Experiment with the diatom Chaetoceros sp. on the impact of temperature, light climate, and carbonate chemistry on TEP production and aggregation processes from May 2015 (OA - Effects of High CO2 project)

Website: https://www.bco-dmo.org/dataset/715125
Data Type: experimental
Version: 2017-08-28

Project
» Will high CO2 conditions affect production, partitioning and fate of organic matter? (OA - Effects of High CO2)

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
Jones, Jonathan	University of California-Santa Barbara (UCSB-MSI)	Principal Investigator
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Coverage

Temporal Extent: 2015-05-20 - 2015-05-28

Dataset Description

In this experiment, we used five-liter rolling tanks to address the question of whether elevated pCO2, temperature, and light climate simulating a future climate scenario will increase the aggregation potential for a phytoplankton clone representing the diatom genus, Chaetoceros. Bloom development, TEP production, and aggregation were monitored over an eight-day period to observe how simulated future ocean conditions may influence bloom dynamics for this species compared to the species' optimal growth condition.

A freshly isolated species of the phytoplankter genus Chaetoceros (10-50um cell length) was used was isolated in June of 2014 in the Eastern Pacific CCS (38.700N 123.671W). In culture, Chaetoceros sp. grew in f/2 media, over a temperature gradient of 12-25 ºC and light climate ranging from 70-400 µmol m-2s-1.

Two experimental treatments were used to assess the impacts of increased light, temperature, and pCO2 stress on the processes of DIC uptake, TEP production, and aggregation. For each treatment, 12 gas-tight polycarbonate rolling tanks were exposed to a single combination of light climate, temperature, and pCO2 representing either optimal or future conditions. Rolling tanks were constructed and maintained to establish solid body rotation. Target temperature (13 °C) and light intensity (100 µmol m-2s-1) for the optimal treatment were determined in the pre-experimental phase with the addition of present-day levels of pCO2 (400 ppm). In the treatment representing predicted increases in stratification, warming, and elevated pCO2, target future conditions were 18 ºC, 200 µmol m-2s-1, and 800 ppm.

Methods & Sampling

All samples were processed at UCSB in the Passow Laboratory. Samples for the carbonate system, DOC, and cell concentration were collected first to forestall changes due to bacterial activity and cell sinking. All carbonate system samples were overfilled by a minimum of 50% volume into acid rinsed borosilicate glass bottles leaving ~1% headspace and fixed with 130µL of saturated mercuric chloride solution (Dickson et al., 2007). All samples were stored at 2 degrees C until analysis. DOC samples were gravity-filtered through precombusted 0.2µm GF/F filters into combusted glass vials and acidified with 60µL of 4N HCl. Samples were collected in duplicate for each replicate tank. All samples were refrigerated until analysis. Approximately 20ml of well-mixed background water was collected and fixed with buffered Formalin (10%) to determine cell concentrations. Background tank water was then sampled for inorganic nutrients, POC, TEP, and biogenic silica (bSi). Inorganic nitrate, nitrite, phosphate, and silicate were collected into 20ml HDPE vials and frozen until analysis. Samples for POC were filtered onto precombusted 0.4 GF/F filters, dried at 60ºC for 24h and stored in a desiccator until analysis. TEP samples were filtered onto 0.4lm polycarbonate filters and stained with Alcian Blue following Passow and Alldredge (1995). The Alcian Blue dye was calibrated using Gum Xanthum equivalents per liter. Samples for bSi were filtered through 0.6lm polycarbonate filters and frozen until analysis.

Once the background water was sampled, aggregates were collected from the bottom of the rolling tanks and transferred with minimal surrounding seawater to acid washed 1L polycarbonate bottles. The aggregate slurry was then mixed gently and measured for cell concentration, POC, TEP, and bSi following the same methods outlined above. Due to the time required to sample each tank, samples for both background water and aggregate slurry were sampled for one replicate before moving on to the next. The entire sampling process took approximately 4h per treatment. Tanks were opened and sampled in a 2 degrees C temperature controlled room to slow bacterial remineralization throughout the sampling process.

