Temperature and nutrient dependent phytoplankton growth and herbivorous protist grazing rates from the Long-term Plankton Time Series site in Narragansett Bay, RI in 2017

Website: https://www.bco-dmo.org/dataset/893500
Data Type: experimental
Version: 1
Version Date: 2023-04-12

Project
» Dimensions: Collaborative Research: Genetic, functional and phylogenetic diversity determines marine phytoplankton community responses to changing temperature and nutrients (Phytoplankton Community Responses)
» Quantifying Temperature Dependence In Growth & Grazing Rates of Planktonic Herbivores (Planktonic Herbivore Temp Dependence)

Program
» Dimensions of Biodiversity (Dimensions of Biodiversity)

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Abstract
Using a microcosm approach, we investigated the effect of simultaneous manipulation of temperature and nutrient availability on a coastal plankton community. The dataset presented shows phytoplankton growth and herbivorous protists grazing rates measured under three different temperatures (in situ, Δ+3, Δ-3) and two nutrient regimes (nutrient repleted and nutrient depleted). The data provided served for the production of Figure 6 and Figure 7 of Franzè et al., 2023 (see related publications, doi.org/10.1002/lno.12289).

Table of Contents

- Funding

Coverage

Spatial Extent: **Lat**:41.57 **Lon**:-71.39
Temporal Extent: 2017-03-20

Methods & Sampling

This dataset represents phytoplankton growth and herbivorous protists grazing rates measured under three different temperatures (in situ, Δ+3, Δ-3) and two nutrient regimes (nutrient-repleted and nutrient depleted) with seawater collected from the Narragansett Bay (NB) Long-term Plankton Time Series site (41.57 ºN, 71.39 ºW).

The experimental set-up consisted of a nested design: source water with plankton communities (< 200 µm) was used to set up long-term (10-day) microcosm incubations at three temperatures and two nutrient concentrations to monitor the community response to temperature and nutrient manipulations in terms of species composition and abundance over the incubation period. Seawater was filtered through a 200 micrometer (µm) mesh to eliminate macrozooplankton grazers. The 20-liter (L) acid-washed carboys were immediately transported to the laboratory. Each microcosm was used to assess phytoplankton growth and microzooplankton herbivory rates following the two-point modification of the dilution method (Landry and Hassett 1982) with 100 percent and 10 percent SW dilution levels. The initial dilution experiment conducted on day 0 (D0) was used to assess metabolic rates under in situ temperature and nutrient load. Then, on day 3 (D3), day 6 (D6), and day 10 (D10) using water from each microcosm, 6 dilution experiments per day (one per each temperature and nutrient level) were conducted for a total of 19 dilution experiments in 10 days.

Experimental bottles were incubated for 24 hours at -0.5 degrees C, 2.6 degrees C, and 6 degrees C under a 12:12 light: dark cycle of cool white fluorescent lights at 115 µmol photons m^{-2} s^{-1}. Triplicate subsamples were taken from the 100 percent SW stocks after 24 hours from each incubation bottle for chlorophyll *a* and microscopy analysis. Chlorophyll *a* extraction and determination followed Graff and Rynearson (2011) and measurements were performed on a Turner Designs AU10 fluorometer. Plankton community enumeration and composition was performed on samples preserved in 2 percent acid Lugol's iodine final concentration (Menden-Deuer et al., 2001). Phytoplankton cells were enumerated using a Sedgewick-Rafter slide (1-milliliter volume) and a Nikon Eclipse E800 light microscope while herbivorous protists were enumerated following the Utermöhl (1958) method settling between 2.5 and 15 milliliters. The entire surface area of the settling chamber was examined at 200x with a Nikon Diaphot 300 inverted microscope. Ciliates and dinoflagellates were identified and classified to the lowest possible taxonomic level by consulting several taxonomic guides (Kofoid and Campbell 1929; Tomas 1997; Strüder-Kypke et al. 2002).

Phytoplankton growth and herbivorous grazing rates were estimated from changes in total chlorophyll *a* concentration over the 24-hour incubation. The instantaneous phytoplankton growth rate (µ) depends on the assumption of unlimited, exponential growth and was calculated following the equation: $\mu = 1/t \ln (N_t/N_0)$, where t is the incubation time in days and N_t and N_0 are the chlorophyll *a* concentration at the beginning and at the end of the experiment. Herbivory rates due to microzooplankton grazing were estimated as the difference between µ measured in the diluted ($\mu_{10\%}$) and whole ($\mu_{100\ percent}$) seawater sample $g = \mu_{10\ percent} - \mu_{100\ percent}$.

Data Processing Description

BCO-DMO processing description:
- Adjusted field/parameter names to comply with BCO-DMO naming conventions

[table of contents | back to top]

Data Files

File
growth_grazing.csv (Comma Separated Values (.csv), 1.10 KB) MD5:a1e2164e871cdf1e1181164961f6beac Primary data file for dataset 893500, version 1.

