Water samples from CTD casts and vehicle-mounted bottles from the R/V Atlantis, R/V Ronald Brown, R/V Falkor, & E/V Nautilus in the Gulf of Mexico & Florida from 2010 to 2014 (Lophelia OA project)

Website: https://www.bco-dmo.org/dataset/658946
Data Type: Cruise Results
Version: 1
Version Date: 2016-09-16

Project
» Physiological and genetic responses of the deep-water coral, Lophelia pertusa, to ongoing ocean acidification in the Gulf of Mexico (Lophelia OA)

Program
» Science, Engineering and Education for Sustainability NSF-Wide Investment (SEES): Ocean Acidification (formerly CRI-OA) (SEES-OA)

Contributors	Affiliation	Role
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Abstract
Water samples from CTD casts and vehicle-mounted bottles from the R/V Atlantis, R/V Ronald Brown, R/V Falkor, & E/V Nautilus in the Gulf of Mexico & Florida from 2010 to 2014 (Lophelia OA project)

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Coverage

Spatial Extent: **N**:29.17 **E**:-84.82 **S**:25.31 **W**:-93.6
Temporal Extent: 2010-01-01 - 2014-12-31

Dataset Description

Water samples from CTD casts and vehicle-mounted bottles collected on the Atlantis, GOMRI, Nautilus, Ronald Brown, and Schmidt between 2010 and 2014.

Methods & Sampling

pH was measured on the total hydrogen scale (pHT) within one hour of sample collection. Each water sample was placed in a 25 degrees C water bath for 10–20 minutes to standardize temperature (mean temperature over all pH measurements of 22.2 +/- 2.6 degrees C). pHT was then measured in duplicate using the Orion 5 Star pH meter and glass electrode (ROSS Ultra pH/ATC Triode 8107BNUMD) calibrated with Tris–HCL buffer solution obtained from the Dickson Lab (Batch 22). Electrode performance was regularly checked against standard Tris-HCl and AMP-HCl buffers in artificial seawater (Nemzer et al. 2005; Dickson et al. 2007). Temperature was measured using the integrated temperature sensor on the ROSS Ultra pH/ATC Triode from 2010–2013, and using a handheld thermocouple (Omega HH81A) in 2014. Total alkalinity (TA) was measured in triplicate by acid titration on a Mettler–Toledo DL15 autotitrator using 0.1 mol L–1 HCl buffered in 0.6 mol L–1 NaCl (modified from SOP 3b, Dickson et al. 2007). The autotitrator was calibrated daily on the NBS scale using certified reference buffers (Orion), and certified reference materials (Dickson Lab, batches 138 and 141) were measured periodically to ensure accuracy (within +/- 10 umol kg-1).

Data Processing Description

CO2SYS software (Pierrot et al. 2006) was used to correct pHT values for in situ temperature and pressure, and to calculate the entire carbonate system from TA, pHT, temperature, salinity, and pressure. For all calculations, we used the carbonic acid constants (K1 and K2) of Mehrbach et al. (1973) refitted by Dickson and Millero (1987), and the aragonite solubility product (Ksp) from Mucci (1983). The effects of nutrients (phosphate and silicate) on the carbonate system were assumed to be negligible (eg. Cai 2003; Yates and Halley 2006). TA and dissolved inorganic carbon (DIC) values were corrected for in situ salinity values using the mean salinity of all sites (35.3 psu) to yield salinity-normalized TA (nTA) and DIC (nDIC).

BCO-DMO Processing Notes:

-Column names reformatted to comply with BCO-DMO standards
-Entered "nd" into blank cells
-Created a separate column for official cruise identification in addition to the PI supplied cruise name

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Data Files

File
carbonate_data.csv(Comma Separated Values (.csv), 69.86 KB) MD5:a438600a1bde2e461f14a420b63aac7a Primary data file for dataset ID 658946

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Related Publications

Cai, W.-J. (2003). Riverine inorganic carbon flux and rate of biological uptake in the Mississippi River plume. Geophysical Research Letters, 30(2). doi:10.1029/2002gl016312 https://doi.org/10.1029/2002GL016312
Methods

Dickson, A. G., & Millero, F. J. (1987). A comparison of the equilibrium constants for the dissociation of carbonic acid in seawater media. Deep Sea Research Part A. Oceanographic Research Papers, 34(10), 1733–1743. doi:10.1016/0198-0149(87)90021-5
Methods

