

# The effect of altered carbonate system chemistry on the abiotic formation of Transparent Exopolymer Particles (TEP) from UCSB MSI Passow Laboratory from 2009 to 2010 (OA - Ocean Acidification and Aggregation project)

**Website:** <https://www.bco-dmo.org/dataset/3623>

**Version:** 20 March 2012

**Version Date:** 2012-03-20

## Project

» [Will Ocean Acidification Diminish Particle Aggregation and Mineral Scavenging, Thus Weakening the Biological Pump?](#) (OA - Ocean Acidification and Aggregation)

## Programs

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

» [Ocean Carbon and Biogeochemistry](#) (OCB)

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## Dataset Description

Series 1: Abiotic TEP Formation - DIC Perturbation

Results form a series of controlled laboratory experiments investigating the effect of altered carbonate system chemistry on the abiotic formation of Transparent Exopolymer Particles (TEP).

The over determination columns (pCO2\_pH\_TA, pCO2\_DIC\_pH, pCO2\_DIC\_TA) give pCO2 (calculated using CO2Sys) for samples for which we measured three parameters, pH, total alkalinity (TA) and dissolved inorganic carbon (DIC). In all others we only measured pH and TA. These columns each give the calculated pCO2 in uatm, using pH and TA; DIC and pH and the DIC and TA respectively for calculations.

**Related Files:** [Passow U \(2012\) The Abiotic Formation of TEP under Ocean Acidification Scenarios. Marine Chemistry 128-129:72-80](#)

## Methods & Sampling

**See:** [Passow U \(2012\) The Abiotic Formation of TEP under Ocean Acidification Scenarios. Marine Chemistry 128-129:72-80](#)

## Data Processing Description

**See:** [Passow U \(2012\) The Abiotic Formation of TEP under Ocean Acidification Scenarios. Marine Chemistry 128-129:72-80](#)

Co2Sys was used to calculate the carbonate system parameter pCO<sub>2</sub>.

pCO<sub>2</sub> calculated from total alkalinity, DIC and pH (total scale) using Co2Sys

### BCO-DMO Processing Notes

Original files: "Data.xls, Sheet: DICperturbation" and "Overcompensation.xls" contributed by Uta Passow

- Approx Lat/Lon of Passow Lab appended to enable data discovery in MapServer
- "nd" (no data) inserted into blank cells
- Parameter names edited to conform to BCO-DMO parameter naming conventions

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## Data Files

File
<b>Series1_AbioticTEP_DICpert.csv</b> (Comma Separated Values (.csv), 7.23 KB) MD5:6579273c69d682a2c17182583c575785
Primary data file for dataset ID 3623

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## Parameters

Parameter	Description	Units
Lab_Id	Lab Id – Lab identifier where experiments were conducted	text
Lat	Approximate Latitude Position of Lab; South is negative	decimal degrees
Lon	Approximate Longitude Position of Lab; West is negative	decimal degrees
Experiment_Number	Experiment Number	integer
Date_Range	Experiment Date Range	MM/DD/YR – MM/DD/YR
Substrate	Substrate	text
Treatment	Treatments	text
Replicates	Replicates	text
pCO2_T0_pH_TA	pCO2 at T0	micro atmospheres
pCO2_T24_pH_TA	pCO2 at T24	micro atmospheres
pCO2_pH_TA	pCO2 pH TA	micro atmospheres
pCO2_DIC_pH	pCO2 DIC pH	micro atmospheres
pCO2_DIC_TA	pCO2 DIC TA	micro atmospheres
pH_T0	pH at T0	sea water scale
pH_T24	pH at T24	sea water scale
TEP_T0	TEP at T0 in ug of Gxeq (xanthan gum weight equivalent) per liter	ug Gxeq/L
TEP_T24	TEP at T24 in ug of Gxeq (xanthan gum weight equivalent) per liter	ug Gxeq/L

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## Instruments

<b>Dataset-specific Instrument Name</b>	Automatic titrator - T50, Mettler Toledo
<b>Generic Instrument Name</b>	Automatic titrator
<b>Dataset-specific Description</b>	In brief, TA ( $\mu\text{mol kg}^{-1}$ ) was measured within 4 hours after sampling by potentiometric titration (T50, Mettler Toledo) using certified acid titrant.
<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>	bottle
<b>Generic Instrument Name</b>	Bottle
<b>Dataset-specific Description</b>	Experiments 3 and 4, respectively, were conducted with 10 $\mu\text{m}$ pre-filtered natural seawater and 10 $\mu\text{m}$ pre-filtered sea water first incubated in 20 L bottles (bottle blooms).
<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>	Conductivity Meter - 3100 Yellow Springs Instruments
<b>Generic Instrument Name</b>	Conductivity Meter
<b>Dataset-specific Description</b>	Salinity was determined from TA samples using a conductivity instrument (3100 Yellow Springs Instruments).
<b>Generic Instrument Description</b>	Conductivity Meter - An electrical conductivity meter (EC meter) measures the electrical conductivity in a solution. Commonly used in hydroponics, aquaculture and freshwater systems to monitor the amount of nutrients, salts or impurities in the water.

