

# Isotopes (d11B, 87Sr/86Sr, d18O, d13C), elemental concentrations (B, Mg, Ca), and carbon content collected from the foraminifera *Ammonia parkinsoniana* and sediments in Celestun Lagoon, Yucatan, Mexico in June 2009 and May 2015

**Website:** <https://www.bco-dmo.org/dataset/941327>

**Data Type:** Other Field Results

**Version:** 1

**Version Date:** 2024-10-25

## Project

» [Calcification in low saturation seawater: What can we learn from organisms in the proximity of low pH; undersaturated submarine springs](#) (CalcificationLowSatSeawater)

## 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

This dataset includes isotopes ( $\delta^{11}\text{B}$ ,  $87\text{Sr}/86\text{Sr}$ ,  $\delta^{18}\text{O}$ ,  $\delta^{13}\text{C}$ ), elemental concentrations (B, Mg, Ca), and carbon content collected from the foraminifera *Ammonia parkinsoniana* and sediments in Celestun Lagoon, Yucatan, Mexico in June 2009 and May 2015. Sediment cores were taken with push corers and piston corers. Sampling sites were distributed unevenly along a transect along the lagoon. These data were collected to investigate the influence of low-pH groundwater-seawater mixing on the boron isotope pH proxy.

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## Coverage

**Location:** Celestún Biosphere Reserve, Yucatan, Mexico. 20.88 N 90.36 E depth 0.5 m.

**Spatial Extent:** N:20.95925 E:-90.32955 S:20.83918 W:-90.38802

**Temporal Extent:** 2009-06-14 - 2015-05-26

## Methods & Sampling

**Location:** Celestún Biosphere Reserve, Yucatan, Mexico. 20.88 N 90.36 E depth 0.5 m.

**Collection:** Data collected from dinghy. No vessel name. June 2009 and May 2015.

Sediment cores were collected during three expeditions to Celestun Lagoon in 2006, 2009, and 2015. Sediments were stored in cold (4 Celcius) storage. Short cores were sectioned at 2 cm intervals, and long cores were processed at 5 cm resolution. Foraminifera samples were sieved, deflocculated, and handpicked for geochemical analysis, including  $\delta^{11}\text{B}$ ,  $87\text{Sr}/86\text{Sr}$ , and  $\delta^{18}\text{O}$ .

Additional methods citations:

- Boron isotope method: Wang et al. (2020).
- Strontium isotope method: Liu et al. (2012).
- pH and borate equations: Foster et al. (2016).
- Organic carbon in sediments. Modified to use chilled sulfuric acid with sonication to ensure complete decarbonation: Verardo et al. (1990).

**Related dataset descriptions** (See section "Related Datasets" for data citations):

Water samples:

BCO-DMO dataset <https://www.bco-dmo.org/dataset/941377> contains water sample data collected concurrently with the May 2015 sampling event.

This study and Paytan (2021, BCO-DMO dataset <https://www.bco-dmo.org/dataset/564766>) both derive groundwater from the same regional aquifer in Yucatan, Mexico, and both studies review the effects of low-pH springs on saturation and calcification of organisms. They are different sample material.

The sediment cores and assemblages in Hardage et al. (2021, doi:10.1016/j.talanta.2011.10.050) at NOAA provide the sample material for the geochemistry reported in this study (foraminifera, bulk sediment, physical observations). The Hardage et al. (2021) dataset also contains additional lithology and geochemistry that can be paired with these new data for interested parties.

## Organism Life Science Identifier (LSID):

Ammonia parkinsoniana, urn:lsid:marinespecies.org:taxname:418095

## Instrument and equipment list:

LDPE bottles: water samples were collected in acid-washed LDPE bottles for trace metals.

rubber septum glass vials: water samples were collected in ashed glass bottles for nutrients.

Piston, Bolivia, Livingstone corers: coring devices used to collect sediments.

0.5 mL micro-centrifuge tubes: used to store crushed foraminifera for cleaning.

Yellow Springs Instrument Model 63 handheld sonde and pH probe.

