

Effect of microplastic ingestion on heterotrophic dinoflagellate functional responses

Website: <https://www.bco-dmo.org/dataset/855595>

Data Type: experimental

Version: 1

Version Date: 2021-07-13

Project

» [Quantifying Temperature Dependence In Growth & Grazing Rates of Planktonic Herbivores](#) (Planktonic Herbivore Temp Dependence)

Contributors	Affiliation	Role
Fulfer, Victoria	University of Rhode Island (URI-GSO)	Principal Investigator
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Abstract

Data were collected examining the effect of microplastic ingestion on heterotrophic dinoflagellate functional responses. Heterotrophic dinoflagellate species *O. marina* and *Gyrodinium* sp. were incubated for 5 days under two conditions: a control, fed only algal prey *I. galbana*, and a treatment fed algal prey and microplastic particles. Samples were taken every 24 hours, with abundances of dinoflagellates, algal prey, and microplastics measured with a Beckman Coulter Counter and verified via microscopy. Ingestion rates were measured and compared between treatments.

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Coverage

Spatial Extent: Lat:41.4501 Lon:-71.4495

Temporal Extent: 2021-01-25 - 2021-01-27

Methods & Sampling

Methodology:

Heterotrophic dinoflagellate species *O. marina* and *Gyrodinium* sp. were incubated for 3 hours under two conditions: a control, fed only algal prey *I. galbana*, and a treatment fed algal prey and microplastic particles. This was done over 15 concentrations of algal prey and plastics. Samples were taken at T0 and Tfinal, with abundances of dinoflagellates, algal prey, and microplastics measured with a Beckman Coulter Counter and verified via microscopy. Ingestion rates of algal prey and of microplastics were measured and compared between treatments to determine the relative proportions of microplastics and prey eaten across a range of particle concentrations. Ingestion rates for all particles types were calculated.

Microplastic Ingestion Experiments:

The possibility and subsequent effects of microplastic ingestion by heterotrophic dinoflagellate species were determined using two treatment conditions: first, a treatment with microplastics, in which heterotrophic dinoflagellates were fed a mixture of algal prey and microplastic particles; and second, an algae-only control, in which heterotrophic dinoflagellates were fed algal prey.

Each of the three target heterotrophic dinoflagellate species was incubated with *I. galbana* and microplastic particles, when applicable, diluted in filtered seawater (FSW) to the target concentrations (Table 1 of Fulfer & Menden-Deuer, 2021). Control treatments of the two prey types in the absence of predators were incubated alongside the grazing experiments. All treatments were prepared in triplicate and in a total volume of 125 mL and incubated in 250 mL polycarbonate bottles on a 12 h: 12 h light-dark cycle at 15°C and a light intensity of 8 – 15 $\mu\text{mol photons m}^{-2} \text{ s}^{-1}$ on a shaker table at 60 rotations-per-minute (rpm) to reduce settling of microplastic particles.

Fluorescent yellow polystyrene (PS) microplastic particles ranging in diameter from 2.5 to 4.5 μm were used in all microplastic feeding experiments (Spherotech, FP-3052-2). This size range was chosen to mimic the size of the algal prey species. Microplastic particles were rinsed three times in DI water and resuspended in autoclaved, filtered seawater directly before use. For each experiment, prey (IG) control treatments were prepared in triplicate in 125 mL polycarbonate bottles with *I. galbana* diluted in filtered seawater (FSW) to a final concentration of 70,000 - 100,000 prey cells mL^{-1} .

To determine if the heterotrophic dinoflagellates were ingesting microplastics and prey at the same rate, or if they displayed a preference for one particle type, short term (3 hrs duration) ingestion experiments were conducted. The two dinoflagellate species were fed only prey or a 1:1 mixture of microplastics and prey. A total of 15 total particle concentrations (prey + microplastics) were used, ranging from 4,000 to 220,000 particles mL^{-1} (Table 1 of Fulfer & Menden-Deuer, 2021). Each treatment contained 900-1100 cells mL^{-1} of *O. marina* or 500 – 800 cells mL^{-1} of *Gyrodinium* sp. and was prepared to a final volume of 125 mL. Samples of 10 mL were taken at time 0 and after 3 hours. The initial and final abundances of microplastic particles, prey, and zooplankton were measured with a 100 μm aperture on a Beckman Coulter Multisizer 3 (Beckman Coulter).

