Results of light-limited growth experiments including the full range of volatile organic compounds (VOCs) produced by the diatom T. weissflogii and alga D. tertiolecta during laboratory experiments conduced in Sept of 2023

Website: https://www.bco-dmo.org/dataset/928006
Data Type: experimental
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Project
» Interactions between phytoplankton and bacterioplankton mediated by volatile organic compounds (Plankton Interactions and VOC)

Contributors	Affiliation	Role
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Abstract
Photosynthetic metabolism changes depending on growth rate. We hypothesized that metabolic shifts associated with light-limited growth would be observed in the amounts and collections of volatile organic compounds (VOCs) produced in different algae. Two different algae, a diatom, Thalassiosira weissflogii and a green alga, Dunaliella tertiolecta, were grown using semicontinuous batch culturing under constant light conditions at 10 uE and 180 uE resulting in steady state growth rates that were 0.3 d-1 and 1.1 d-1, respectively, and VOCs were collected. These light limited growth rate experiments were conducted in September of 2023.

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Coverage

Location: Laboratory study
Temporal Extent: 2023-09

Methods & Sampling

VOCs were collected from axenic. *Dunaliella tertiolecta* (urn:lsid:marinespecies.org:taxname:178590) and *Thalassiosira weissflogii* (urn:lsid:marinespecies.org:taxname:163513) using proton transfer reaction time-of-flight mass spectroscopy (PTR-TOF/MS; Ionicon, Austria) as previously described (Moore et al., 2020). Autoclaved f/2+Si media was measured alongside the samples as blank (background) controls. 100 ml culture, media, or HPLC water was transferred to a dynamic stripping chamber (Halsey et al., 2017) and bubbled with breathing-grade air passed first through a hydrocarbon trap and then through a glass frit in the bottom of the chamber at 50 ml min^{-1} for 5 min to strip VOCs from the sample. The stripped gasses were directed into the

PTR-ToF/MS for measurement via soft ionization with H_3O^+. The mass spectrum (30-240 a.m.u.) was acquired at 5 s intervals. PTR-TOF/MS data were analyzed using PTR viewer 3.4.3 (Ionicon Analytik). A three-point calibration was performed on each .h5 file using a search range of 0.2 m/z. Within the three-point calibration mode, each mass spectrum was calibrated against three internal standards known to be present within the spectrum, namely 29.998 (NO+), 203.943, and 330.848 (1,3-diiodobenzene).

Data Processing Description

PTR-TOF/MS data were analyzed using PTR viewer 3.4.3 (Ionicon Analytik).

BCO-DMO Processing Description

* Sheets within submitted file "Excel spreadsheets of D.T & T.W.xlsx" were imported into the BCO-DMO data system for this dataset. Tables were concatenated with an additional column to contain the sheet name as it appeared in Excel. Sheet "Sample Information" was not concatenated, but instead added as a supplemental table to the dataset page.

** Missing data values are displayed differently based on the file format you download. They are blank in csv files, "NaN" in MatLab files, etc.

* Column names adjusted to conform to BCO-DMO naming conventions designed to support broad re-use by a variety of research tools and scripting languages. [Only numbers, letters, and underscores. Can not start with a number]

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Related Publications

Halsey, K. H., Giovannoni, S. J., Graus, M., Zhao, Y., Landry, Z., Thrash, J. C., Vergin, K. L., & de Gouw, J. (2017). Biological cycling of volatile organic carbon by phytoplankton and bacterioplankton. Limnology and Oceanography, 62(6), 2650–2661. Portico. https://doi.org/10.1002/lno.10596
Methods

Ionicon Analytik Ges.m.b.H. (2021) PTR-MS VIEWER 3.4.3 UPDATE. Available from https://www.ionicon.com/blog/2021/ptr-ms-viewer-343-update
Software

Moore, E. R., Davie-Martin, C. L., Giovannoni, S. J., & Halsey, K. H. (2020). Pelagibacter metabolism of diatom-derived volatile organic compounds imposes an energetic tax on photosynthetic carbon fixation. Environmental Microbiology, 22(5), 1720–1733. Portico. https://doi.org/10.1111/1462-2920.14861
Results

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Parameters

Parameters for this dataset have not yet been identified

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Instruments

Dataset-specific Instrument Name	Proton transfer reaction time-of-flight mass spectroscopy (PTR-TOF/MS; Ionicon, Austria).
Generic Instrument Name	Mass Spectrometer
Generic Instrument Description	General term for instruments used to measure the mass-to-charge ratio of ions; generally used to find the composition of a sample by generating a mass spectrum representing the masses of sample components.

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Project Information

Interactions between phytoplankton and bacterioplankton mediated by volatile organic compounds (Plankton Interactions and VOC)

NSF Award Abstract:
Communication amongst plants and animals often occurs through molecules that readily evaporate at normal temperatures, called volatile organic compounds (VOCs). Some VOCs that are produced in the ocean and then enter the atmosphere as gases have been seen to play an important role in climate. Since marine microbes both produce and consume these compounds they affect the concentration of VOCs in the surface ocean. The investigators found that as much as 20% of the carbon resulting from photosynthesis leaked out of microscopic plants in the form of VOCs. These molecules were then used by bacteria as a source of carbon and energy. This suggests that VOCs may play a more important role in the flow of carbon in the marine environment than previously thought. This project examines how microscopic plants and bacteria produce and consume different VOCs. It supports professional development training workshops for Oregon high school teachers from rural areas in OSU's Science & Math Investigative Learning Experiences (SMILE) program. SMILE's mission is to close the achievement gap for underserved students by increasing their STEM-content knowledge, preparing them to succeed in higher education, and inspiring them to pursue STEM careers. This project also contributes to three workshops per year, training teachers and engaging students with hands-on learning activities on the topic of Carbon Cycling by Marine Microorganisms such as "Clouds in a Bottle". One graduate student, one post-doctoral scholar, and at least six undergraduate researchers are being trained by participating in research activities.

Field observations suggest that volatile organic compounds (VOCs) produced by phytoplankton are either rapidly consumed by bacterioplankton in the surface ocean or emitted into the atmosphere. VOCs are an understudied path for carbon transfer in microbial food webs throughout sunlit marine ecosystems because these compounds require specialized detection methods. Using a new system to study VOCs in suspensions of live plankton cells, 20% of photosynthetic carbon fixation was seen to be transferred as VOCs from a diatom to SAR11 bacterioplankton in co-cultures. Many of these transferred VOC compounds were not known to be growth substrates for bacterioplankton. Both the magnitude and complexity of the observed VOC transfer were surprising. This project extends these observations to a larger set of phytoplankton and bacterioplankton through controlled studies of cultures, co-cultures, and mesocosms. VOC are detected via proton transfer reaction time-of-flight mass spectrometry and isotopic labeling is used to measure the impact of VOC exchange on rates of photosynthesis and bacterial production. VOC production by phytoplankton is measured in response to nutrient-driven variation in growth rates, and over day-night cycles to discern the relationship of VOC production to photosynthetic metabolism and other cellular processes. These experiments enable a better understanding of field observations, in which bacterial consumption of VOCs can appear to significantly outpace production, while temporal variability in VOC production across daily to seasonal scales can cause VOCs to accumulate transiently to pM-nM concentrations in the surface ocean. This project contributes to close the significant gap in knowledge about the range and quantity of VOCs produced by phytoplankton, and about the roles played by these compounds in phytoplankton metabolism.

This award reflects NSF's statutory mission and has been deemed worthy of support through evaluation using the Foundation's intellectual merit and broader impacts review criteria.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1948163

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