

Growth rates of *Trichodesmium erythraeum* GBRTLIN201 and *Synechococcus* WH8012 from phosphate-manipulation laboratory culture experiments

Website: <https://www.bco-dmo.org/dataset/1010479>

Version: 1

Version Date: 2026-10-21

Project

» [NSFGEO-NERC: Understanding the consequences of changing phytoplankton elemental use efficiencies for global ocean biogeochemistry](#) (EUEs and global ocean biogeochemistry)

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Abstract

This dataset contains growth rates for two marine cyanobacteria, *Trichodesmium erythraeum* (strain GBRTLIN201) and *Synechococcus* WH8012, measured across a range of phosphate concentrations under multiple temperatures in laboratory culture experiments conducted at the University of Southern California. The goal of this experiment was to test whether temperature-dependent P-limitation responses reflect changes in phosphate growth affinity. The experiment was conducted at 21, 28, and 33 °C using cultures pre-acclimated during the TPC experiments (see relevant dataset). Both strains were grown across nine phosphate concentrations (0, 0.1, 0.2, 0.4, 0.7, 1, 2, 5, and 10 µM). Maximum specific growth rates (μ_{max}) and half-saturation constants ($K_{1/2}$) were determined by fitting growth rates to the Monod equation. Growth rates were determined from in vivo chlorophyll a fluorescence measurements.

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Coverage

Location: Laboratory culture experiments conducted at the University of Southern California

Temporal Extent: 2025-07 - 2026-04

Methods & Sampling

Culturing Methods

Synechococcus WH8012 and *Trichodesmium erythraeum* GBRTLIN201 were isolated from the Sargasso Sea and the North Great Barrier Reef Lagoon, respectively (Waterbury et al. 1986; Bell et al. 2005). Thermal

performance curves were established by stepwise acclimation of stock cultures from 28 °C to target temperatures, with approximately 3–4 days of acclimation between sequential transfers to minimize transient stress responses. *Synechococcus* was grown from 15 to 34 °C and *Trichodesmium* from 20 to 34 °C, both at 2–3 °C intervals. Triplicate cultures were grown in 0.2 µm-filtered, microwave-sterilized artificial seawater under a range of phosphate concentrations (0, 0.1, 0.2, 0.4, 0.7, 1, 2, 5, and 10 µM). In addition to phosphate, 100 µM nitrate, 10 µM phosphate, and 125 nM Fe-25 µM EDTA were added. Light was provided at ~40 µmol photons m⁻² s⁻¹ (*Synechococcus*) and ~150 µmol photons m⁻² s⁻¹ (*Trichodesmium*) on a 12:12 h light: dark cycle. Cultures were maintained in batch culture, and measurements were conducted at the exponential growth phase.

Physiological Analyses

Growth rate. Daily growth rates were determined from in vivo chlorophyll *a* fluorescence measured with a Turner Designs 10-AU fluorometer. Specific growth rates were calculated as $\mu = \ln[N(T1)/N(T0)] / (T1 - T0)$. Maximum specific growth rates (μ_{max}) and half-saturation constants ($K_{1/2}$) were determined by fitting growth rates to the Monod equation.

Data Processing Description

Growth rates

Growth rates were calculated from in vivo chlorophyll *a* fluorescence readings measured with a Turner Designs 10-AU fluorometer using the equation: $\mu = \ln[N(T1)/N(T0)] / (T1 - T0)$, where $N(T0)$ and $N(T1)$ are fluorescence values at two consecutive time points. Maximum specific growth rates (μ_{max}) and half-saturation constants ($K_{1/2}$) were determined by fitting growth rates to the Monod equation (Monod, 1949)

BCO-DMO Curation Notes

Curation Actions Performed on Data File

- Loaded P curve expt_Growth Rate.csv as table 1010479_v1_lab_cultured_cyanobacteria_growth_rate_data (CSV format, header in row 1; empty rows removed; empty strings and "nd" interpreted as missing values).
- Renamed P concentration (µM) to P_concentration, Specific growth rates (d-1) to Specific_growth_rates, and Date (yyyy-mm-dd) to Date.
- Set Date as a date formatted %Y-%m-%d; P_concentration and Specific_growth_rates as numbers; temperature as an integer; and Species and sampleID as strings.
- Updated column metadata, including descriptions, BCO-DMO standard name IDs, and supplied units, for Date, P_concentration, Species, Specific_growth_rates, sampleID, and temperature.
- Saved the processed file as 1010479_v1_lab_cultured_cyanobacteria_growth_rate_data.csv.