Dickson, A.G., Sabine, C.L. and Christian, J.R. (Eds.) 2007. Guide to best practices for ocean CO2 measurements. PICES Special Publication 3, 191 pp. ISBN: 1-897176-07-4. URL: https://www.nodc.noaa.gov/ocads/oceans/Handbook_2007.html https://hdl.handle.net/11329/249
Methods

Georgian, S. E., DeLeo, D., Durkin, A., Gomez, C. E., Kurman, M., Lunden, J. J., & Cordes, E. E. (2015). Oceanographic patterns and carbonate chemistry in the vicinity of cold-water coral reefs in the Gulf of Mexico: Implications for resilience in a changing ocean. Limnology and Oceanography, 61(2), 648–665. doi:10.1002/lno.10242
Methods

Lunden, J. J., Georgian, S. E., & Cordes, E. E. (2013). Aragonite saturation states at cold-water coral reefs structured byLophelia pertusain the northern Gulf of Mexico. Limnology and Oceanography, 58(1), 354–362. doi:10.4319/lo.2013.58.1.0354
Methods

Mehrbach, C., Culberson, C. H., Hawley, J. E., & Pytkowicx, R. M. (1973). Measurement of the apparent dissociation constants of carbonic acid in seawater at atmospheric pressure. Limnology and Oceanography, 18(6), 897–907. doi:10.4319/lo.1973.18.6.0897
Methods

Mucci, A. (1983). The solubility of calcite and aragonite in seawater at various salinities, temperatures, and one atmosphere total pressure. American Journal of Science, 283(7), 780-799. doi:10.2475/ajs.283.7.780
Methods

Nemzer, B. V., & Dickson, A. G. (2005). The stability and reproducibility of Tris buffers in synthetic seawater. Marine Chemistry, 96(3-4), 237–242. doi:10.1016/j.marchem.2005.01.004
Methods

Pierrot, D. E. Lewis,and D. W. R. Wallace. 2006. MS Excel Program Developed for CO2 System Calculations. ORNL/CDIAC-105a. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee. doi: 10.3334/CDIAC/otg.CO2SYS_XLS_CDIAC105a.
Methods

Yates, K. K., & Halley, R. B. (2006). CO32− concentration and pCO2 thresholds for calcification and dissolution on the Molokai reef flat, Hawaii. Biogeosciences, 3(3), 357–369. doi:10.5194/bg-3-357-2006
Methods

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Parameters

Parameter	Description	Units
cruise_name	Project investigator's cruise name	unitless
instrument	Instrument used to collect water samples; V (vehicle-mounted bottle) or CTD	unitless
measurement_location	Location where water sample was taken; WC= water column or B= bottom	unitless
sample_ID	Sample ID number	unitless
year	Year of sample; YYYY	unitless
lat	Latitude	decimal degrees
lon	Longitude	decimal degrees
site	Site code where sample was taken; see lat/lons for exact location.	unitless
depth	Depth at which sample was taken	meters
salinity	Salinity of water sample	practical salinity units (PSU)
pressure	Pressure at depth	decibar (dbar)
temperature	Temperature at depth	celsius
measured_temp	Temperature of sample after being standardized in 25 degree celsius water bath for 10-20 minutes.	celsius
input_pH	pH measurement of sample (total scale)	total pH scale
TA	Total alkalinity of sample	micromoles per killigram (umol/kg)
nTA	Salinity normalized total alkalinity	micromoles per killigram (umol/kg)
pHT	pH measured on the total hydrogen scale	total pH scale
omega_aragonite	saturation state of aragonite	unitless
DIC	Dissolved inorganic carbon values	micromoles per killigram (umol/kg)
pCO2	Carbond dioxide concentration	microatomospheres (uatm)
revelle_factor	A measure inversely proportional to the capacity for seawater to absorb atmospheric CO2	unitless
bicarbonate_ion	Bicarbonate ion concentration	micromoles per killigram (umol/kg)
carbonate_ion	Carbonate ion concentration	micromoles per killigram (umol/kg)
TA_DIC	Total alkalinity and dissolved inorganic carbon ratio	unitless
comments	Comments	unitless
cruise_id	Official cruise identification	unitless
month	Month of sampling; MM	unitless
day	Day of sampling; DD	

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Instruments

Dataset-specific Instrument Name	Aquarium
Generic Instrument Name	Aquarium
Dataset-specific Description	Experiments conducted using aquaria
Generic Instrument Description	Aquarium - a vivarium consisting of at least one transparent side in which water-dwelling plants or animals are kept

Dataset-specific Instrument Name	Mettler-Toledo EL15 autotitrator
Generic Instrument Name	Automatic titrator
Dataset-specific Description	Measured total alkalinity
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.

