min	1 hr 17 min
22	14 min	21 min	28 min	44 min	58 min	1 hr 13 min
23	13 min	20 min	26 min	42 min	56 min	1 hr 10 min
24	13 min	19 min	25 min	40 min	53 min	1 hr 07 min
25	12 min	18 min	24 min	38 min	51 min	1 hr 04 min

Table 1. Time interval between XBT launches based on ship speed and desired sampling spacing.

If the planned sampling is interrupted for any reason (such as an autolauncher failure) the procedure will be to drop another probe as close as possible to the planned drop and continue with the desired spacing of the XBTs for that section of the cruise track (according to the above guide). If a serious malfunction of the autolauncher occurs then manually deploy the XBTs from the stern of the ship using the hand launcher. While this happens, please be troubleshooting the problems and be in contact with Zach Barton, Ulises Rivero (*Ulises.Rivero@noaa.gov),* Kyle Seaton (*Kyle.Seaton@noaa.gov),* Andy Stefanick (*Andrew.Stefanick@noaa.gov)*, or Pedro Pena (*pedro.pena@noaa.gov*).

The ship-rider will work as needed around the clock to:

1) check and load the auto-launcher;
2) check that the system is logging data correctly;
3) keep a log of problems, repeated casts due to suspected XBT errors and weather conditions;
4) inform NOAA personnel of any difficulties; and,
5) deploy ARGO profiling floats and surface drifting buoys as necessary.

Argo float deployments

No Argo floats will be deployed during this cruise

Drifter deployments

No drifters will be deployed during this cruise

Summary

This high resolution XBT transect will require 111 probes plus an anticipated 10% failure rate of 11 probes. This typically requires a total of 122 probes per crossing and about 488 probes per year.

What oceanographic features we are expecting:

Numerous XBT sections have been taken in areas similar to the ones to be taken on this AX10 cruise. Several of the previously taken sections provide guidance in determining where the XBTs will be dropped. Figure 3 shows the expected currents in the region during the cruise.

Figures 4, 5 and 6 show some of the typical sections that show features we will be attempting to sample. The most prominent feature is the deepening of temperature contours (isotherms) marking the Gulf Stream (figure 4). The northern edge or 'wall' of the Gulf Stream (or front) is often demarked by the northernmost position that the 15°C isotherm occurs deeper than 150-200 m. Further south of the Gulf Stream this isotherm is typically about 600 m (or more) deep. Some investigators use the position that the 15°C isotherm goes deeper than 500 m to denote the southern edge of the Gulf Stream.

The Gulf Steam is an unstable jet (or front) that wiggles or meanders considerably as the current proceeds farther into the Atlantic Ocean. We will attempt to approximate the exact position of the Gulf Stream from satellite sea-surface temperature (SST) imagery. Near 70-74°W the Gulf Stream is thought to meander over a 300 km distance between about 35°N to 38°N. Occasionally these meanders in the Gulf Stream will pinch off and form rings of anomalously warm (or cold) water that appear to the north (or south) of the Gulf Stream.