Problem Description

No problems or issues related to this dataset have been reported by the dataset authors.

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Related Publications

Bell, P. R. F., Uwins, P. J. R., Elmetri, I., Phillips, J. A., Fu, F. X., & Yago, A. J. E. (2005). Laboratory culture studies of *Trichodesmium* isolated from the Great Barrier Reef Lagoon, Australia. *Hydrobiologia*, 532(1-3), 9–21. <https://doi.org/10.1007/s10750-004-8768-1>
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Monod, J. (1949). THE GROWTH OF BACTERIAL CULTURES. *Annual Review of Microbiology*, 3(1), 371–394. <https://doi.org/10.1146/annurev.mi.03.100149.002103>

Methods

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Waterbury, J. B., Watson, S. W., Valois, F. W., & Franks, D. G. (1986). Biological and ecological characterization of the marine unicellular cyanobacterium *Synechococcus*. In T. Platt & W. K. W. Li (Eds.), *Photosynthetic picoplankton* (Canadian Bulletin of Fisheries and Aquatic Sciences, No. 214, pp. 71–120). Department of Fisheries and Oceans. <https://publications.gc.ca/pub?id=9.952113&sl=0> [cir.nii.ac.jp](https://cir.nii.ac.jp/crid/1573105974970382336)

<https://cir.nii.ac.jp/crid/1573105974970382336>

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Related Datasets

IsRelatedTo

Hutchins, D. A., Fu, F. (2026) **Growth, carbon fixation, and nitrogen fixation rates of *Trichodesmium erythraeum* GBRTLIN201 and *Synechococcus* WH8012 from laboratory culture experiments under temperature and nutrient limitation treatments.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2026-10-21 <http://lod.bco-dmo.org/id/dataset/1010465> [[view at BCO-DMO](#)]

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Parameters

Parameter	Description	Units
sampleID	A unique identifier for each sample, formatted as species code-temperature-phosphate concentration-replicate number. SYN and TRI indicate the species codes; 21, 28, and 33 indicate the experimental temperature in degree C; the phosphate value indicates the experimental phosphate concentration; and 1, 2, and 3 indicate replicate numbers.	unitless
Species	Species name	unitless
temperature	Experimental temperature	degree C
P_concentration	Experimental phosphate concentration	micromole
Specific_growth_rates	The specific growth rate under certain experimental condition	day -1
Date	Experimental date	unitless

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Instruments

Dataset-specific Instrument Name	Turner Designs 10-AU fluorometer (Turner Designs, San Jose, CA, USA)
Generic Instrument Name	Fluorometer
Dataset-specific Description	Growth rates were calculated from in vivo chlorophyll a fluorescence readings measured with a Turner Designs 10-AU fluorometer using the equation: $\mu = \ln[N(T1)/N(T0)] / (T1 - T0)$, where N(T0) and N(T1) are fluorescence values at two consecutive time points. Maximum specific growth rates (μ_{max}) and half-saturation constants (K1/2) were determined by fitting growth rates to the Monod equation (Monod, 1949)
Generic Instrument Description	A fluorometer or fluorimeter is a device used to measure parameters of fluorescence: its intensity and wavelength distribution of emission spectrum after excitation by a certain spectrum of light. The instrument is designed to measure the amount of stimulated electromagnetic radiation produced by pulses of electromagnetic radiation emitted into a water sample or in situ.

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Project Information

NSFGEO-NERC: Understanding the consequences of changing phytoplankton elemental use efficiencies for global ocean biogeochemistry (EUEs and global ocean biogeochemistry)

Coverage: Global

NSF Award Abstract:

This project is jointly funded by the National Science Foundation's Directorate of Geosciences (NSF/GEO) and the National Environment Research Council (UKRI/NERC) of the United Kingdom (UK) via the NSF/GEO-NERC Lead Agency Agreement. This Agreement allows a single joint US/UK proposal to be submitted and peer-reviewed by the Agency whose investigator has the largest proportion of the budget. Upon successful joint determination of an award, each Agency funds the proportion of the budget and the investigators associated with its own investigators and component of the work.