Neptune multi-collector inductively coupled plasma mass spectrometer (MC-ICPMS).

Lachat QuikChem 8000.

UIC Carbon Coulometer Analyzer.

Orion 950 Titrator.

Thermo Scientific Element XR ICPMS.

ThermoFinnigan Delta Plus XP isotope ratio mass spectrometer.

Kiel IV Carbonate Device.

ThermoScientific MAT-253 dual-inlet isotope ratio mass spectrometer.

Carlo Erba elemental analyzer IRMS.

## Data Processing Description

Element data were corrected for blank, drift, mass bias, and calcium matrix effects.

Boron isotopes were corrected using the standard-sample-standard bracket technique to correct drift and bias across each individual sample.

pKB\* was calculated according to Hain et al. (2015).

*Global Biogeochemical Cycles* using the MATLAB code implemented by Rae (2018).

*Boron Isotopes*.

$\delta^{11}\text{B}$  borate was calculated using Table A2.2 of

Hönisch et al. (2019). *Boron Proxies in Paleoceanography and Paleoclimatology*.

Note about aggregated data (means, standard deviations):

The averages are from the instruments themselves, not from true replicates. They typically take 4 to 10 readings and average the result, depending on the instrument. Since these are mass spectrometers counting individual ions, this averaging is necessary to reduce noise.

## BCO-DMO Processing Description

\* Data table from submitted file "Hardage\_boron\_foraminifera\_parameter\_values.csv" was imported into the BCO-DMO data system for this dataset. Values "-999" imported as missing data values.

\*\* In the BCO-DMO data system missing data identifiers are displayed according to the format of data you access. For example, in csv files it will be blank (null) values. In Matlab .mat files it will be NaN values. When viewing data online at BCO-DMO, the missing value will be shown as blank (null) values.

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## Related Publications

Foster, G. L., & Rae, J. W. B. (2016). Reconstructing Ocean pH with Boron Isotopes in Foraminifera. *Annual Review of Earth and Planetary Sciences*, 44(1), 207–237. <https://doi.org/10.1146/annurev-earth-060115-012226>

*Methods*

Hönisch, B., Eggins, S. M., Haynes, L. L., Allen, K. A., Holland, K. D., & Lorbacher, K. (2019). Boron proxies in paleoceanography and paleoclimatology. <https://isbnsearch.org/isbn/9781119010647>

*Methods*

Liu, H.-C., You, C.-F., Huang, K.-F., & Chung, C.-H. (2012). Precise determination of triple Sr isotopes ( $\delta^{87}\text{Sr}$  and  $\delta^{88}\text{Sr}$ ) using MC-ICP-MS. *Talanta*, 88, 338–344. <https://doi.org/10.1016/j.talanta.2011.10.050>

*Methods*

Verardo, D. J., Froelich, P. N., & McIntyre, A. (1990). Determination of organic carbon and nitrogen in marine sediments using the Carlo Erba NA-1500 analyzer. *Deep Sea Research Part A. Oceanographic Research Papers*, 37(1), 157–165. [https://doi.org/10.1016/0198-0149\(90\)90034-s](https://doi.org/10.1016/0198-0149(90)90034-s)

*Methods*

Wang, B.-S., You, C.-F., Huang, K.-F., Wu, S.-F., Aggarwal, S. K., Chung, C.-H., & Lin, P.-Y. (2010). Direct separation of boron from Na- and Ca-rich matrices by sublimation for stable isotope measurement by MC-ICP-MS. *Talanta*, 82(4), 1378–1384. doi:[10.1016/j.talanta.2010.07.010](https://doi.org/10.1016/j.talanta.2010.07.010)

*Methods*

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## Related Datasets

## IsRelatedTo

Hardage, K., Street, J., Herrera-Silveira, J. A., Oberle, F. K. J., & Paytan, A. (2021). *NOAA/WDS Paleoclimatology - Celestun Lagoon, Yucatan 5300 Year Foraminifera Census and Geochemistry* [Data set]. NOAA National Centers for Environmental Information. <https://doi.org/10.25921/QKC1-YW35> <https://doi.org/10.25921/qkc1-yw35>