Dataset-specific Instrument Name	Vehicle mounted bottle
Generic Instrument Name	Bottle
Dataset-specific Description	Water samples collected by vehicle-mounted bottle
Generic Instrument Description	A container, typically made of glass or plastic and with a narrow neck, used for storing drinks or other liquids.

Dataset-specific Instrument Name	CTD
Generic Instrument Name	CTD - profiler
Dataset-specific Description	Water samples taken from CTD casts
Generic Instrument Description	The Conductivity, Temperature, Depth (CTD) unit is an integrated instrument package designed to measure the conductivity, temperature, and pressure (depth) of the water column. The instrument is lowered via cable through the water column. It permits scientists to observe the physical properties in real-time via a conducting cable, which is typically connected to a CTD to a deck unit and computer on a ship. The CTD is often configured with additional optional sensors including fluorometers, transmissometers and/or radiometers. It is often combined with a Rosette of water sampling bottles (e.g. Niskin, GO-FLO) for collecting discrete water samples during the cast. This term applies to profiling CTDs. For fixed CTDs, see https://www.bco-dmo.org/instrument/869934.

Dataset-specific Instrument Name	Orion 5 Star pH themeter
Generic Instrument Name	pH Sensor
Dataset-specific Description	pHT was measured using this instrument
Generic Instrument Description	An instrument that measures the hydrogen ion activity in solutions. The overall concentration of hydrogen ions is inversely related to its pH. The pH scale ranges from 0 to 14 and indicates whether acidic (more H+) or basic (less H+).

Dataset-specific Instrument Name	Temperature sensor
Generic Instrument Name	Water Temperature Sensor
Dataset-specific Description	Sensor that measured water temperature
Generic Instrument Description	General term for an instrument that measures the temperature of the water with which it is in contact (thermometer).

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Deployments

AT26-14

Website	https://www.bco-dmo.org/deployment/658949
Platform	R/V Atlantis
Start Date	2014-04-27
End Date	2014-05-16

RB1007

Website	https://www.bco-dmo.org/deployment/659009
Platform	NOAA Ship Ronald H. Brown
Start Date	2010-10-14
End Date	2010-11-04

NA028

Website	https://www.bco-dmo.org/deployment/659016
Platform	E/V Nautilus
Report	https://scholarsphere.psu.edu/downloads/x346dx36d
Start Date	2013-06-21
End Date	2013-07-05

FK004E

Website	https://www.bco-dmo.org/deployment/659019
Platform	R/V Falkor
Report	http://www.rvdata.us/catalog/FK004E
Start Date	2012-08-27
End Date	2012-09-01

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Project Information

Physiological and genetic responses of the deep-water coral, Lophelia pertusa, to ongoing ocean acidification in the Gulf of Mexico (Lophelia OA)

Coverage: Northern Gulf of Mexico

The Gulf of Mexico deep water ecosystems are threatened by the persistent threat of ocean acidification. Deep-water corals will be among the first to feel the effects of this process, in particular the deep-water scleractinians that form their skeleton from aragonite. The continued shoaling of the aragonite saturation horizon (the depth below which aragonite is undersaturated) will place many of the known, and as yet undiscovered, deep-water corals at risk in the very near future. The most common deep-water framework-forming scleractinian in the world's oceans is *Lophelia pertusa*. This coral is most abundant in the North Atlantic, where aragonite saturation states are relatively high, but it also creates extensive reef structures between 300 and 600 m depth in the Gulf of Mexico where aragonite saturation states were previously unknown. Preliminary data indicate that pH at this depth range is between 7.85 and 8.03, and the aragonite saturation state is typically between 1.28 and 1.69. These are the first measurements of aragonite saturation state for the deep Gulf of Mexico, and are among the lowest Aragonite saturation state yet recorded for framework-forming corals in any body of water, at any depth.