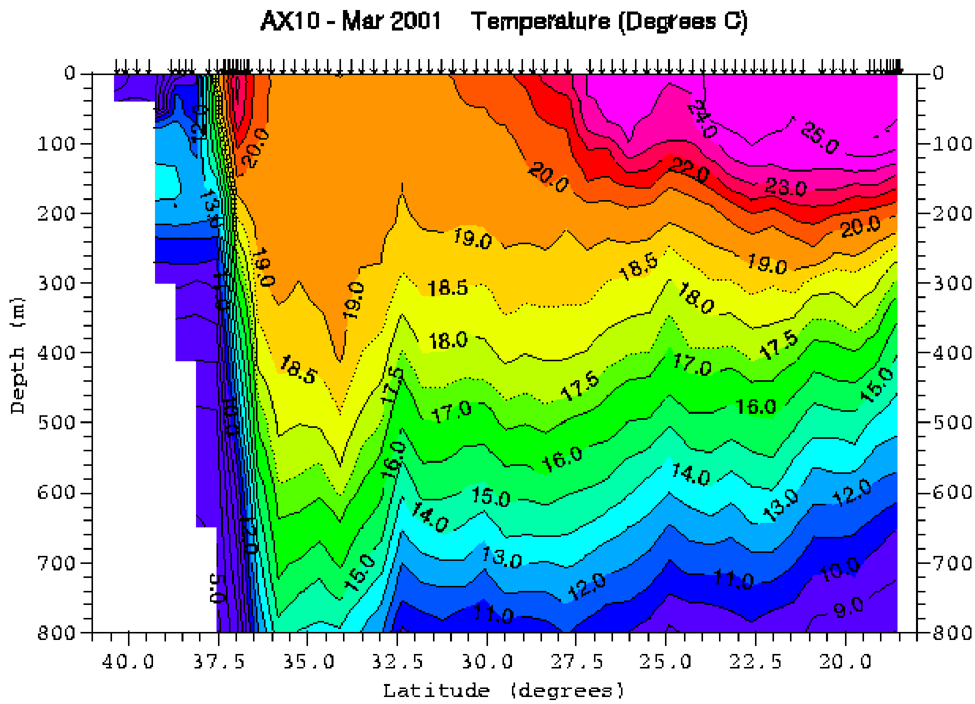

Figure 4. Temperature section of a typical crossing along AX10 (temperature contours as marked are in ^{0}C). This section was taken aboard the ***M/V CSX HAWAII*** in March of 2001.

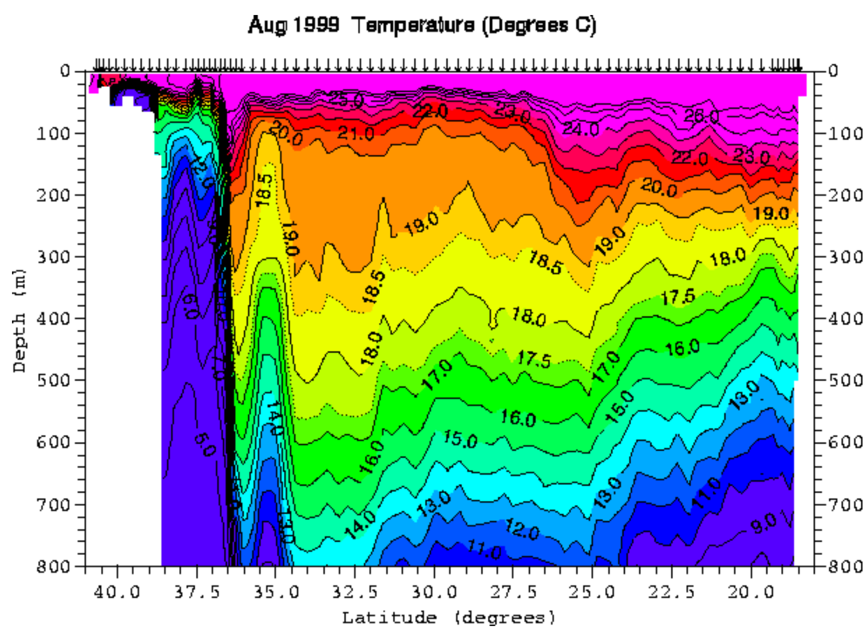

Figure 5. Temperature section along AX10 showing a cold core ring (temperature contours as marked are in ^{0}C). This section was taken aboard the **M/V SEALAND CRUSADER** in August '99.

One example of a cold ring is shown in figure 5. In this figure starting at the left hand side that is closest to the coast, the cold water off the NE United States is seen (blue contours at depth). The abrupt deepening of many isotherms (constant temperature surfaces) of the Gulf Stream occurs near 36-37°N. Further south, the isotherms rise and fall again briefly marking the presence of a cold 'core' ring (centered at about 35°N). A warm core ring can be seen in figure 5 located approximately 300 km offshore near 38°N. Warm core rings are characterized by isolated regions of relatively warm water usually at depth. Often these are "capped" over by water consistent with the local environment. Optimally we would like to sample the Gulf Stream and any rings with fine horizontal sampling (15-20 km) while the rest of the ocean is sampled more coarsely (40 km).

Some other features we are looking for include:

• ***The pocket of warm water typically found along the axis of the Gulf Stream***.
Note this is marked by waters warmer than 23°C in figure 4 and greater than 25°C in figure 5. This is primarily an advective feature that marks a long filament of warm waters from the Florida Straits and is seen clearly in SST maps. This feature is occasionally obscured during summer when surface heat creates fairly uniformed warm surface temperatures.

