CARIACO (CArbon Retention In A Colored Ocean) Project

University of South Florida, College of Marine Science

NSF Annual Report for Award # 0326268

Period Covered:

October 2003 – October 2004

(Cruises CAR 94 – 105)

Report updated 11 November, 2004

SUMMARY

This project continues the time series of monthly observations at 10 deg 30’ N, 64 deg 40' W that began in November, 1995, under the CARIACO (CArbon Retention In A Colored Ocean) Program by the University of South Florida (USF). This program also includes at least seasonal cruises to examine microbial processes (SUNY group), deployment of a sediment trap mooring (U. South Carolina), and a current meter mooring (USF). The sediment trap mooring now has five sediment traps (150, 275, 350, 450, and 1,200 m), instead of four, which provide bi-weekly sample collections at each depth. The current meter mooring holds two Acoustic Doppler Current Profilers (ADCP), one looking up and the other looking down from a depth of about 250 m, to measure currents from below the sill depth to the surface. Cruises to collect zooplankton samples in the upper 300 m have now been added and are conducted every two months for biomass and taxonomy estimates. This year, two grid transects were conducted in the eastern Cariaco Basin, between the coast and 11'20' N, 64'16' W and 65'03' W. The objective was to understand the characteristics of source water involved in intrusions and upwelling, as well as to determine the source of surface low salinities detected every year in September. These data show that the fresh water is more likely derived from local rivers as opposed to being derived from the Orinoco River. Regional wind and sea level are examined using both local and remotely-sensed data to establish whether forcing for upwelling occurs primarily through local or gyre-scale processes. Sediments from the Cariaco basin were collected using cores and grabs, and are being analyzed to reconstruct the oceanographic condition in the Cariaco Basin over the past century. This provides additional insight into longer-scale paleoceanographic studies.

INTRODUCTION

The CARIACO time-series station is located at 10 deg 30' N, 64 deg 40' W in the Cariaco Basin. This is a 1,400-m deep depression on the continental margin off Venezuela that is openly connected to the Caribbean Sea by a shallow (~140 m) sill. Time-series cruises to the Cariaco station to collect a series of "core" observations are conducted monthly. Additional cruises are conducted periodically, at a frequency varying between bi-monthly and seasonally, to collect zooplankton samples and conduct microbial process studies, as well as to service two moorings, one holding a series of sediment traps at different depths, and the other hosting two Acoustic Doppler Current Profiler (acoustic current meters).

During each monthly core cruise (Table 1), a set of key parameters (Table 2) is collected. This includes a series of CTD casts to obtain temperature, salinity, and oxygen profiles from 0 to 1310 m, a variety of chemical determinations at discrete depths, primary productivity, particle concentration, and continuous profiles of optical parameters.

The CARIACO data are publicly available via an Internet server (http://imars.usf.edu) upon passing quality control, within periods ranging from weeks to about 6 months depending on the difficulty of processing an observation.

Table 1. Cruise number and dates carried out from 2001 up to date

Cruise number	Date	Cruise number	Date
62	Jan/11/2001	84	Dec/05/2002
63	Feb/16/2001	85	Jan/14/2003
64	Mar/14/2001	86	Feb/11/2003
65	Apr/04/2001	87	Mar/11/2003
66	May/05/2001	88	Apr/08/2003
67	May/11/2001	89	May/13/2003
68	Jul/09/2001	90	Jun/10/2003
69	Aug/06/2001	91	Jul/08/2003
70	Sep/11/2001	92	Aug/04/2003
71	Oct/08/2001	93	Sep/09/2003
72	Nov/05/2001	94	Nov/11/2003
73	Dec/11/2001	95	Dec/09/2003
74	Jan/11/2002	96	Jan/13/2004
75	Feb/16/2002	97	Feb/08/2004
76	Mar/14/2002	98	Mar/08/2004
77	Apr/04/2002	99	Apr/06/2004
78	May/05/2002	100	May/13/2004
79	Jun/12/2002	101	Jun/08/2004
80	Jul/09/2002	102	Jul/06/2004
81	Aug/06/2002	103	Aug/10/2004
82	Oct/03/2002	104	Sep/10/2004
83	Nov/07/2002	105	Oct/05/2004

Table 2. List of parameters collected during each CARIACO cruise, the depth range, instrument, and processed data available online.

