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 2005 – October 2006

(Cruises CAR 116 –)

Report updated 1 April, 2006

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SUMMARY

This project continues the time series of monthly observations at 10° 30' N, 64° 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). Additional cruises are conducted periodically to the station, at a frequency varying between bi-monthly and seasonally, to collect zooplankton samples in the upper 300 m for biomass and taxonomy estimates. The sediment trap mooring has five sediment traps (125, 225, 400, 800, and 1,255 m) 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 are conducted every two months for biomass and taxonomy estimates. 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 project has been collecting measurements in the Cariaco Basin (10° 30' N, 64° 40' W) since November 1995. The Cariaco Basin is located off the coast of Eastern Venezuela, and is a 1,400-m deep depression of tectonic origin. The basin is openly connected to the Caribbean Sea by two shallow (~140 m) sills, one to the north and one to the north-west (Figure 1). Time-series cruises to the Cariaco station are carried out monthly to collect a series of "core" observations. Additional cruises are conducted periodically, at a frequency varying between bi-monthly and seasonally, to collect zooplankton samples and perform 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).

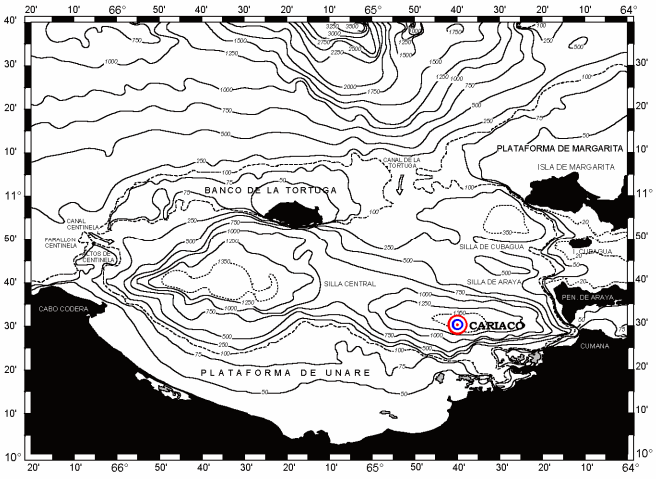

Figure 1: The Cariaco Basin. Location of the CARIACO time-series station is indicated (from Muller-Karger et al., 2001)

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://www.imars.usf.edu/CAR/index.html) 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	95	Dec/09/2003
63	Feb/16/2001	96	Jan/13/2004
64	Mar/14/2001	97	Feb/08/2004
65	Apr/04/2001	98	Mar/08/2004
66	May/05/2001	99	Apr/06/2004
67	May/11/2001	100	May/13/2004
68	Jul/09/2001	101	Jun/08/2004
69	Aug/06/2001	102	Jul/06/2004
70	Sep/11/2001	103	Aug/10/2004
71	Oct/08/2001	104	Sep/10/2004
72	Nov/05/2001	105	Oct/05/2004
73	Dec/11/2001	106	Nov/09/2004
74	Jan/11/2002	107	Dec/07/2004
75	Feb/16/2002	108	Jan/11/2005
76	Mar/14/2002	109	Feb/10/2005
77	Apr/04/2002	110	Mar/08/2005
78	May/05/2002	111	Apr/05/2005
79	Jun/12/2002	112	May/10/2005
80	Jul/09/2002	113	Jun/14/2005
81	Aug/06/2002	114	Jul/12/2005
82	Oct/03/2002	115	Aug/10/2005
83	Nov/07/2002	116	Oct/05/2005
84	Dec/05/2002	117	Dec/15/2005
85	Jan/14/2003	118	Jan/16/2006
86	Feb/11/2003	119	Feb/7/2006
87	Mar/11/2003	120	Mar/16/2006
88	Apr/08/2003		
89	May/13/2003		
90	Jun/10/2003		
91	Jul/08/2003		
92	Aug/04/2003		
93	Sep/09/2003		
94	Nov/11/2003		

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	SBE-25 (SeaBird)	1-120
Temperature	0-1310 m	SBE-25 (SeaBird)	1-120
Conductivity (Salinity)	0-1310 m	SBE-25 (SeaBird)	1-120
Dissolved Oxygen	0-1310 m	SBE-43 (SeaBird)	1-120
Fluorescence (Chl)	0-1310	Fluorometer	1-120
Beam attenuation (c660)	0-1310	C-Star (WetLabs)	1-120
2. Water Column Chemical Measurements			
Dissolved Oxygen	0-1310 m	Titration	1-120
DOC & TOC	0-1310 m	High Temp Comb	1-63; 110-120
Total Alkalinity	0-1310 m	Gran Titration	1-120
pH	0-1310 m	Spectrophotometer	1-120
Salinity	0-1310 m	Guildline Portasal 8410	1-120
Nitrate	0-1310 m	Autoanalyzer	1-120
Nitrite	0-1310 m	Autoanalyzer	1-120
Amonia	0-1310 m	Autoanalyzer	1-120
Phosphorus	0-1310 m	Autoanalyzer	1-120
Silicate	0-1310 m	Autoanalyzer	1-120
Diss. Org. Nitrogen	0-1310 m	Persulfate oxidation	102-120
Diss. Org. Phosphorous	0-1310 m	Persulfate oxidation	102-120
Partic. Organic Carbon	0-1310 m	High Temp Comb	1-120
Partic. Organic Nitrogen	0-1310 m	High Temp Comb	1-120
3. Biomass Measurements			
Chl. *a* and Phaeopig.	0-100 m	Flourometry	1-120
Bacteria	0-1310 m	(Various/SUNY)	(see SUNY report)
4. Carbon Assimilation and Particle Flux			
Primary Production	0-100 m	^{14}C	1-120
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	1-120
Upwelling Radiance and Downwelling Irradiance	0-150 m	PRR-600	1-99
6. Moored Instruments			
Sediment Traps	150, 275, 450, 900, 1200	(U. South Carolina)	(see USC report)
Acoustic Doppler Current Profiler (ADCP)	<200 m	ADCP (RDI)	1996-1998; 2002-2005
Lowered ADCP	1-1300 m	Sentinel 300 (RDI)	2005

Methods

During each monthly core cruise (Table 1), a set of key parameters is collected. Table 2 lists these parameters and general methods used. Because the methods have been described in detail by Muller-Karger et. al. (2001), and changes to those procedures were revised in the last NSF progress report, only new modifications and additions will be discussed here.

