Estimated thermal capacities for phytoplankton strains

Website: https://www.bco-dmo.org/dataset/839713
Data Type: Other Field Results
Version: 1
Version Date: 2021-02-04

Project
» Dimensions: Collaborative Research: Genetic, functional and phylogenetic diversity determines marine phytoplankton community responses to changing temperature and nutrients (Phytoplankton Community Responses)

Program
» Dimensions of Biodiversity (Dimensions of Biodiversity)

Contributors	Affiliation	Role
Rynearson, Tatiana A.	University of Rhode Island (URI-GSO)	Principal Investigator
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Abstract
Estimated thermal capacities for phytoplankton strains assessed in Anderson et al., Marine Phytoplankton Functional Types Exhibit Diverse Responses to Thermal Change (in review).

Table of Contents

Coverage

Spatial Extent: **N**:74.65 **E**:180 **S**:-65 **W**:-180

Methods & Sampling

Metrics for thermal capacity were calculated for phytoplankton strains of known origin (coccolithophores = 24, cyanobacteria = 31, diatoms = 115, dinoflagellates = 38). Trait values (derived_traits.csv) were used to compute the TSM (T_{opt} – $T_{habitat}$) and the WT (T_{max}-$T_{habitat}$). Additionally, we defined a new metric termed the distance to the growth equivalence (DGE), which describes the distance (ºC) to the temperature at which growth is equivalent to that at the organism's mean habitat temperature ($T_{\mu equiv}$ – $T_{habitat}$), but on the opposite side of the reaction norm.

To estimate past and future habitat temperatures for each phytoplankton strain, we utilized an ensemble mean of modeled sea surface temperature (SST) projections from the Coupled Model Intercomparison Project phase 5 (CMIP5), available at a 1.25° resolution, and presented in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Collins et al., 2013). This data was extracted from the Royal Netherlands Meteorological Institute Climate Explorer portal (http://climexp.knmi.nl). Projections for sea surface temperature (SST) warming were calculated between a baseline (1950-1970) and future (2080-2100) time period under Representative Concentration Pathway RCP8.5.

All analyses were conducted in R 3.6.1 (2019).

Complete information on each isolate and their thermal traits can be found in related dataset, https://www.bco-dmo.org/dataset/839689.

Data Processing Description

BCO-DMO Processing:
- renamed fields (replaced periods with underscores).

[table of contents | back to top]

Data Files

File
thermal_capacity.csv(Comma Separated Values (.csv), 17.50 KB) MD5:247e3df1dfa1b70265243cbe699f3ab8 Primary data file for dataset ID 839713

[table of contents | back to top]

Related Publications

Collins, M. et al. Long-term Climate Change: Projections, Commitments and Irreversibility. in Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (eds. Stocker, T. F. et al.) 1029–1136 (Cambridge University Press, 2013).
Methods

R Core Team (2019). R: A language and environment for statistical computing. R v3.5.1. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/
Software

[table of contents | back to top]

Related Datasets

IsRelatedTo

Rynearson, T. A. (2021) **Estimated thermal traits for phytoplankton.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2021-02-04 doi:10.26008/1912/bco-dmo.839689.1 [view at BCO-DMO]
Relationship Description: Contains complete information on each isolate and their thermal traits.

[table of contents | back to top]

Parameters

Parameter	Description	Units
isolate_code	Unique isolate ID adpated from Thomas et al. (2012). Full isolate information contained in related dataset https://www.bco-dmo.org/dataset/839689	unitless
isolation_longitude	longitude of isolation location	degrees East (0 to 360)
isolation_latitude	latitude of isolation location	degrees North
Thab_past	Modeled habitat temperature for strain's isolation location over the 1950-1970 time period	degrees Celsius
Thab_fut	Modeled habitat temperature for strain's isolation location over the 2080-2100 time period	degrees Celsius
safety_margin	Thermal Safety Margin (Difference between thermal optimum and habitat temperature)	degrees Celsius
warming_tolerance	Warming tolerence (Difference between thermal maximum and habitat temperature)	degrees Celsius
growth_eq	The temperature at which growth is equivalent to that at the organism's mean habitat temperature, but on the opposite side of the thermal reaction norm	degrees Celsius
DGE	Distance to the Growth Equivalence (DGE). Describes the distance (degrees C) to growth equivalence (Tuequiv – Thabitat)	degrees Celsius

[table of contents | back to top]