This project will examine the effects of ocean acidification on *L. pertusa*, combining laboratory experiments, rigorous oceanographic measurements, the latest genome and transcriptome sequencing platforms, and quantitative PCR and enzyme assays to examine changes in coral gene expression and enzyme activity related to differences in carbonate chemistry. Short-term and long-term laboratory experiments will be performed at Aragonite saturation state of 1.45 and 0.75 and the organismal (e.g., survivorship and calcification rate) and genetic (e.g., transcript abundance) responses of the coral will be monitored. Genomic DNA and RNA will be extracted, total mRNA purified, and comprehensive and quantitative profiles of the transcriptome generated using a combination of 454 and Illumina sequencing technologies. Key genes in the calcification pathways as well as other differentially expressed genes will be targeted for specific qPCR assays to verify the Illumina sequencing results. On a research cruise, *L. pertusa* will be sampled (preserved at depth) along a natural gradient in carbonate chemistry, and included in the Illumina sequencing and qPCR assays. Water samples will be obtained by submersible-deployed niskin bottles adjacent to the coral collections as well as CTD casts of the water column overlying the sites. Water samples will be analyzed for pH, alkalinity, nitrates and soluble reactive phosphorus. These will be used in combination with historical data in a model to hindcast Aragonite saturation state.

This project will provide new physiological and genetic data on an ecologically-significant and anthropogenically-threatened deepwater coral in the Gulf of Mexico. An experimental system, already developed by the PIs, offers controlled conditions to test the effect of Aragonite saturation state on calcification rates in scleractinians and, subsequently, to identify candidate genes and pathways involved in the response to reduced pH and Aragonite saturation state. Both long-term and population sampling experiments will provide additional transcriptomic data and specifically investigate the expression of the candidate genes. These results will contribute to our understanding of the means by which scleractinians may acclimate and acclimatize to low pH, alkalinity, and Aragonite saturation state. Furthermore, the investigators will continue a time series of oceanographic measurements of the carbonate system in the Gulf of Mexico, which will allow the inclusion of this significant body of water in models of past and future ocean acidification scenarios.

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Program Information

Science, Engineering and Education for Sustainability NSF-Wide Investment (SEES): Ocean Acidification (formerly CRI-OA) (SEES-OA)

Website: https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503477

Coverage: global

NSF Climate Research Investment (CRI) activities that were initiated in 2010 are now included under Science, Engineering and Education for Sustainability NSF-Wide Investment (SEES). SEES is a portfolio of activities that highlights NSF's unique role in helping society address the challenge(s) of achieving sustainability. Detailed information about the SEES program is available from NSF (https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504707).

In recognition of the need for basic research concerning the nature, extent and impact of ocean acidification on oceanic environments in the past, present and future, the goal of the SEES: OA program is to understand (a) the chemistry and physical chemistry of ocean acidification; (b) how ocean acidification interacts with processes at the organismal level; and (c) how the earth system history informs our understanding of the effects of ocean acidification on the present day and future ocean.

Solicitations issued under this program:
NSF 10-530, FY 2010-FY2011
NSF 12-500, FY 2012
NSF 12-600, FY 2013
NSF 13-586, FY 2014
NSF 13-586 was the final solicitation that will be released for this program.

PI Meetings:
1st U.S. Ocean Acidification PI Meeting(March 22-24, 2011, Woods Hole, MA)
2nd U.S. Ocean Acidification PI Meeting(Sept. 18-20, 2013, Washington, DC)
3rd U.S. Ocean Acidification PI Meeting (June 9-11, 2015, Woods Hole, MA – Tentative)

NSF media releases for the Ocean Acidification Program:

Press Release 10-186 NSF Awards Grants to Study Effects of Ocean Acidification

Discovery Blue Mussels "Hang On" Along Rocky Shores: For How Long?

Discovery nsf.gov - National Science Foundation (NSF) Discoveries - Trouble in Paradise: Ocean Acidification This Way Comes - US National Science Foundation (NSF)

Press Release 12-179 nsf.gov - National Science Foundation (NSF) News - Ocean Acidification: Finding New Answers Through National Science Foundation Research Grants - US National Science Foundation (NSF)

Press Release 13-102 World Oceans Month Brings Mixed News for Oysters

Press Release 13-108 nsf.gov - National Science Foundation (NSF) News - Natural Underwater Springs Show How Coral Reefs Respond to Ocean Acidification - US National Science Foundation (NSF)

Press Release 13-148 Ocean acidification: Making new discoveries through National Science Foundation research grants

Press Release 13-148 - Video nsf.gov - News - Video - NSF Ocean Sciences Division Director David Conover answers questions about ocean acidification. - US National Science Foundation (NSF)

Press Release 14-010 nsf.gov - National Science Foundation (NSF) News - Palau's coral reefs surprisingly resistant to ocean acidification - US National Science Foundation (NSF)

Press Release 14-116 nsf.gov - National Science Foundation (NSF) News - Ocean Acidification: NSF awards $11.4 million in new grants to study effects on marine ecosystems - US National Science Foundation (NSF)

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1220478

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