# Carbonate chemistry and light data from bottle samples

**Website**: https://www.bco-dmo.org/dataset/719535
**Data Type**: Other Field Results
**Version**:
**Version Date**: 2017-11-17

**Project**
» BErmuda ocean Acidification and COral reef iNvestigation (BEACON)

**Program**
» Ocean Carbon and Biogeochemistry (OCB)

| Contributors | Affiliation | Role |
|---|---|---|
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## Coverage

**Spatial Extent**: **N**:32.457333 **E**:-64.797469 **S**:32.400777 **W**:-64.834759

## Dataset Description

Surface seawater samples were collected approximately monthly and analyzed for carbonate chemistry and nutrients.

These data were utilized in the following publication:


Courtney, T. A., Lebrato, M., Bates, N. R., Collins, A., de Putron, S. J., Garley, R., ... & Andersson, A. J. (2017). Environmental controls on modern scleractinian coral and reef-scale calcification. *Science advances*, *3*(11), e1701356. doi: 10.1126/sciadv.1701356


### Methods & Sampling

At each sample site, a 5 liter Niskin bottle was deployed at 0.5-1.0 m depth according to best practices. Samples for DIC and TA were collected in 200 mL Kimax glass sample bottles, and immediately fixed using 100 µL saturated solution of HgCl2. TA samples were analyzed via closed cell potentiometric titrations using a VINDTA 3S system and DIC was analyzed using coulometric methods on a VINDTA 3c or an infrared based analysis on an AIRICA system. Accuracy and precision of TA and DIC measurements were evaluated by

certified reference materials provided by the laboratory of Prof. A. Dickson at Scripps Institution of Oceanography yielding typical precision and accuracy of ±1–2 µmol/kg. A YSI Handheld Multiparameter Instrument was used to measure in situ temperature (±0.15°C), salinity (±1%), dissolved oxygen (±2 %), and percent saturation dissolved oxygen (±2%). Nutrient samples were filtered upon sampling using a 0.4 µM filter and frozen in opaque plastic bottles until processing at Woods Hole Oceanographic Institution Nutrient Analytical Facility using agency methods of analysis for ammonium (detection limit 0.034 µmol/L, method G-172-96), nitrite+nitrate (detection limit 0.010 µmol/L, method G-177-96), silicate (detection limit 0.016 µmol/L, method G-177-96), and phosphate (detection limit 0.025 µmol/L, method G-297-03).

Sampling locations: Bermuda Platform: Hog Reef (32.45733, -64.83476) and Crescent Reef (32.40078, -64.79747).

### Data Processing Description

TAcorr and DICcorr represents instrument TA value and instrument DIC value calibrated as fixed offsets to certified reference material from the laboratory of A. Dickson at Scripps Institution of Oceanography.

BCO-DMO Data Manager Processing Notes:
* added a conventional header with dataset name, PI name, version date
* modified parameter names to conform with BCO-DMO naming conventions
* NaN values changed to nd for "no data"
* Added Lat,Lon for Hog and Cres reefs into the data

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## Data Files

| File |
|---|
| **BottleSamples.csv** (Comma Separated Values (.csv), 11.24 KB)<br>MD5:38c166f3ea7fefdea7d2bb702867a350<br><br>Primary data file for dataset ID 719535 |