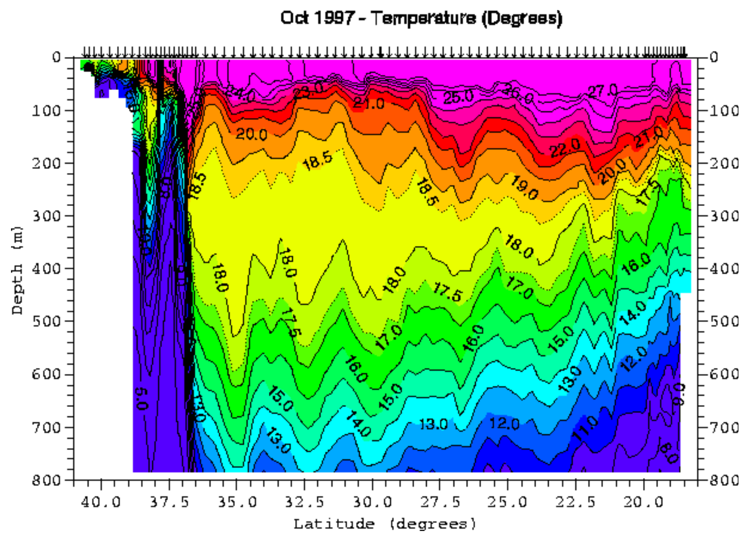

Figure 6. Temperature section along AX10 showing a warm core ring (temperature contours as marked are in ^{0}C). This section was taken aboard the **M/V SEALAND CRUSADER** in October 1997.

• ***The large volume of "18°C" water south of the Gulf Stream***. This water is formed through surface cooling during winter and can form very deep layers of homogeneous properties (over 400m thick). Figure 4 shows isotherms extending vertically to the surface with uniform (or near uniform) water properties from the surface to more than 300 m depths. The presence of this water type (we call it a water mass) can still be seen in the summer section, figure 5, when the surface is warmer by noting the large distance between the 17°C and 19°C isotherms. Note that the volume and specific temperature of this "18°C" water mass varies substantially as a function of time. For example the October 1997 section contains a large volume of water between 18 to 18.5°C, while the August 1999 section contains more water in the 19 to 20°C range.

• **The shelf-slope front.** Very near the coast, surface cooling and advection of cold waters from the north produce very cold water that typically follows the edge of the continental shelf where it meets the continental slope (where the bottom topography deepens from less than 100m to over 500m). An example of this is shown in figure 4. In figure 4, the shelf slope front is evident by the cluster of closely spaced isotherms 39°N that slope downwards towards the coast and bottom topography. The slope front is generally coincident with the abrupt change in the bottom topography about 200 km from Ambrose Tower. Note that this feature and its offshore extension will include vertical temperature inversions of as much as 5°C (in 100m) with colder water on top of warmer water (figure 4). This is due to the low salinity of the coastal waters compensating for the lower temperatures. At present we are not measuring the salinity along AXl0. We hope that some arguments about the correspondence between temperature and salinity from historical coastal data can be used to estimate the actual density from temperature alone.

Typical Temperature Profile Examples

Below are examples of typical temperature profiles expected on this transect.

