Growth rates for Emiliania huxleyi thermal response curve across 12 temperatures from 8.5-28.6C

Website: https://www.bco-dmo.org/dataset/782911
Data Type: experimental
Version: 1
Version Date: 2019-11-26

Project
» How does intensity and frequency of environmental variability affect phytoplankton growth? (Enviro variability and phytoplankton growth)

Contributors	Affiliation	Role
Hutchins, David A.	University of Southern California (USC)	Principal Investigator
Copley, Nancy	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Abstract
This dataset presents growth rates for Emiliania huxleyi thermal response curve across 12 temperatures from 8.5-28.6C.Global warming will be combined with predicted increases in thermal variability in the future surface ocean, but how temperature dynamics will affect phytoplankton biology and biogeochemistry is largely unknown. Here, we examine the responses of the globally important marine coccolithophore Emiliania huxleyi to thermal variations at two frequencies (1 d and 2 d) at low (18.5 °C) and high (25.5 °C) mean temperatures. Elevated temperature and thermal variation decreased growth, calcification and physiological rates, both individually and interactively. The 1 d thermal variation frequencies were less inhibitory than 2 d variations under high temperatures, indicating that high-frequency thermal fluctuations may reduce heat-induced mortality and mitigate some impacts of extreme high-temperature events. Cellular elemental composition and calcification was significantly affected by both thermal variation treatments relative to each other and to the constant temperature controls. The negative effects of thermal variation on E. huxleyi growth rate and physiology are especially pronounced at high temperatures. These responses of the key marine calcifier E. huxleyi to warmer, more variable temperature regimes have potentially large implications for ocean productivity and marine biogeochemical cycles under a future changing climate.

Table of Contents

- Coverage
- Dataset Description
    - Methods & Sampling
    - Data Processing Description
- Data Files
- Related Publications
- Parameters
- Instruments
- Project Information
- Funding

Coverage

Temporal Extent: 2017-01-01 - 2017-10-31

Dataset Description

This dataset presents growth rates for Emiliania huxleyi thermal response curve across 12 temperatures from 8.5-28.6C. Global warming will be combined with predicted increases in thermal variability in the future surface ocean, but how temperature dynamics will affect phytoplankton biology and biogeochemistry is largely unknown. Here, we examine the responses of the globally important marine coccolithophore Emiliania huxleyi to thermal variations at two frequencies (1 d and 2 d) at low (18.5 °C) and high (25.5 °C) mean temperatures. Elevated temperature and thermal variation decreased growth, calcification and physiological rates, both individually and interactively. The 1 d thermal variation frequencies were less inhibitory than 2 d variations under high temperatures, indicating that high-frequency thermal fluctuations may reduce heat-induced mortality and mitigate some impacts of extreme high-temperature events. Cellular elemental composition and calcification was significantly affected by both thermal variation treatments relative to each other and to the constant temperature controls. The negative effects of thermal variation on E. huxleyi growth rate and physiology are especially pronounced at high temperatures. These responses of the key marine calcifier E. huxleyi to warmer, more variable temperature regimes have potentially large implications for ocean productivity and marine biogeochemical cycles under a future changing climate.

These data and methods are published in Wang, X., Fu, F., Qu, P., Kling, J. D., Jiang, H., Gao, Y., & Hutchins, D. A. (2019). How will the key marine calcifier Emiliania huxleyi respond to a warmer and more thermally variable ocean?. Biogeosciences, 16(22), 4393-4409. doi:10.5194/bg-2019-179.

Methods & Sampling

Specific growth rates were calculated using change in fluorescence over time (verified using cell count data) and the equation $\mu=\ln[N(T2)/N(T1)]/(T2-T1)$. N(T1) and N(T2) are the in vivo fluorescence values. Chlorophyll a, total particulate carbon (TPC), particulate organic carbon (POC), particulate organic nitrogen (PON), and particulate organic carbon (POP) were filtered onto GF/F filters and analyzed following the methodology used in Fu et al., 2007. Particulate inorganic carbon was defined as the difference between TPC and POC after POC filters had been subjected to concentrated HCl fumes for 24 hours to remove all inorganic carbon. Calcification, photosynthesis, and carbon fixation rates were all measured following the procedures outlined in Feng et al., 2008.

All data was processed using either R (v 3.4.4) or Microsoft Excel 2016.