Dissolved organic nitrogen and phosphorous (DON and DOP)
As indicated in Table 2, DON and DOP sampling are being collected monthly as part of the core observations. Up to cruise #114, both DON and DOP were being analyzed using a persulfate oxidation method. Though this technique seems to work for DON, the combination of persulfate oxdation and ascorbic acid used in the analysis introduces new phosphorous to the solution, yielding an overestimation of DOP. Car117 DOP was analyzed using UV oxidation, which uses a mercury-vapor light source to oxidize total dissolved phosphorous into organic and inorganic species. Because the project measures dissolved inorganic phosphorous independently, dissolved organic phosphorus (DOP) can be estimated by difference (Armstrong et al., 1966).

To address the variability observed in the DON data, several tests were carried out in December 2005 to see whether by changing sampling techniques the results of the DON analysis could be improved (Dore et al., 1996; Karl and Björman, 2002). However, there was no significant difference between filtration techniques or bottle sampling, indicating the high variability observed in the dissolved nutrient results may reside in the analytical techniques. The handling, processing and analysis of DON introduces the observed variability to the data. Despite this, our standard deviation and reported DON concentrations fall within published values.

FINDINGS AND RESULTS

In September 2005, the CARIACO project lost the rosette and CTD ensemble when the winch cable broke during our regular monthly sampling cruise. A new CTD and rosette were purchased with the aid of the Office of Research and the College of Marine Science at USF.

While the rosette ensemble was being purchased, the core sampling continued using a smaller 2.5 lt. rosette and an SBE19 belonging to EDIMAR, our Venezuelan partners in CARIACO. The smaller rosette limited our water sampling capacity, but nutrients, pH and alkalinity were still measured, as well as discrete oxygen and salinity. Primary production and chlorophyll measurements were also carried out. The SBE19 provided CTD temperature and salinity, and one of the old YSI oxygen probes was attached to get continuous oxygen measurements. The new rosette, of 12L capacity, and CTD were assembled and tested in December 2005 and are fully functional. Figure 2 shows our temperature time series, spanning 10 years.

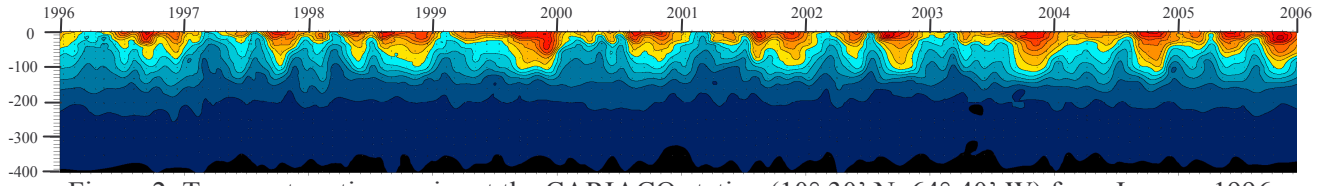

Figure 2: Temperature time series at the CARIACO station (10° 30’ N, 64° 40’ W) from January 1996 through December 2005.

DOC: DOC makes up one of the largest bioreactive pool of carbon, second only to the dissolved inorganic carbon (DIC) pool. DOC profiles usually exhibit net production at the surface and net consumption at depth; dissolved organic carbon concentrations usually peak as phytoplankton blooms decline (Hansell, 2002). While many upwelling sites may have higher DOC at the surface, caused by the surfacing of deeper, DOC-rich water, we don't observe this in the Cariaco Basin. Concentrations of surface DOC in the southern Caribbean Sea range from ~90 μM C in stations outside the basin, not influenced by the upwelling plume, to ~60 μM C near the Gulf of Santa Fe (Figure 3), the coldest upwelling focus (Figure 4).

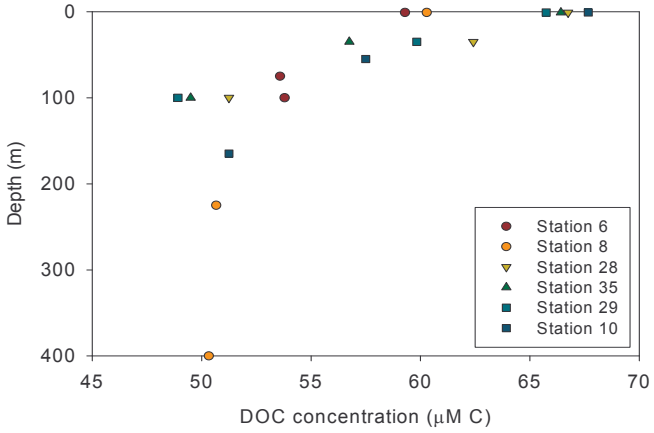

Figure 3: DOC distribution throughout the Eastern Cariaco Basin as measured during March 2004