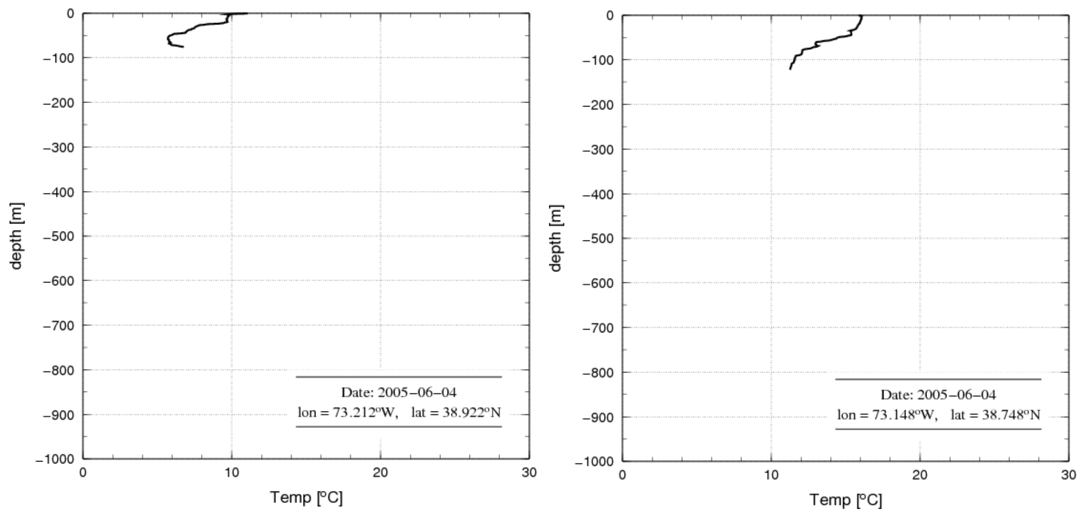

Figure 7a and 7b. Temperature Profiles, Hitting Bottom on Shelf out of NY (left). Sitting on Bottom (right)

Figure 7a shows cold shelf water with a small temperature increase at the bottom of the profile just before the probe hits the bottom (near 100 m depth). No obvious "hit bottom" spike is distinguishable from the increased (noisy) temperature near the bottom, but the profile in **Figure 7b** shows a classic signature of the probe sitting on the bottom (perhaps some wire stretch). The shelf out of New York is quite broad and the slope is not encountered until around 38.8 N.

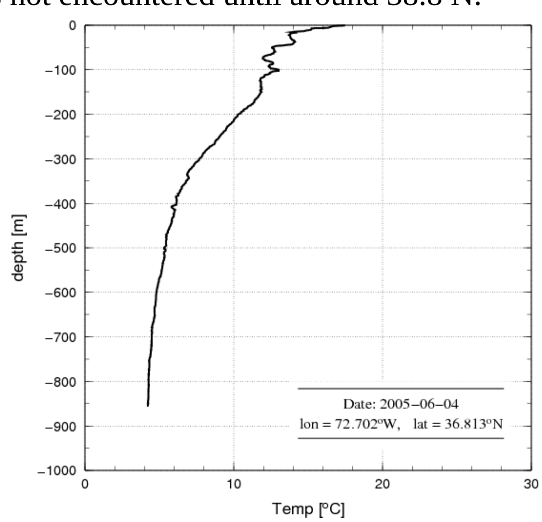

Figure 8. Typical Temperature Profile, North of Gulf Stream. Example of Electrical Noise

Upper 200 m temperature inversions are common north of the Gulf Stream. Note the large-scale, relatively smooth temperature variations in **Figure 8**. Note that profile exhibits regularly spaced in depth (time) fine scale "noise". This is not natural and is likely electrical interference or grounding issues. These very small scale "wiggles" can be filtered out, but are not ideal.

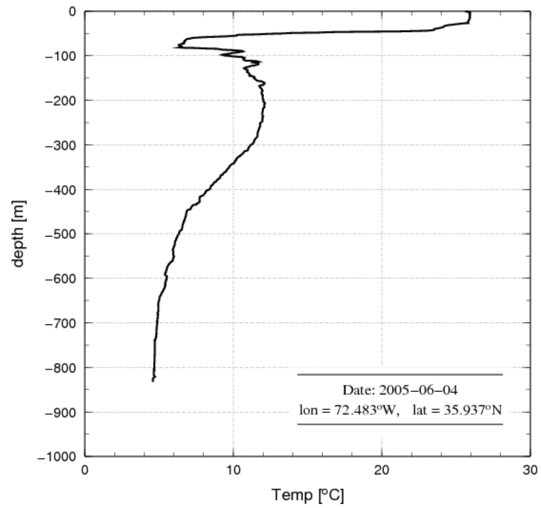

Figure 9. Typical Temperature Profile, Crossing the Gulf Stream. Temperature Inversion above 200m

Figure 9 signals the crossing of the Gulf Stream. Near the northern part of the Gulf Stream temperature inversions can be seen well below 200 m; here two occur up to 350 m. This particular profile shows water near 75 m to be warmer than water on the shelf (see **Figure 7)** but colder than the water in between (see **Figure 8**). The cold inversion in **Figure 9** is likely from the shelf and is a filament or pinched off ring.