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## Parameters

| Parameter | Description | Units |
|---|---|---|
| Date | Day of sampling in formay DD-MM-YY | unitless |
| Time | Time of sampling in format HH:mm | unitless |
| Site | Site name of coral in situ growth (Hog = Hog Reef, Bermuda or Cres = Crescent Reef, Bermuda) | unitless |
| Lat | Latitude of site | decimal degrees |
| Lon | Longitude of site | decimal degrees |
| Temp | Sea surface temperature | degrees Celsius |
| Sal_YSI | Sea surface salinity measured by YSI instrument | parts per thousand (ppt) |
| Sal_Salinometer | Sea surface salinity by Autosal Salinometer | Practical Salinity Units (PSU) |
| DO_mg_l | Sea surface dissolved oxygen | milligrams per liter (mg/L) |
| DO_percent | Sea surface dissolved oxygen | percent saturation (%) |
| uM_NH4 | Sea surface ammonium | micromolar (µmol/L) |
| uM_SiO4 | Sea surface silicate | micromolar (µmol/L) |
| uM_PO4 | Sea surface phosphate | micromolar (µmol/L) |
| uM_NO2_NO3 | Sea surface nitrite + nitrate | micromolar (µmol/L) |
| TAcorr | Sea surface total alkalinity (corrected value, see processing description) | micromoles per liter per kilogram (µmol/kg) |
| DICcorr | Sea surface dissolved inorganic carbon (corrected value, see processing description) | micromoles per liter per kilogram (µmol/kg) |

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## Instruments

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| **Dataset-specific Instrument Name** | MARIANDA VINDTA 3S |
| **Generic Instrument Name** | Automatic titrator |
| **Dataset-specific Description** | Total alkalinity (TA) samples were analyzed via closed cell potentiometric titrations using a VINDTA 3S system. VINDTA (Versatile INstrument for the Determination of Titration Alkalinity). The system uses a Metrohm Titrino 719S, an ORION-Ross pH electrode and a Metrohm reference electrode. The burette, the pipette and the analysis cell have a water jacket around them. Precision is typically +/- 1 umol/kg for TA. Please see for a complete instrument description. |
| **Generic Instrument Description** | Instruments that incrementally add quantified aliquots of a reagent to a sample until the end-point of a chemical reaction is reached. |

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| **Dataset-specific Instrument Name** | Autosal Salinometer 8400B (Salinity) |
| **Generic Instrument Name** | Autosal salinometer |
| **Dataset-specific Description** | Samples for salinity were collected in glass bottles and later analyzed using an autosalinometer (Guildline Instruments) |
| **Generic Instrument Description** | The salinometer is an instrument for measuring the salinity of a water sample. |

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| **Dataset-specific Instrument Name** | AIRICA (Marianda Inc.) |
| **Generic Instrument Name** | Inorganic Carbon Analyzer |
| **Dataset-specific Description** | The Automated Infra Red Inorganic Carbon Analyzer (AIRICA) utilizes infrared detection of CO2 gas purged from an acidified seawater sample. A high-precision syringe pump extracts the seawater sample, acidifies the sample with phosphoric acid, and analyzes the gas released with an infrared light analyzer (LICOR). The CO2 signal is integrated for each sample to quantify the total inorganic carbon for a given aliquot of seawater analyzed. Three aliquots and peak integrations are performed for each seawater sample and averaged to determine the dissolved inorganic carbon for each sample. Precision was typically ±1–2 µmol/kg for TA. Please see http://marianda.com/index.php?site=products&subsite=airica for a complete instrument description. |
| **Generic Instrument Description** | Instruments measuring carbonate in sediments and inorganic carbon (including DIC) in the water column. |

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| **Dataset-specific Instrument Name** | VINDTA 3c (Marianda Inc.) |
| **Generic Instrument Name** | MARIANDA VINDTA 3C total inorganic carbon and titration alkalinity analyser |
| **Dataset-specific Description** | DIC was analyzed using coulometric methods on a VINDTA 3c or an infrared-based analysis on an AIRICA system. The Versatile INstrument for the Determination of Total inorganic carbon and titration Alkalinity (VINDTA) 3C is a laboratory alkalinity titration system combined with an extraction unit for coulometric determination of total dissolved inorganic carbon. The instrument analyzes alkalinity and dissolved inorganic carbon content of a sample in parallel. The sample transport is performed with peristaltic pumps and acid is added to the sample using a membrane pump. No pressurizing system is required and only one gas supply (nitrogen or dry and CO2-free air) is necessary. The system uses a Metrohm Titrino 719S, an ORION-Ross pH electrode and a Metrohm reference electrode. The burette, the pipette and the analysis cell have a water jacket around them. Precision is typically ±1 µmol/kg for TA. DIC is analyzed with a UIC coulometer. Please see http://marianda.com/index.php?site=products&subsite=vindta3c> for a complete instrument description. |
| **Generic Instrument Description** | The Versatile INstrument for the Determination of Total inorganic carbon and titration Alkalinity (VINDTA) 3C is a laboratory alkalinity titration system combined with an extraction unit for coulometric titration, which simultaneously determines the alkalinity and dissolved inorganic carbon content of a sample. The sample transport is performed with peristaltic pumps and acid is added to the sample using a membrane pump. No pressurizing system is required and only one gas supply (nitrogen or dry and CO2-free air) is necessary. The system uses a Metrohm Titrino 719S, an ORION-Ross pH electrode and a Metrohm reference electrode. The burette, the pipette and the analysis cell have a water jacket around them. Precision is typically +/- 1 umol/kg for TA and/or DIC in open ocean water. |

