**Title:**

Phytoplankton growth and microzooplankton grazing rates from NES-LTER transect cruises, EN608 – EN617 – EN627.

**Abstract:**

Phytoplankton growth and microzooplankton grazing rates were measured from incubation experiments using the dilution method in the framework of the Northeast US Shelf Long-Term Ecological Research project. The dataset gathers plankton population dynamics rates obtained during cruises onboard the R/V Endeavor in winter 2018 (EN608), summer 2018 (EN617), and winter 2019 (EN627) along a North/South transect from Martha’s Vineyard to the shelf-break. This is an ongoing dataset reporting the first phytoplankton growth and microzooplankton rates used for a publication. The dataset includes only rates obtained from surface samples. Different light treatments were used to simulate different environmental conditions and to better understand the role of light on plankton population dynamics. Phytoplankton growth and microzooplankton grazing rates were measured for the total phytoplankton community (Chl-a concentrations) and for size fractions (Chl-a size fractionation) less than and greater than 10 µm. Phytoplankton growth and microzooplankton grazing rates, the first trophic interaction between primary producers and higher trophic levels, are essential parameters to assess the cycling and export of carbon in the ocean and to better understand marine food webs.

**Keywords:**

LTER Core Research Area(s):

Primary production, Populations

LTER controlled vocabulary terms:

Phytoplankton, growth, zooplankton, grazing, population dynamics, trophic dynamics, aquatic ecosystems, marine

Additional terms:

Phytoplankton growth, microzooplankton grazing

**Methods:**

## Sample collection

At each station, hydrographic data of depth, temperature, and salinity were collected with a SBE911 (Seabird Electronics Inc.) CTD-rosette system. Seawater for the experiments was collected near the surface (1.6-7 m) using multiple Niskin bottles and sometimes from different CTD casts at a given location. Cast and bottle numbers are reported in the data table. Depth, temperature and salinity values of the seawater collected for the experiments reported in the data table are averaged from bottle summary files produced with Seabird software onboard ship and have not been corrected to salts.

## Experimental set-up

Rates of phytoplankton growth and microzooplankton grazing were quantified using a 2-point modification of the dilution method (Morison & Menden-Deuer, 2017). Whole seawater (WSW) was gently transferred from a Niskin to a 10 L polycarbonate carboy through a 200 µm mesh to remove mesozooplankton predators (e.g. copepods). Diluent was prepared by gravity filtration through a 0.2 µm membrane filter capsule (PALL) from the Niskin to the carboys. The appropriate amount of WSW was added to the filtered water to obtain a 20 percent WSW dilution (20WSW). The carboys were covered by black trash bags and gently mixed while water was siphoned into duplicate 1.2 L clear polycarbonate bottles. To ensure the gross growth rate of the phytoplankton was not dependent upon dilution, a central assumption of the dilution method (Landry and Hasset, 1982), incubation bottles were amended with macronutrients (10 µM SiO4, 10 µM NO3, 1 µM PO4). An additional set of WSW bottles without additional nutrients was added to assess nutrient limitation or toxicity effects. For each dilution (20WSW and WSW), nutrient (nutrient amended and without nutrient) and light (high and low light, see below) treatment, incubation bottles were duplicated.

Bottles were incubated for 24 h in a clear deck-board, flow through, 1 m^3, incubator. Surface water was incubated at two light-levels that simulated the contrasting light conditions (e.g. sunny/cloudy weather, well-mixed/stratified water column) under which phytoplankton could be growing in the surface ocean. Mesh, screen, bags were used to create High Light (HL) and Low Light (LL) treatments that simulated 65 percent and 15 percent of light attenuation. The incubator was free of overhead obstructions to avoid shading during the day and covered by a tarp at night to minimize light pollution from deck lighting. Natural movement of the ship kept the bottles in the incubator agitated over the incubation period. Temperature within the incubators was maintained equivalent to current surface temperature through continuous flow-through from the ship seawater system. Temperature and light in the incubators were monitored at 5-minute intervals with a Hobo (Onset) data logger. Temperature and light measurements recorded during each of the incubation experiments are available in .csv files following the links present in the last column of the data table.