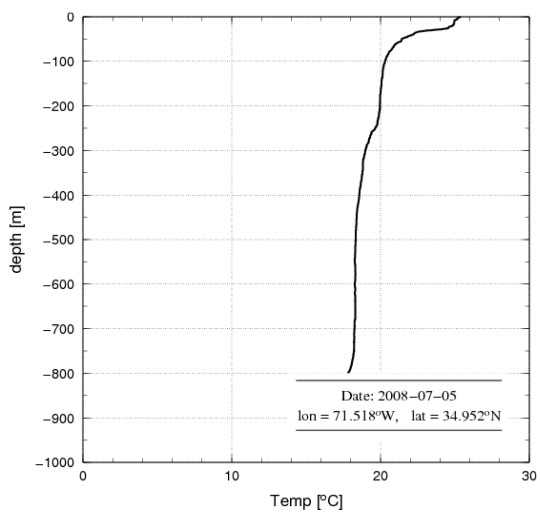

Figure 10. Typical Temperature Profile, South of the Gulf Stream – Uniform Temperature to Deep Water

South of the Gulf Stream, temperature profiles are usually smoothly decreasing with increasing depth but very uniform water (near 18 C) can be found quite deep (e.g. **Figure 10** to 800 m). Sometimes there will appear one or more subsurface nearly uniform temperature layers. These are thought to be “capped over” mixed layers from previous winters.

Basic Ship Visit and Rider Rules – *courtesy of Steve Cook et al*

The following guidelines pertain to any person who might have occasion to visit, install, repair or replace equipment, or ride on any Ship of Opportunity Program (SOOP) ship participating in any program to collect scientific observations. Most of these guidelines are based upon common sense and respect for those who "live" on the vessel. Visitors are essentially being invited into their home as a guest and, as a guest, desire to be invited back. A goal within the SOOP has always been to minimize the shipboard impact as much as possible. These are not "Cruise Ships" or "Research Vessels" and therefore ship riders strive for self-sufficiency. There are times, like departing or arriving in port or navigating congested waters that the bridge officers and crew have to concentrate on their own responsibilities and not the rider's. Please leave them alone during this time. It is always a good idea to brief the Captain and Chief Engineer prior to departure as to the plans and scope of the work and exactly what will be needed from the bridge officers or any other assistance.

These guidelines are not just for the novitiate "first timer", but also for those who have often visited or ridden the same ship many times. It is certainly acceptable and beneficial to be knowledgeable about the ship's standard operation but don't become familiar to the point of complacency and forget the basic rules of respect. Ship riders should always remember that they are professionals involved in the collection of important scientific information and they not only represent themselves but also Scripps and the SOOP program.

Following is a list of basic guidelines that should be observed.

- Always see the Captain and/or Chief Officer when first boarding the ship.
- If riding the ship, then learn the ship's daily watch schedule. Know when meal times and coffee breaks are scheduled and plan activities accordingly.
- Be in good health, as this work can be very exhausting and the hours long.
- If alcohol is allowed on board, limit consumption in order to use good judgment in regards to personal interactions and because it may be necessary at any time to go to work
- Be cognizant of ship customs and protocol.
  - For instance, if people wait for the Captain to sit down, then don't sit down before he does.
  - Wait to be invited or ask permission to enter special places like the bridge, engine room or lounge area.
  - If the officers remove their shoes before entering their lounge area or stateroom, then follow the example
- Wear appropriate clothing and shoes. Ragged shorts, bathing suits or sandals are inappropriate.
- Don't sleep in a public space or prop feet up on any table or desk and "kick back".
- **Don't bring food out on deck, especially in port, and especially in Australia. Instant $1000 fine!**
- If it is necessary to conduct a meeting in a stateroom leave the door open.
- Clean up messes and keep gear stowed away when not in use. Work areas should be kept tidy so ship's personnel don't have to "step over" the equipment or supplies to conduct their own jobs.
- When there is a lot of activity on the bridge, limit questions and conversations. A detailed briefing of what is required from the bridge officers conducted prior to departure should minimize confusion and stress.
- Bring all necessary tools. Don't ask to borrow ship's tools if possible.
- Use email or telephone whenever possible to keep the ship and agents apprised of schedule and plans.