Data Processing Description

All data were processed using R: version 3.2.4 (2016-03-10) -- "Very Secure Dishes" Copyright (C) 2016 The R Foundation for Statistical Computing Platform: x86_64-apple-darwin13.4.0 (64-bit)

BCO-DMO Processing Notes:

Replaced "NA" with "nd" to be compatible with the BCO-DMO system.

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Data Files

File
ChaetImpact.csv (Comma Separated Values (.csv), 3.39 KB) MD5:564efa9f2bdb490018864c2775527f20 Primary data file for dataset ID 715125

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Related Publications

Brzezinski, M. A., & Nelson, D. M. (1995). The annual silica cycle in the Sargasso Sea near Bermuda. Deep Sea

Research Part I: Oceanographic Research Papers, 42(7), 1215–1237. doi:10.1016/0967-0637(95)93592-3
General

Carlson, C. A., Hansell, D. A., Nelson, N. B., Siegel, D. A., Smethie, W. M., Khatiwala, S., Meyers, M. M., Halewood, E. (2010). Dissolved organic carbon export and subsequent remineralization in the mesopelagic and bathypelagic realms of the North Atlantic basin. Deep Sea Research Part II: Topical Studies in Oceanography, 57(16), 1433–1445. doi:10.1016/j.dsr2.2010.02.013
General

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

Krause, J. W., Nelson, D. M., & Lomas, M. W. (2009). Biogeochemical responses to late-winter storms in the Sargasso Sea, II: Increased rates of biogenic silica production and export. Deep Sea Research Part I: Oceanographic Research Papers, 56(6), 861–874. doi:10.1016/j.dsr.2009.01.002
General

Passow, U., & Alldredge, A. L. (1995). A dye-binding assay for the spectrophotometric measurement of transparent exopolymer particles (TEP). Limnology and Oceanography, 40(7), 1326–1335. doi:10.4319/lo.1995.40.7.1326
Methods

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Parameters

Parameter	Description	Units
Sample_Date	date the sample was taken in YYYYMMDD format	unitless
Tank_Label	Tank identifier	unitless
Treatment_type	Treatment type	unitless
Temp	Temperature	degrees Celsius (C)
Light_climate	photosynthetic photon flux density	micromoles per meter squared (umol/m^2)
Total_Vol	Full tank volume	Liters (L)
SSW_Vol	surrounding seawater volume	Liters (L)
Slurry_Vol	Aggregate slurry volume	Liters (L)
SSW_PO4	Surrounding seawater phosphate	micromoles per liter (umol/L)
SSW_Si	Surrounding seawater silicic acid	micromoles per liter (umol/L)

SSW_NO3	Surrounding seawater nitrate	micromoles per liter (umol/L)
SSW_TA	Surrounding seawater total alkalinity	micromoles per kilogram (umol/kg)
SSW_pH	Surrounding seawater pH	pH units (total scale)
SSW_POC	Surrounding seawater particulate organic carbon	micrograms per liter (ug/L)
SSW_DOC	Surrounding seawater dissolved organic carbon	micromole per liter (umol/L)
SSW_TEP	Surrounding seawater transparent exopolymer particles	xanthum gum equivalents per liter
SSW_bSi	Surrounding seawater biogenic silica	micromoles per liter (umol/L)
SSW_cells	Surrounding seawater phytoplankton cells	cells per liter (cells/L)
AGG_POC	Aggregate slurry particulate organic carbon	micrograms per tank volume
AGG_TEP	Aggregate slurry transparent exopolymer particles	xanthum gum equivalents per tank volume
AGG_bSi	Aggregate slurry biogenic silica	micromoles per tank volume
AGG_cells	Aggregate slurry phytoplankson cells	cells per tank volume

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Instruments

Dataset-specific Instrument Name	CHN organic elemental analyzer (CEC 440HA, Exeter Analytical)
Generic Instrument Name	CHN Elemental Analyzer
Dataset-specific Description	POC samples were processed on a CHN organic elemental analyzer (CEC 440HA, Exeter Analytical).
Generic Instrument Description	A CHN Elemental Analyzer is used for the determination of carbon, hydrogen, and nitrogen content in organic and other types of materials, including solids, liquids, volatile, and viscous samples.