Parameter	Depth Range	Instrument/Method	Processed Data (Cruise number range or year)
1. Continuous Parameters			
Pressure (Depth)	0-1310 m	SeaBird CTD	1-105
Temperature	0-1310 m	SeaBird CTD	1-105
Conductivity (Salinity)	0-1310 m	SeaBird CTD	1-105
Dissolved Oxygen	0-1310 m	YSI on CTD	1-105
Fluorescence	0-1310	fluorometer	1-105
Light transmiss. (c660)	0-1310	transmissometer	1-105
2. Water Column Chemical Measurements			
Dissolved Oxygen	0-1310 m	Titration	1-105
Dissolved organic Carbon	0-1310 m	Coulometry	1-63
Total Alkalinity	0-1310 m	Gran Titration	1-98
pH	0-1310 m	Spectrophotometer	1-98
Salinity	0-1310 m	Guildline AutSal	1-98
Nitrate	0-1310 m	Autoanalyzer	1-100
Nitrite	0-1310 m	Autoanalyzer	1-100
Amonia	0-1310 m	Autoanalyzer	1-100
Phosphorus	0-1310 m	Autoanalyzer	1-100
Silicate	0-1310 m	Autoanalyzer	1-100
Partic. Organic Carbon	0-1310 m	High Temp Comb	1-99
Partic. Organic Nitrogen	0-1310 m	High Temp Comb	1-99
3. Biomass Measurements			
Chlor. a and Phaeopig.	0-100 m	Flourometry	1-99
Bacteria	0-1310 m	(Various/SUNY)	(see SUNY report)
4. Carbon Assimilation and Particle Flux			
Primary Production	0-100 m	14C	1-98
Bacterial Production and Respiration	0-1310 m	(Various/SUNY)	(see SUNY report)
Protozoan grazing	0-1310 m	(Various/SUNY)	(see SUNY report)
5. Optical Measurements			
Incident Irradiance	Surface	Spectrascan	1-102
Upwelling Radiance and Downwelling Irradiance	0-150 m	PRR-600	1-99
6. Moored Instruments			
Sediment Traps	275,450,900,1200	(U South Carolina)	(see USC report)
Acoustic Doppler Current Profiler (ADCP)	<200 m		1996-1998; 2002-2004

METHODS

The methods have been described in detail in Muller-Karger et. al., 2001, therefore only changes in those procedures are described below.

Oxygen

Beginning with cruise 72 we have changed our oxygen analysis to incorporate an automatic titrator with integrated burette module. This instrument shortened the analysis time; however we did not see an improvement in the quality of our dissolved oxygen measurements with this new instrument. Therefore, we are studying the possibility to use an automatic titrator capable of detecting the end point spectrally and by computer. Continuous dissolved O_2 profiles from the electronic sensor on the CTD have been made accessible via the web URL:
http://imars.marine.usf.edu/cariaco/data/CTD_DATA/

Nutrients

The filtering, storage and transportation of the nutrient samples has changed in order to improve the data quality. All samples since cruise 71 have been filtered through a 0.8um Nucleopore filter (0.2um) as recommended by the JGOF protocol. The silicate samples are now transported unfrozen to the lab at USF for analyses whereas prior to cruise 70, samples were frozen upon collection. 30 ml sample bottles are currently being used for all the nutrients that will be analyzed at USF (unfrozen for Silica and frozen for other nutrients). The frozen samples have arrived at our lab in the U.S. completely frozen, given that the smaller bottles allow for more room in the coolers for gel-ice and dry ice. These new bottles have:

- Wider mouth for easy filling and insertion of the auto-analyzer needle without touching the bottle.
- Just enough volume (30 ml) for direct measurement in the original bottle. To insert the auto-analyzer needle in the samples, several of these bottles are placed into a rack. If the sample bottles did not fit in this rack then the samples would have to be transferred to a suitable bottle, increasing the possibility for error.
- Smaller volume for easier transportation (Porlamar - St. Petersburg).

Mislabeling of samples had caused some errors in previous years. Now samples bottles are labeled before the cruise, and filters between samples are washed with additional sample water.