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| **Dataset-specific Instrument Name** | Niskin Bottle |
| **Generic Instrument Name** | Niskin bottle |
| **Dataset-specific Description** | From 2007 to 2012, surface seawater samples from the Bermuda coral reef platform were collected once a month at 0.5–1-m depth using a 5-L Niskin bottle. |
| **Generic Instrument Description** | A Niskin bottle (a next generation water sampler based on the Nansen bottle) is a cylindrical, non-metallic water collection device with stoppers at both ends. The bottles can be attached individually on a hydrowire or deployed in 12, 24, or 36 bottle Rosette systems mounted on a frame and combined with a CTD. Niskin bottles are used to collect discrete water samples for a range of measurements including pigments, nutrients, plankton, etc. |

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| **Dataset-specific Instrument Name** | YSI 556 Handheld Multiparameter Instrument |
| **Generic Instrument Name** | Water Quality Multiprobe |
| **Dataset-specific Description** | A YSI 556 Handheld Multiparameter Instrument was used to measure in situ temperature (accuracy ± 0.15°C), salinity (accuracy ± 1%), DO_mg (accuracy ± 2%), and DO_% (accuracy ± 2%). |
| **Generic Instrument Description** | An instrument which measures multiple water quality parameters based on the sensor configuration. |

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## Deployments

**BIOS_BEACON**

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| **Website** | https://www.bco-dmo.org/deployment/626096 |
| **Platform** | BIOS_Small_Boat |
| **Start Date** | 2007-06-15 |
| **End Date** | 2012-09-18 |
| **Description** | Sample collection platforms for the BEACON Project. The samples were collected from a small boat (27 ft Twin Vee or 26 ft Seadance) |

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## Project Information

**BErmuda ocean Acidification and COral reef iNvestigation (BEACON)**

**Website**: https://scripps.ucsd.edu/research/projects/bermuda-ocean-acidification-and-coral-reef-investigation-beacon

**Coverage**: Bermuda

NSF abstract:

Ocean acidification owing to anthropogenic emission of CO2 is a significant and imminent threat to marine calcifying organisms and ecosystems such as corals and coral reefs. As a result of future ocean acidification, i.e., increasing seawater CO2, and decreasing pH, carbonate ion concentration [CO3], and carbonate saturation state, it is likely that marine calcifiers will have difficulty growing their shells and skeletons of calcium carbonate (CaCO3) at their present rates. Dissolution of carbonate sediments and structures are also likely to increase, and could ultimately exceed calcification and CaCO3 production, leading to a transition from net accumulation to a net loss in carbonate material of individual coral colonies, coral communities and coral reef ecosystems. Because of Bermuda's relatively high-latitude location (32° N), the annual average surface seawater [CO3] is lower in Bermuda than regions closer to the tropics. As a consequence, the Bermuda coral reef is likely to experience critical [CO3] values and net dissolution before its tropical counterparts as a result of continued ocean acidification. Furthermore, a natural gradient in [CO3] exists along the Bermuda reef with environmental parameters such as, light, temperature, and nutrients being near identical. This gradient allows for unique cross-comparisons of calcification of individual calcifiers and calcifying communities under different [CO3] in a natural environment.