Earth system computer models that simulate the global cycles of carbon and other elements are one of our most valuable tools to predict environmental change in the future ocean. However, existing modeling methods cannot realistically test how increasing ocean temperatures will affect the needs of marine micro-organisms for the limiting nutrients that usually control their growth, including nitrogen, phosphorus and iron. Because these limiting nutrients govern how much photosynthesis occurs in the ocean, they strongly influence the fate of carbon dioxide produced by human fossil-fuel burning. For this reason, determining how nutrient use by plankton will respond to greenhouse warming of the surface ocean is a priority for scientists and policy makers. This project supports a collaboration between two marine microbiologists in the United States and an Earth system modeler from the United Kingdom that is aiming to better understand how oceanic limiting nutrient cycles and the biological communities they support will react to global warming. The U.S. investigators are using laboratory culture experiments, field work in the coastal ocean, and existing collections of past open ocean chemistry and biology measurements to generate quantitative estimates of rising temperature effects on nutrient elemental use efficiencies (EUEs). An EUE is defined as the rate at which a marine microbe can take up carbon dioxide via photosynthesis, per unit of limiting nutrient in the cell. Preliminary results show that EUEs are highly sensitive to changing temperature, which in turn has far-reaching consequences for how ocean ecosystems function. The U.K. investigator is using these experimentally-determined values to build a new Earth system model that is centered on how warmer conditions will affect EUEs for important groups of marine micro-organisms. This novel approach has the potential to yield much better estimates of the ways that ocean carbon uptake and nutrient cycling will be altered as the ocean continues to warm in the future. Broader Impacts include breaking new scientific ground in oceanography and climate science through improved Earth system models, providing educational opportunities for graduate students, undergraduate researchers, K-12 students, and postdoctoral investigators, and strengthening collaborative ties between the marine science

communities of the U.S. and the U.K.

Quantitative relationships between phytoplankton nutrient limitation, primary production and globally-rising sea surface temperatures are still not well understood, largely due to a lack of mechanistic experimental data. This is problematic for Earth system modelers who are trying to project future oceanic productivity levels that underpin predicted changes in ocean ecosystems, information that is urgently needed to inform environmental policy makers. This project addresses this knowledge gap in a closely coordinated, collaborative project between two U.S. marine microbiologists and a biogeochemical modeler from the U.K. The international team of interdisciplinary researchers are applying the emergent concept of Elemental Use Efficiencies (EUEs) to integrate flexible thermal and resource limitation responses into a new generation of Earth system models. EUEs are defined as the amount of carbon fixed per unit time, normalized to the amount of a limiting resource in a phytoplankton cell, as represented by the cellular nutrient quota. Preliminary work suggests that EUEs can be very sensitive to future ocean warming, with major downstream consequences for nutrient-limited marine plankton assemblages and thus also for ocean carbon and nutrient biogeochemistry. The investigators are using high-throughput thermal block methodology to measure EUEs for the limiting nutrients nitrogen, phosphorus and iron in a diverse set of four different functional groups of laboratory phytoplankton isolates across their entire thermal ranges. EUEs obtained for these three key limiting nutrient resources as a function of temperature and degree of nutrient stress are being applied in an iterative manner to inform a novel EUE-centric version of the established NEMO-PISCES ocean model. Field EUE data from coastal and open ocean regimes are being collected for comparison to and ground-truthing of both the laboratory culture results, and the modeling output. This project will advance the discipline of ocean global change biology by providing unique new insights into how biogeochemically-critical marine microbial functional groups may respond to simultaneous shifts in temperature and limiting nutrient resource availability both today, and in the future changing ocean.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

NERC award abstract:

A major focus of biological oceanography is to understand and quantify the effects of temperature and resource availability on phytoplankton productivity and ecosystem dynamics in the world ocean. Classic paradigms like Eppley's temperature curve and the resource response relationships of Liebig and Monod have served the field well, but they fail to capture the full dynamic and interactive nature of resource availability and temperature influences on primary production. This shortcoming is especially problematic for earth system modelers as they urgently try to estimate future oceanic productivity levels that underpin projected changes in the ocean ecosystem, properties that are needed to inform policy makers such as the assessment reports of the IPCC and IPBES. This proposal describes a closely coordinated collaborative project between two U.S. marine microbiologists and a biogeochemical modeler from the U.K. that will apply the emergent concept of Elemental Use Efficiencies (EUEs) to integrate flexible thermal and resource limitation responses into a new generation of earth system models. EUEs are defined as the amount of carbon fixed, per unit of cellular nutrient resource, per unit time. This simple, yet novel concept provides a unique opportunity to integrate the observed consequences of concurrent warming and altered nutrient availability for primary productivity in ocean models to quantify biogeochemical and biological responses in the rapidly changing ocean environment.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-2149837

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