Biological turnover of acrylate and dimethylsulphoniopropionate from coral reefs sampled in Moorea, French Polynesia in April 2018

Website: https://www.bco-dmo.org/dataset/879158
Data Type: Other Field Results, experimental
Version: 1
Version Date: 2022-09-01

Project
» Photolysis and Photoproduction of Acrylate in Seawater and their Impact on the Marine Organosulfur Cycle (Impact Acrylate in Seawater)

Program
» United States Surface Ocean Lower Atmosphere Study (U.S. SOLAS)

Contributors	Affiliation	Role
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Abstract
Shallow-water coral reefs hold large quantities of acrylate and its precursor dimethylsulfoniopropionate (DMSP). The main sources of acrylate in coral reefs are from the coral algal symbionts in the family Symbiodiniaceae and from the photolysis of dissolved organic matter. Heterotrophic consumption is the main loss for these compounds, albeit these processes are poorly characterized. This dataset contains rate-constant data for the biological consumption of dissolved acrylate and DMSP in near-surface seawater collected from a Mo'orea coral reef, French Polynesia, and the offshore open Pacific Ocean. The coral reef and Pacific Ocean stations were located offshore from the UC Berkeley Gump Research Station. Samples were collected from April 6 to April 24, 2018. Details of the sampling and experimental procedures for this dataset are reported in Xue et al. (2022).

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Coverage

Spatial Extent: **N**:-17.4552 **E**:-149.831 **S**:-17.4823 **W**:-149.841
Temporal Extent: 2018-04-06 - 2018-04-24

Acquisition Description

Study area: The main field study was conducted in a coral reef offshore from the Richard Gump South Pacific

Research Station located next to Cook's Bay on the northern shore of Mo'orea, French Polynesia. Research was conducted by small boat in a shallow-water coral reef and offshore Pacific Ocean. See Figure 1 in Xue et al. (2022) for the geographic locations of French Polynesia, the island of Mo'orea, and the schematic description of the reef structure and the reef-ocean transect sampling locations.

Water samples: A study was conducted to determine the rate constant and rate for the biological consumption of dissolved acrylate and DMSP. Experiments were performed using unfiltered water samples collected during diel sampling in the back reef and open Pacific Ocean stations.

Biological consumption of dissolved acrylate: To perform an incubation experiment for the biological consumption of acrylate, acrylate was added to unfiltered water samples in triplicate 250 milliliter (mL) polycarbonate (PC) bottles to yield an initial concentration of 10-15 nanomolar (nM). Another set of three PC bottles received no acrylate addition. Once samples were prepared, they were placed in a large incubator with hosing to continuously pump ambient seawater through the incubator to maintain the temperature at ~28 degrees Celsius. Samples were incubated in the dark. Subsamples (15 mL) were collected at four time points from each PC bottle during incubation, and the total length of each incubation was 14 hours for the back reef samples and 18 hours for the Pacific Ocean samples.

Biological consumption of dissolved DMSP: The biological consumption of DMSP was determined using the glycine betaine (GBT) inhibition method outlined in Kiene and Gerard (1995). Briefly, six PC bottles were filled with freshly collected, unfiltered seawater. Three bottles were treated with GBT to a final concentration of 10 micromolar (µM) and the other three bottles were left untreated. All samples were incubated in dark in the same incubator used for acrylate experiments. Subsamples (15 mL) were collected at several time points from each bottle for the measurement of DMSP concentrations.

