Diel carbonate and nutrient chemistry reported for different benthic reef communities under ambient and acidified conditions during summer and winter

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Data Type: Other Field Results, experimental
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Project
» CAREER: Biogeochemical Modification of Seawater CO2 Chemistry in Near-Shore Environments: Effect of Ocean Acidification (Nearshore CO2)

Contributors	Affiliation	Role
Andersson, Andreas	University of California-San Diego Scripps (UCSD-SIO)	Principal Investigator
Page, Heather	University of California-San Diego Scripps (UCSD-SIO)	Student, Contact
Rauch, Shannon	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
Diel carbonate and nutrient chemistry are reported for different benthic reef communities under ambient and acidified conditions during summer and winter.

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Coverage

Spatial Extent: **Lat**:21.433019 **Lon**:-157.786461
Temporal Extent: 2013-08-21 - 2014-01-11

Methods & Sampling

General study design:
This experiment was designed to quantify and compare the influence of different benthic reef communities on diel seawater carbonate and nutrient chemistry under ambient and acidified conditions during summer and winter in flow-through mesocosms.

Methods description:
Different coral reef benthic communities (carbonate sand, crustose coralline algae, coral, fleshy macroalgae, and a mixed community) were created in outdoor flow-through mesocosms at Hawaii Institute of Marine Biology. Diurnal seawater chemistry was measured for communities experiencing ambient or acidified (ambient pH – 0.4) seawater conditions during summer (August 2013) and winter (January 2014). Acidification treatments were achieved by CO2 (g) bubbling of the header tank. Hourly water quality measurements were taken over the course of 26-hours with water samples collected for analysis of dissolved inorganic carbon and total alkalinity every 2 hours and for inorganic nutrients every 4 hours. A total of four experiments were conducted across two seasons (Summer and Winter) and two pH treatments (ambient and acidified). Seawater chemistry data were used to calculate diurnal net community production (NCP) and net community

calcification (NCC) rates using modified standard equations (Langdon et al. 2010). In addition, the attribution of these processes to diurnal pH and saturation state changes were quantified.;

For additional details, please see Page et al. (2016).

Analytical Methods:
Seawater samples were collected by hand using 250 ml Pyrex glass bottles and immediately fixed with 100 µL HgCl2 as per standard protocols (Dickson et al. 2007). Handheld YSI multi-meter instrument was used to measure temperature, salinity, dissolved oxygen, and pH at the time of sampling. All seawater samples were transported to the Scripps Coastal and Open Ocean Biogeochemistry lab and analyzed for TA via an open-cell potentiometric acid titration system developed at Scripps Institution of Oceanography (SIO) by A. Dickson (Dickson et al. 2007) and DIC via an automated infra-red inorganic carbon analyzer (AIRICA, Marianda Inc).

Quality Control:
Standard protocols were followed for sampling and analysis of seawater TA and DIC (Dickson et al. 2007). YSI multi-meter instrument was calibrated prior to each sampling period with accuracies of 0.2 °C for temperature, 1% for salinity, ±2% for dissolved oxygen saturation, 0.2 mg/L for dissolved oxygen concentration, and 0.2 for pH. The accuracy and precision of TA (-0.2 ± 3.3 µmol/kg) and DIC (-1.0 ± 2.3 µmol/kg) measurements were evaluated using certified reference materials (CRM) provided by the laboratory of A. Dickson at SIO and analyzed every 5 samples for DIC and ~15-20 samples for TA.

Known Problems:
Rows where Date is 06-01-14 and Time values are 10:14 to 10:44 (inclusive) (lines 866-881 in original Excel file): The YSI Pro Plus Handheld Multi-meter temporarily malfunctioned, so temperature and salinity data were measured using an alternate handheld multi-meter probe.

Data Processing Description

Data Processing:
Carbonate chemistry (pH_calc, pCO2_calc, and omega_calc) was constrained using CO2SYS software (Lewis and Wallace 1998). Data were processed and statistically compared using R Software (v 3.2.0).

BCO-DMO Processing:
- added UTC date/time field in ISO8601 format.

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Related Publications

Page, H. N., Andersson, A. J., Jokiel, P. L., Rodgers, K. S., Lebrato, M., Yeakel, K., ... Bahr, K. D. (2016). Differential modification of seawater carbonate chemistry by major coral reef benthic communities. Coral Reefs, 35(4), 1311–1325. doi:10.1007/s00338-016-1490-4
Results

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Parameters

Parameter	Description	Units
Season	Season during which experiments were conducted	unitless
Treatment	CO2 treatment for each experiment	unitless
Date	Date of measurements (local time; HST); format: DD-MM-YY	unitless

Time	Time of measurements (local time; HST); format: hh:mm:ss	unitless
ISO_DateTime_UTC	Date and time of measurements (UTC) in ISO8601 format: YYYY-MM-DDThh:mm:ssZ	unitless
MesocosmID	Mesocosm identification	unitless
Community	Reef community within the mesocosm	unitless
Temp	In situ temperature	degrees Celsius
Salinity	In situ salinity	unitless
DO_sat	In situ dissolved oxygen percent saturation	unitless (percent)
DO_conc	In situ dissolved oxygen concentration	milligrams per liter (mg/L)
pH_ysi	In situ pH	unitless
TA	In situ total alkalinity	micromoles per kilogram (umol/Kg)
DIC	In situ dissolved inorganic carbon	micromoles per kilogram (umol/Kg)
Total_N	In situ dissolved inoganic nitrogen and nitrate	micromoles per liter (umol/L)
Nitrite	In situ dissolved nitrite	micromoles per liter (umol/L)
Inorg_P	In situ dissolved inorganic phosphorus	micromoles per liter (umol/L)
Silicate	In situ dissolved silicate	micromoles per liter (umol/L)
Ammonia	In situ dissolved ammonia	micromoles per liter (umol/L)
Nitrate	In situ dissolved nitrate	micromoles per liter (umol/L)
pH_calc	In situ pH (total scale) calculated from in situ temperature, salinity, TA, and DIC	unitless