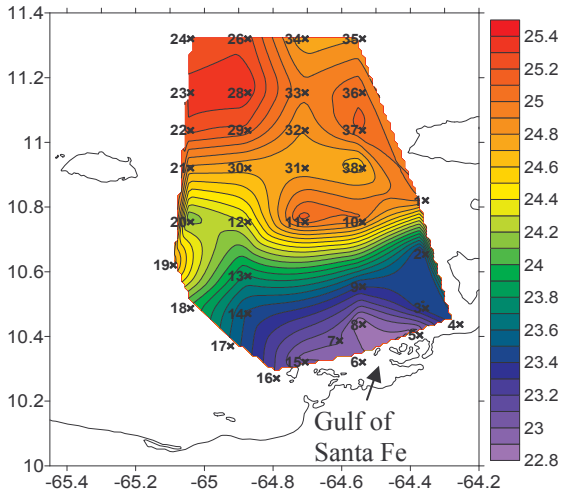

Figure 4: Temperature distribution in the Eastern Cariaco Basin during March 2004.

Indeed, in the Cariaco Basin there is a clear trend in surface DOC distribution, caused by the emergence of cold, nutrient rich waters; Station 6 in Figure 3 was located at the focus of the upwelling, where the lowest temperature and DOC values were recorded. Station 8 was close by (Figure 4). The correlation between sea surface temperature and DOC (r^2 = 0.87, Figure 5) reinforces this relationship and suggests that higher DOC concentrations are not associated with upwelled waters. Alvarez Salgado et al. (1999) observed a similar DOC surface distribution in waters off the coast of the Iberian Peninsula, and associated this pattern to wind relaxation and upwelling "spin down". Most of the DOC that upwells with the cold water near the Gulf of Santa Fe has been transported by the SUW. DOC concentration decreases exponentially with depth as it is easily remineralized (Figure 6). Surface DOC values measured at the CARIACO time-series

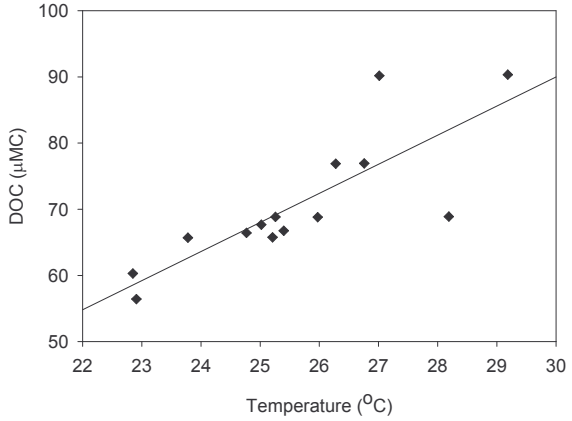

Figure 5: Temperature/DOC relationship in the Cariaco Basin.

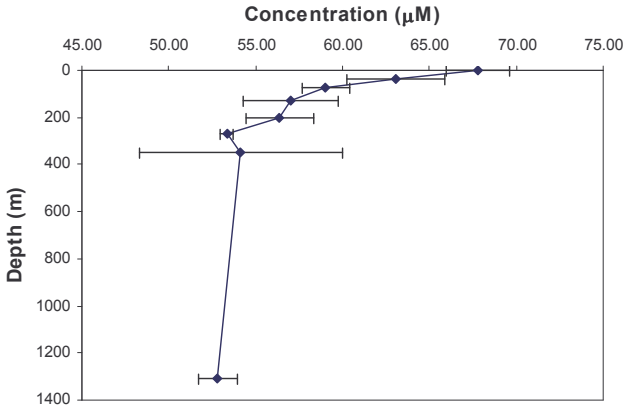

Figure 6: DOC distribution at the CARIACO time-series station.

station are similar to those found at the BATS time-series station (Hansell and Carlson, 2001), the Equatorial Pacific Ocean (Hansell et al., 1997) and the Arabian Sea (Hansell and Peltzer,

1998). However, deep (>200 m) DOC values are ~5-10 μM above concentrations measured at the locations mentioned above.

At the CARIACO time-series station, DOC exhibits seasonality in the upper water column, with lower DOC values measured during the upwelling season (~65 μM), and higher (~90 μM) concentrations observed during the rainy season. This seasonality also suggests that the surface DOC observed is composed mainly of highly labile carbon, whereas the carbon at mid-depth (above the interface) is biologically semi-labile (turnover scales of months to years). This is in part confirmed by $\Delta^{14}C$ data (unpublished). Higher DOC concentrations have been observed at the oxic-anoxic interface, suggesting microbial DOC production in this part of the water column. Mid-water maximum of DOC through time matches the location of the oxic-anoxic interface.

DON: Dissolved organic Nitrogen (DON) is an important component of the ocean dissolved organic matter (DOM) pool and a source of energy for organisms. DON is highest at the surface and decreases concentration with depth. About 60% of the total dissolved nitrogen (TDN) in surface waters is organic, whereas it becomes less than 10% in the deep ocean (Bronk, 2002). DON usually ranges between 0.8-13 μM (±2 μM) in surface waters, and has been observed to be highly variable, depending on non-point sources such as upwelling and river plumes.

DON in the Cariaco Basin decreases with depth, from ~6.8 μM N (±1.94; N = 14) to ~4.4 (±1.12; N = 14) (Figure 7). Okuda et al. (1969) estimated DON in the basin during the summers of 1965 and 1967. They found high (16-18 μM N) surface values which decreased with depth (~6 μM N at 1000 m). These values are higher than the ones currently observed in the Basin and the discrepancy could be attributed to different analytical methods. There is high variability in the DON measurements, but they falls within published values (Hansell, 1993; Hansell and Waterhouse, 1997; Hansell and Carlson, 2001). A consistent "bump" in DON has been observed at the interface, likely caused by microbial DON production (Bronk, 2002). The high variability observed at the surface can be attributed to phytoplankton production (Bronk, 2002). Most of the TDN observed in the surface waters of the Cariaco Basin during early 2005 was organic (~90%). This percentage decreases to ~15% at 1310 m.