Paytan, A. (2021) **Results of an experiment on recruitment and succession on a tropical benthic reef community in response to in-situ ocean acidification in Puerto Morelos, Quintana Roo, Mexico from 2010-2011 (CalcificationLowSatSeawater project)**. Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2015-09-09 doi:10.26008/1912/bco-dmo.564766.1 [[view at BCO-DMO](#)]

*Relationship Description: Low-pH spring studies on the eastern coast of the Yucatan Peninsula. Both derive groundwater from the same regional aquifer in Yucatan, Mexico, and both studies review the effects of low-pH springs on saturation and calcification of organisms. They used different sample material.*

Paytan, A., You, C., Herrera-Silveira, J. A., Wang, T. D., Liu, H. A., Street, J. H. (2024) **Measured and calculated geochemistry values and uncertainty for water samples taken from the water column of Celestun Lagoon, Yucatan, Mexico in May of 2015**. Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2024-10-25 <http://lod.bco-dmo.org/id/dataset/941377> [[view at BCO-DMO](#)]

*Relationship Description: Datasets collected as part of the same study. Both contain data from samples collected from Celestun Lagoon, Yucatan, Mexico in May of 2015.*

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## Parameters

Parameter	Description	Units
site	Site code for sediment sample.	unitless
lat	Site latitude in WGS84; north is positive.	decimal degrees
long	Site longitude in WGS84; east is negative.	decimal degrees
distance	Distance along the central lagoon axis from the northern fringe mangrove to the southern lagoon opening to the ocean.	kilometers (km)
core	Sediment core taken at site. Subsampled for analysis of sediment organic matter and calcite of the benthic foraminifera <i>Ammonia parkinsoniana</i> .	unitless
depth	Depth in the sediment core, which is the same as depth below sediment-water interface.	centimeters (cm)
MgCa	Magnesium to calcium ratio measured in the calcite of <i>Ammonia parkinsoniana</i> .	millimol per mole (mmol/mol)
MgCa_2sd	Magnesium to calcium ratio 2 standard deviations, determined from lab standards.	millimol per mole (mmol/mol)

BCa	Boron to calcium ratio measured in the calcite of Ammonia parkinsoniana.	micromol per mole (umol/mol)
BCa_2sd	Boron to calcium ratio 2 standard deviations, determined from lab standards.	micromol per mole (umol/mol)
d11B	Boron-11 isotope ratio measured in the calcite of Ammonia parkinsoniana.	per mil (0/00)
d11B_2sd	Boron-11 isotope ratio 2 standard deviations, determined from lab standards.	per mil (0/00)
d18O	Oxygen-18 isotope ratio measured in the calcite of Ammonia parkinsoniana. Uncertainty is +- 0.06, determined from lab standards.	per mil (0/00)
d13C	Carbon-13 isotope ratio measured in the calcite of Ammonia parkinsoniana. Uncertainty is +- 0.13, determined from lab standards.	per mil (0/00)
Sr8786	Radiogenic strontium ratio $87\text{Sr}/86\text{Sr}$ measured in the calcite of Ammonia parkinsoniana.	unitless
Sr8786_2sd	Radiogenic strontium ratio $87\text{Sr}/86\text{Sr}$ 2 standard deviations, determined from lab standards.	unitless
d13C_om	Carbon-13 isotope ratio measured in the organic matter (carbon) fraction of bulk sediment.	per mil (0/00)
d13C_om_sd	Carbon-13 isotope ratio standard deviation, determined from lab standards.	per mil (0/00)
om_content	Weight percent organic matter (carbon) content of bulk sediment.	percent (%)
om_content_sd	Weight percent organic matter (carbon) standard deviation, determined from lab standards.	percent (%)
date	Date of sample collection in ISO 8601 format. GMT-6 (Central Standard Time in Yucatan, Mexico)	date

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## Instruments

<b>Dataset-specific Instrument Name</b>	Orion 950 Titrator
<b>Generic Instrument Name</b>	Automatic titrator
<b>Generic Instrument Description</b>	Instruments that incrementally add quantified aliquots of a reagent to a sample until the end-point of a chemical reaction is reached.