We have started collection of samples for dissolved organic nitrogen (DON) and dissolved organic phosphorus (DOP) measurements, in order to address the questions we posed on the carbon and nutrient cycles in our proposal. A special filtration rig was developed by Dr. Fanning's laboratory (USF) that would allow the concentrations of both dissolved organic nutrients and particulate organic nutrients to be obtained from the same seawater sample, with up to eight samples being processed simultaneously. In each of the eight filter assemblies, the GF/F filter that separates the particulate organic nutrients from the filtrate containing the dissolved inorganic and organic nutrients is held in an apparatus that permits vacuum to be applied from two possible locations downstream of the filter. The first location is immediately beneath the filter, allowing the filtrate to go directly to a waste line, and the second is through a plastic sample bottle further downstream from the filter so that the filtrate may be captured in the bottle. When the bottle is full of filtrate, a valve may be adjusted to switch the vacuum source from the bottle to the position immediately beneath the filter. Thus, if desired, additional particulate organic matter can be collected, with the filtrate now being exhausted to the main waste line as in a more typical filter assembly.

The DON method to be followed will be based on: Solorzano, L. and J.H. Sharp. 1980. *Determination of total dissolved nitrogen in natural waters*. Limnol. Oceanogr. 25:753-756. This procedure produces a filtered seawater sample for analysis of total dissolved fixed nitrogen (=nitrate + nitrite + ammonium + DON). The persulfate oxidation in the procedure converts the last three solutes to nitrate, which is thus added to the nitrate already present. Then a total nitrate determination is made on the oxidized filtrate solution using the method presented in the Cariaco proposal. This determination will give the total dissolved fixed nitrogen concentration in the seawater sample. Since our standard nutrient protocol (see proposal) determines concentrations of nitrate, nitrite, and ammonium in the seawater sample separately, the DON concentration can be obtained by difference.

DOP will be analyzed in the same persulfate-oxidized filtrate solution as the DON. That solution will have an total inorganic phosphate concentration which is composed of the inorganic phosphate concentration originally in the seawater, plus an additional phosphate concentration due to the conversion of DOP to phosphate. Since our standard nutrient protocol (see proposal) determines the concentration of inorganic phosphate in the un-oxidized sample, the DOP concentration can be obtained by difference.

Since cruise 72, all samples collected for colored dissolved organic matter (CDOM) absorption coefficient determinations have been filtered through both a 0.8 um glass fiber filter and a 0.2um nuclepore filter. Values from previous samples, while not filtered, are not incorrect. We are still evaluating the data and its possible uses.

CO2 system (pH, Alkalinity, TCO2 and fCO2)

Our original spectrometer/spectrophotometer PC-based card started to perform suspiciously and lose stability in early-2001. The instrument stopped working after cruise #65. Data were not collected on several cruises, but Ocean Optics provided a new double spectrometer (SD 2000) as of cruise 71. This new and improved instrument uses two identical channels to measure a divided light beam. One channel measures the sample and the other measures the stability of the light source and corrects when necessary.

Contour plots for all parameters were created using a Delaunay triangulation method for gridding. This method involves interpolating regularly gridded values from the original values associated with vertices of triangles. To smooth the contour lines, a smooth quintic polynomial interpolation was applied. These time series may be examined at the following web (URL) addresses:

Temperature: http://imars.marine.usf.edu/cariaco/salinity.html
Salinity: http://imars.marine.usf.edu/cariaco/salinity.html
Chlorophyll-a: http://imars.marine.usf.edu/cariaco/chl.html
Phaeopigments: http://imars.marine.usf.edu/cariaco/phaeopigments.html
Primary Production: http://imars.marine.usf.edu/cariaco/pp.html
Oxygen: http://imars.marine.usf.edu/cariaco/oxygen.html

Phosphate: http://imars.marine.usf.edu/cariaco/PO4.html

Nitrate: http://imars.marine.usf.edu/cariaco/NO3.html

Nitrite: http://imars.marine.usf.edu/cariaco/NO2.html

Amonia: http://imars.marine.usf.edu/cariaco/NH4.html

Silica: http://imars.marine.usf.edu/cariaco/Si.html

pH T (at 25º C): http://imars.marine.usf.edu/cariaco/pH.html

TCO2: http://imars.marine.usf.edu/cariaco/TCO2.html

fCO2: http://imars.marine.usf.edu/cariaco/fCO2.html

ACTIVITIES AND FINDINGS: RESEARCH AND EDUCATION ACTIVITIES

In October 2004, the CARIACO time series completed nine years of monthly hydrographic observations (105 months of observation) and the series continues with a robust monthly cruise plan. During the period of performance (October 2003-October 2004), we conducted monthly cruises and deployed and recycled a current meter mooring (separate from the sediment trap mooring). This mooring has two Acoustic Doppler Current Profilers, one looking down at ~310 m and one looking up from ~280 m, to provide good vertical coverage of most of the water column.