Project Information

Dimensions: Collaborative Research: Genetic, functional and phylogenetic diversity determines marine phytoplankton community responses to changing temperature and nutrients (Phytoplankton Community Responses)

Coverage: Narragansett Bay, RI and Bermuda, Bermuda Atlantic Time-series Study (BATS)

NSF Award Abstract:
Photosynthetic marine microbes, phytoplankton, contribute half of global primary production, form the base of most aquatic food webs and are major players in global biogeochemical cycles. Understanding their community composition is important because it affects higher trophic levels, the cycling of energy and elements and is sensitive to global environmental change. This project will investigate how phytoplankton communities respond to two major global change stressors in aquatic systems: warming and changes in nutrient availability. The researchers will work in two marine systems with a long history of environmental monitoring, the temperate Narragansett Bay estuary in Rhode Island and a subtropical North Atlantic site near Bermuda. They will use field sampling and laboratory experiments with multiple species and varieties of phytoplankton to assess the diversity in their responses to different temperatures under high and low nutrient concentrations. If the diversity of responses is high within species, then that species may have a better chance to adapt to rising temperatures and persist in the future. Some species may already be able to grow at high temperatures; consequently, they may become more abundant as the ocean warms. The researchers will incorporate this response information in mathematical models to predict how phytoplankton assemblages would reorganize under future climate scenarios. Graduate students and postdoctoral associates will be trained in diverse scientific approaches and techniques such as shipboard sampling, laboratory experiments, genomic analyses and mathematical modeling. The results of the project will be incorporated into K-12 teaching, including an advanced placement environmental science class for underrepresented minorities in Los Angeles, data exercises for rural schools in Michigan and disseminated to the public through an environmental journalism institute based in Rhode Island.

Predicting how ecological communities will respond to a changing environment requires knowledge of genetic, phylogenetic and functional diversity within and across species. This project will investigate how the interaction

of phylogenetic, genetic and functional diversity in thermal traits within and across a broad range of species determines the responses of marine phytoplankton communities to rising temperature and changing nutrient regimes. High genetic and functional diversity within a species may allow evolutionary adaptation of that species to warming. If the phylogenetic and functional diversity is higher across species, species sorting and ecological community reorganization is likely. Different marine sites may have a different balance of genetic and functional diversity within and across species and, thus, different contribution of evolutionary and ecological responses to changing climate. The research will be conducted at two long-term time series sites in the Atlantic Ocean, the Narragansett Bay Long-Term Plankton Time Series and the Bermuda Atlantic Time Series (BATS) station. The goal is to assess intra- and inter-specific genetic and functional diversity in thermal responses at contrasting nutrient concentrations for a representative range of species in communities at the two sites in different seasons, and use this information to parameterize eco-evolutionary models embedded into biogeochemical ocean models to predict responses of phytoplankton communities to projected rising temperatures under realistic nutrient conditions. Model predictions will be informed by and tested with field data, including the long-term data series available for both sites and in community temperature manipulation experiments. This project will provide novel information on existing intraspecific genetic and functional thermal diversity for many ecologically and biogeochemically important phytoplankton species, estimate generation of new genetic and functional diversity in evolution experiments, and develop and parameterize novel eco-evolutionary models interfaced with ocean biogeochemical models to predict future phytoplankton community structure. The project will also characterize the interaction of two major global change stressors, warming and changing nutrient concentrations, as they affect phytoplankton diversity at functional, genetic, and phylogenetic levels. In addition, the project will develop novel modeling methodology that will be broadly applicable to understanding how other types of complex ecological communities may adapt to a rapidly warming world.

[table of contents | back to top]

Program Information

Dimensions of Biodiversity (Dimensions of Biodiversity)

Website: http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503446

Coverage: global

(adapted from the NSF Synopsis of Program)
Dimensions of Biodiversity is a program solicitation from the NSF Directorate for Biological Sciences. FY 2010 was year one of the program. [MORE from NSF]

The NSF Dimensions of Biodiversity program seeks to characterize biodiversity on Earth by using integrative, innovative approaches to fill rapidly the most substantial gaps in our understanding. The program will take a broad view of biodiversity, and in its initial phase will focus on the integration of genetic, taxonomic, and functional dimensions of biodiversity. Project investigators are encouraged to integrate these three dimensions to understand the interactions and feedbacks among them. While this focus complements several core NSF programs, it differs by requiring that multiple dimensions of biodiversity be addressed simultaneously, to understand the roles of biodiversity in critical ecological and evolutionary processes.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1638834

[table of contents | back to top]