<b>Dataset-specific Instrument Name</b>	
<b>Generic Instrument Name</b>	Bottle
<b>Dataset-specific Description</b>	LDPE bottles: water samples were collected in acid-washed LDPE bottles for trace metals.
<b>Generic Instrument Description</b>	A container, typically made of glass or plastic and with a narrow neck, used for storing drinks or other liquids.

<b>Dataset-specific Instrument Name</b>	Carlo Erba elemental analyzer IRMS
<b>Generic Instrument Name</b>	Elemental Analyzer
<b>Generic Instrument Description</b>	Instruments that quantify carbon, nitrogen and sometimes other elements by combusting the sample at very high temperature and assaying the resulting gaseous oxides. Usually used for samples including organic material.

<b>Dataset-specific Instrument Name</b>	Thermo Scientific Element XR ICPMS
<b>Generic Instrument Name</b>	Inductively Coupled Plasma Mass Spectrometer
<b>Generic Instrument Description</b>	An ICP Mass Spec is an instrument that passes nebulized samples into an inductively-coupled gas plasma (8-10000 K) where they are atomized and ionized. Ions of specific mass-to-charge ratios are quantified in a quadrupole mass spectrometer.

<b>Dataset-specific Instrument Name</b>	ThermoFinnigan Delta Plus XP isotope ratio mass spectrometer
<b>Generic Instrument Name</b>	Isotope-ratio Mass Spectrometer
<b>Generic Instrument Description</b>	The Isotope-ratio Mass Spectrometer is a particular type of mass spectrometer used to measure the relative abundance of isotopes in a given sample (e.g. VG Prism II Isotope Ratio Mass-Spectrometer).

<b>Dataset-specific Instrument Name</b>	Kiel IV Carbonate Device
<b>Generic Instrument Name</b>	Isotope-ratio Mass Spectrometer
<b>Generic Instrument Description</b>	The Isotope-ratio Mass Spectrometer is a particular type of mass spectrometer used to measure the relative abundance of isotopes in a given sample (e.g. VG Prism II Isotope Ratio Mass-Spectrometer).

<b>Dataset-specific Instrument Name</b>	ThermoScientific MAT-253 dual-inlet isotope ratio mass spectrometer.
<b>Generic Instrument Name</b>	Isotope-ratio Mass Spectrometer
<b>Generic Instrument Description</b>	The Isotope-ratio Mass Spectrometer is a particular type of mass spectrometer used to measure the relative abundance of isotopes in a given sample (e.g. VG Prism II Isotope Ratio Mass-Spectrometer).

<b>Dataset-specific Instrument Name</b>	Lachat QuikChem 8000
<b>Generic Instrument Name</b>	Lachat QuikChem 8000 flow injection analyzer and Ion Chromatography (IC) system
<b>Generic Instrument Description</b>	The Lachat QuikChem 8000 can operate flow injection analysis and ion chromatography simultaneously and independently on the same instrument platform. Instrument includes sampler, dilutor, sampling pump, electronics unit, and data station. Analysis takes 20-60 seconds, with a sample throughput of 60-120 samples per hour. Measurements are in the range of parts per trillion to parts per hundred.

<b>Dataset-specific Instrument Name</b>	Neptune multi-collector inductively coupled plasma mass spectrometer (MC-ICPMS).
<b>Generic Instrument Name</b>	Multi Collector Inductively Coupled Plasma Mass Spectrometer
<b>Generic Instrument Description</b>	A Multi Collector Inductively Coupled Plasma Mass Spectrometry (MC-ICPMS) is a type of mass spectrometry where the sample is ionized in a plasma (a partially ionized gas, such as Argon, containing free electrons) that has been generated by electromagnetic induction. A series of collectors is used to detect several ion beams simultaneously. A MC-ICPMS is a hybrid mass spectrometer that combines the advantages of an inductively coupled plasma source and the precise measurements of a magnetic sector multicollector mass spectrometer. The primary advantage of the MC-ICPMS is its ability to analyze a broader range of elements, including those with high ionization potential that are difficult to analyze by Thermal Ionization Mass Spectrometry (TIMS). The ICP source also allows flexibility in how samples are introduced to the mass spectrometer and allows the analysis of samples introduced either as an aspirated solution or as an aerosol produced by laser ablation.