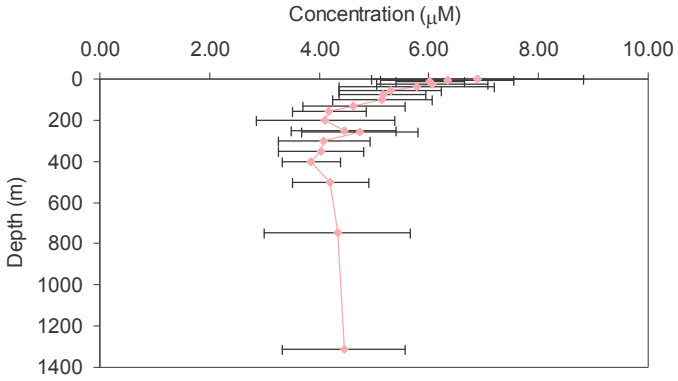

Figure 7: DON distribution at the CARIACO time-series station

Zooplankton and phytoplankton taxonomy: Anadiuska Rondon, a student of Marlon L. Lewis at Dalhousie/Oceanography, Halifax, Canada, has been studying phytoplankton composition and community structure in the Cariaco Basin using data collected at the time series station. This structure appears to be dominated by five major groups: diatoms, nanoflagellates, coccolithophorids, dinoflagellates and cyanobacteria. They identified upwelling induced by the seasonal trade winds and geostrophic circulation as the main factors responsible for the

variability in phytoplankton species composition and community structure. Presence, abundance, and dominance of each group in the community vary with incidence of upwelling and upwelling relaxation processes.

Phytoplankton taxonomy data are currently being analyzed by Luis Troccoli of the Universidad de Oriente in Margarita Island. A new graduate student working under Eduardo Klein (Universidad Simon Bolivar) will also begin to study phytoplankton taxonomy and distribution collected in the spatial cruises and correlating it to temperature and nutrient data with the objective of further understanding the factors controlling spatial phytoplankton distribution in the Cariaco Basin.

Zooplankton taxonomy has been collected in the Basin since October 2001 and analyzed jointly between Javier Gutierrez of EDIMAR and Dr. Kendra Daly at USF. The zooplankton CARIACO collects comes from both the oxic and the anoxic portion of the basin (from the surface to 140 m and between 250 m – 350 m depth, respectively). Half of the oxic samples are taken with a 500 µm mesh bongo net, while the other half with a 200 µm mesh bongo net. Anoxic samples are taken using a 500 µm opening-closing net. Based on preliminary analyses, zooplankton abundance increases during spring after the upwelling period, with a second maxima occurring mid to late autumn. The spring increase in zooplankton is related to the upwelling-driven increase in primary production. The underlying mechanism supporting the autumn increase in zooplankton abundance is unknown at this time. Copepods have been observed as the dominant organisms during all seasons in the near-surface samples.

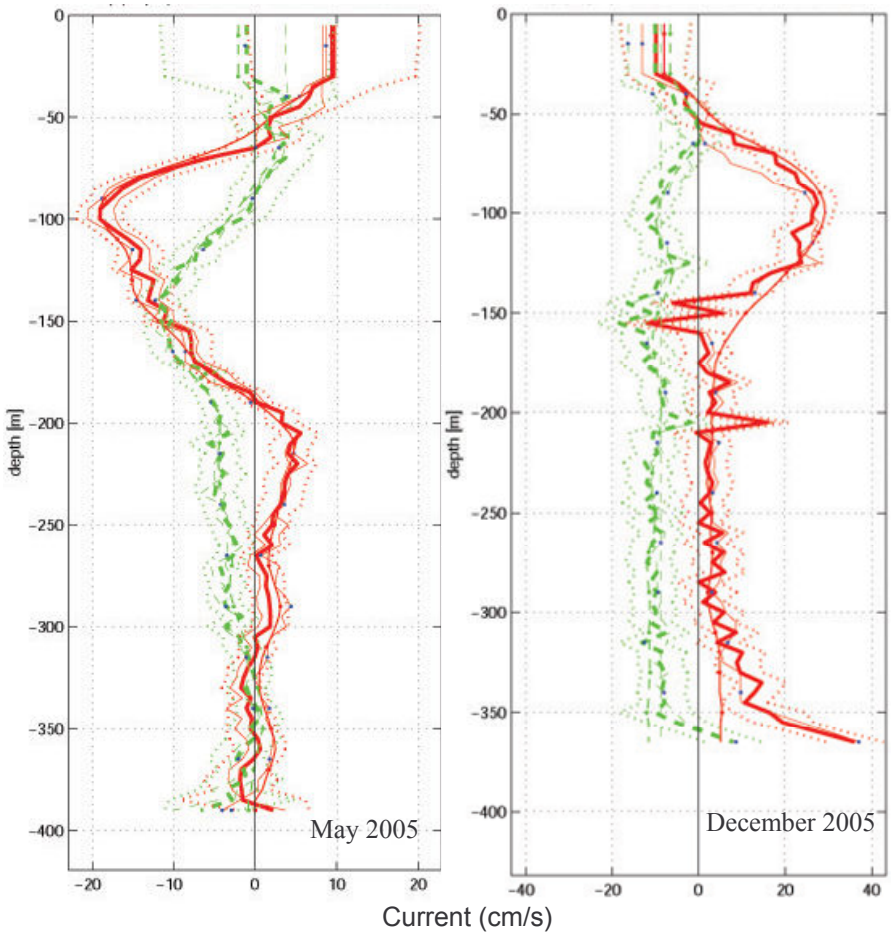

Figure 8: LADCP current measurements for May 2005 and December 2005. Red line corresponds to the *u* component; green line corresponds to the *v* component. Data for December 2005 below 350m is invalid. Data processed using the LDEO LADCP software, v. 8b (April 2004).