## Phytoplankton growth and protist grazing rate estimates

Initial (T0) chlorophyll-a (Chl-a) concentration was determined from triplicate 120-150 mL subsamples from carboys used to fill incubation bottles. Final Chl-a concentration (TF) was determined from triplicate 120-150 mL subsamples from bottles at the end of the incubation. The extraction method followed Graff and Rynearson (2011) except here we used 95 percent ethanol as a solvent (Jespersen and Christoffersen, 1987). Extracted Chl-a concentration was determined using a Turner AU10 fluorometer after a 12 h extraction period. In addition, the size structure of the initial phytoplankton community was characterized from T0 triplicate size-fractionated Chl-a samples (greater than 0.7 µm GF/F, greater than 5 µm, greater than 10 µm, and greater than 20 µm). At TF, size-fractionated Chl-a concentration at 10 µm were also measured for 20WSW and WSW nutrient amended bottles. During the first winter cruise in 2018 (EN608) size fractionation was only performed on bottles incubated under high light conditions.

Phytoplankton growth rates and protist grazing rates were estimated from 24 h changes in Chl-a concentration. For each incubation bottle, the apparent growth rates (k, d^-1) were calculated as:

k=1⁄t×ln(C\_t⁄C\_0 )

where t is the incubation time (d) and C\_t and C\_0 the final and initial Chl-a concentration (µg L^-1), respectively.

Protist grazing rates (g, d^-1) were estimated with the equation:

g=((k\_d-k\_N ))⁄((1-x))

where k\_d and k\_N are the apparent growth rates in 20WSW and WSW nutrient amended treatments, respectively, and x is the achieved fraction of WSW in the diluted treatment calculated from T0 Chl-a in 20WSW and WSW (Landry et al., 1984). Accordingly, the instantaneous, or in situ, growth rate (mu\_0, d^-1) was estimated as in (Landry et al., 2008):

mu\_0=g+k\_NoN

where k\_NoN is apparent phytoplankton growth rate k without nutrient addition.

The potential for nutrient limitation was assessed by comparing apparent phytoplankton growth rates k in nutrient amended (k\_N) and nonamended (k\_NoN) replicates using a paired t-test. If a significant difference was found (p below 0.05) between k\_N and k\_NoN, nutrient-amended growth rates (mu\_N, d^-1) were also calculated as mu\_N = g + k\_N. Otherwise, all k\_N and k\_NoN triplicate of replicate values were used to calculate both g and mu\_0.

Since size fractionation at 10 µm was performed only on nutrient amended samples, growth rates reported on greater than 10 µm and less than 10 µm fractions in this study were nutrient-amended growth rates (mu\_N) when nutrient limitation was observed. If no nutrient limitation was observed, mu\_N obtained is equivalent to mu\_0.

The uncertainty of g estimates was quantified using the standard error of the slope fit from a linear regression between replicate k values and dilution levels. When the slope obtained was not significantly different from zero (p higher than 0.05), g was set to 0. Thus, the average k\_N represented mu\_N and the average k\_NoN represented mu\_0 (Murrell et al., 2002; Chen et al. 2009). A significant positive slope (i.e. higher growth in the WSW treatment than in the diluted) represents a violation of the method’s assumption. In such cases, g was reported as ‘undetermined’, and k in the undiluted bottles represented mu\_N and mu\_0. Uncertainties relative to mu\_N and mu\_0 were estimated from the standard deviations observed on k\_N and k\_NoN triplicate values.

## Data Cleaning

Data cleaning (i.e., separating numerical and categorical variables, referring to multiple casts and bottles, and assuring date and time of sampling) and metadata template assembly were performed in R Markdown. Further documentation can be found on GitHub, at <https://github.com/WHOIGit/nes-lter-growth-grazing-chl>.

## Quality Assurance

We assured that all values reported in the clean data table for geographic (latitude, longitude, depth, station), temporal (date\_time\_UTC, date\_time\_start\_UTC, date\_time\_end\_UTC), and other cruise metadata and data (cast, bottle, temp, sal) were as expected.

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