# Predictions of photosynthesis and carbon use for diffusive uptake under light, temperature and pCO2 using a productivity model, 2014-2015 (Seaweed OA Resilience project)

**Website**: https://www.bco-dmo.org/dataset/731256
**Data Type**: model results
**Version**: 1
**Version Date**: 2018-03-21

**Project**
» Ocean Acidification: Scope for Resilience to Ocean Acidification in Macroalgae (Seaweed OA Resilience)

**Program**
» Science, Engineering and Education for Sustainability NSF-Wide Investment (SEES): Ocean Acidification (formerly CRI-OA) (SEES-OA)



| Contributors | Affiliation | Role |
|---|---|---|
| Kubler, Janet E. | California State University Northridge (CSUN) | Principal Investigator |
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**Abstract**
This dataset represents calculations from a model of photosynthesis by diffusive uptake of only CO2 given expected abundance of carbonate chemistry parameters in ocean water of known temperature salinity and depth.

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## Coverage

**Spatial Extent**: **N**:34 **E**:-118 **S**:33 **W**:-119
**Temporal Extent**: 2014-02 - 2015-02

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## Dataset Description

This dataset represents calculations from a model of photosynthesis by diffusive uptake of only CO2 given expected abundance of carbonate chemistry parameters in ocean water of known temperature salinity and depth.

#### Methods & Sampling

Expected values of carbonate chemistry in seawater of specified conditions were calculated using CO2Calc (Robbins et al. 2010). Estimates of photosynthetic responses of CO2-using red algae under specified conditions of light intensity, temperature and pCO2 were made using published data on rates of photosynthesis as functions of light intensity and temperature and the predicted availability and diffusive uptake rate of CO2 at the plant surface in seawater. Pathlength of diffusion of CO2 from seawater to the site of carbon fixation was assumed to be 20 microns for these data representing photosynthetic rates (See Kübler and Dudgeon 2015). Further methodology references are listed below.

#### Data Processing Description

**BCO-DMO Processing Notes:**
- added a conventional header with dataset description, PI names, version date
- modified parameter names to conform with BCO-DMO naming conventions

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## Data Files

| File |
| --- |
| **CO2_diffusion_model.csv**(Comma Separated Values (.csv), 44.46 KB)<br>MD5:8105ecddebdf2c93698e50dc7f05c654<br>Primary data file for dataset ID 731256 |

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## Related Publications

Hill R, Whittingham CP. Photosynthesis. Methuen, London, U.K. 1955
*Methods*

Johnston, A. M., Maberly, S. C., & Raven, J. A. (1992). The acquisition of inorganic carbon by four red macroalgae. Oecologia, 92(3), 317–326. doi:10.1007/bf00317457 https://doi.org/10.1007/BF00317457
*Methods*

Kübler, J. E., & Dudgeon, S. R. (2015). Predicting Effects of Ocean Acidification and Warming on Algae Lacking Carbon Concentrating Mechanisms. PLOS ONE, 10(7), e0132806. doi:10.1371/journal.pone.0132806
*Related Research*

Mook, W. G., Bommerson, J. C., & Staverman, W. H. (1974). Carbon isotope fractionation between dissolved bicarbonate and gaseous carbon dioxide. Earth and Planetary Science Letters, 22(2), 169–176. doi:10.1016/0012-821x(74)90078-8 https://doi.org/10.1016/0012-821X(74)90078-8
*Methods*

Raven, J. (1997). Inorganic Carbon Acquisition by Marine Autotrophs. Advances in Botanical Research, 85–209. doi:10.1016/s0065-2296(08)60281-5 https://doi.org/10.1016/S0065-2296(08)60281-5
*Methods*

Robbins LL, Hansen ME, Kleypas JA, Meylan SC CO2 calc: A user-friendly seawater carbon calculator for Windows, Mac OS X, and iOS (iPhone). U.S. Geological Survey Open File Report 2010-1280, 2010. https://pubs.usgs.gov/of/2010/1280/
*Methods*

Zeebe, R. E. (2011). On the molecular diffusion coefficients of dissolved , and and their dependence on isotopic mass. Geochimica et Cosmochimica Acta, 75(9), 2483–2498. doi:10.1016/j.gca.2011.02.010
*Methods*