Data Processing Description

Data Processing:

Ingestion rates (I) were calculated via the ingestion rate equation in Frost 1972. Ingestion rates of plastic were also calculated using the change in plastic concentration ($N_i - N_f$).

BCO-DMO Processing:

- renamed fields to conform with BCO-DMO naming conventions (removed spaces and special characters)

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Data Files

File
microplastic_functional_response.csv (Comma Separated Values (.csv), 5.83 KB) MD5:7aa2c8843312c35970e4a1ed0d034d39
Primary data file for dataset ID 855595

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Related Publications

Frost, B. W. (1977). Feeding behavior of *Calanus pacificus* in mixtures of food particles¹. Limnology and Oceanography, 22(3), 472–491. doi:[10.4319/lo.1977.22.3.0472](https://doi.org/10.4319/lo.1977.22.3.0472)
Methods

Fulfer, V. & Menden-Deuer, S. (2021). Heterotrophic Dinoflagellate Growth and Grazing Rates Reduced by Microplastic Ingestion. Frontiers in Marine Science. doi: [10.3389/fmars.2021.716349](https://doi.org/10.3389/fmars.2021.716349)

Related Datasets

IsRelatedTo

Fulfer, V., Menden-Deuer, S. (2021) **Effect of microplastic ingestion on heterotrophic dinoflagellate growth rates.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2021-07-13 doi:10.26008/1912/bco-dmo.855583.1 [[view at BCO-DMO](#)]

Fulfer, V., Menden-Deuer, S. (2021) **Effect of microplastic ingestion on heterotrophic dinoflagellate ingestion rates.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2021-07-13 doi:10.26008/1912/bco-dmo.855573.1 [[view at BCO-DMO](#)]

Parameters

Parameter	Description	Units
Species	Dinoflagellate species	unitless
Treatment	Experimental treatment: IG = fed algae only; MP + IG = fed algae and Microplastics	unitless
Replicate	Experimental replicate id (A, B, C)	unitless
time_total	Time between T0 and tfinal	hours
I_galbana_Abundance_T0	Abundance of algal prey I. galbana at T0	per milliliter (mL-1)
I_galbana_Abundance_Tfinal	Abundance of algal prey I. galbana at Tfinal	per milliliter (mL-1)
Microplastics_Abundance_T0	Abundance of Microplastics particles at T0	per milliliter (mL-1)
Microplastic_Abundance_Tfinal	Abundance of Microplastics particles at Tf	per milliliter (mL-1)
Het_Dino_Abundance_T0	Abundance of heterotrophic dinoflagellate at T0	per milliliter (mL-1)
Het_Dino_Abundance_Tfinal	Abundance of heterotrophic dinoflagellate at Tfinal	per milliliter (mL-1)
Total_Prey_Particle_Count_T0	Abundance of algal prey + microplastics at t0	per milliliter (mL-1)
Total_Prey_Particle_Count_Tfinal	Abundance of algal prey + microplastics at tfinal	per milliliter (mL-1)
I_galbana_Geometric_Mean	Calculated geometric mean for each day	per milliliter (mL-1)
Microplastic_Geometric_Mean	Calculated geometric mean for each day	per milliliter (mL-1)
All_Particles_Geometric_Mean	Calculated geometric mean (prey + plastic) for each day	per milliliter (mL-1)
Het_Dino_Geometric_Mean	Calculated geometric mean for each day	per milliliter (mL-1)
Ingestion_Rate_of_Prey	Rate het. Dino ingested algal prey	cells per predator per hour
Ingestion_Rate_of_Microplastics	Rate het. Dino ingested microplastics	cells per predator per hour
Ingestion_Rate_of_All_Particle_Types	Rate het. Dino ingested prey + microplastics	cells per predator per hour

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Instruments

Dataset-specific Instrument Name	Beckman Coulter Multisizer 3
Generic Instrument Name	Particle Size Analyzer
Dataset-specific Description	Abundances of prey, predators, and microplastic particles were measured with a Beckman Coulter Multisizer 3 (Beckman Coulter) using a 100 µm aperture.
Generic Instrument Description	Particle size analysis, particle size measurement, or simply particle sizing is the collective name of the technical procedures, or laboratory techniques which determines the size range, and/or the average, or mean size of the particles in a powder or liquid sample.

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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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