Omega_calc	Seawater saturation state with respect to aragonite calculated from in situ temperature, salinity, TA, and DIC	unitless
pCO2_calc	In situ pCO2 calculated from in situ temperature, salinity, TA, and DIC	microatmospheres (uatm)
NCC	Net community calcification rate	millimoles per square meter per hour (mmol/m^2/h)
NCP	Net community primary production rate	millimoles per square meter per hour (mmol/m^2/h)

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Instruments

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. 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.

Dataset-specific Instrument Name	Open-cell potentiometric acid titration system
Generic Instrument Name	Titrator
Dataset-specific Description	The open-cell potentiometric acid titration system was developed by the laboratory of A.G. Dickson. Briefly, a known amount of seawater is added to an open cell beaker where hydrochloric acid as acidified to a pH of 3.5-4.0 and allowed to stabilize to remove CO2 gas formed by the addition of acid. Small aliquots of hydrochloric acid are then added to pH of ~ 3.0. The titration is monitored by a glass electrode and the total alkalinity of the sample is calculated using a non-linear least-squares method following Dickson et al. (2007).
Generic Instrument Description	Titrators are instruments that incrementally add quantified aliquots of a reagent to a sample until the end-point of a chemical reaction is reached.

Dataset-specific Instrument Name	YSI Professional Plus (Pro Plus) Handheld Multiparameter
Generic Instrument Name	Water Quality Multiprobe
Dataset-specific Description	YSI Handheld Multiparameter Instruments were used to monitor in situ temperature (accuracy ± 0.2°C), salinity (accuracy ± 1%), DO_mg (accuracy ± 0.2 mg/L), and DO_% (accuracy ± 2%), and pH (accuracy ± 0.2).
Generic Instrument Description	An instrument which measures multiple water quality parameters based on the sensor configuration.

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Project Information

CAREER: Biogeochemical Modification of Seawater CO2 Chemistry in Near-Shore Environments: Effect of Ocean Acidification (Nearshore CO2)

Coverage: San Diego, California; Bermuda; Oahu, Hawaii

NSF Award Abstract:
Because of well-known chemical principles, changes in the CO2 chemistry of seawater in the open ocean as a result of rising atmospheric CO2 can be predicted very accurately. On the other hand, in near-shore environments, these projections are much more difficult because the CO2 chemistry is largely modified by biogeochemical processes operating on timescales of hours to months. To make predictions on how near-shore seawater CO2 chemistry will change in response to ocean acidification (OA), it is critical to consider the relative influence of net ecosystem production (NEP) and net ecosystem calcification (NEC), and how these processes might change in response to this major perturbation. Understanding how future OA will alter near-shore seawater CO2 chemistry and variability was identified as a major critical knowledge gap at the recent IPCC WG II/WG I workshop on impacts of ocean acidification on marine biology and ecosystems in January of 2011, and also at the International Ocean Acidification Network workshop in Seattle in June of 2012.

With funding from this CAREER award, a researcher at the Scripps Institute of Oceanography and his students will study how biogeochemical processes and the relative contributions from NEP and NEC modify seawater CO2 chemistry in near-shore environments influenced by different benthic communities under well-characterized environmental and physical conditions, and how these processes might change in response to OA. The team will investigate a limited number of contrasting habitats in subtropical (reef crest, back/patch reef, lagoon, seagrass bed, algal mat) and temperate (kelp bed, inter- and sub-tidal, marsh) environments during summer and winter, employing a method that evaluates the function and performance of the carbon cycle of a system using a stoichiometric vector approach based on changes in total dissolved inorganic carbon (DIC) and total alkalinity (TA). These field studies will be complemented by controlled mesocosm experiments with contrasting and mixed benthic communities under different OA scenarios.

The project has two educational components: (1) developing a research-driven OA and biogeochemistry course based on inquiry-, experience-, and collaborative-based learning; and (2) working with the Ocean Discovery Institute (ODI) to engage individuals from a local underrepresented minority community in science through educational activities focused on OA, and also providing a moderate number of internships for high school and college students to engage in this research project.

Broader Impacts: This project will directly support one PhD student, one junior research technician, and two high school and college interns from underrepresented minorities (URM) each summer of the project. It will contribute to the education of 80 undergraduate and graduate students participating in the research based ocean acidification/biogeochemistry course offered four times throughout the duration of the project at SIO/UCSD. Education and curricular material on the topics of OA, including hands-on laboratories, classroom and field-based activities will be developed through the collaboration with the ODI and brought to hundreds of

URM students and their teachers in the City Heights area, a community with the highest poverty and ethnic diversity in the San Diego region. This collaboration will enable URM students to directly engage in a rapidly evolving field of research that has high relevance at both the local and global scales. To ensure broad dissemination of this project and the topic of OA, the research team will work with the Google Ocean team to incorporate information and educational material in the Google Ocean Explorer.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1255042

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