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## Parameters

| **Parameter** | **Description** | **Units** |
|---|---|---|
| Temp | Temperature of seawater | degrees Celsius |
| pH | Potential of Hydrogen in pH scale | unitless |
| pCO2 | Partial pressure of CO2 in seawater | micro-atmospheres (µatm) |
| HCO3 | Concentration of bicarbonate in seawater | micromoles/kilogram (µmol/kg) |
| CO3 | Concentration of carbonate in seawater | micromoles/kilogram (µmol/kg) |
| CO2 | Concentration of CO2 in seawater | micromoles/kilogram (µmol/kg) |
| DCO2 | Molecular diffusion coefficient of CO2 (taken from Zeebe 2011) | CP2/meter^2/second (m-2 . s-1) |
| eb_a | Ratio of carbon isotope fractionation of dissolved CO2 with respect to dissolved HCO3 (taken from Table 4 of Mook et al. 1974) | unitless |
| HCO3_CO3_frac | Ratio of bicarbonate to carbonate fraction expressed per total inorganic carbon | unitless |
| d13C_CO2_SW | Predicted delta 13C fraction of CO2 in seawater | parts per thousand (ppt) |
| alpha_org | Weighted average of discrimination by organism against 13C due to discrimination against 13C by RUBISCO (1.029) and diffusion (1.0007) (see Raven 1997) | unitless (a ratio of rate constants) |
| d13C | Predicted Isotopic composition of delta 13C of plant relative to Pee Dee Belemnite calculated as (((d13_CO2_SW/1000) - alpha_org+1)/alpha_org)*1000 | parts per thousand (ppt) |
| D | Predicted Discrimination against 13C by plant calculated as: ((((d13_CO2_SW/1000)-(d13C/1000))/(1+d13C/10000)))*1000 | parts per thousand (ppt) |
| K_half_sat | Light-dependent values of K1/2 for carbon fixation taken from saturating and low light CO2-using seaweeds in Johnston et al. 1992 | moles/meter^3 (mol . m-3) |
| PS | Predicted photosynthetic rate based on Hill-Whittingham equation for aquatic phototrophs with diffusive uptake of carbon (Hill and Whittingham 1955) | micromoles C-fixed/meter^2/second |
| Light | Light intensity | ? |

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## Project Information

**Ocean Acidification: Scope for Resilience to Ocean Acidification in Macroalgae (Seaweed OA Resilience)**

**Coverage**: Temperate coastal waters of the USA (30 - 45 N latitude, -66 to -88 W and -117 to -125 W longitude)

Benthic macroalgae contribute to intensely productive near shore ecosystems and little is known about the potential effects of ocean acidification on non-calcifying macroalgae. Kübler and Dudgeon will test hypotheses about two macroalgae, *Ulva* spp. and *Plocamium cartilagineum*, which, for different reasons, are hypothesized to be more productive and undergo ecological expansions under predicted changes in ocean chemistry. They have designed laboratory culture-based experiments to quantify the scope for response to ocean acidification in *Plocamium*, which relies solely on diffusive uptake of CO2, and populations of *Ulva* spp., which have an inducible concentrating mechanism (CCM). The investigators will culture these algae in media equilibrated at 8 different pCO2 levels ranging from 380 to 940 ppm to address three key hypotheses. The first is that macroalgae (such as Plocamium cartilagineum) that are not able to acquire inorganic carbon in changed form will benefit, in terms of photosynthetic and growth rates, from ocean acidification. There is little existing data to support this common assumption. The second hypothesis is that enhanced growth of Ulva sp. under OA will result from the energetic savings from down regulating the CCM, rather than from enhanced photosynthesis per se. Their approach will detect existing genetic variation for adaptive plasticity. The third key hypothesis to be addressed in short-term culture experiments is that there will be a significant interaction between ocean acidification and nitrogen limited growth of *Ulva* spp., which are indicator species of eutrophication. Kübler and Dudgeon will be able to quantify the individual effects of ocean acidification and nitrogenous nutrient addition on *Ulva* spp. and also, the synergistic effects, which will inevitably apply in many highly productive, shallow coastal areas. The three hypotheses being addressed have been broadly identified as urgent needs in our growing understanding of the impacts of ocean acidification.

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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)

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## Funding

| Funding Source | Award |
| --- | --- |
| NSF Division of Ocean Sciences (NSF OCE) | OCE-1316198 |

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