Gulf of Finland chromophoric dissolved organic matter (CDOM) Naperian absorption coefficients

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Project
» Transforming our understanding of DIC Photoproduction in Oceanic Waters (MODIE)

Contributors	Affiliation	Role
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Abstract
These data are chromophoric dissolved organic matter (CDOM) Naperian absorption coefficients from the LightCycle DOM photodegradation experiments conducted in the western Gulf of Finland, Baltic Sea. The LightCycle experiments were conducted as a part of the AQUACOSM JOMEX project: Systems Responses to A Pulse of Dissolved Organic Carbon, at the Tvärminne Mesocosm Facility (TMF, Tvärminne Zoological Station (TZS), University of Helsinki, https://www.aquacosm.eu/mesocosm/tvarminne-mesocosm-facility-tmf/). The JOMEX experiment ran from 26 June to 10 July 2019 and the mesocosms were divided into three treatment groups: three control mesocosms with no humic substances or nutrients added, three humic-amended mesocosms with only humic substances added to a final concentration of 2 mg L−1 in each mesocosm and three humic+nutrients-amended mesocosms with humic substances (2 mg L−1 final concentration) and NH4Cl and KH2PO4 (80 µg L−1 N and 20 µg L−1 P final concentrations) added. Surface (1 m) water samples for the LightCycle experiments were collected from one each of control, humic-amended and humic+nutrients-amended mesocosms, immediately after the amendment (day 1) and 2, 5, 7, 9 and 12 days after the amendment (days 3, 6, 8, 10 and 13). These water samples were filtered with 0.2 mm filters and irradiated under a solar simulator. CDOM absorbance at different irradiation time points were measured for these experiments using a Shimadzu UV-2501PC UV-VIS recording spectrophotometer or an Agilent 8453 UV-visible Spectrophotometer, and converted to Naperian absorption coefficients. The measurements of CDOM absorption and the subsequent calculation of CDOM fading (decrease in absorption) offered clues to the degradation of CDOM, and provided insights into the potential of photochemistry to remove added terrestrial dissolved organic matter (DOM) and the interactions of DOM photochemistry with eutrophication in this Baltic Sea system, where there are increasing concerns that climate change and anthropogenic activities can lead to increased terrestrial input of humic substances to surface waters and browning of surface waters. These data were collected by Kun Ma and Jay Brandes of the Skidaway Institute of Oceanography, Department of Marine Sciences, University of Georgia.

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Methods & Sampling

Surface (1 m) water samples were collected using precleaned 10 L HDPE canisters (Plastex®, Finland) and then filtered through 0.2 µm Whatman Polycap 36 AS nylon membrane cartridge filters, using a Masterflex L/S Digital Standard Drive peristaltic pump with Easy Load II and Masterflex L/S 17 silicone tubing at 100 mL

min−1, directly into precleaned 10 L polyethylene Hedwin CubitainersTM. Filtered sample waters were stored in the dark in an environmental chamber set at temperatures matching the *in situ* temperatures before use. Samples from each treatment group were partitioned into six 10-cm-pathlength cylindrical Spectrocell spectrophotometric quartz cells (~30 mL volume each). Each cell was rinsed three times with sample water from the corresponding cubitainers, and then filled without headspace directly from the cubitainers. Each cell was capped with two Spectrocell caps fitted with Microsolv Teflon-lined butyl septa. Five cells for each treatment type (15 total) were placed vertically into a temperature (15°C)-controlled black aluminum block, and irradiated under an Atlas Suntest CPS+ solar simulator equipped with a 1.5 kW xenon lamp. The solar simulator was fitted with a daylight filter (excluding light below ~300 nm) to provide the cells with precisely known, full spectral light. One cell for each treatment type was wrapped in aluminum foil to serve as dark control and placed in the same water bath that provided cooling water to the aluminum block. Absorbance ($A(\lambda)$) in the control and irradiated samples were measured at 250–800 nm at 1.0 nm intervals, in duplicate, in a 1-cm-pathlength quartz spectrophotometric cuvette. At the Tvärminne Zoological Station, a Shimadzu UV-2501PC UV-VIS recording spectrophotometer with UV-Probe software was used, with air as an internal reference and Milli-Q water as blanks. At Skidaway Institute of Oceanography, absorbances were measured using an Agilent 8453 UV-visible spectrophotometer with ChemStation software, with the same parameters as above and Milli-Q water as blanks. The average absorbance spectra of blanks were subtracted from the absorbance spectra of the sample water. Absorbance spectra were further corrected for potential offsets and instrument drift by subtracting the average absorbance at 690–710 nm, before converting $A(\lambda)$ to Napierian absorption coefficients ($a_g(\lambda)$; m−1), using the following equation: $a_g(\lambda) = A(\lambda)\ \ln 10/L$, where L (m) is the pathlength.