<b>Dataset-specific Instrument Name</b>	Yellow Springs Instrument Model 63 handheld sonde and pH probe.
<b>Generic Instrument Name</b>	Multi Parameter Portable Meter
<b>Generic Instrument Description</b>	An analytical instrument that can measure multiple parameters, such as pH, EC, TDS, DO and temperature with one device and is portable or hand-held.

<b>Dataset-specific Instrument Name</b>	
<b>Generic Instrument Name</b>	Piston Corer
<b>Generic Instrument Description</b>	The piston corer is a type of bottom sediment sampling device. A long, heavy tube is plunged into the seafloor to extract samples of mud sediment. A piston corer uses a "free fall" of the coring rig to achieve a greater initial force on impact than gravity coring. A sliding piston inside the core barrel reduces inside wall friction with the sediment and helps to evacuate displaced water from the top of the corer. A piston corer is capable of extracting core samples up to 90 feet in length.

<b>Dataset-specific Instrument Name</b>	UIC Carbon Coulometer Analyzer
<b>Generic Instrument Name</b>	unknown
<b>Generic Instrument Description</b>	No relevant match in BCO-DMO instrument vocabulary.

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## Project Information

### Calcification in low saturation seawater: What can we learn from organisms in the proximity of low pH; undersaturated submarine springs (CalcificationLowSatSeawater)

**Coverage:** Puerto Morelos, Quintana Roo, Mexico

#### *NSF Abstract:*

To date scientists have primarily used short-term single species experiments to study responses of organisms to increased pCO<sub>2</sub>. While these experiments are important, they represent an artificial situation, being isolated from many of the biological interactions. Moreover, these experiments do not truly reflect the effects on organisms over longer timescales in actual field situations.

In this study, researchers at the University of California at Santa Cruz will assess the utility of low pH submarine springs as field study sites for investigating calcification at low aragonite saturation. It has been reported that many reef-building corals cease calcification at saturation as high as 2.0; around these springs calcifying corals inhabit waters well below this value. Work will take place at a series of springs in Mexico where discharging water pH ranges from 8.07 to 7.25 and saturation from less than 0.5 to 5. While these springs are by no means analogs for future ocean calcification they can still provide a natural laboratory to study controls on coral calcification. Field observations are usually confounded by the presence of many potentially important variables in addition to saturation. Moreover, it is not trivial to quantify the natural spatial and temporal variability of the parameters of interest. Thus it is not clear how useful this setting might be for conducting extensive field based calcification research (high risk). Accordingly, the research team will conduct field surveys to map the chemical and physical characteristics of the water around the springs (and corals) and describe population and community patterns along the saturation gradient. They will install probes to capture the temporal and spatial variability. These observations should allow assessment of the site's utility for researching processes that sustain calcification at low saturation and for future manipulative experiments.



#### *Background publications:*

Crook ED, Potts D, Rebolledo-Vieyra M, Hernandez L, Paytan A. 2011. Calcifying coral abundance near low pH springs: implications for future ocean acidification. *Coral Reefs*, 31(1): 239-245.

Paytan A, Crook ED, Cohen AL, Martz T, Takeshita Y et al. 2014. Reply to Iglesias-Prieto et al.: Combined field and laboratory approaches for the study of coral calcification. *Proc Natl Acad Sci USA*, 111 (3): E302-E303.

Crook ED, Cohen AL, Rebolledo-Vieyra M, Hernandez L, Paytan A. 2013. Reduced calcification and lack of acclimatization by coral colonies growing in areas of persistent natural acidification. *Proc Natl Acad Sci USA*, 110 (27): 1044-1049.

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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](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](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
<a href="#">NSF Division of Ocean Sciences (NSF OCE)</a>	<a href="#">OCE-1040952</a>

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