<u>Current meter data:</u> Lowered ADCP (LADCP) data is collected irregularly during the time-series

cruises. The time it takes to profile the Basin depends on the local currents, and sometimes currents are too strong to deploy the current meter. However, we have collected several profiles and some features stand out, features that have also been observed in the long-term deployments of the moored ADCP's. One such feature is a strong current at 100 m. This current has been observed both during the rainy season and during the upwelling season (Figure 8). The direction and intensity of the current varies seasonally, but is always present. During the upwelling season the 100m current can reach 30 cm/s; these values are similar to the ones observed in the moored ADCP (Figure 9).

The moored current meter data (processed by Dr. Weisberg's group) shows signals in the vertical velocity and echo amplitude files. These results will be presented at the CARIACO All-Hands meeting scheduled for May 17th, 2006. Dr. Weisberg's group has been working on numerical modeling, satellite analyses, climatology, and ADCP data analyses for the Cariaco Basin. They have nested a regional ROMS model in the 1/12th degree North Atlantic HYCOM for the Cariaco region and are currently analyzing preliminary runs. These results should provide a context in which to diagnose the years of currents and how these relate to the larger scale basin circulation and its interactions with the adjacent Caribbean Sea. They also have continued to update satellite SSH and geostrophic currents analyses for the Intra-America Seas (IAS) and have analyzed altimetry data from 1992-present. All of the climatological T/S data will be put in a convenient web based atlas accessible to the public. Moored current data is already available through their web portal (http://ocgweb.marine.usf.edu/)

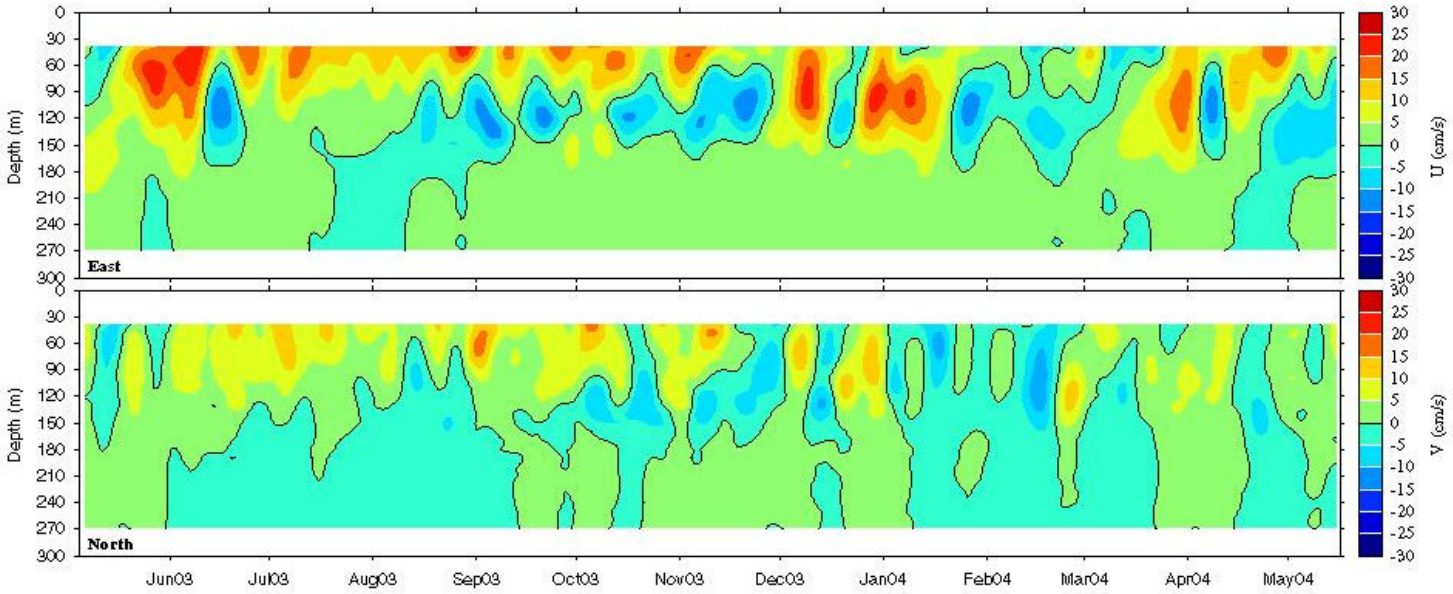

Figure 9: Contours of east (*u*) and north (*v*) components of velocity measured at the CARIACO station during 2003-2004. Data used for these plots have been 10-day low-pass filtered. Data processed by the OGC group, USF.

ALL HANDS MEETING

Our annual All-Hands meeting will be held May 17th, 2006 at EDIMAR in Margarita Island. The principal investigators will be present, as well as out counterparts of the Venezuelan-funded Cariaco Project. This exchange is essential for maintaining a good will, open communication and to introduce new ideas of research for the time-series project.

A meeting with the BATS investigators is also being planned for August 2006. This meeting has the objective to bring closer the two time-series, as well as to completely revise the methodology employed in the CARIACO project.