Dataset-specific Instrument Name	flow injection analyzer (QuickChem 8000, Lachat Instruments, Zellweger Analytics)
Generic Instrument Name	Flow Injection Analyzer
Dataset-specific Description	Nutrient samples were measured on a flow injection analyzer (QuickChem 8000, Lachat Instruments, Zellweger Analytics)
Generic Instrument Description	An instrument that performs flow injection analysis. Flow injection analysis (FIA) is an approach to chemical analysis that is accomplished by injecting a plug of sample into a flowing carrier stream. FIA is an automated method in which a sample is injected into a continuous flow of a carrier solution that mixes with other continuously flowing solutions before reaching a detector. Precision is dramatically increased when FIA is used instead of manual injections and as a result very specific FIA systems have been developed for a wide array of analytical techniques.

Dataset-specific Instrument Name	ocean optics flame spectrometer
Generic Instrument Name	Spectrometer
Dataset-specific Description	pH was measured at 25ºC (total hydrogen ion scale) on an ocean optics flame spectrometer with unpurified m-cresol dye against Tris pH buffer purchased from Andrew Dickson at Scripps.
Generic Instrument Description	A spectrometer is an optical instrument used to measure properties of light over a specific portion of the electromagnetic spectrum.

Dataset-specific Instrument Name	spectrophotometer (Thermo Scientific Genesys 105 VIS)
Generic Instrument Name	Spectrophotometer
Dataset-specific Description	The stained TEP filters were dissolved in sulfuric acid for 4h and measured coloimetrically through absorption at 787nm on a spectrophotometer (Thermo Scientific Genesys 105 VIS).
Generic Instrument Description	An instrument used to measure the relative absorption of electromagnetic radiation of different wavelengths in the near infra-red, visible and ultraviolet wavebands by samples.

Dataset-specific Instrument Name	Apollo SciTech (AS-ALK2)
Generic Instrument Name	Titrator
Dataset-specific Description	TA samples were measured following best practices (Dickson et al., 2007) on an Apollo SciTech (AS-ALK2) using certified titrant and certified reference materials purchased from Andrew Dickson at Scripps Institute of Oceanography.
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	Shimadzu TOC-V
Generic Instrument Name	Total Organic Carbon Analyzer
Dataset-specific Description	DOC was analyzed on a Shimadzu TOC-V following Carlson et al., (2010) with glucose and Santa Barbara Channel reference calibration standards.
Generic Instrument Description	A unit that accurately determines the carbon concentrations of organic compounds typically by detecting and measuring its combustion product (CO2). See description document at: http://bcodata.whoi.edu/LaurentianGreatLakes_Chemistry/bs116.pdf

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Deployments

lab_UCSB_MSI_Passow

Website	https://www.bco-dmo.org/deployment/58780
Platform	UCSB MSI Passow
Report	http://www.msi.ucsb.edu/people/research-scientists/uta-passow
Start Date	2009-09-01
End Date	2016-01-22
Description	Results form a series of controlled laboratory experiments investigating the effect of altered carbonate system chemistry on the abiotic formation of TEP

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Project Information

Will high CO2 conditions affect production, partitioning and fate of organic matter? (OA - Effects of High CO2)

Website: http://www.msi.ucsb.edu/people/research-scientists/uta-passow

Coverage: Passow Lab, Marine Science Institute, University of California Santa Barbara

From the NSF Award Abstract

Coastal waters are already experiencing episodic exposure to carbonate conditions that were not expected until the end of the century making understanding the response to these episodic events as important as understanding the long-term mean response. Among the most striking examples are those associated with coastal upwelling along the west coast of the US, where the pH of surface waters may drop to 7.6 and pCO2 can reach 1100 uatm. Upwelling systems are responsible for a significant fraction of global carbon export making them prime targets for investigations on how ocean acidification is already affecting the biological pump today.