In this study, researchers at the Bermuda Institute of Ocean Science (BIOS) will launch the BEACON project to further our understanding of the consequences of ocean acidification to the process of calcification and CaCO3 production at three different spatial scales including (1) individual coral colonies, (2) local reef communities, and (3) regional coral reef ecosystems. They will conduct (1) in situ and in vitro experiments to assess growth and evaluate net calcification of individual coral colonies of three different species common to Bermuda and the Caribbean exposed to different [CO3] under both natural and controlled experimental conditions; (2) diel and quasi-lagrangian calcification experiments to evaluate net calcification of local reef communities and in moving water masses along the natural [CO3] gradient existent on the Bermuda platform; and (3) time series data collected across the Bermuda platform and offshore, to evaluate net calcification and CaCO3 production of the Bermuda coral reef ecosystem and platform over seasonal and annual cycles.

Broader impacts: This project will provide fundamental data on the consequences of ocean acidification to coral reefs on different temporal and spatial scales. Combined, knowledge at each of the scales will contribute to an improved understanding of this problem in a broader context, i.e., the effect on coral reefs as a global entity and role in the global carbon cycle during past, present and future seawater chemical conditions. As the meaning implies, the research team envisions BEACON to serve as a guiding light to assist researchers and policymakers in framing future strategies and making decisions regarding the management of coral reefs and CO2 emission policies in order to establish CO2 stabilization targets. Scientific understanding and research products from the project will be specifically used in the BIOS explorer program, CoE POGO ocean acidification module, and the coral reef ecology class taught at BIOS. It will also contribute to developing the research and technical skills of one graduate student and one research technician at BIOS, and will include the involvement of interns and NSF REU fellowship students each year of the project.

Based on the findings of the BEACON project, and especially the results published in Andersson et al. (Nature Climate Change, 4, 56-61, 2014) and Yeakel et al. (PNAS, 112, 14512-14517, 2015), BEACON II (https://www.bco-dmo.org/project/737955) aims to assess the links between offshore and reef biogeochemistry by continuing and expanding on the physical and chemical measurements on the Bermuda coral reef and in the surrounding Sargasso Sea.

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## Program Information

**Ocean Carbon and Biogeochemistry (OCB)**

**Website**: http://us-ocb.org/

**Coverage**: Global

The Ocean Carbon and Biogeochemistry (OCB) program focuses on the ocean's role as a component of the

The Ocean Carbon and Biogeochemistry (OCB) program focuses on the ocean's role as a component of the global Earth system, bringing together research in geochemistry, ocean physics, and ecology that inform on and advance our understanding of ocean biogeochemistry. The overall program goals are to promote, plan, and coordinate collaborative, multidisciplinary research opportunities within the U.S. research community and with international partners. Important OCB-related activities currently include: the Ocean Carbon and Climate Change (OCCC) and the North American Carbon Program (NACP); U.S. contributions to IMBER, SOLAS, CARBOOCEAN; and numerous U.S. single-investigator and medium-size research projects funded by U.S. federal agencies including NASA, NOAA, and NSF.

The scientific mission of OCB is to study the evolving role of the ocean in the global carbon cycle, in the face of environmental variability and change through studies of marine biogeochemical cycles and associated ecosystems.

The overarching OCB science themes include improved understanding and prediction of: 1) oceanic uptake and release of atmospheric CO2 and other greenhouse gases and 2) environmental sensitivities of biogeochemical cycles, marine ecosystems, and interactions between the two.

The OCB Research Priorities (updated January 2012) include: ocean acidification; terrestrial/coastal carbon fluxes and exchanges; climate sensitivities of and change in ecosystem structure and associated impacts on biogeochemical cycles; mesopelagic ecological and biogeochemical interactions; benthic-pelagic feedbacks on biogeochemical cycles; ocean carbon uptake and storage; and expanding low-oxygen conditions in the coastal and open oceans.

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## Funding


| Funding Source | Award |
|---|---|
| NSF Division of Ocean Sciences (NSF OCE) | OCE-0928406 |


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