The CARIACO Ocean Time-Series: two decades of biogeochemistry and ecological research to understand ocean and climate variability

F. Muller-Karger, L. Lorenzoni, E. Montes, C. Benitez-Nelson, M. Scranton, G. Taylor, R. Thunell, R. Varela, Y. Astor, and many, many others
The CARIACO Ocean Time-Series

• 1995-present

• The Cariaco Basin: large tectonic depression located on the continental shelf off E. Venezuela

• Strong seasonality:
  – ITCZ migration leads to:
  – Dry, upwelling conditions / Dec-May
  – Rainy, reduced upwelling / Aug-Nov

• Restricted circulation and high primary production (>400 gC/m²/y)
  ➔ anoxic below ~250m

Goñi et al., 2009

http://imars.marine.usf.edu/cariaco
The CARIACO Ocean Time-Series

Sediment at bottom of Cariaco Basin is ‘varved’: composition and quantity changes under varying ocean surface conditions (>600,000 year record)

- Important implications for the paleoclimate record (light/dark laminae)
The CARIACO Ocean Time-Series

Coccolithophores in sediment shows dilution of $^{13}$C isotope due to anthropogenic fossil fuel combustion since 1800’s

Black et al., 2011
The CARIACO Ocean Time-Series: Objectives

• Understand the variability in the composition and quantity of settling particles related to
  – Ecology
  – Ocean chemistry
  – Terrigenous inputs
  – Hydrography

• Identify links between local ecosystem changes and regional/global climate processes.

• Deconvolve bacterial production and carbon decomposition across the oxic-anoxic interface
The CARIACO Ocean Time-Series: Measurements

Satellite data products

Time series + Community facility (>100 collaborators)

The Cariaco Basin

http://imars.marine.usf.edu/cariaco
CARIACO cruises and data policy

Since Nov 1995:
222 core cruises (September 2015)
39 sediment trap and current meter recovery-redeployment cruises
29 biogeochemical and microbial process cruises
6 regional cruises

Policy for open and public sharing of samples, data, and information

CARIACO Methods Manual
(Spanish and English)

http://cariaco.ws (Spanish)

http://www.bco-dmo.org/project/2047

http://imars.marine.usf.edu/cariaco (English)
Publications

113 peer reviewed publications through 09/2015

CARIACO as a community platform

>100 scientists from around the world have participated or received data/samples from the CARIACO program

>60 students have been supported under CARIACO or have worked directly with it
The CARIACO Ocean Time-Series: insights from 20 years of measurements

- Sea surface temperature increased ~1 °C since 1995.
- Net Primary Production has decreased ~20%
- Ecosystem shift: from larger to smaller phytoplankton cells; increase in zooplankton biomass.
- Change in the Trade Winds and upwelling intensity

From Taylor et al., 2012
The CARIACO Ocean Time-Series: insights from 20 years of measurements

- Tropical western North Atlantic has also warmed; CARIACO is representative of SST and Chl changes in the Tropical Atlantic.
- Southern Caribbean change of ~0.5 C per decade because of diminished upwelling
The CARIACO Ocean Time-Series: insights from 20 years of measurements

- Circulation and ventilation of Cariaco Basin impacted by eddies.
- Decrease in ventilation of anoxic waters since 2004.
- Decrease in intrusions of denser Caribbean water caused decreasing density (dominance of vertical mixing)

From Scranton et al., 2014)
CARIACO: where are we now?

- Documents physical and ecosystem changes over the past 20 years.

- Provides records of net primary production (NPP) variability and export fluxes in a tropical, upwelling-dominated continental margin.

- CARIACO captures changes that occur at larger spatial scales (e.g. tropical North Atlantic)

- Data are open and free [http://imars.marine.usf.edu/cariaco](http://imars.marine.usf.edu/cariaco)
CARIACO: where are we going?

• High temporal resolution, long-term measurements, needed to quantify relationships between carbon production, export, and seasonal to climate-scale change.

• Understanding the relationship between physical drivers and biogeochemistry at CARIACO is important for reconstructing past ocean and climate conditions using the basin’s sediment record.