Equivalent spherical diameter of Heterosigma akashiwo grown at different temperatures

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Data Type: experimental
Version: 2
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Project
» Quantifying Temperature Dependence In Growth & Grazing Rates of Planktonic Herbivores (Planktonic Herbivore Temp Dependence)

Contributors	Affiliation	Role
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Abstract
A key component of the effects of temperature on growth and production of phytoplankton is not only through changes in numerical abundance, but also biomass and proxies for biomass such as biovolume. To understand how temperature affected size and biovolumetric growth, repeated measurements of the mean size feature, equivalent spherical diameter (ESD), were recorded for each experimental replicate culture of Heterosigma akashiwo across a broad range of temperature treatments. These data were collected as part of the experiment designed to study the effect of changing temperature on phytoplankton growth rates.

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Coverage

Spatial Extent: **Lat**:41.65583 **Lon**:-71.44778
Temporal Extent: 2018-06-25 - 2018-09-06

Dataset Description

A key component of the effects of temperature on growth and production of phytoplankton is not only through changes in numerical abundance, but also biomass and proxies for biomass such as biovolume. To understand how temperature affected size and biovolumetric growth, repeated measurements of the mean size feature, equivalent spherical diameter (ESD), were recorded for each experimental replicate culture of *Heterosigma akashiwo* across a broad range of temperature treatments. These data were collected as part of the experiment designed to study the effect of changing temperature on phytoplankton growth rates.

Also see dataset 'Phytoplankton Growth Acclimation': https://www.bco-dmo.org/dataset/783500

Acquisition Description

Experimental setup

H. akashiwo (CCMP 3374) was isolated from Narragansett Bay June 10, 2010 when in situ water temperature was 21.2°C. After isolation the culture was maintained at 15°C. All experiments were conducted with cells that were grown in autoclaved, 0.2 µm sterile-filtered seawater (30-31 ppt) amended with F/2 media without silica (Guillard 1975). All cultures were maintained under a light intensity of 150 µmol photons m-2 s-1 and a 12:12 h light: dark cycle. Preliminary experiments to determine the characteristics of this strains' growth patterns were used to maintain cultures in exponential phase by transferring cultures as needed every 4 to 10 days (depending on growth temperature), resulting in cell densities of 500-24,000 cell mL-1. To avoid convolution of thermal response and effect of unconditioned media just after transfer culture transfers were restricted from 1 day prior and 1 day post change in temperature (Grabski and Tukaj 2008).

Temperature treatments

Temperature was manipulated in the experiment through a series of sequential temperature shifts. Beginning with a culture which had remained at 15 °C since collection, every four days a triplicate set of the most extreme, current temperature treatments were split with one fraction retained at its current treatment and one fraction shifted a temperature step outward (i.e. further towards the temperature extremes). Only the cultures growing at the highest and lowest temperatures were split and transferred to new temperatures, but all other cultures were

continually maintained in exponential growth phase. Cultures maintained at 15 °C throughout the duration of the experiment served as an acclimated control, and as a reference for the temporal consistency in acclimated rates. Including all temperature steps and extrema, the nine treatments included: 6, 8, 10, 12, 18, 22, 25, 28, 31, and the control at 15°C. It took 20 days to complete the individual temperature shifts at 4-day intervals to reach the most extreme temperature treatments.

Dedicated incubators were used for control (15°C, Model 2015 Low Temperature Incubator, VWR Scientific); 4, 6 (I-41LLVL, Percival Scientific); 8, 18, 22 (I-36LLVL, Percival Scientific); and 10 °C (Environ Air, Holman Engineering). Twenty-five, 28, and 31 °C treatments were accomplished with clear 10 L baths controlled by a coupled aquarium heater and thermostat (Fluval, Tru Temp), housed in an illuminated incubator. Light intensity was consistently controlled across temperature treatments.

Population and growth rate measurements

To quantify changes in cell size, population growth rate, and volumetric growth rate, the abundance and size (Equivalent Spherical Diameter, ESD) distribution of each culture were measured with a 100 µm aperture on a Beckman Coulter Multisizer 3 (Beckman Coulter, Brea California; Kim and Menden-Deuer 2013). The default bin size was the instrument standard of 0.2 µm. Each treatment set was measured daily for 15 days following the initial transfer to the target temperature. Experiments were terminated after 15 days because the objective of these experiments was to establish the response to relatively short-term temperature fluctuations.

Statistical analysis

Mean and standard deviation of size distribution and cell counts as measured by the Coulter Counter were estimated from the raw data by a gaussian distribution, fit with maximum likelihood estimation to the frequency of particles greater than 8 µm. Measurements that immediately followed culture inoculation and those from the growth were omitted. Cell volumes were estimated with equivalent spherical diameter (ESD) and spherical shape approximation.

