

CARICOOS-OCEAN ACIDIFICATION MONITORING PROGRAM

Sustained monitoring of near-reef carbonate chemistry at the Atlantic Ocean Acidification NCRMP Class III Station, La Parguera, Puerto Rico

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Performance Period: Jun 1 – Nov 31, 2018

LONG-TERM GOALS

A principal CARICOOS mission is to understand and predict changes in our ocean and coasts and inform decision makers in the US Caribbean region. Ocean acidification (OA) represents one such change unfolding in direct response to increasing atmospheric carbon dioxide (CO₂) concentrations. This project works to improve our understanding of how OA impacts the coral reef ecosystem and the biogeochemical process controlling the near-reef carbonate dynamics. This is achieved using high-temporal resolution chemical monitoring, which aids NOAA's Coral Reef Monitoring Program efforts to establish baselines and track changes in both carbonate chemistry and associated ecological impacts of OA. Furthermore, this effort supports NOAA's progress towards achieving a holistic understanding of the Earth system, identified as a core objective of NOAA's Science and Technology Enterprise.

MILESTONES / OBJECTIVES

1. Provide information about the existing and foreseeable carbon chemistry conditions to help mitigate the causes and effects of OA and support adaptation to ecosystem changes.
2. Continued the bimonthly (formerly bi-weekly) discrete sampling for carbonate chemistry at selected sites along the offshore to nearshore gradient in La Parguera Marine Reserve (LPMR). Data is used for validating automated collection by the MapCO₂ buoy and assessing the role of near-shore ecosystems in the local carbonate chemistry.
3. Provide operational maintenance to the MapCO₂ buoy and support data management and product dissemination.
4. Quality assurance, synthesis, and reporting of acquired data.
5. Provide yearly maintenance of the MapCO₂ buoy.
6. Continue progress on Ph.D. studies for Melendez under Salisbury's supervision.

WORK COMPLETED

- The field cruises and laboratory analyses were successfully completed. These include, 12 cruises to collect surface water samples and CTD profiles. The pH and TA laboratory analyses

are currently being analyzed. Around 50 DICs samples have been analyzed at UNH.

- The discrete data set is archived on the National Centers for Environmental Information (NCEI) at <http://www.nodc.noaa.gov/oceanacidification/data/0145164.xml>
- We replaced the SBE and Sami pH between September and November 2018.
- We will continue with the periodic issuance of data management and product dissemination. Work in progress is a further improvement of the CARICOOS data portal. The MapCO₂ data is retrieved and transmitted through the:
 1. IOOS Pacific Region Ocean Acidification (IPACOA) data portal: http://www.ipacoa.org/Explorer?action=oiw:fixed_platform:PMELCO2_laparguera:observations:A1_CO2Air
 2. Global Ocean Acidification Observing Network: <http://portal.goa-on.org/Explorer>
 3. Pacific Marine Environmental Laboratories (PMEL): <http://www.pmel.noaa.gov/co2/story/La+Parguera>

MAJOR OUTCOMES

- The manuscript entitled “Seasonal Net Ecosystem Metabolism of the Near-Shore Reef System in La Parguera, Puerto Rico” was submitted to a peer-review process for the journal of *Biogeosciences* and provide the first long-term monitoring of ecosystem metabolism and ocean acidification using time series observations in a coral reef system. The paper is currently undergoing review and is available to read online here: <https://www.biogeosciences-discuss.net/bg-2018-408/>
- We have synthesized and modeled the biological and physical processes of nine years (2009 – 2017) of data collected by the buoy in Enrique. The results indicated that temperature and biological activity are the main drivers of the seawater CO₂ changes, with physical processes having minor impacts on the carbonate chemistry. It also suggested that the site is experiencing prolonged periods (> 50 % of the seasonal year) of carbonate loss. Based on these results, the capacity of calcifying organisms to adapt from other climate-scale stressors including rising sea surface temperatures and coral bleaching are likely to be compromised.
- We expect to provide valuable indexes to monitor anthropogenic and ecosystem processes using real-time data from fixed stations. These can be used by coastal managers or industry leaders to develop the early warning capabilities needed to identify processes involved in supporting or degrading the ecosystem health. Also, it can be used to predict ecological changes that may occur as a result of OA and other environmental changes (e.g., warming and sea level rise).

RELATED PROJECTS

- The Sea Grant magazine *Marejada* featured on November 2018 the ocean acidification studies conducted at the buoy site and the Sea Grant Project entitled “Natural Coastal Barriers at Risk: A First Assessment of Biogeochemical and Physical Stressors.”
- NOAA OAP/IOOS 2015 – 2018 - Tracking Ocean Alkalinity using New Carbon Measurement Technologies (TAACT). PI: Joe Salisbury Co-PIs: Steffen Aßmann, Peer Fietzek, Carsten Frank, Jonathan Hare, William Mook, Ru Morrison, Douglas Vandemark, Christopher W. Hunt, Rik Wanninkhof
- Julio Morell, Melissa Meléndez and Joe Salisbury are part of the Puerto Rico Climate Change Council (PRCCC). We are working on the State of the Climate 2014-2017, based on the previous PRCCC publication, State of the Climate 2010-2013.
- Meléndez and Morell contributed to the U.S. Fourth National Climate Assessment, Caribbean chapter.