In addition to our monthly cruises to the Cariaco Station, we conducted 2 spatially extensive cruises throughout the Cariaco Basin to improve our understanding of spatial variation in hydrography and distribution of other key variables, such as particles.

In September 2003 an extended cruise was conducted, incorporating 37 hydrographic stations throughout the Cariaco Basin. During this 4 day cruise, continuous CTD measurements were collected at each station. In addition, sediment grab samples and optical measurements were collected at several locations. The objectives of this cruise were to understand 1) the basin-wide hydrography, 2) the bio-optical parameters contributing to ocean color in the Cariaco Basin, and 3) the water and sediment flux into the basin from surrounding rivers.

During the most recent upwelling period, in March 2004, a second extended cruise was conducted to help understand the characteristics of source water involved in intrusions and upwelling within the Cariaco Basin. During this 5 day cruise, 36 stations were sampled throughout the basin and just north of the sill in a grid fashion. Continuous CTD measurements were collected at each station and water-column chemical measurements of DIC, DOC, and inorganic nutrients were collected at different locations.

The CARIACO project at present supports two graduate students at USF: Ms. Laura Lorenzoni, who graduated from Venezuela's Universidad Simon Bolivar, and MSc. Digna Rueda, who has recently been accepted into the PhD Program. CARIACO has trained two young technicians, one in the USA (Mr. John Akl) and one in Venezuela (Ms. Glenda Arias). Glenda Arias visited the Remote Sensing Lab. at the University of South Florida for a 4-week training period during Oct. 2001.

The project continues a very positive and productive collaboration with Mr. Ramon Varela and MSc. Yrene Astor, of the Fundación La Salle in Venezuela, who assist in carrying out the logistics of monthly cruises, data processing and sample analyses.

A new website has been implemented to address concerns of design, speed, and security. This new site is located at: http://www.imars.marine.usf.edu/CAR/

PRELIMINARY RESULTS AND OBSERVATIONS

The CARIACO program successfully completed 105 cruises to the CARIACO station in October 2004. This comprises nine years of uninterrupted observations including nine upwelling cycles between November 1995 and May 2004.

A winter-spring upwelling process was observed each year between January and May. This event varied in intensity each year (Table 3, figure 1), was marked by strong but brief events, and each strongly affected the hydrography of the upper 150 m. A secondary upwelling event was observed in July or August for most years.

The upwellings seen during the winter-spring of 1997 and 2001 are considered anomalously strong events in which the surface temperatures were lowered to 21.5°C, and the average primary production during upwelling exceeded 2000 $mg/C/m^2$. The upwelling event during 1998 was a shorter and weaker event. The upwelling events during 1996, 1999, and 2000, are considered normal periods in which the surface temperatures are lowered to 23°C and the average primary production was 1700-1800 $mg/C/m^2$.

The past two upwelling seasons (2002 and 2003) show a return to normal conditions after anomalously strong upwelling of 2001 (figure 1).

The most recent winter-spring upwelling event of 2004 has shown weak upwelling strength with an average primary production from December 2003 – March 2004 of 1215 mg/C/m^2. No summer upwelling was observed in or 2003, whereas in 2002 surface temperatures fell to 24.1 ^{o}C in July (figure 1).

Table 3. Nine winter-spring upwelling periods observed at the CARIACO station described by the surface temperature during the peak upwelling, and average primary production during the upwelling period.

Upwelling Strength	Normal	Strong	Weak	Normal	Normal	Strong	Normal	Normal	Weak
Year	1996	1997	1998	1999	2000	2001	2002	2003	2004
Surface Temperature (°C)	23	21.5	23	23	23.5	21.5	23	23	23
Primary Production (mg/C/m^2/d)	1784	2638	1387	1821	1735	2313	1764	1850	1215

At the CARIACO station, several observations have been made of lateral intrusions of oxygenated waters coming from outside the sill (Table 4). These ventilation events vary in frequency and strength. No intrusions were observed during 1996, 1999, or 2000. None were observed during the 2004 upwelling season or up to the date of this report. Ventilations were observed during the extended cruise of September 2003 at other locations around the basin.

The uplift of the Subtropical Underwater mass during the winter-spring upwelling cycles of 1998 and 2002-2003, and the exceptionally strong upwelling of 1997 and 2001, appear to have forced ventilation of the Cariaco Basin, with oxygen penetrating deeper than the sill depth. The ventilation events of 2001 were not observed until April of that year, i.e. at the end of the upwelling cycle. The positive oxygen anomaly (ventilation) was observed for 5 months after its initial detection in the continuous oxygen profiles collected monthly. During the spring upwelling of 2002 intrusions were observed during March and April, during the peak of upwelling. Intrusions were again observed during November and December 2002, and towards the end of the winter-spring upwelling of 2003.