FUTURE PLANS

We have just concluded the first 2006 extended cruise, which focused on the Western side of the Cariaco Basin, a side virtually unexplored for almost two decades. The cruise was a joint effort between the CARIACO project and Boston University's student Nahysa Martinez. Martinez is a Ph.D. candidate under Dr. Rick Murray who's work focuses on discerning the sources of sediment that feed the Eastern Basin, where the time-series collects data and CARIACO's sediment traps are located. Martinez collected sediments from the mouths of the major rivers of the Western Basin and hopes to find elemental tracers she can tie to the sediments captured in the sediment traps. We also measured basic hydrography, as well as fugacity, DOC, chlorophyll and phytoplankton taxonomy. Beam attenuation was also gathered near the coast to understand how bottom nepheloid layers are contributing to the sediment transport from the coast to the deep. A second extended cruise will be carried out in September 2006 to the Eastern part of the basin, in a similar fashion as the one conducted in September 2003 and March 2004 (refer to 2004 and 2005 annual reports for more information on the extended cruises of 2003 and 2004). The objective of this cruise is to collect current data using the LADCP, in order to shed more light to the internal circulation of the basin and how it compares to processes occurring in the open Caribbean Sea. LADCP measurements will also be compared with dynamic height data to evaluate how reliable LADCP data are of general circulation of the Basin. Other objectives are also to measure DOC and fugacity in order to be able to spatially understand this side of the basin in both the rainy and the upwelling season, and to evaluate how representative the CARIACO time-series station is of the rest of the basin. We will also measure other variables similar to March 2004 in order to compare seasonal/yearly differences in CDOM and BNL distribution.

BUDGET REQUEST

We request NSF support as per our original budget request.

EDUCATION AND OUTREACH

In 2006 a new Venezuelan graduate student (Enrique Montes Herrera) will join the CARIACO project, supported by a Fulbright fellowship. CARIACO also recently supported an internship at USF for MSc. Adriana Giuliante, a researcher from the Instituto Venezolano de Investigaciones Cientificas (IVIC). MSc. Giuliante specializes in nutrient analysis and is assembling at IVIC, together with Dr. Tibisay Perez, a laboratory where nutrient analysis can be carried out for the project. MSc. Giuliante was trained in Dr. Fanning's lab at USF, under the supervision of Drs. Rob Masserini and Yulia Serebrennikova, to complete both inorganic and organic nutrient

analyses, and assisted Fanning's lab in several tests and establishing analysis protocols for the measurements of DON and DOP for the project.
So far, five Venezuelan graduate students (A. Odriozola, J. R. Diaz, J. Gomez, D. Rueda and L. Lorenzoni), and one undergraduate student (J. Akl) have studied in the U.S. with full or partial support from this project. Others are studying under co-I support and advice. Odriozola, Akl and Lorenzoni also served as technicians for the CARIACO program. Five undergraduate students at Fundación La Salle, two undergraduates at Universidad Simón Bolívar, two undergraduates at the Universidad Central de Venezuela, and two undergraduate and two graduate students at the Universidad de Oriente have participated in data collection and recently derived theses from this work under direction of FMK. Below is a list of the projects' academic contributions.

Doctoral Dissertations (Ph. D.)

- Maria Iabichella-Armas (in progress) Title: Measurements on the production and microbial abundance, their relationship with processes that occur in the surface and vertical transport to suboxic layers in the Cariaco Basin. Advisor: Dr. Gordon Taylor. (State University of New York).
- Matthew K. Reuer (in progress) Title: The Trace Element Geochemistry of Surface Corals and planktonic foraminifera: Decadal-to Millennial-Scale Variability of the Tropical North Atlantic. Advisor: Edward A. Boyle (Massachusetts Institute of Technology). Status: In progress.
- Jose Rafael Diaz (in progress) Title: Phytoplankton composition and colored particulate matter and their influence on remote sensing data. Advisor: Frank Muller-Karger (University of South Florida). Status: In progress.
- Kessler, J. D., 2005. Title: Studies on Oceanic Methane: Concentrations, Stable Isotope Ratios (δ^2H-CH_4, δ^{13}C-CH_4), and Natural Radiocarbon Measurements (^{14}C-CH_4). Ph.D. Dissertation, 199 pp. Advisor: Professor William S. Reeburgh. University of California Irvine.
- Tung-Yuan, Ho. 2000. Title: Acetate cycling and redox zonation in the water column of the Cariaco Basin: Seasonal and vertical variability and implication for carbon cycling. Advisor: Mary Scranton (State University of New York)
- Tedesco, K, 2002. Title: Development of Paleoenvironmental Proxies and Their Application to the Holocene Climate Record of the Cariaco Basin, Venezuela., Ph.D. Dissertation, 199 pp. Advisor: Robert Thunell University of South Carolina, Columbia

Masters Theses

- Anadiuska N. Rondon. (in progress). Title: Seasonal Variability in Phytoplankton Species Composition in the Cariaco Basin, Venezuela. Dalhousie University, Canada. Status: In progress
- Lorenzoni, L. 2005. The Influence Of Local Rivers On The Eastern Cariaco Basin, Venezuela. University of South Florida.
- Hayes, M.K. 2004. Title: Vertical distributions of thiosulfate and sulfite in the Cariaco Basin. Stony Brook University.
- Marquez, Aristides. 2004. Title: Fluctuaciones temporales del perfil hidroquimico de la Cuenca de Cariaco (periodo Enero 2002-septiembre 2003). Universidad de Oriente, Cumaná, Venezuela.
- Li Li. 2002. Distribution and cycling of some low molecular weight fatty acids through the Cariaco Basin water column. Stony Brook University.
- Madrid, V. 2000. Title: Characterization of the bacterial communities in the anoxic zone of the Cariaco basin. Stony Brook University.
- Vilma Velásquez. 2000. Title: Estructura Termohalina de la Fosa de Cariaco (Noviembre/1995-Septiembre /1998). Universidad de Oriente, , Cumaná, Venezuela.
- Digna Rueda. 2000. Title: Distribución de la Biomasa fitoplanctonica en la fosa Cariaco y sus relaciones con los aspectos hidrográfico. Universidad de Oriente, Cumaná, Venezuela.