Data Processing Description

The average absorbance spectra of blanks were subtracted from the absorbance spectra of the sample water.

Absorbance spectra were further corrected for potential offsets and instrument drift by subtracting the average absorbance at 690–710 nm.

$A(\lambda)$ was converted to Napierian absorption coefficients ($a_g(\lambda)$; m−1), using the following equation: $a_g(\lambda) = A(\lambda)\ \ln 10/L$, where L (m) is the pathlength.

Software: R, 2021

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Related Publications

Ma, K., Powers, L. C., Seppälä, J., Norkko, J., & Brandes, J. A. (2022). Effects of Added Humic Substances and Nutrients on Photochemical Degradation of Dissolved Organic Matter in a Mesocosm Amendment Experiment in the Gulf of Finland, Baltic Sea. Photochemistry and Photobiology, 98(5), 1025–1042. Portico. https://doi.org/10.1111/php.13597
Results

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Parameters

Parameters for this dataset have not yet been identified

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Instruments

Dataset-specific Instrument Name	Atlas Suntest CPS+ solar simulator
Generic Instrument Name	Materials Testing System
Dataset-specific Description	Atlas Suntest CPS+ solar simulator equipped with a 1.5 kW xenon lamp was used for photodegradation experiments.
Generic Instrument Description	Testing systems that are used to test a wide range of materials in tension or compression.

Dataset-specific Instrument Name	Shimadzu UV-2501PC UV-VIS recording spectrophotometer
Generic Instrument Name	Spectrophotometer
Dataset-specific Description	A Shimadzu UV-2501PC UV-VIS recording spectrophotometer with UV-Probe software and Agilent 8453 UV-visible spectrophotometer with ChemStation software were used to take chromophoric dissolved organic matter absorbance measurements.
Generic Instrument Description	An instrument used to measure the relative absorption of electromagnetic radiation of different wavelengths in the near infra-red, visible and ultraviolet wavebands by samples.

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Project Information

Transforming our understanding of DIC Photoproduction in Oceanic Waters (MODIE)

Coverage: South Atlantic Bight, Bermuda BATS, Hawaii HOT

NSF Award Abstract:
Photoproduction describes chemical reactions which use the energy of sunlight to change the molecular structure of one product to another. This process has been shown to play an important role in the coastal ocean changing dissolved organic carbon (DOC) to dissolved inorganic carbon (DIC); however, minimal information is available on the extent to which this process takes place in the open ocean. The main obstacle to obtaining DIC production data for open ocean waters is the inability to measure the small DIC production rates against the large background of seawater DIC. Currently the most common method for high precision measurement of DIC production has unacceptable detection limits to resolve this difference. Researchers from the University of Georgia have developed MoDIE (Moderate DI13C Isotope Enrichment), a novel means of determining low levels of DIC produced in the open ocean with high precision. As part of this project, they plan to refine their MoDIE method and obtain measurements of DIC photoproduction in open ocean waters (i.e, South Atlantic Bight, North Atlantic Ocean and North Pacific Ocean subtropical gyres). Results from this work will provide improved estimates of DIC photoproduction in the open ocean which in turn will improve existing models of carbon cycling.

The broader impacts of this project are particularly exciting. The proponents plan to create an exhibit at the University of Georgia Marine Extension public aquarium to teach the general public about ocean color and marine carbon cycling. In addition, they plan to participate in the Skidaway Institute for Oceanography ?Marine Science Day? open house to share their science with the public and incorporate results into their class curricula. One of the researchers is a first-time investigator who plans to incorporate education and training of undergraduate and graduate students in the project. Finally, undergraduate interns from underrepresented groups will be involved in the project to give them research experience and help with retention in a science discipline and career.

Photoproduction of dissolved inorganic carbon (DIC) from dissolved organic carbon (DOC) has been shown to

be a non-negligible process in the marine carbon cycle; however, it is still unclear the extent and importance of this process to the overall carbon cycle in the open ocean (blue water chemistry). The major issue causing this uncertainty is the lack of available methods with acceptable detection limits. The high background of DIC in the open ocean (2mM) makes it difficult to measure the photoproduced portion of DIC when the detection limits are high. Additionally, the current best method requires pre-stripping samples of background DIC, which could introduce unnecessary errors by over manipulating samples. This project will develop a new method called MoDIE (Moderate DI13C Isotope Enrichment) to get accurate measurements of DIC photoproduction in the open ocean. MoDIE works by enriching a sample in 13C and monitoring the dilution of DI13C under irradiation using liquid chromatography-isotope ratio mass spectrometry (LC-IRMS). By removing the need for pre-sample treatment and introducing a highly precise measurement technique, the researchers will be able to compare their techniques with published methods of photochemical DIC detection and put forth more accurate estimate of marine DIC photoproduction in the global ocean. This will greatly improve marine carbon cycle models.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1635618

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