The intrusion events are also evident in the nitrate data. The maximum concentration of nitrate is generally between 120 and 160 m (figure 2), as a result of input of water from outside the basin and likely enrichment due to local nitrification. Below 200 m, denitrification rates increase; however, ventilation of deeper waters inputs nitrate at these depths as well.

Table 4. Ventilation events observed at the CARIACO station.

Cruise Number	Date of Observation	Depth of ventilation
15	January 7, 1997	200-250
16	February 13, 1997	200-250
20	June 17, 1997	250-300
22	August 17, 1997	250
24	October 14, 1997	250-300
26	December 17, 1997	250-300
28	February 11, 1998	250-300
29	March 12, 1998	250-300
31	June 9, 1998	250-300
65	April 4, 2001	200-400
66	May 5, 2001	200-400
67	June 12, 2001	250-300
69	August 7, 2001	300-350
76	March 12, 2002	250-300
77	April 2, 2002	200-250
83	November 7, 2002	250-300
84	December 5, 2002	250-300
88	April 8, 2003	200-230
90	June 10, 2003	280-290

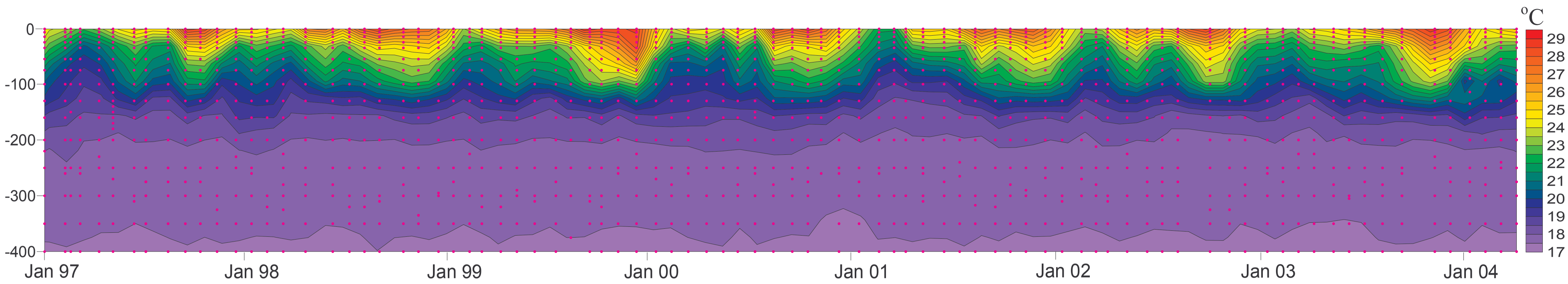

Figure 1: Temperature contour at the Cariaco time-series station (10°30'N, 64°40' W) from 1997 - April 2004.

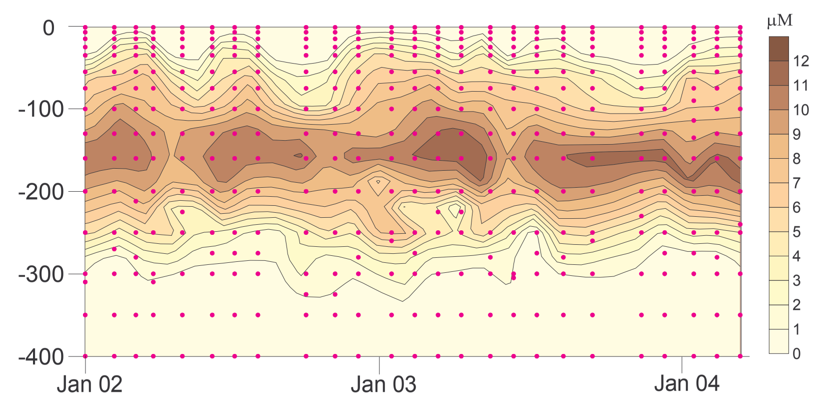

Figure 2: NO_3 contour plots for the years 2002, 2003 and part of 2004 at the Cariaco Station (10°30'N, 64°40' W).