In this study, researchers at the University of California at Santa Barbara will investigate the potential effects of ocean acidification on the strength of the biological pump under the transient increases in CO2 experienced due to upwelling. Increases in CO2 are expected to alter the path and processing of carbon through marine food webs thereby strengthening the biological pump. Increases in inorganic carbon without proportional increases in nutrients result in carbon over-consumption by phytoplankton. How carbon over-consumption affects the strength of the biological pump will depend on the fate of the extra carbon that is either incorporated into phytoplankton cells forming particulate organic matter (POM), or is excreted as dissolved organic matter (DOM). Results from mesocosm experiments demonstrate that the mechanisms controlling the partitioning of fixed carbon between the particulate and dissolved phases, and the processing of those materials, are obscured when both processes operate simultaneously under natural or semi-natural conditions. Here, POM and DOM production and the heterotrophic processing of these materials will be separated experimentally across a range of CO2 concentrations by conducting basic laboratory culture experiments. In this way the mechanisms whereby elevated CO2 alters the flow of carbon along these paths can be elucidated and better understood for use in mechanistic forecasting models.

Broader Impacts- The need to understand the effects of ocean acidification for the future of society is clear. In addition to research education, both formal and informal, will be important for informing the public. Within this project 1-2 graduate students and 2-3 minority students will be recruited as interns from the CAMP program (California Alliance for Minority Participation). Within the 'Ocean to Classrooms' program run by outreach personnel from UCSB's Marine Science Institute an educational unit for K-12 students will be developed. Advice and support is also given to the Education Coordinator of NOAA, Channel Islands National Marine Sanctuary for the development of an education unit on ocean acidification.

PUBLICATIONS PRODUCED AS A RESULT OF THIS RESEARCH

Arnosti C, Grossart H-P, Muehling M, Joint I, Passow U. "Dynamics of extracellular enzyme activities in seawater under changed atmsopheric pCO2: A mesocosm investigation.," Aquatic Microbial Ecology, v.64, 2011, p. 285.

Passow U. "The Abiotic Formation of TEP under Ocean Acidification Scenarios.," Marine Chemistry, v.128-129, 2011, p. 72.

Passow, Uta; Carlson, Craig A.. "The biological pump in a high CO2 world," MARINE ECOLOGY PROGRESS SERIES, v.470, 2012, p. 249-271.

Gaerdes, Astrid; Ramaye, Yannic; Grossart, Hans-Peter; Passow, Uta; Ullrich, Matthias S.. "Effects of Marinobacter adhaerens HP15 on polymer exudation by Thalassiosira weissflogii at different N:P ratios," MARINE ECOLOGY PROGRESS SERIES, v.461, 2012, p. 1-14.

Philip Boyd, Tatiana Rynearson, Evelyn Armstrong, Feixue Fu, Kendra Hayashi, Zhangi Hu, David Hutchins, Raphe Kudela, Elena Litchman, Margaret Mulholland, Uta Passow, Robert Strzepek, Kerry Whittaker, Elizabeth Yu, Mridul Thomas. "Marine Phytoplankton Temperature versus Growth Responses from Polar to Tropical Waters - Outcome of a Scientific Community-Wide Study," PLOS One 8, v.8, 2013, p. e63091.

Arnosti, C., B. M. Fuchs, R. Amann, and U. Passow. "Contrasting extracellular enzyme activities of particle-associated bacteria from distinct provinces of the North Atlantic Ocean," Frontiers in Microbiology, v.3, 2012, p. 1.

Koch, B.P., Kattner, G., Witt, M., Passow, U., 2014. Molecular insights into the microbial formation of marine dissolved organic matter: recalcitrant or labile? Biogeosciences Discuss. 11 (2), 3065-3111.

Taucher, J., Brzezinski, M., Carlson, C., James, A., Jones, J., Passow, U., Riebesell, U., submitted. Effects of warming and elevated pCO2 on carbon uptake and partitioning of the marine diatoms Thalassiosira weissflogii and Dactyliosolen fragilissimus. Limnology and Oceanography

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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)

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.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1041038

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