Undergraduate Theses

- Myerelys Peñuela. (in progress). Title: Variación de la biomasa y de la composición de zooplancton el la estación CARIACO. Advisor: B. Marín. Universidad de Oriente, , Cumaná, Venezuela

- Espinoza, Virginia. 2004. Title: Distribucion vertical de la biomasa fitoplanctonica por fraccion de talla en la Fosa de Cariaco, desde abril del 2002 hasta junio del 2003. Advisor: Troccoli Luis. Universidad de Oriente, , Cumaná, Venezuela.

Technical Institute Theses

- Guzman, Laurencia, 2004. Title: Factores que regulan la distribución temporal de la biomasa y la producción primaria en la estación Cariaco en el periodo Diciembre 1998-2003. Advisor: Ramón Varela. IUTEMAR.
- Rojas, Jamie, 2004. Title: Características de la surgencia en la Fosa de Cariaco entre Septiembre 1996 y Diciembre 2002 Advisor: Yrene Astor. IUTEMAR
- Salas, Vladimir, 2000. Title: Procesamiento de datos de los batitermografos desechables (XBT) del Proyecto CARIACO (03/1999 – 13/2000). Advisor: Yrene Astor. IUTEMAR.
- Tarazona, Ghersi, 1999. Title: El color del mar y su relación con la clorofila, la fluorescencia y la productividad primaria. Advisor: Ramon Varela (IUTEMAR).
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- Lombardi, Franco 1998. Title: Estructuras biogenicas colectadas en trampas de sedimentos en la Fosa de Cariaco. Advisor:Martín LLano. IUTEMAR.
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- Arias, Glenda. 1997. Title: Evaluación de la calidad de los análisis de pH y alcalinidad del Proyecto Cariaco. Advisor: Yrene Astor. IUTEMAR.
- Castellanos, Paola. 1997. Title: Distribución espacio-temporal de la temperatura superficial del mar en la región sur del Mar Caribe (Observaciones con el AVHRR). Advisor: Ramón Varela. IUTEMAR.

High School projects

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- Carly Gomes. 1999. Title: Dynamics of flagellated protozoan populations in the Cariaco Basin. Sachem High School. Advisor: Gordon Taylor.
- Christopher Hein. 1999. Title: Vertical distribution of viral particles in the Cariaco Basin. Commack High School. Advisor: Gordon Taylor.

PRESENTATIONS

CARIACO project results are presented yearly at several national and international meetings. Below is a list of 2005-2006 CARIACO-related work presented at such meetings.

2006

- Lin, X., G. Taylor, M. I. Scranton and R. Varela. Impacts of Grazing and Anoxia on Bacterial Taxon Richness and Activity in the Cariaco Basin's Redoxcline. Ocean Sciences Meeting, February 20-24, Honolulu, Hawaii.
- Lyons, G., R. M. Styles, C. Benitez-Nelson, R. Thunell and L. Lorenzoni. Composition of Riverine Derived Particulate Phosphorus in the Cariaco Basin, Venezuela. Ocean Sciences Meeting, February 20-24, Honolulu, Hawaii.
- Percy, D., Y. Astor and M. I. Scranton. Spatial Investigations of Geochemical Variability in the Cariaco Basin. Ocean Sciences Meeting, February 20-24, Honolulu, Hawaii.
- Scranton, M., K. Fanning, D. Percy, R. Bohrer and Y. Astor. Long Term Trends in the Cariaco Basin. Ocean Sciences Meeting, February 20-24, Honolulu, Hawaii.
- Taylor, G., X. Lin, M. Iabichella-Armas, S. Epstein, A. Chistoserdov and M. I. Scranton. Glimpses into the Black Box: Lessons from a Decade's Microbiogeochemical Exploration of the Cariaco's Redoxcline. Ocean Sciences Meeting, February 20-24, Honolulu, Hawaii.
- Thunell, R., C. Benitez-Nelson, F. Muller-Karger, L. Lorenzoni, R. Varela and Y. Astor. Particulate Organic Carbon Cycling in an Upwelling Dominated Continental Margin: Results from the Cariaco Basin Ocean Time Series. Ocean Sciences Meeting, February 20-24, Honolulu, Hawaii.
- Woodworth, M. P., R. Thunell, M. Goni and T. Guilderson. Radiocarbon Measurements of Bulk Organic Carbon in Sinking Particles from the Cariaco Basin. Ocean Sciences Meeting, February 20-24, Honolulu, Hawaii.