Preliminary results from the extended cruises show, specifically in March 2004, the movement of water from outside the basin rising up over the sill, sloping down towards the center of basin and upwelling again near the coast. We saw a similar pattern with the nutrients: water with high nutrient concentrations north of the sill entered the basin and upwelled near the coast. There is a temperature and salinity difference between the rainy and the dry season throughout the Eastern Cariaco basin (figure 3), caused mainly by the upwelling processes that occur in this region. During the rainy season, temperatures were ~2 ^{o}C higher than in the dry season, whereas salinities were ~0.1 lower.

During the March 2004 cruise we tested a new DOC protocol, developed under the guidance of Dr. Dennis Hansell (RSMAS). The DOC results showed surface values ranging from 58 – 69 micromoles. The highest concentrations were found north of the sill, whereas lowest concentrations were found near the coast. All 8 DOC profiles collected show a clear decrease in concentration with depth. The precision of our measurements was 1.9 micromoles, based on duplicate measurements. Following this successful test of the new protocol, we plan to implement DOC measurements into our regular monthly cruises.

During March 2004, plankton samples were also collected at three stations throughout the basin, with the purpose of understanding key specie distribution of foraminifera found in sediment cores of matching locations.

The contribution of local vs. larger South American rivers, like the Amazon and Orinoco, to Cariaco was also determined during the extended September 2003 cruise. No direct influence from larger South American rivers was observed, whereas the smaller, local rivers exert a considerable influence, both in the sediment transport to the basin and on the optical properties of the adjacent water, especially during the rainy season. At the Cariaco station, the lowest salinity has been consistently registered during the month of September, period in which local rivers, such as the Unare and Neveri, reach their maximum water discharge. The influence of these local rivers was visible in the sea surface salinity measured during the September 2003 extended cruise (figure 3)

The deep CDOM pool was also studied for the first time during the extended cruises. Concentrations of CDOM increase threefold below the oxic-anoxic interface, due to the slow turnover of the basin and to the rapid decomposition of organic matter that occurs in this region.

