CO2 parameters as function of salinity and temperature

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Project
» Ocean Acidification: Collaborative Research: Investigation of seawater CO2 system thermodynamics under high pCO2 conditions (High pCO2 Thermodynamics)

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

Contributors	Affiliation	Role
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Abstract
This dataset contains CO2 parameters between salinity 20 to 40 and temperature 5 to 40 degree Celsius collected in a lab experiment.

Table of Contents

Methods & Sampling

CO2 system parameters were collected over salinity 20 to 40 and temperature 5 to 40 degree range. Seawater was collected from offshore in Golf of Mexico. Salinity other than 35 were obtained by either evaporation or dilution. 1 liter sample was put in constant waterbath, CO2 gases from 200 ppm to 2000 ppm(200, 400, 600, 800, 1000, 1300, 1600 and 2000 ppm) were used to bubble the sample at rate of 100 ml/min until the solution reached equilibration with each gas. pH, DIC and TA samples were taken from each sample bottle for analysis.

Sampling and Analytical Procedures

The dataset is a laboratory collection of CO2 parameters under a controlled environment. The experiment involved equilibrating CO2 gases with samples at different salinities and temperatures.
pH was measured using purified mCP ((Liu et al. 2011)) on Agilent 8453 following the protocol of SOP 6b (Dickson et 2017). For low-temperature data, a measurement system was built in the waterbath to ensure the temperature of pH measurement was the same as the sample. Samples were drawn using PEEK tubing by gravity into dried 10 cm cylindrical cells. 3 cell volume was allowed to overflow to ensure uncontaminated sample. Collected sample were thermostatted at equilibrating temperature and analyzed. Two indicators additions were made to get an assessment of indicator perturbation for each sample.

DIC was measured using a custom-built acidification module (Liu et al. 2018). The instrument was built directly in the equilibration waterbath to ensure samples were in equilibration at the proper temperature. The instrument was equipped with a two position Vici switch to automate the sample introduction and acidification process, and a multiposition Vici switch to sample up to 10 samples automatically. The evolved CO2 was

measured either by coulometry by UIC or Picarro's CRD instrument. DIC was calibrated with CRM provided by Andrew Dickson's lab.

After pH and DIC samples were drawn, TA samples were taken. The sample was weighed on a balance. TA was measured using a custom built single point titration system (Liu et al. 2015).
xCO2 of the equilibrating gases were measured on Picarro CRD instruments using two standard gases traceable to NIST.

[table of contents | back to top]

Related Publications

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

Liu, X., Byrne, R. H., Lindemuth, M., Easley, R., & Mathis, J. T. (2015). An automated procedure for laboratory and shipboard spectrophotometric measurements of seawater alkalinity: Continuously monitored single-step acid additions. Marine Chemistry, 174, 141–146. doi:10.1016/j.marchem.2015.06.008
Methods

Liu, X., Patsavas, M. C., & Byrne, R. H. (2011). Purification and Characterization of meta-Cresol Purple for Spectrophotometric Seawater pH Measurements. Environmental Science & Technology, 45(11), 4862–4868. doi:10.1021/es200665d
Methods

[table of contents | back to top]

Parameters

Parameters for this dataset have not yet been identified

[table of contents | back to top]

Project Information

Ocean Acidification: Collaborative Research: Investigation of seawater CO2 system thermodynamics under high pCO2 conditions (High pCO2 Thermodynamics)

NSF abstract:

Assessments of the effects of ocean acidification in a high CO2 world require well-constrained models that interrelate measurable carbon system parameters: total dissolved inorganic carbon (CT) and total alkalinity (AT), CO2 fugacity (fCO2), pH and carbonate ion concentration ([CO3 2-]). Current thermodynamic models that relate CT and AT to fCO2 using carbonic acid dissociation constants (K1' and K2') developed for seawater analyses have been shown to provide good results at current fCO2 values ca. 380 uatm, but break down at the elevated CO2 concentrations (>500 uatm) that are likely to occur before the end of this century. Studies of the effects of elevated CO2 on organismal and ecosystem functions require robust thermodynamic models to ensure that results, which occasionally involve measurements of only two system-variables, provide accurate depictions of the investigated system in its entirety. Because accurate predictions of the consequences of ocean acidification are critical to guide management and policy decisions, development of accurate thermodynamic CO2 system models is essential.

In this project, researchers at the University of South Florida and SRI International will perform best practices measurements of CT, AT, fCO2 and pH, and subsequently assess the magnitudes of K1', K2' and KB' that produce an internally consistent thermodynamic model of the marine CO2 system. The proposed work is facilitated by (a) the recent development and characterization of purified indicators for precise and accurate seawater pH measurements and (b) the development of accurate borate to salinity ratios that provide an

improved account of the contributions of boric acid to the buffer intensity of seawater. The study will include investigations of the AT contributions of uncharacterized seawater protolytes (e.g. from dissolved organic matter) as well as the possible interactions between carbonate and borate ions that may influence CO2 equilibria under high pCO2 conditions. The proposed work will additionally be promoted by the recent development of UV spectrometric procedures for direct measurements of carbonate ion concentrations in seawater.

Broader Impacts: The OCB Ocean Acidification Principal Investigator Workshop Report (2011) identified a near-term need to "determine the consequences of large pH change on the carbonate system; as pH shifts the carbonate system may respond in ways different from the range we customarily measure". Since interpretation of the results of CO2 system perturbation experiments depend on accurate knowledge of the carbon system parameters under which the experiments were performed, development of improved carbon system equilibrium relationships, especially at high CO2 levels, is vitally important to the study of ocean acidification.

Graduate and undergraduate students involved in the project will benefit from learning carbon system best practices as well as obtaining a comprehensive understanding of CO2 system thermodynamics. The field component will provide hands-on experience in at sea measurements and statistical analysis of CO2 system relationships. Furthermore, we intend to develop an ocean acidification classroom and laboratory module that will be taught at a local high school serving an ethnically-diverse student population. The lesson plans developed during this activity will be presented to teachers at the annual District-wide Training for High School Science/Math for Pinellas County schools.

[table of contents | back to top]

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)

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 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.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1220289
NSF Division of Ocean Sciences (NSF OCE)	OCE-1220110

[table of contents | back to top]