Laboratory results on phytoplankton temperature traits and data sources collected Michigan State University in 2012

Website: https://www.bco-dmo.org/dataset/544801
Version: 2014-12-22

Project
» Phytoplankton Traits, Functional Groups and Community Organization: A Synthesis (Phytoplankton Traits)

Contributors	Affiliation	Role
Litchman, Elena	Michigan State University (MSU)	Principal Investigator
Klausmeier, Christopher	Michigan State University (MSU)	Co-Principal Investigator
Thomas, Mridul	Swiss Federal Institute of Aquatic Science and Technology (EAWAG)	Contact
Copley, Nancy	Woods Hole Oceanographic Institution (WHOI BCO-DMO)	BCO-DMO Data Manager

Table of Contents

Dataset Description

This dataset gives phytoplankton temperature optima and the literature sources for the studies. The data are estimates from statistical fits to a compilation of measurements made in laboratories around the world.

Methods & Sampling

Text here is modified from the supplementary information of Thomas et al. (2012):

Statistical analysis of thermal tolerance curves

Temperature dependent specific growth rates can be described by the following equation:

$f(\mathrm{T}) = aebT[1-\{(T-z)/(w/2)\}2]$ - (S.1)

Here specific growth rate f is an explicit function of temperature, T. The shape of the thermal tolerance curve is controlled by two important species traits, z and w. The range of temperatures over which growth rate is positive, or the thermal niche width, is given by w. Species trait z determines the location of the maximum of the quadratic portion of this function. In the case where parameter $b = 0$, this value is identical to the temperature at which a species achieves its maximum growth rate. However, when b is non-zero, the maximum value of S.1 falls above (or potentially below, $b < 0$) the value of z, and can be found through numerical optimization.

We allowed a and b to be free parameters, fit simultaneously with z and w. To describe the growth data for each isolate, we used a maximum likelihood approach, such that the mean growth rate at a given temperature followed equation (S.1),

$\mu = f(\mathrm{T}) + N(0, \sigma 2)$ -(S.2)

Here observational error was described by a normal distribution with a mean of zero and variance of σ2.

Determining physiological parameter uncertainty

While confidence intervals for the point estimates of the parameters of (S.1) were easy to obtain, it was not straightforward to determine uncertainty for implicit properties such as the temperature at which growth rate is maximized (or, the 'optimum temperature'). Yet, this was the property that we were mainly interested in, leading us to adopt a parametric bootstrapping approach.

We used a Monte Carlo approach such that for each thermal tolerance curve having n data points, we simulated n new data points, drawn from a normal distribution such that:

1) The mean of the distribution corresponds to the value of (S.1) at each of the original experimental temperatures, given the coefficients previously estimated for the original curve.

2) The standard deviation of the distribution, σ, was obtained by adjusting the original maximum likelihood estimate, to account for uncertainty in its estimation.

Equation (S.1) was then fit to the simulated data using maximum likelihood estimation, and the new parameter values, as well as the numerically estimated optimum temperature, were retained. Repeating this process a total of 10,000 times (for each isolate), yielded bootstrapped distributions of all parameter estimates. From these distributions we calculated the 95% confidence intervals as the range between the 2.5th and 97.5th quantiles.

Related Reference:

Thomas, M. K., Kremer, C. T., Klausmeier, C. A., & Litchman, E. (2012). A global pattern of thermal adaptation in marine phytoplankton. Science, 338(6110), 1085-1088. DOI: 10.1126/science.1224836.

Supplemental materials: http://www.sciencemag.org/content/suppl/2012/10/25/science.1224836.DC1/Thomas.SM.pdf

[table of contents | back to top]

Data Files

File
temp_traits.csv (Comma Separated Values (.csv), 18.31 KB) MD5:ace2b5d7ac9a5e6ef7bee37942e307d5 Primary data file for dataset ID 544801

[table of contents | back to top]

Parameters

Parameter	Description	Units
sample	Index number for each strain in the dataset.	unitless
taxon	Species name, including strain/clone name where available. In some cases, taxa were not identified to a species level; in this case the available identifying information was provided.	unitless
study	Reference to the published paper from which the data were collected. The complete reference may be found in the supplementary information of Thomas et al. (2012). Thomas, M. K., Kremer, C. T., Klausmeier, C. A., & Litchman, E. (2012). A global pattern of thermal adaptation in marine phytoplankton. Science, 338(6110), 1085-1088. Specifically, pages 27-36 at http://www.sciencemag.org/content/suppl/2012/10/25/science.1224836.DC1/Thomas.SM.pdf	unitless
environment	Whether these strains were isolated from marine or estuarine environments.	unitless
temp_opt	Estimated optimum temperature for growth (in degrees C) of a phytoplankton strain based on statistical fits of a thermal reaction norm equation to measurements of population growth rates across a range of temperatures.	degrees Celsius
opt_CI_low	Lower bound of 95% confidence interval (i.e. 2.5th quantile) of the optimum temperature for growth (in degrees C) estimated through a bootstapping procedure.	degrees Celsius
opt_CI_up	Upper bound of 95% confidence interval (i.e. 97.5th quantile) of the optimum temperature for growth (in degrees C) estimated through a bootstapping procedure.	degrees Celsius
temp_niche	Estimated range of temperatures over which a strain's population growth rate is positive (in degrees C).	degrees Celsius
niche_CI_low	Lower bound of 95% confidence interval (i.e. 2.5th quantile) of the temperature niche width (in degrees C) estimated through a bootstapping procedure.	degrees Celsius
niche_CI_up	Upper bound of 95% confidence interval (i.e. 97.5th quantile of the temperature niche width (in degrees C) estimated through a bootstapping procedure.	degrees Celsius

[table of contents | back to top]

Deployments

Litchman_2012

Website	https://www.bco-dmo.org/deployment/544811
Platform	lab Litchman
Start Date	2009-09-01
End Date	2015-08-31
Description	Phytoplankton growth and temperature optima from literature search.

[table of contents | back to top]

Project Information

Phytoplankton Traits, Functional Groups and Community Organization: A Synthesis (Phytoplankton Traits)

Description from NSF award abstract:
Phytoplankton account for half of global primary productivity and their biomass and community composition significantly impact global carbon and other biogeochemical cycles and ecosystem functioning. Explaining patterns of global distributions of phytoplankton groups and predicting how phytoplankton communities will re-organize under anthropogenic environmental change requires knowledge of diverse eco-physiological traits defining ecological niches of phytoplankton species. In this project, the investigators will assemble a query-based database of diverse phytoplankton traits such as cell/colony size, growth rates, resource acquisition and predator avoidance traits, among others. Data for all available species and strains will be included. They will use the database to answer

fundamental questions in phytoplankton ecology such as:
1) what traits exhibit trade-offs (pairwise and beyond) and what shapes are they?
2) What traits scale allometrically with cell/body size? Can scaling exponents from first principles be predicted? What are potential limits to allometric scaling as a way of simplifying the complex trait space that characterizes real organisms?
3) What are trait differences among major functional/taxonomic groups of phytoplankton and how much does taxonomy/phylogeny constrain particular functional traits?
4) Are there differences in trait distributions between marine and freshwater groups?

The investigators will also use the database to parameterize novel models of phytoplankton community organization and evolution based on adaptive dynamics approaches. They will use the models to explore how community structure emerges under different environmental scenarios, given physiological constraints and ecological interactions. Changes in elemental stoichiometry, size structure and functional group distributions at different spatial and temporal scales will also be examined.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-0928819

[table of contents | back to top]