Some of the participating SOOP support several different scientific projects and, as such, the combined impacts of those projects become cumulative and can increase the stress on the officers and crews. It is essential that all projects coordinate their ship support activities so they don't overburden the system and are asked to leave the ship entirely. There are real-time operational requirements that contribute to safety at sea issues and there are special scientific projects that support science. Both can be accommodated but it is incumbent on those who meet and greet these ships to take the time and effort to accommodate the basic needs of the mariners who contribute so much to the program's success.

High Density Check-in list for the Ship Rider **Date Completed**

The ship rider is the primary person responsible for ensuring the success of the cruise. This includes checking that all the necessary equipment has been tested and loaded in the ship, verifying weather conditions, ship schedules, possible ship delays etc. Before traveling the rider must have all documents and contact information required for the cruise.

Equipment testing: ____________

- Verify that all equipment to be sent from AOML has been thoroughly tested before shipping.
- Comment if not testing was performed:

  ____
  ____
  ____

Check equipment shipping and loading: ____________

- Contact Zach Barton (*Zach.Barton@noaa.gov, 305-361-4548)* to confirm the status of equipment shipment and loading.

Check ship route ____________

- Contact Zach Barton (*Zach.Barton@noaa.gov, 305-361-4548)* to confirm that the ship is on the scheduled route two days in advance of the cruise's planned date as well as the day before of your travel. Also communicate with Robert and Zach to inform them of your travel arrangements for the cruise.

Contact support at Newark ____________

- Contact James Farrington at least two days in advance of the cruise's planned date (*James.W.Farrington@noaa.gov, 757 651-3794*) to coordinate airport pick up, ship access, etc.

Record height of deployments: ______________

- Please take note of and put in your report the approximate height that the deployments were made from. (Top of the water to where the probe was launched from.)

Useful information:

Address of the entrance of the APM terminal at Port Elizabeth is:

1100 McLester St
Elizabeth, New Jersey 07201

Address of FedEx depot at Newark Airport:

FedEx Metroplex
Building 155
Newark IAP, New Jersey 07114
(757) 441-3062 (Jim Farrington)

High Density Check-out list for the Ship Rider **Date Completed**

Data submission to AOML after the cruise ___________________

The following files should be sent to AOML after the cruise, regardless of data transmissions during the cruise:

1. All XBT data in .BIN (c:\users\public\Documents\AMVERSEAS_V9\Archive\XbtDataRecorder\), and electronic XBT drop log sheet.
2. HistoryAllAttempts.txt – found at:
   c:\users\public\Documents\AMVERSEAS_V9\Archive\XbtDataRecorder\
3. Cruise summary for the web page
4. Cruise Report
5. Drifting buoy log sheet and ARGO float log sheet in case of deployments of these instruments

The data can be submitted in a CD, memory stick or in a zip file as an email attachment.

Sent the XBT data and HistoryAllAttempts.txt to each of the following:

Yeun-Ho Daneshzadeh	*Yeun-Ho.Chong@noaa.gov*	___________________
Francis Bringas	*Francis.Bringas@noaa.gov*	___________________
Zach Barton	*Zach.Barton@noaa.gov*	___________________

Argo deployment information while underway:
e-mailed to: *aoml.argo@noaa.gov* and *deploymentinfo@whoi.edu* ___________________

Drifting buoy deployment information while underway:
Shaun Dolk *Shaun.Dolk@noaa.gov* ___________________

Cruise summary for the webpage. This information goes on the webpage and includes the number of XBTs deployed, drifters/floats deployed, any data affecting issues, etc. Send an email to each of the following with your summary:

Gustavo Goni	*Gustavo.Goni@noaa.gov*	___________________
Shenfu Dong	*Shenfu.Dong@noaa.gov*	___________________
Molly Baringer	Molly.baringer@noaa.gov	___________________
Yeun-Ho Daneshzadeh	*Yeun-Ho.Chong@noaa.gov*	___________________
Francis Bringas	*Francis.Bringas@noaa.gov*	___________________

Please email a Cruise Report to Shenfu Dong, Gustavo Goni, Zach Barton, and Francis Bringas stating the following:

- XBTs deployed
- Drifters deployed (ID, date, time, latitude, longitude)
- Profiling floats deployed (start time, deployment time, latitude, longitude)
- GTS transmission (Real-time, twice a day, problems)
- Additional equipment, tools, supplies needed
- Problems
- Recommendations
- Other narrative