Acrylate and organosulfur quantification: Acrylate concentrations were determined using a pre-column derivatization HPLC method (Xue and Kieber, 2021). For derivatization, 300 microliter (µL) thiosalicylic acid (20 mM) reagent was added into a 5 milliliter (mL) precleaned borosilicate vial containing 3 mL of a standard or seawater sample. The pH in each vial was adjusted to 4.0. Then each vial was tightly screw-capped and incubated at 90 degrees Celsius in a water bath for 6 hours. After cooling to room temperature, each derivatized sample was filtered using a 0.2 micrometer (µm) Nylon syringe filter followed by injection of a 1 mL sample into a Shimadzu reverse-phase HPLC with UV absorbance detection at 257 nanometers (nm). To measure concentrations of DMSP and DMSO, both compounds were first converted to DMS. To convert DMSP or DMSO to DMS, 200 µL 5 M NaOH or 20% $TiCl_3$ was added to 1 mL of a standard or seawater sample in a precleaned borosilicate serum vial, which was immediately capped and sealed followed by incubation overnight for DMSP at room temperature or for DMSO at 55 degrees C for 1 hour. The produced DMS was analyzed using a cryogenic purge-and-trap system and a Shimadzu GC-14A with a flame photometric detector (Kinsey et al., 2016).

Notes: All samples from the biological consumption experiments were processed, stored, and analyzed for acrylate and DMSP using the same procedures used to measure DMSP and acrylate concentrations in the transect study (https://www.bco-dmo.org/dataset/879142).

Kbio_acrylate and Kbio_DMSP denote the first-order rate constants for biological consumption of acrylate and DMSP in the unit of per day (d-1).

Dissolved acrylate (Acrylate_d) and dissolved dimethylsulfoniopropionate (DMSP_d) concentrations were determined in the water samples used for the biological consumption experiments.

The concentrations of acrylate or DMSP at different time points were fit into a first-order decay kinetic model and the rate constants (+/- standard deviation) were determined by taking the slope of the best-fit line from linear regression analysis.

The biological consumption rate was calculated by multiplying the concentration of acrylate or DMSP with the rate constant in each sample.

Processing Description

This dataset used Microsoft excel, SigmaPlot version 11.0 for analyses.

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

- Added a conventional header with dataset name, PI names, version date
- Combined date and time, and converted local time to ISO 8601 standard time (UTC)
- Added latitude and longitude in decimal degrees for the sites (Back reef and Open Ocean)

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Related Publications

Kiene, R. P., & Slezak, D. (2006). Low dissolved DMSP concentrations in seawater revealed by small-volume gravity filtration and dialysis sampling. Limnology and Oceanography: Methods, 4(4), 80–95. doi:10.4319/lom.2006.4.80
Methods

Kiene, R., & Gerard, G. (1995). Evaluation of glycine betaine as an inhibitor of dissolved dimethylsulfoniopropionate degradation in coastal waters. Marine Ecology Progress Series, 128(1/3), 121-131. Retrieved from http://www.jstor.org/stable/24855505
Methods

Kinsey, J. D., Kieber, D. J., & Neale, P. J. (2016). Effects of iron limitation and UV radiation on Phaeocystis antarctica growth and dimethylsulfoniopropionate, dimethylsulfoxide and acrylate concentrations. Environmental Chemistry, 13(2), 195. https://doi.org/10.1071/en14275 https://doi.org/10.1071/EN14275
Methods

Xue, L., & Kieber, D. J. (2021). Photochemical Production and Photolysis of Acrylate in Seawater. Environmental Science & Technology, 55(10), 7135–7144. https://doi.org/10.1021/acs.est.1c00327
Results

Xue, L., Kieber, D, J, Masdeu-Navarro, M., Cabrera-Brufau, M., Rodgiguez-Ros, P., Gardner, S. G., Marrase, C., and Simo, R. (2022). Concentrations and biological consumption of acrylate and DMSP in the tropical Pacific and coral reef ecosystem in Mo'orea, French Polynesia. Under review at Frontier in Marine Science.
Results

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Related Datasets

IsRelatedTo

Xue, L., Kieber, D. J. (2022) **Concentrations of acrylate and dimethylsulphonioproprionate from the surface of coral reefs sampled in Moorea, French Polynesia in April 2018.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2022-08-31 doi:10.26008/1912/bco-dmo.879142.1 [view at BCO-DMO]