2005

- Chollett, I., C. Castillo and E. Klein Estimación del área de surgencia costera del oriente de Venezuela. 1ras Jornadas Nacionales de Geomática. September 24-27, Caracas, Venezuela.
- Chollett, I., E. Klein and C. Castillo. Estimación del área de surgencia de la región oriental de Venezuela. Congreso Venezolano de Ecología, November 8-11**,** Maracaibo, Venezuela.
- Guzman Pocaterra, L. and R. Varela. Factores que regulan la distribución de la biomasa y la producción primaria en la estación Cariaco. Congreso Venezolano de Ecología, November 8-11**,** Maracaibo, Venezuela.
- Klein, E, C. Castillo, I. Chollett and M. Lurgi. CARIACO: un sistema Web para el análisis de datos oceanográficos obtenidos de sensores remotos. 1ras Jornadas Nacionales de Geomática, September 24-27, Caracas, Venezuela.
- Percy, D.F., G.T. Taylor, Y. Astor and M. I. Scranton. Spatial Investigations of Geochemical Variability in the Cariaco Basin. Gordon Conference, August 7-12, 2005, Tilton School. Tilton, New Hampshire.
- Rojas, J. and Y. Astor. Características de la surgencia en la Fosa de Cariaco. Congreso Venezolano de Ecología, November 8-11**,** Maracaibo, Venezuela.
- Rondón, A. N., M. R. Lewis, F. E. Müller-Karger, R. Varela and L. Trocolli. Seasonal variability in phytoplankton species composition in the Cariaco Basin, Venezuela. ASLO 2005 Summer Meeting, Santiago de Compostela, Spain, June 19-24.
- Scranton, M.I., G. Taylor, M. Iabichella-Armas, X. Lin, D. Percy and Y Astor. Relación entre geoquímica y microbiología en las Aguas de la Fosa de Cariaco, Venezuela.. Congreso Venezolano de Ecología, November 8-11**,** Maracaibo, Venezuela.
- Scranton, M.I., Y. Astor and K. Fanning. Remineralization pathways in the Cariaco Basin. Gordon Conference, August 7-12, 2005, Tilton School. Tilton, New Hampshire.
- Stavrinaky, A., P. Spiniello and R. Varela. Efecto del microzooplancton sobre el fitoplancton en una zona de surgencia costera como la Fosa de Cariaco. Congreso Venezolano de Ecología, November 8-11**,** Maracaibo, Venezuela.

- Taylor, G. T., M. Iabichella-Armas, R. Thunell, R. Varela and Y Astor. Hydrolytic ectoenzyme activity associated with suspended and sinking organic particles in the anoxic Cariaco Basin. ASLO 2005 Summer Meeting, Santiago de Compostela, Spain, June 19-24.
- Varela, R. and J. Gutierrez. Estudios ecológicos a largo plazo en el medio marino costero, proyectos CARICOMP y CARIACO. Congreso Venezolano de Ecología, November 8-11**,** Maracaibo, Venezuela.
- Varela, R., L. Gúzman and F. E. Müller-Karger. The primary production cicle at the Cariaco time-series station, 1998-2003. ASLO 2005 Summer Meeting, Santiago de Compostela, Spain, June 19-24.
- Woodworth, M., R. Thunell, M. A. Goñi, and T. P. Guilderson. Radiocarbon Measurements of Bulk Organic Carbon in Sinking Particles from the Cariaco Basin. The 10th International Conference on Accelerator Mass Spectrometry, September 5-10, Berkeley, CA.

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Submitted

- Black, D., Thunell, R. and others. Seasonal sea surface temperature variability in the tropics, 1165-1990 A.D.: High-resolution stable isotope records from the Cariaco Basin, Venezuela. Nature
- G.T. Taylor, M. Iabichella-Armas, R. Varela, Y. Astor and M. I. Scranton. Hydrolytic Ectoenzyme Activity Associated with Suspended and Sinking Organic Particles Above and Within the Anoxic Cariaco Basin. Deep-Sea Research or J. of Marine Research
- Kessler, J. D., W. S. Reeburgh and S. C. Tyler. Controls on Water Column Methane Concentration and Stable Isotope (δ^2H-CH_4 and δ^{13}C-CH_4) Distributions in the Black Sea and Cariaco Basin. Global Biogeochemical Cycles: Submitted.
- Lin, X., S.G. Wakeham, I.F. Putnam, Y.M.Astor, M. I.Scranton, A.Y. Chistoserdov and G.T. Taylor. Vertical distributions of prokaryotic assemblages in the anoxic Cariaco Basin and Black Sea compared using fluorescence in situ hybridization (FISH). Applied and Environmental Microbiology.
- Lorenzoni, L., C. Hu, F. Muller-Karger, Y. Astor and R. Varela. Influence of rivers on the distribution of particulate and dissolved matter in the Eastern Cariaco Basin, Venezuela. Limnology and Oceanography.
- Martinez, N., R.V. Murray, R. Thunell, L.C. Peterson, F. Muller-Karger, Y. Astor and R. Varela. Modern Climate Forcing of Terrigenous Deposition in the Tropics (Cariaco Basin, Venezuela). Science.
- Muller-Karger, F., R. Varela, R.C. Thunnell, M.I. Scranton, G.T. Taylor, Y. Astor, E. Tappa, M.A. Goñi, R. N. Sambrotto, H. Zhang, B. Marín, Ch. Hu, and R. H. Weisberg. CARIACO: a Time Series of primary production and vertical export in the Cariaco Basin. Chapter of JGOFS Continental Margins Task Team Synthesis book, edited by K.K.Liu and L. Atkinson.
- Woodworth, M., Goñi,M.A., E. Tappa, K. Tedesco, R. Thunnell, Y. Astor, R. Varela, R.W. Murray, J.R. Díaz-Ramos and F. Muller-Karger. Seasonal succession of carbon fixation mechanisms by marine phytoplankton. Geophysical Research Letters
- Woodworth, M., M. Goñi, E. Tappa, K. Tedesco, R. Thunell, Y. Astor, R. Varela, R. Murray, Muller-Karger F. Variable Carbon Fixation Mechanisms by Marine Phytoplankton. Nature.

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