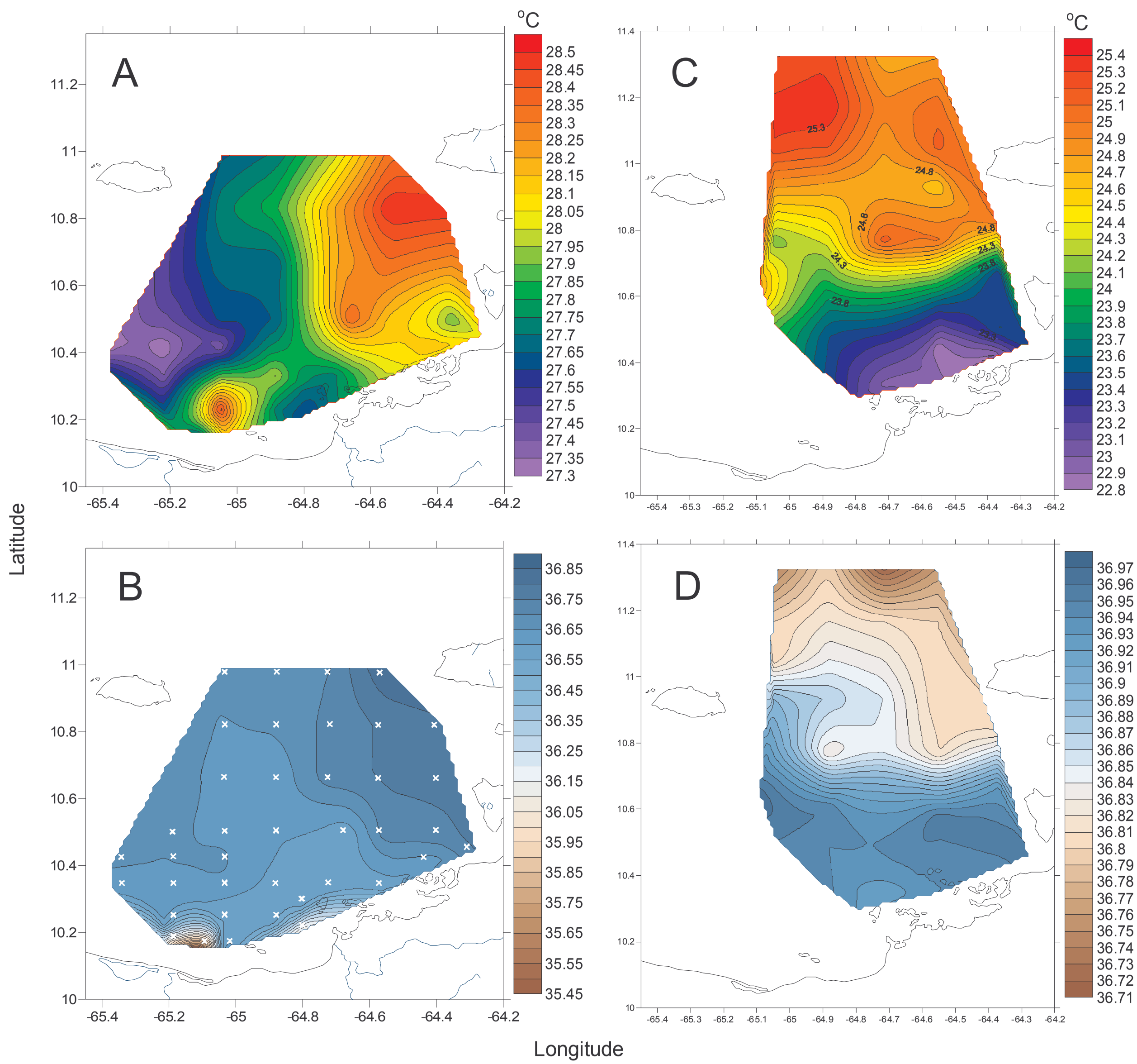

Figure 3: Surface temperature and salinity of the Cariaco Basin measured during the September 2003 (A and B) and March 2004 (C and D) extended cruises.

Water circulation at the Cariaco station was measured using a moored ADCP for the years 2002, 2003 and 2004; currents for 2002-2003 are accessible via the web URL: http://ocg6.marine.usf.edu/cariaco_index.html.

In order to cover a broader portion of the water column, the 2002-2003 and 2003-2004 deployments were done using two ADCP's, one looking up and a second one looking down. The upward looking ADCP was deployed at a depth of ~280m (covering depths between 250m and 30m), and the downward looking was stationed at ~310m (covering depths between 350m and 600m). Unfortunately, the downward looking ADCP failed to collect useful data in both occasions, due to technical problems. The data from the upward-looking one for the 2003-2004 deployment is currently being processed.

Between 2002 and 2003, water flow in the upper 100 m was predominantly towards the East, consistent with previous observations (1996-1998). In this upper layer, currents can be relatively strong (~30 cm/s) (figure 4). A westward current, consistent with the Ekman layer structure, was observed between 100-150 m. This current was strongest (~25 cm/s) during the summer, and relatively weak during winter-spring. These observations agree with earlier measurements (1996-1998). Below sill depth (150 – 200 m), currents are very weak (> 5 cm/s).