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Parameters

Parameter	Description	Units
Sampling_site	Site of sampling	unitless
Sampling_Date	Date of sampling	unitless
Local_Sampling_Time	Sampling time in local timezone for Moorea, French Polynesia in format HH:MM	unitless
Acrylate_d	Dissolved Acrylate concentration	nanomolar (nM)
kbio_acrylate	First order rate constant for biological consumption of acrylate	per day
std_dev_kbio_acrylate	Standard deviation of first order rate constant for biological consumption of acrylate	per day
consumption_rate_acrylate	Consumption rate of acrylate	nanomolar per day (nM/day)
std_dev_consumption_rate_acrylate	Standard deviation for consumption rate of acrylate	per day
DMSP_d	Dissolved DMSP (dimethylsulfoniopropionate)	nanomolar (nM)
kbio_DMSP	First order rate constant for biological consumption of DMSP	per day
std_dev_kbio_DMSP	Standard deviation of first order rate constant for biological consumption of DMSP	per day
consumption_rate_DMSP	Consumption rate of DMSP	nanomolar per day (nM/day)
std_dev_consumption_rate_DMSP	Standard deviation for consumption rate of DMSP	per day
ISO_DateTime_UTC	Datetime of sampling in ISO8601 format (UTC)	unitless
Latitude	Latitude of sampling site	decimal degrees
Longitude	Longitude of sampling site	decimal degrees

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Instruments

Dataset-specific Instrument Name	Niskin bottles
Generic Instrument Name	Niskin bottle
Dataset-specific Description	Sea-surface water samples were collected in Niskin bottles during cruises in the Pacific Ocean, Atlantic Ocean, and the Gulf of Mexico
Generic Instrument Description	A Niskin bottle (a next generation water sampler based on the Nansen bottle) is a cylindrical, non-metallic water collection device with stoppers at both ends. The bottles can be attached individually on a hydrowire or deployed in 12, 24, or 36 bottle Rosette systems mounted on a frame and combined with a CTD. Niskin bottles are used to collect discrete water samples for a range of measurements including pigments, nutrients, plankton, etc.

Dataset-specific Instrument Name	Shimadzu Prominence
Generic Instrument Name	High Performance Liquid Chromatograph
Dataset-specific Description	Shimadzu Prominence high performance liquid chromatography (HPLC) system with a model SPD-20A/V UV-Vis absorbance detector set at 257 nm.
Generic Instrument Description	A High-performance liquid chromatograph (HPLC) is a type of liquid chromatography used to separate compounds that are dissolved in solution. HPLC instruments consist of a reservoir of the mobile phase, a pump, an injector, a separation column, and a detector. Compounds are separated by high pressure pumping of the sample mixture onto a column packed with microspheres coated with the stationary phase. The different components in the mixture pass through the column at different rates due to differences in their partitioning behavior between the mobile liquid phase and the stationary phase.

Dataset-specific Instrument Name	Shimadzu GC-14A
Generic Instrument Name	Gas Chromatograph
Dataset-specific Description	DMS was analyzed using a cryogenic purge-and-trap system and a Shimadzu GC-14A with a flame photometric detector
Generic Instrument Description	Instrument separating gases, volatile substances, or substances dissolved in a volatile solvent by transporting an inert gas through a column packed with a sorbent to a detector for assay. (from SeaDataNet, BODC)

Dataset-specific Instrument Name	Shimadzu FPD-14 flame photometric detector
Generic Instrument Name	flame photometric detector
Dataset-specific Description	DMS was analyzed using a cryogenic purge-and-trap system and a Shimadzu GC-14A with FPD-14 flame photometric detector
Generic Instrument Description	The determination of sulfur or phosphorus containing compounds is the job of the flame photometric detector (FPD). This device uses the chemiluminescent reactions of these compounds in a hydrogen/air flame as a source of analytical information that is relatively specific for substances containing these two kinds of atoms. The emitting species for sulfur compounds is excited S2. The lambda max for emission of excited S2 is approximately 394 nm. The emitter for phosphorus compounds in the flame is excited HPO (lambda max = doublet 510-526 nm). In order to selectively detect one or the other family of compounds as it elutes from the GC column, an interference filter is used between the flame and the photomultiplier tube (PMT) to isolate the appropriate emission band. The drawback here being that the filter must be exchanged between chromatographic runs if the other family of compounds is to be detected.