<b>Dataset-specific Instrument Name</b>	in-situ incubator
<b>Generic Instrument Name</b>	In-situ incubator
<b>Generic Instrument Description</b>	A device on a ship or in the laboratory that holds water samples under controlled conditions of temperature and possibly illumination.

<b>Dataset-specific Instrument Name</b>	Aquarium Pump
<b>Generic Instrument Name</b>	Pump
<b>Dataset-specific Description</b>	Bottle blooms were incubated in clear 20 L bottles at 14 °C, at 15-30 $\mu\text{E s}^{-1}$ for 12:12 hours and bubbled with an aquarium pump during the light hours to keep the carbonate system stable.
<b>Generic Instrument Description</b>	A pump is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action. Pumps can be classified into three major groups according to the method they use to move the fluid: direct lift, displacement, and gravity pumps

<b>Dataset-specific Instrument Name</b>	Roller Tank
<b>Generic Instrument Name</b>	Roller Tank
<b>Dataset-specific Description</b>	All experiments were conducted in rolling tanks at 14 °C in the dark.
<b>Generic Instrument Description</b>	Rolling tanks, which keep particles in suspension, thus simulating aggregate formation in situ. Marine snow experiments are conducted in roller tanks, which turn continuously, keeping marine snow in suspension. It is important for marine snow not to touch surfaces. The rolling tanks, which keep particles in suspension, thus simulate aggregate formation in situ. Marine snow formation due to different types of oil was tested. Some treatments are easily identifiable as containing oil by their color (middle). UCSB, CA 2012.

<b>Dataset-specific Instrument Name</b>	spectrophotometer - Shimadzu Biospec 16-1
<b>Generic Instrument Name</b>	Spectrophotometer
<b>Dataset-specific Description</b>	The pHT (total scale) was measured with a spectrophotometer (Shimadzu Biospec 16-1) using the indicator dye m cresol purple (Sigma-Aldrich) within 1-2 hours after sampling.
<b>Generic Instrument Description</b>	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.

<b>Dataset-specific Instrument Name</b>	TD-700
<b>Generic Instrument Name</b>	Turner Designs 700 Laboratory Fluorometer
<b>Dataset-specific Description</b>	Chl. a was determined during growth of cultures and bottle blooms using a fluorometer (Turner 700) by filtration of samples onto 0.4 µm PC filters and soaking the filters in 90% acetone over night in the freezer (Strickland, 1972).
<b>Generic Instrument Description</b>	The TD-700 Laboratory Fluorometer is a benchtop fluorometer designed to detect fluorescence over the UV to red range. The instrument can measure concentrations of a variety of compounds, including chlorophyll-a and fluorescent dyes, and is thus suitable for a range of applications, including chlorophyll, water quality monitoring and fluorescent tracer studies. Data can be output as concentrations or raw fluorescence measurements.

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## Deployments

### lab\_UCSB\_MSI\_Passow

<b>Website</b>	<a href="https://www.bco-dmo.org/deployment/58780">https://www.bco-dmo.org/deployment/58780</a>
<b>Platform</b>	UCSB MSI Passow
<b>Report</b>	<a href="http://www.msi.ucsb.edu/people/research-scientists/uta-passow">http://www.msi.ucsb.edu/people/research-scientists/uta-passow</a>
<b>Start Date</b>	2009-09-01
<b>End Date</b>	2016-01-22
<b>Description</b>	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 Ocean Acidification Diminish Particle Aggregation and Mineral Scavenging, Thus Weakening the Biological Pump? (OA - Ocean Acidification and Aggregation)

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

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

## **Will Ocean Acidification Diminish Particle Aggregation and Mineral Scavenging, Thus Weakening the Biological Pump?**

This award is funded under the American Recovery and Reinvestment Act of 2009 (Public Law 111-5).

The pH of the ocean is predicted to decrease by 0.2-0.5 pH units in the next 50 to 100 years as a result of increasing atmospheric CO<sub>2</sub>. To date almost all the research on impending ocean acidification has focused on the impacts to calcifying organisms and the carbonate system. However, ocean acidification will also affect other significant marine processes that are pH dependent.

In this project, researchers at the University of California at Santa Barbara will investigate the impact of ocean acidification on the organic carbon or 'soft tissue' biological pump. They predict that a decline in oceanic pH will result in an increase in the protonation of negatively charged substances, especially of Transparent Exopolymer Particles (TEP), the gel-like particles that provide the matrix of aggregates and bind particles together. A decreased polarity of these highly surface-active particles may reduce their "stickiness" resulting in decreased aggregation of organic-rich particles and a decreased ability of aggregates to scavenge and retain heavy ballast minerals. A reduction in aggregation will lower the fraction of POC enclosed in fast-sinking aggregates. Decreased scavenging of minerals by aggregates will result in reduced sinking velocities and consequently a decline in the fraction of material escaping degradation in the water column. Both processes ultimately reduce carbon flux to depth. The resulting weakening of the biological pump will alter pelagic ecology and potentially produce a positive feed-back pathway that further increases atmospheric CO<sub>2</sub> concentrations.