[table of contents | back to top]

Related Publications

Anderson, S. I., Franzè, G., Kling, J. D., Wilburn, P., Kremer, C. T., Menden-Deuer, S., Litchman, E., Hutchins, D. A., & Rynearson, T. A. (2022). The interactive effects of temperature and nutrients on a spring phytoplankton community. Limnology and Oceanography, 67(3), 634–645. Portico. https://doi.org/10.1002/lno.12023
IsRelatedTo

Franzè, G., Anderson, S. I., Kling, J. D., Wilburn, P., Hutchins, D. A., Litchman, E., Rynearson, T. A., & Menden-Deuer, S. (2022). Interactive effects of nutrients and temperature on herbivorous predation in a coastal plankton community. Limnology and Oceanography. Portico. https://doi.org/10.1002/lno.12289
Results

Graff, J. R., & Rynearson, T. A. (2011). Extraction method influences the recovery of phytoplankton pigments from natural assemblages. Limnology and Oceanography: Methods, 9(4), 129–139. doi:10.4319/lom.2011.9.129
Methods

Strüder-Kypke, M., & Montagnes, D. (2002). Development of web-based guides to planktonic protists. Aquatic Microbial Ecology, 27, 203–207. https://doi.org/10.3354/ame027203
Methods

Tomas, C. R. (Ed.). (1997). Identifying marine phytoplankton. Elsevier.
Methods

Utermöhl, H. (1958). Zur vervollkommnung der quantitativen phytoplankton-methodik: Mit 1 Tabelle und 15 abbildungen im Text und auf 1 Tafel. Internationale Vereinigung für theoretische und angewandte Limnologie: Mitteilungen, 9(1), 1-38.
Methods

[table of contents | back to top]

Related Datasets

IsRelatedTo

Anderson, S. I., Franze, G., Kling, J. D., Wilburn, P., Kremer, C. T., Menden-Deuer, S., Litchman, E., Hutchins, D. A., Rynearson, T. A. (2021) **Elemental composition of phytoplankton communities from multivariate mesocosm experiments conducted with a natural phytoplankton community from Narragansett Bay, RI.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2021-04-26 doi:10.26008/1912/bco-dmo.848587.1 [view at BCO-DMO]

Anderson, S. I., Franze, G., Kling, J. D., Wilburn, P., Kremer, C. T., Menden-Deuer, S., Litchman, E., Hutchins, D. A., Rynearson, T. A. (2021) **Microscopy cell counts from multivariate mesocosm experiments conducted with a natural phytoplankton community from Narragansett Bay, RI.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2021-04-14 doi:10.26008/1912/bco-dmo.848977.1 [view at BCO-DMO]

Anderson, S. I., Franze, G., Kling, J. D., Wilburn, P., Kremer, C. T., Menden-Deuer, S., Litchman, E., Hutchins, D. A., Rynearson, T. A. (2021) **Size-fractionated chlorophyll a from multivariate mesocosm experiments conducted with a natural phytoplankton community from Narragansett Bay, RI.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2021-04-14 doi:10.26008/1912/bco-dmo.848948.1 [view at BCO-DMO]

Franzè, G., Menden-Deuer, S., Anderson, S. I., Kling, J. D., Wilburn, P., Hutchins, D. A., Litchman, E., Rynearson, T. A. (2023) **Herbivorous protist abundances under simultaneous manipulation of**

temperature and nutrients from the Long-term Plankton Time Series site in Narragansett Bay, RI in 2017. Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-04-10 doi:10.26008/1912/bco-dmo.893414.1 [view at BCO-DMO]

[table of contents | back to top]

Parameters

Parameter	Description	Units
Growth_per_day	Phytoplankotn growth rate	unitless
Grazing_per_day	Herbivorous protists grazing rate	unitless
Day	Days of incubation where the rates were measured	unitless
Temperature	Incubation temperature	degrees Celsius
Nutrient_added	Nutrient amendment (y=nutrient added; n=no nutrient added)	unitless

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	Nikon Diaphot 300
Generic Instrument Name	Inverted Microscope
Generic Instrument Description	An inverted microscope is a microscope with its light source and condenser on the top, above the stage pointing down, while the objectives and turret are below the stage pointing up. It was invented in 1850 by J. Lawrence Smith, a faculty member of Tulane University (then named the Medical College of Louisiana). Inverted microscopes are useful for observing living cells or organisms at the bottom of a large container (e.g. a tissue culture flask) under more natural conditions than on a glass slide, as is the case with a conventional microscope. Inverted microscopes are also used in micromanipulation applications where space above the specimen is required for manipulator mechanisms and the microtools they hold, and in metallurgical applications where polished samples can be placed on top of the stage and viewed from underneath using reflecting objectives. The stage on an inverted microscope is usually fixed, and focus is adjusted by moving the objective lens along a vertical axis to bring it closer to or further from the specimen. The focus mechanism typically has a dual concentric knob for coarse and fine adjustment. Depending on the size of the microscope, four to six objective lenses of different magnifications may be fitted to a rotating turret known as a nosepiece. These microscopes may also be fitted with accessories for fitting still and video cameras, fluorescence illumination, confocal scanning and many other applications.

Dataset-specific Instrument Name	Nikon Eclipse E800
Generic Instrument Name	Microscope - Optical
Generic Instrument Description	Instruments that generate enlarged images of samples using the phenomena of reflection and absorption of visible light. Includes conventional and inverted instruments. Also called a "light microscope".

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)

[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.

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.

[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-1638958
NSF Division of Ocean Sciences (NSF OCE)	OCE-1638804
NSF Division of Ocean Sciences (NSF OCE)	OCE-1638834
NSF Division of Ocean Sciences (NSF OCE)	OCE-1736635

[table of contents | back to top]