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Project Information

Photolysis and Photoproduction of Acrylate in Seawater and their Impact on the Marine Organosulfur Cycle (Impact Acrylate in Seawater)

Website: https://mooreareefresearch.wordpress.com/

Coverage: Gump Research Station on the island of Mo'orea in French Polynesia (17.50 °S, 149.833 °W), State University of New York, College of Environmental Science and Forestry (43.034° N, 76.137° W)

NSF Award Abstract:

This project would investigate the marine chemistry of the compound acrylate. Acrylate is a mostly overlooked by-product of a very well-studied process through which a compound known as DMSP (dimethylsulfoniopropionate), a compound produced by phytoplankton, is converted to the gas dimethylsulfide (known as DMS). This process is an important part of understanding the marine cycling of sulfur, and DMS plays a role in cloud formation and climate. Thus, these aspects of the conversion of DMSP to DMS have received considerable attention. On the other hand, very little is known about acrylate concentrations, fluxes, or impacts in the oceans, even though it is produced during the conversion of DMSP to DMS. Acrylate concentrations and fluxes should at times be substantial, especially in shallow-water coral reefs or during blooms of DMSP-rich phytoplankton that are common throughout the world's oceans and often harmful or toxic. It is likely that acrylate is a reactive form of marine organic matter that significantly impacts the carbon cycle and ecology of the upper ocean. This project will foster research and educational opportunities for undergraduates and one graduate student through several avenues including field work with international collaborators, attendance at national and local meetings, mentoring, preparing for and delivering college-level lectures, and presentations made to the general public at forums such as Syracuse's Milton J. Rubenstein Museum of Science. Results will be disseminated through peer-reviewed publications, media communications, web-based data bases, and presentations at scientific meetings, public forums and in the classroom.

A three-year project is proposed to study the effect of sunlight on the formation and loss of acrylate in seawater, to model these processes in the water column, and to determine if photoproduction and photolysis are important pathways in the marine acrylate cycle in a shallow-water coral reef. Four objectives are planned to carry out this research: (1) synthesize radiocarbon-labeled DMSP as a source of radiocarbon-labeled acrylate for photolysis and uptake studies; (2) conduct laboratory experiments using a solar simulator to study the photolysis and photoproduction of acrylate in water and seawater under varying conditions (e.g., pH, temperature, oxygen concentration); (3) determine temperature and wavelength-dependent quantum yields for acrylate photolysis and acrylate photoproduction in seawater using a monochromatic irradiation system; and (4) conduct a field study at the Richard Gump Research Station to determine rates of photolysis, photoproduction and microbial consumption of acrylate in a shallow-water coral reef.

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Program Information

United States Surface Ocean Lower Atmosphere Study (U.S. SOLAS)

Website: http://www.us-solas.org/

Coverage: Global

The Surface Ocean Lower Atmosphere Study (SOLAS) program is designed to enable researchers from different disciplines to interact and investigate the multitude of processes and interactions between the coupled ocean and atmosphere.

Oceanographers and atmospheric scientists are working together to improve understanding of the fate, transport, and feedbacks of climate relevant compounds, and also weather and hazards that are affected by

processes at the surface ocean.

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Physical, chemical, and biological research near the ocean-atmosphere interface must be performed in synergy to extend our current knowledge to adequately understand and forecast changes on short and long time frames and over local and global spatial scales.

The findings obtained from SOLAS are used to improve knowledge at process scale that will lead to better quantification of fluxes of climate relevant compounds such as CO2, sulfur and nitrogen compounds, hydrocarbons and halocarbons, as well as dust, energy and momentum. This activity facilitates a fundamental understanding to assist the societal needs for climate change, environmental health, weather prediction, and national security.

The US SOLAS program is a component of the International SOLAS program where collaborations are forged with investigators around the world to examine SOLAS issues ubiquitous to the world's oceans and atmosphere.

Â» International SOLAS Web site

Science Implementation Strategy Reports

US-SOLAS (4 MB PDF file)
Other SOLAS reports are available for download from the US SOLAS Web site

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1756907

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