

# Cell growth phase of *Skeletonema marinoi* growth and aggregation under future ocean acidification conditions from UCSB MSI Passow Laboratory from 2009 to 2010 (OA - Ocean Acidification and Aggregation project)

**Website:** <https://www.bco-dmo.org/dataset/3924>

**Version:** 2

**Version Date:** 2017-10-11

## 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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## Table of Contents

- [Dataset Description](#)
  - [Methods & Sampling](#)
  - [Data Processing Description](#)
- [Data Files](#)
- [Parameters](#)
- [Deployments](#)
- [Project Information](#)
- [Program Information](#)
- [Funding](#)

## Dataset Description

### Series 3: *Skeletonema marinoi* growth and aggregation under future ocean acidification conditions

- Phase 1: Cell Growth Phase
- Experiments 1 and 2

## METHODS

**2.1 General set up:** The experiment consisted of two treatments (Present and Future) representing different pCO<sub>2</sub> conditions and two sequential experimental phases: **the cell growth phase** and **the aggregation phase**. The experiment was sequentially replicated. The two replicates are going to be referred as Experiment 1 and Experiment 2.

**2.2 Cell growth phase:** During the cell growth phase, the effect of OA was tested on a culture of *S. marinoi* that was incubated for five days, in 5 l transparent bags. Two replicate bags were used for each treatment. The pH was measured daily immediately after collection in each bag, while the TA samples were collected for later analysis in one sample per treatment at the beginning and at the end of the cell growth phase. The algal cells were counted, sized and their instantaneous in vivo chlorophyll fluorescence (Ft) and quantum yield (Qy)

were measured daily in the morning. The concentration of bacteria and TEP were measured at t 0 ,t2.8 and t4.6. The nutrients concentration was sampled at t2.8 and t4.6. The dry weight, particulate carbon, hydrogen and nitrogen were measured at t4.6. After 5 days the cultures in the two bags per treatment were pooled, the carbonate system was readjusted to the starting conditions and subsequently they were inoculated into cylindrical rolling tanks.

**2.3 Aggregation phase:** The aggregation phase consisted in the incubation of the cultures into cylindrical tanks on rolling tables (Edmondson, 1989). A total of 8 tanks (4 replicates per treatment) were incubated over the rolling table for two days in the darkness in the environmental room at 15°C. Solid body rotation is established in these rolling tanks within less than three hours (Ploug, Terbrüggen, Kaufmann, Wolf- Gladrow, & Passow, 2010) and the sinking of particles through the water column was simulated and aggregation promoted. After 38 hours of incubation the aggregates sinking velocity, number and size were measured. The algal cell number, bacterial cell number, TEP, dry weight, particulate carbon, hydrogen and nitrogen were evaluated, both for the aggregated fraction and for the surrounding water. The carbonate system was characterized by measuring pH in all the tanks and TA in one tank per treatment.

## Methods & Sampling

See: [S. Marinoi Growth and Aggregation - Methods](#)

## Data Processing Description

See: [S. Marinoi Growth and Aggregation - Methods](#)

### BCO-DMO Processing Notes

Generated from original .xlsx file "Data T.Rossi.xlsx", Version in e-mail of 02May2013 contributed by Tullio Rossi  
 Sheets: "Experiment 1 Phase 1" and "Experiment 2 Phase 1"

**Note:** Earlier version of spreadsheet contained erroneous data corrected in the 02May2013 version

- Approx Lat/Lon of Passow Lab appended to enable data discovery in MapServer
  - Column inserted for Experiment Number
  - Column inserted for Bag Description
  - Date/Time split into two columns
  - Date reformatted to YYYYMMDD
  - Time reformatted to HHMM
  - Parameter names edited to conform to BCO-DMO parameter naming conventions
  - "nd" (no data) inserted into blank cells
  - Column inserted for "Silicate" in Experiment 2 (all "nd") for compatibility with Experiment 1
- Version 2017-10-11 is revised slightly from version 2013-05-02 by reducing digits right of decimal (rounded).

[ [table of contents](#) | [back to top](#) ]

## Data Files

File
<b>Series3_Smarinoi_GrAgg_Ph1.csv</b> (Comma Separated Values (.csv), 3.86 KB) <small>MD5:a2ab4250c4424db072234105e8dafcad</small>
Primary data file for dataset ID 3924

[ [table of contents](#) | [back to top](#) ]

## Parameters

Parameter	Description	Units

Experiment_Number	Experiment Number	dimensionless
Bag	Bag Number	text
t	Cumulative time expressed in days starting at t=0 (first day of experiment)	Decimal days
Date	Date at which the bags were sampled for the measurement of the various parameter	YYYYMMDD
Time	Time at which the bags were sampled for the measurement of the various parameter	HHMM
Algal_Count	Algal Culture Parameters - Count	Cells/mL
Algal_Ft	Algal Culture Parameters - In Vivo Instantaneous Chlorophyll Fluorescence (Ft)	Relative units
Algal_Qy	Algal Culture Parameters - In Vivo Instantaneous Quantum Yield (Qy)	Dimensionless
pH_at_15_C	Carbonate System - pH - At Ambient Temperature of 15degC	Total pH scale
TA	Carbonate System - Total Alkalinity (TA)	umol kg <sup>-1</sup>
Bacteria	Bacterial Concentration	Bacteria/mL
Cell_Length	Cell Length	um
DOC	Dissolved Organic Carbon (DOC)	umol per liter
TEP	Transparent Exopolymer Particles (TEP). In ug of Gxeq (xanthan gum equivalent) per liter. This is an absorbance equivalence.	Gxeq/L
Nitrite_plus_Nitrate	Nutrients - Nitrite + Nitrate	umol per liter
Phosphate	Nutrients - Phosphate	umol per liter
Silicate	Nutrients - Silicate	umol per liter

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

[ [table of contents](#) | [back to top](#) ]

## 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

[ [table of contents](#) | [back to top](#) ]

## 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 Erwaermung. 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.

## 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](#)

## 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.

[ [table of contents](#) | [back to top](#) ]

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## Funding

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

[ [table of contents](#) | [back to top](#) ]