The research team will experimentally investigate TEP-production, aggregation rates and aggregate characteristics, mineral scavenging and sinking velocity as a function of ocean acidification, because these parameters are susceptible to pH and central in determining sedimentation rate of organic carbon. They will determine potential changes in the abiotic formation of TEP or in the release rate of TEP or TEP-precursors by phytoplankton that have been adapted to increased CO<sub>2</sub> regimes for multiple generations, up to 1000 doublings. Additionally, they will experimentally test potential changes in the aggregation rate of adapted phytoplankton and natural particles, and measure impacts on scavenging rates of ballast minerals by aggregates. Effects of various acidification levels on aggregate characteristics, including size, composition, density, and sinking velocity will also be determined. These results are expected to provide parameterization for a predictive model that will be used to investigate the impact of changing ballasting or aggregation on carbon flux.

Broader impact: Climate and environmental change are a global challenge to society. We need to know if possible positive feed back mechanisms to the biological pump will further increase atmospheric CO<sub>2</sub> in order to prepare for and hopefully manage future climate changes.

These data are also available at [Pangea](#)

### **RELATED FILES:**

Passow U (2012) The Abiotic Formation of Tep under Ocean Acidification Scenarios. *Marine Chemistry* 128-129:72-80

### **PUBLICATIONS PRODUCED AS A RESULT OF THIS RESEARCH**

Bathmann U, Passow U. "Global Erwärmung. Kohlenstoffpumpen im Ozean steuern das Klima.," *Biologie in unserer Zeit* 5, v.5, 2010.

Benner I, Passow U. "Utilization of organic nutrients by coccolithophores," *Marine Ecology Progress Series*, v.404, 2010, p. 21.

Feng Y, Hare C, Leblanc K, Rose J, Zhang Y, DiTullio G, Lee P, Wilhelm S, Rowe J, Sun J, Nemcek N, Gueguen C, Passow U, Benner I, Brown C, Hutchins D. "Effects of increased pCO<sub>2</sub> and temperature on the North Atlantic spring bloom. I. The phytoplankton community and biogeochemical response," *Marine Ecology Progress Series*, v.388, 2009, p. 13.

Gaerdes A, Iversen MH, Grossart H-P, Passow U, Ullrich M. "Diatom associated bacteria are required for aggregation of *Thalassiosira weissflogii*," *ISME Journal*, 2010, p. 1.

Leblanc K, Hare CE, Feng Y, Berg GM, DiTullio GR, Neeley A, Benner I, Sprengel C, Beck A, Sanudo-Wilhelmy SA, Passow U, Klinck K, Rowe JM, Wilhelm SW, Brown CW, Hutchins DA. "Distribution of calcifying and silicifying phytoplankton in relation to environmental and biogeochemical parameters during the late stages of the 2005 North East Atlantic Spring Bloom," *Biogeosciences*, v.6, 2009, p. 2155.

Ploug H, Terbruggen A, Kaufmann A, Wolf-Gladrow D, Passow U. "A novel method to measure particle sinking velocity in vitro, and its comparison to three other in vitro methods.," *Limnology and Oceanography Methods*, v.8, 2010, p. 386.

Passow, U., Rocha, C.L.D.L., Fairfield, C., Schmidt, K., 2014. Aggregation as a function of pCO<sub>2</sub> and mineral particles. *Limnology and Oceanography* 59 (2), 532-547.

De La Rocha, C.L., Passow, U., 2014. The biological pump. In: Turekian, K.K., Holland, H.D. (Eds.), *Treatise on Geochemistry*. Elsevier, Oxford, pp. 93-122.

Boyd, P., Rynearson, T., Armstrong, E., Fu, F., Hayashi, K., Hu, Z., Hutchins, D., Kudela, R., Litchman, E., Mulholland, M., Passow, U., Strzepek, R., Whittaker, K., Yu, E., Thomas, M., 2013. Marine Phytoplankton Temperature versus Growth Responses from Polar to Tropical Waters - Outcome of a Scientific Community-Wide Study. *PLoS ONE* 8 (5), e63091.

Passow, U., Carlson, C., 2012. The Biological Pump in a High CO<sub>2</sub> World. *Marine Ecology Progress Series* 470, 249-271.

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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 \(NSF\)](#)

## **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 CO<sub>2</sub> 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**

<b>Funding Source</b>	<b>Award</b>
<a href="#">NSF Division of Ocean Sciences (NSF OCE)</a>	<a href="#">OCE-0926711</a>

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