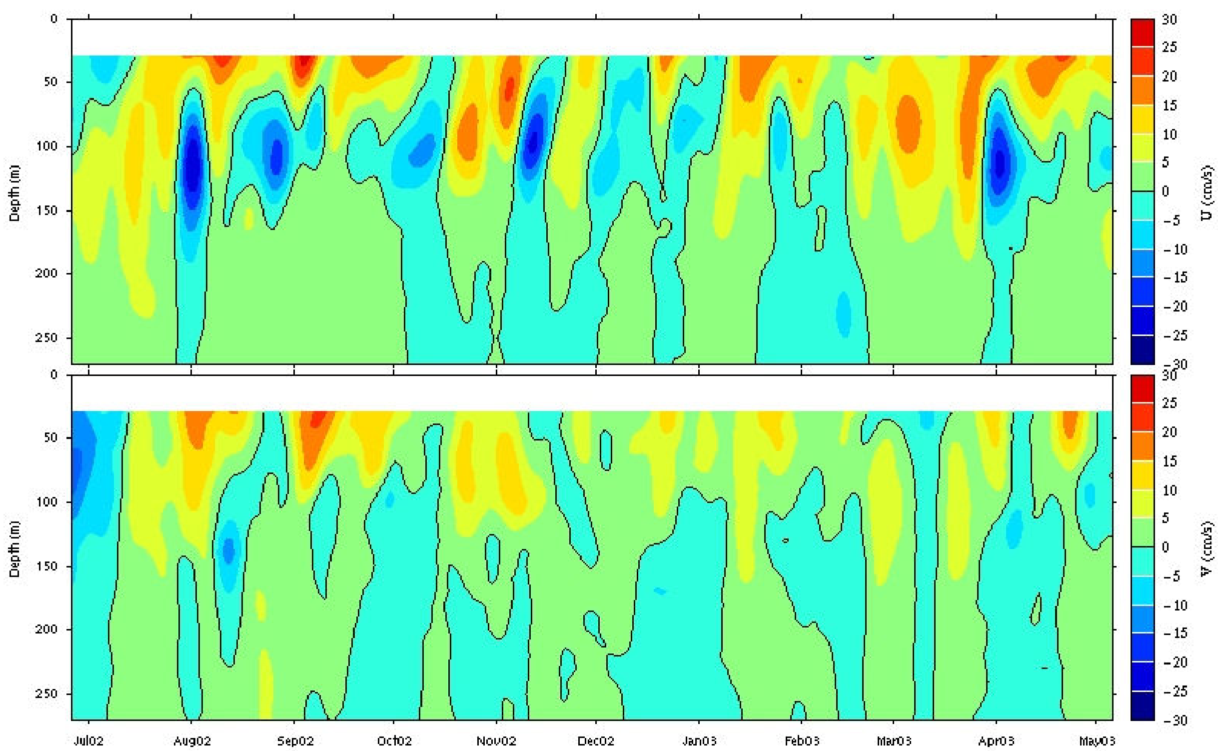

Figure 4: Contours of east (u) and north (v) components of velocity measured at the CARIACO station during 2002-2003. Data used for these plots have been 10-day low-pass filtered.

Because the mooring is located in the middle of the basin, this is not necessarily indicative of the circulation within and around the periphery of the basin. Some of the open questions will be answered with the deployment of the second mooring at the sill and through model developments. Global/basin models will be crucial in understanding how the water moves inside and outside the basin.

Nutrient data quality at USF has been kept high throughout the projects, and techniques are constantly under revision for further improvements. *Oxygen* – Oxygen concentrations are highest at surface and decrease below the euphotic zone, reaching values of less than 20 µM at depths of 200 – 250 m. The oxic-anoxic interface depth varies annually, and it is usually shallower during the upwelling season. For the period of January-May 2004, the interface fluctuated between 200-250 m, reaching its shallowest position in March 2004. This depth range was comparable to the one seen for the same period in 2003. *Phosphate* – Concentrations are always low in the upper 35-55 m, and increase monotonically with depth. Some peaks in phosphate have been observed at 200 – 300 m in past years, events that we now think are associated with oxygen intrusions leading to scavenging of PO_4 by iron oxides. *Nitrate* – Nitrate profiles feature a maximum at 150 m, consistently seen throughout the years. Below this depth, Nitrate concentrations decreases rapidly, reaching zero at depths between 250 and 350 m. This zero-depth varies annually (figure 2).

ALL HANDS MEETING

During 22-23 May 2004, an all-hands working meeting was held at EDIMAR, in Margarita Island, Venezuela. All US institutions involved in the core program, and all Venezuelan institutions involved or interested in the project participated in this meeting. The objectives were to evaluate our progress to date, determine whether we are on the right track in addressing our objectives and hypotheses, how we can improve our measurements, and where we are going with the future of the CARIACO Project. This meeting was very successful and will result in improving and extending the physical, biological, chemical, and geological aspects of the project. A list of action items has been assembled and distributed to participants.

FUTURE PLANS

During 2004-2005 we plan to continue the monthly CARIACO field program as described in our original proposal. We will increase the quality of our dissolved oxygen and nutrient measurements. We will implement measurements of dissolved organic carbon, dissolved organic nitrogen and dissolved organic phosphate into our regular monthly sampling scheme.

During the winter-spring upwelling event of 2005 we will conduct a spatially extensive cruise corresponding to the cruise made this past spring. With this cruise we will capture the extent of the upwelling plume as it enters and circulates through the basin. We will also describe the hydrography of the basin, both spatially and temporally, as well as the nutrient distribution. In 2004-2005 we will improve and extend our physical oceanographic measurements by integrating a lowered ADCP instrument into our monthly hydrographic casts, deploy an additional moored ADCP at the northern sill of the basin, and develop a local and regional model to understand the entrance and circulation of subsurface water into the basin.

During May 2005 we will carry out another CARIACO meeting, involving mainly the principal investigators of the project. The objective of this meeting is to discuss the achievements and status of the action items outlined in the All-hands CARIACO meeting of 2004.

Future plans also include a fourth extended cruise to better understand the transport of sediments into the basin by local rivers, and the connection between paleoceanographic data and local processes.

PAPERS, ABSTRACTS, and PRESENTATIONS

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