WORK PLAN FOR UPCOMING PERFORMANCE PERIOD (June. 1 – Nov. 30 2018)

- Continue the collaborative effort with the UNH to maintain and enhance OA observational capabilities (i.e., provide analytical support for DIC and TA determinations).
- The yearly operations and maintenance of the MapCO₂ buoy are scheduled for March 2019.
- Continue collaborating in data management and product dissemination. Work in progress includes the further improvement of the CARICOOS data portal to provide a seasonal estimate of calcification, production/respiration. We think this could offer a valuable tool to managers offering a useful objective metric with regards to the health of the system. For example, were they to reduce nutrient loading we should be able to detect changes in the P/R ratio of the reef system over time reflecting reductions in net respiration? Also, should restoration efforts out-plant extra coral cover, we should be able to detect this in the calcification signal over-time offering measurable feedback to coastal reef managers.
- Continue collaborations with the UPR-Mayaguez Engineering School in the observation of hydrodynamic processes in LPMR and support modeling efforts.
- Salisbury and Meléndez participate in the Global Ocean Acidification (OA) Observing Network Pier2Peer program, where they provide professional support to five African scientists. As part of this network, The Ocean Foundation recently invited Melendez to serve as a lecturer and trainer for the Latin America and the Caribbean Interdisciplinary Ocean Acidification Symposium and Advance Training scheduled to occur in Jan 2019. This visit expects to provide the stakeholders (policy and industry leaders) from Latin American and Caribbean the monitoring tools available as part of CARICOOS network. It will also deliver an overview of groups and International mechanisms to address OA and the methods of monitoring chemistry. We expect to learn models for partnerships between researchers, industry, and NGOs and strength our regional collaborations.
- As part of the education and outreach participation, we propose continued training of CARICOOS interns in basic oceanography techniques, pH and TA analyses, autonomous instrumentation, and current OA issues. In addition, included will be a poster and talk presentations to the CARICOOS Annual General Assembly and the 2019 ASLO meeting.

Also, dissemination of educational information through the CARICOOS webpage, local news articles and local press, and participation in the Marine Science Day and UPRM-Department of Marine Science yearly open house.

PUBLICATIONS & PRODUCTS

PUBLICATIONS

1. **Meléndez**, M., Salisbury, J., Gledhill, D., Langdon, C., Morell, J. M., Manzello, D., Musielewicz, S., and Sutton, A.: Seasonal Net Ecosystem Metabolism of the Near-Shore Reef System in La Parguera, Puerto Rico, *Biogeosciences Discuss.*, <https://doi.org/10.5194/bg-2018-408>, in review, 2018.
2. Sutton, A. J., **et al.** Autonomous seawater $p\text{CO}_2$ and pH time series from 40 surface buoys and the emergence of anthropogenic trends, *Earth Syst. Sci. Data Discuss.*, <https://doi.org/10.5194/essd-2018-114>, in review, 2018.
3. Cyronak, T., **et al.** Taking the metabolic pulse of the world's coral reefs. *PloS one*, 13(1), e0190872. <https://doi.org/10.1371/journal.pone.0190872>, 2018.
4. Gould, W.A., E.L. Díaz, (co-leads), N.L. Álvarez-Berrios, F. Aponte-González, W. Archibald, J.H. Bowden, L. Carrubba, W. Crespo, S.J. Fain, G. González, A. Goulbourne, E. Harmsen, E. Holupchinski, A.H. Khalyani, J. Kossin, A.J. Leinberger, V.I. Marrero-Santiago, O. Martínez-Sánchez, K. McGinley, P. Méndez-Lázaro, **J. Morell**, **M. Meléndez**, I.K. Parés-Ramos, R. Pulwarty, W.V. Sweet, A. Terando, and S. Torres-González, 2018: U.S. Caribbean. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, doi: 10.7930/NCA4.2018.CH20
5. Puerto Rico's State of the Climate 2014-2017 Report. Puerto Rico Climate Change Council, Puerto Rico Department of Natural and Environmental Resources. In progress.
6. Gonzalez-Gonzalez, M. (2018, November). Acidificación del Océano. *Marejada*, 15 (2), 22-28.
Retrieved from https://issuu.com/seagrantpr/docs/marejada_vol_15_nu_m_2_2017

TALKS

1. J. Salisbury, M. Melendez, S. Rodriguez, E. Garcia, J. Morell. Natural Reef Barriers at Risk: a first physical and biogeochemical spatial assessment. 2018 Sea Grant Site Visit Holiday Inn Hotel, Mayaguez, November 06, 2018.

POSTERS

1. **Meléndez M** and Salisbury J, Morell J. Corals at the breaking point. Caribbean Regional Association for Coastal Ocean Observing, Isla Verde, Carolina, PR; June 1, 2018

DATA SETS

1. Meléndez, M., Morell, J. M., and Salisbury, J. E.: Dissolved inorganic carbon, total alkalinity, pH, phosphate, dissolved oxygen, and other variables collected from surface discrete observations using Nixsin bottle and other instruments from R/V Sultana in the southwest coast of Puerto Rico from 2009-01-05 to 2016-02-01 (NCEI Accession 0145164). Version 1.1. NOAA National Centers for Environmental Information, Dataset, doi:10.7289/V52J68ZC, 2016.
2. Sutton, A. J., Sabine, C. L., Morell, J. M., Musielewicz, S., Maenner, S., Dietrich, C., Bott, R., Osborne, J.: High-resolution ocean and atmosphere pCO₂ time-series measurements from mooring La_Parguera_67W_18N in the Caribbean Sea: NODC Accession 0117354. Version 5.5. National Oceanographic Data Center, NOAA, Dataset, doi:10.3334/CDIAC/OTG.TSM_LA_PARGUERA_67W_18N, 2014.