These experiments were conducted at the University of Rhode Island, Graduate School of Oceanography in the laboratory of Dr. Susanne Menden-Deuer

Processing Description

BCO-DMO Processing Notes:
- added conventional header with dataset name, PI name, version date
- reduced precision of ESD from 9 to 1 decimal place

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Related Publications

Grabski, K., & Tukaj, Z. (2007). Autoinduction activity of a conditioned medium obtained from high density cultures of the green alga Scenedesmus subspicatus. Journal of Applied Phycology, 20(3), 323–330. doi:10.1007/s10811-007-9260-x

Guillard, R. R. L. (1975). Culture of Phytoplankton for Feeding Marine Invertebrates. Culture of Marine Invertebrate Animals, 29–60. doi:10.1007/978-1-4615-8714-9_3

Kim, H., & Menden-Deuer, S. (2013). Reliability of rapid, semi-automated assessment of plankton abundance, biomass, and growth rate estimates: Coulter Counter versus light microscope measurements. Limnology and Oceanography: Methods, 11(7), 382–393. doi:10.4319/lom.2013.11.382

Menden-Deuer, S., & Lessard, E. J. (2000). Carbon to volume relationships for dinoflagellates, diatoms, and other protist plankton. Limnology and Oceanography, 45(3), 569–579. doi:10.4319/lo.2000.45.3.0569

Norberg, J. (2004). Biodiversity and ecosystem functioning: A complex adaptive systems approach. Limnology and Oceanography, 49(4,part2), 1269–1277. doi:10.4319/lo.2004.49.4_part_2.1269

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Parameters

Parameter	Description	Units
Culture	culture identifier	unitless
Temperature	temperature treatment	degrees Celsius
MeanESD	Mean Equivalent Spherical Diameter for a culture at single observations	micrometers

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Instruments

Dataset-specific Instrument Name	Beckman Coulter Multisizer III Counter
Generic Instrument Name	Coulter Counter
Dataset-specific Description	Used to count cells.
Generic Instrument Description	An apparatus for counting and sizing particles suspended in electrolytes. It is used for cells, bacteria, prokaryotic cells and virus particles. A typical Coulter counter has one or more microchannels that separate two chambers containing electrolyte solutions. from https://en.wikipedia.org/wiki/Coulter_counter

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Project Information

Quantifying Temperature Dependence In Growth & Grazing Rates of Planktonic Herbivores (Planktonic Herbivore Temp Dependence)

Coverage: Narragansett Bay

NSF Award Abstract: Plankton, single-celled organisms that inhabit the world's oceans are responsible for the generation of oxygen, cycling energy and matter between the atmosphere and the deep ocean and are the basis for virtually all seafood harvested. These life-giving functions critically depend on the relative rates at which plankton grow and get eaten. How temperature influences those rates is essential to understand plankton responses to environmental changes and ocean dynamics. It is well established that plankton grow faster when temperatures are higher however, whether feeding has a similar temperature dependence is unknown. That means oceanographers are missing key data required to build global predictive models. This project will fill essential knowledge gaps and measure physiological rates of singled celled zooplankton across temperature gradients representing the global ocean, from polar to tropical regions and throughout the seasonal cycle. Researchers will combine laboratory experiments with specimens taken from the coastal ocean (Narragansett Bay), which is exemplary in its strong seasonal temperature variations.

These data will provide a clear picture of the production capacity and activity of plankton in a global and dynamic ocean. The project supports an early career scientist, as well as graduate and undergraduate students. Scientists will continue communicating their research to the public through large-scale outreach events, education at the high-school level, and engagement through online and other media. Moreover, researchers will continue collaborating with the Metcalf Institute for Marine & Environmental Reporting to support their Annual Science Immersion Workshop for Journalists and their ongoing work to disseminate research findings through web-based seminars. Grazing is the single largest loss factor of marine primary production and thus affects a key transfer rate between global organic and inorganic matter pools. Remarkably, data for herbivorous protist growth and grazing rates at temperatures representative of the vast polar regions and during winter and spring periods are extremely sparse. By combining laboratory experiments with ground truthing fieldwork, this project alleviates a central knowledge gap in oceanography and delivers the empirical measurements necessary to derive algorithms to incorporate temperature dependence of heterotrophic protist growth and grazing rates into biogeochemical models. The extraordinary seasonal temperature fluctuations in a temperate coastal estuary (Narragansett Bay) are exploited to measure rates of heterotrophic protists isolated from different temperatures and seasons and to quantify the temperature and acclimation responses of these ecotypes. This project delivers data urgently needed to solve the conundrum of whether herbivorous growth and predation is depressed at low temperatures, implying low trophic transfer rates and high carbon export, or if predation proceeds at rates comparable to temperate systems with primary production largely lost to predation. Large temperature gradients in the global ocean mean that cross-biome and biogeochemical models are particularly sensitive to assumptions about the temperature dependence in modeled rate processes. Establishment of the dependence of heterotrophic plankton physiological rates (growth and grazing) to gradients of temperature, mimicking realistic conditions experienced by plankton in a changing ocean, is a key step towards integrating much needed biological information in biogeochemical modeling efforts. This project makes a significant contribution to linking ecological research with ecosystem models by providing empirically rooted algorithms of the temperature dependence of protistan herbivory and growth rates, key processes in the transformation of organic matter in global biogeochemical cycles and tools critically missing in ecosystem models.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1736635

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