Intracellular elemental quotas under low and high temperatures for E. huxleyi in constant and fluctuating thermal environments

Website: https://www.bco-dmo.org/dataset/782901
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
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Abstract
Intracellular elemental quotas under low and high temperatures for E. huxleyi in constant and fluctuating thermal environments. This dataset includes the growth rates under low and high temperatures for E. huxleyi in constant and fluctuating thermal environments. 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.

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Coverage

Temporal Extent: 2017-01 - 2017-10

Dataset Description

Intracellular elemental quotas under low and high temperatures for E. huxleyi in constant and fluctuating thermal environments. This dataset includes the growth rates under low and high temperatures for E. huxleyi in constant and fluctuating thermal environments. 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 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

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
- combined two Excel sheet (low and high temp tables)
- changed parameter names by removing spaces and units
- reduced precision from 14 to 4 decimal places for all values

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Data Files

File
Ehux_therm_var_physiology.csv (Comma Separated Values (.csv), 5.50 KB) MD5:8d48181851610124f4f9f51f793817c1 Primary data file for dataset ID 782901

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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

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Parameters

Parameter	Description	Units
Temperature	treatment temperature	degrees Celsius
variation	temperature variation treatment description	unitless
POC	concentration of Particulate Organic Carbon	picograms/cell
PIC	concentration of Particulate Inorganic Carbon	picograms/cell
PON	concentration of Particulate Organic Nitrogen	picograms/cell
TPC	concentration of Total Particulate Carbon	picograms/cell
POP	concentration of Particulate Organic Phosphorous	picograms/cell
Chla	concentration of Chlorophyll a	picograms/cell
carbon_fix_rate	carbon fixation rate using a 14C incubation technique	10 -7 umol Carbon cell-1 hr-1
photosyn_rate	photosynthetic rate using a 14C incubation technique	10 -7 umol Carbon cell-1 hr-1
calcification_rate	calcification rate using a 14C incubation technique	10 -7 umol Carbon cell-1 hr-1
Chla_POC	Chla to POC ratio	milligrams/gram
calcif_photosyn	calcificationto photosynthesis ratio	unitless
PIC_POC	PIC to POC ratio (mol/mol)	unitless
POC_POP	POC to POP ratio (mol/mol)	unitless
PON_POP	PON to POP ratio (mol/mol)	unitless
TPC_PON	TPC to PON ratio (mol/mol)	unitless

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Instruments

Dataset-specific Instrument Name	440 elemental analyzer (Costech Inc., CA)
Generic Instrument Name	Elemental Analyzer
Dataset-specific Description	Used to measure organic/inorganic carbon and nitrogen.
Generic Instrument Description	Instruments that quantify carbon, nitrogen and sometimes other elements by combusting the sample at very high temperature and assaying the resulting gaseous oxides. Usually used for samples including organic material.

Dataset-specific Instrument Name	Perkin Elmer (CA) Liquid Scintillation Counter
Generic Instrument Name	Liquid Scintillation Counter
Dataset-specific Description	Used to process radioactive assays.
Generic Instrument Description	Liquid scintillation counting is an analytical technique which is defined by the incorporation of the radiolabeled analyte into uniform distribution with a liquid chemical medium capable of converting the kinetic energy of nuclear emissions into light energy. Although the liquid scintillation counter is a sophisticated laboratory counting system used the quantify the activity of particulate emitting (ß and a) radioactive samples, it can also detect the auger electrons emitted from 51Cr and 125I samples.

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)

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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.

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Funding

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

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