Data Processing Description

BCO-DMO Processing Notes:
- added conventional header with dataset name, PI name, version date
- unmerged Excel cells for Temperature and repeated value from preceding rows.
- removed 'C' from Temperature values
- changed param name 'growth rate (d-1)' to 'Growth_Rate'
- reduced Growth_Rate precision from 14 to 4 decimal places

[table of contents | back to top]

Data Files

File
Ehux_thermal_curve_growth_rates.csv (Comma Separated Values (.csv), 678 bytes) MD5:cd4f611ebf4238b65cbbf8ed46a11a8a Primary data file for dataset ID 782911

[table of contents | back to top]

Related Publications

Feng, Y., Warner, M. E., Zhang, Y., Sun, J., Fu, F.-X., Rose, J. M., & Hutchins, D. A. (2008). Interactive effects of increased pCO2, temperature and irradiance on the marine coccolithophoreEmiliania huxleyi(Prymnesiophyceae). European Journal of Phycology, 43(1), 87–98. doi:10.1080/09670260701664674
Methods

Fu, F.-X., Warner, M. E., Zhang, Y., Feng, Y., & Hutchins, D. A. (2007). Effects of Increased temperature and CO2 on photosynthesis, growth, and elemental ratios in marine Synechococcus and Prochlorococcus (cyanobacteria). Journal of Phycology, 43(3), 485–496. doi:10.1111/j.1529-8817.2007.00355.x

Methods

Wang, X., Fu, F., Qu, P., Kling, J. D., Jiang, H., Gao, Y., & Hutchins, D. A. (2019). How will the key marine calcifier Emiliania huxleyi respond to a warmer and more thermally variable ocean?. Biogeosciences, 16(22), 4393-4409. doi:10.5194/bg-2019-179.
Results

[table of contents | back to top]

Parameters

Parameter	Description	Units
Temperature	treatment temperature	degrees Celsius
Growth_Rate	E. huxleyi growth rate by fluorescence and cell counts	per day

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	Olympus BX51 microscope
Generic Instrument Name	Fluorescence Microscope
Dataset-specific Description	Used to count cell samples
Generic Instrument Description	Instruments that generate enlarged images of samples using the phenomena of fluorescence and phosphorescence instead of, or in addition to, reflection and absorption of visible light. Includes conventional and inverted instruments.

Dataset-specific Instrument Name	
Generic Instrument Name	Turner Designs Fluorometer 10-AU
Generic Instrument Description	The Turner Designs 10-AU Field Fluorometer is used to measure Chlorophyll fluorescence. The 10AU Fluorometer can be set up for continuous-flow monitoring or discrete sample analyses. A variety of compounds can be measured using application-specific optical filters available from the manufacturer. (read more from Turner Designs, turnerdesigns.com, Sunnyvale, CA, USA)

[table of contents | back to top]

Project Information

How does intensity and frequency of environmental variability affect phytoplankton growth? (Enviro variability and phytoplankton growth)

Coverage: laboratory experiment

NSF Award Abstract:
Microscopic plants called phytoplankton are key members of global oceanic ecosystems, since their photosynthesis supports the majority of the marine food chain and produces about as much oxygen as land plants. Because of this, oceanographers have often carried out experiments examining how factors such as temperature and carbon dioxide levels may affect phytoplankton growth. Most previous experiments have used constant levels of temperature and carbon dioxide, but it is clear from looking at measurements from real ocean ecosystems that these two factors often vary greatly over timescales of days to weeks. Using field and laboratory experiments along with computer modeling, this project will test how the growth of several major groups of phytoplankton differs under constant conditions of temperature and carbon dioxide, compared to conditions in which these factors fluctuate in intensity and frequency. This research will give marine scientists a better picture of how phytoplankton may respond to a varying natural environment today and in the future, and therefore help us to understand how ocean food webs function to support critical living resources such as fisheries. The project will train graduate and undergraduate students and a postdoctoral researcher, and the lead scientists will be involved in an ocean science education program for largely minority high school students from a downtown Los Angeles school district.

The goal of this project is to use laboratory culture and natural community experiments to understand how realistically fluctuating temperature and pCO2 conditions may affect globally important phytoplankton groups in ways that differ from the artificial constant exposures used in previous work. Culture experiments will test how the intensity and frequency of short-term thermal and carbonate fluctuations affects the growth responses of diazotrophic and picoplanktonic cyanobacteria, coccolithophores, and diatoms under both current and projected future environmental conditions. These lab results will be supported and extended by parallel experiments using mixed natural assemblages from the California upwelling regime, allowing us to test these same questions using phytoplankton communities that experience large seasonal shifts between highly dynamic thermal and carbonate system conditions during the spring upwelling season, and relatively much more static conditions during fall stratification events. These results will be synthesized using a new generation of numerical models that employ novel approaches to incorporating realistic environmental variations to allow more accurate predictions of phytoplankton responses to a dynamic environment in today's marine ecosystems, and in the future changing ocean.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1538525

[table of contents | back to top]