Measurements of Chlorophyll, NO2, NO3, PO4, Silicate, NH4, PIC, POC, PON, BSi from CTD casts on R/V Endeavor cruise EN616 in July 2018

Website: https://www.bco-dmo.org/dataset/837074
Data Type: Cruise Results
Version: 1
Version Date: 2021-03-08

Project
» Coccolithophore Mixotrophy (Cocco-Mix)

Contributors	Affiliation	Role
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Abstract
Measurements of Chlorophyll, NO2, NO3, PO4, Silicate, NH4, PIC, POC, PON, BSi from CTD casts on R/V Endeavor cruise EN616 in July 2018.

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Coverage

Spatial Extent: **N**:43.71835 **E**:-66.51748 **S**:36.98572 **W**:-72.92708
Temporal Extent: 2018-07-05 - 2018-07-13

Methods & Sampling

Techniques used are described in Balch et al. (2008).

Biogenic Silicas:
To determine reactive silicate, 200 mL of seawater sample is filtered onto a 25 mm, 0.4um pore size polycarbonate filter. Filters are folded and placed in a super clear polypropylene centrifuge tube and dried in a drying oven at 60°C for 24 hours then tightly capped and stored until analysis. On shore, 0.2N NaOH is added and the sample is placed in a 95C water bath. The digestions are then cooled and neutralized with 1N HCl. After centrifuging, the supernatant is transferred to a new tube and diluted with MilliQ water. Molybdate reagent is added and then a reducing agent is added to reduce silicomolybdate to silicomolybdous acid. The transmission at 810 nm is read on a Hitachi U-3010 spectrophotometer (SN 0947-010). Reactive silicate is calculated using a silicate standard solution standard curve prepared at least every 5 days or whenever new reagents are prepared. Readings are corrected using a reagent blank run at the same time as the standard curve and three tube blanks interspersed in each batch.

References: Brzezinski & Nelson (1989); JGOFS (1994); Strickland & Parsons (1977).

PIC (Particulate Organic Carbon):
Water samples are filtered through a 25mm, 0.4 µm pore size polycarbonate filter. The dry filter is rinsed with Potassium tetraborate (6.11 g/l $K_2B_4O_7 \cdot 4H_2O$) buffer while still in the filter tower to remove as much seawater salt and also to maintain a high pH (~8.1) during sample storage and preserve the $CaCO_3$ on the filter. Filters are placed into trace metal clean polypropylene centrifuge tubes and dried at approximately 60°.

For analysis, the filters are currently sent out to the Sawyer Environmental Chemistry Laboratory at the University of Maine or Department of Earth Sciences at Boston University. Filters are digested in a 5% nitric acid solution for 12 hours to dissolve all $CaCO_3$ and the solution is analyzed by ICP-AES (Inductively Couple Plasma – Atomic Emission Spectrometry) for Ca concentration. We have filter and dissolution blanks as well as QC standards run with each batch of samples. We also use the concentration of dissolved Na in the digestate to correct for any Ca present in sea salts left on the filter. PIC concentrations are calculated using the volumes of water filtered and the volume of the digestions, and assuming all Particulate Inorganic Carbon is in the form of $CaCO_3$.

POC (Particulate Organic Carbon):
Water samples are filtered onto 25mm GF/F filters which have been pre-combusted (450°, 5 hours). Filters are rinsed with filtered seawater (FSW) and then stored in individual petri-plates and dried (60°) for storage. Prior to analysis, the plates are opened and placed overnight in a sealed container like a dessicator with saturated HCL fumes to remove any PIC. We send these samples to the University of Maine's Darling Marine Center for analysis. The filters are packed into pre-combusted nickel sleeves and analyzed on a Perkin Elmer 2400 Series II CHNS/O for C, N, and H.

The analyzer is calibrated using tin capsules as blanks and acetanilide to calibrate instrument response to carbon and nitrogen. NIST certified check standards consisting of either low organic content soil or sediment are analyzed to determine accuracy of carbon detection. NIST certified organic check standards such as corn flour or rice flour are analyzed to determine the accuracy of nitrogen detection. If values vary by more than 4% from stated values, instrument is examined, any problems are addressed and instrument is recalibrated and check standards rerun until error is within acceptable limits. Duplicate samples are run during each sample run to ensure results are reproducible. If duplicates cannot be run on actual samples, as in the case of filter samples, duplicate check standards are analyzed. Duplicate samples typically vary less than 2%.

One instrument blank is analyzed for every 12 samples run. One acetanilide standard is analyzed for every 15 samples run. If blank or acetanilide values differ significantly from previous values, a new series of standards and blanks are analyzed to recalibrate the instrument.

The actual minimum detection limit (3 times the standard error) determined from the standard error of the instrument blanks is 2 micrograms for carbon and 4 micrograms for nitrogen.

References: JGOFS (1994).

Nutrients:
Water samples are collected in clean 60ml plastic bottles and immediately frozen (-20°). These samples are kept frozen with dry ice and sent to the University of California, Santa Barbara's Marine Science Analytical Lab. They are analyzed on a Lachat QuickChem 8000 for Nitrite, Nitrate plus Nitrate, Phosphate, and Silcate.

Chlorophyll a:
Water samples are filtered onto a 25mm Millipore HA filter (mixed cellulose ester, 0.45 µm pore size). The filters are transferred to test tubes filled with chilled 90% acetone for extraction and vortexed until the filter dissolves. Tubes are stored in the dark in a freezer for 24 hours before analysis. Tubes are then re-vortexed and gently centrifuged (~1300g) for 5 minutes before being decanted into a glass cuvette for the fluorometer. We use a Turner Designs 10AU to read Fb of the sample and then add 50 µl of 10% HCL and read Fa. The fluorometer was calibrated previously with a pure chlorophyll extract (Turner Designs part# 10-850) to determine Tau τ=(Fb/Fa pure chl a) and chlorophyll a can then be calculated from: (Fb – Fa) * (τ/ τ-1) * (Vfiltered/Vextracted). Generally all surface measurements are made in triplicate.

The fluorometers (Turner 10-AUs) are calibrated at least annually using the calibration method defined by Turner Designs using standards purchased from Turner Designs. Additionally, for long cruises (e.g. Great Belt, COPAS, etc), a calibration is performed on the ship.

References: Trees, et al.

Data Processing Description

BCO-DMO Processing:
- replaced spaces with underscores in parameter names;
- replaced "-999" with "nd" as the "no data" value;
- rounded Latitude and Longitude to 5 decimal places;
- rounded columns POC through Avg_Corr_Phaeo to 4 decimal places.

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Data Files

File
en616_discretes.csv (Comma Separated Values (.csv), 7.85 KB) MD5:60e787e5332b9dc9e79754d1e1f17871 Primary data file for dataset ID 837074

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Related Publications

Balch, W. M., Drapeau, D. T., Bowler, B. C., Booth, E. S., Windecker, L. A., & Ashe, A. (2007). Space-time variability of carbon standing stocks and fixation rates in the Gulf of Maine, along the GNATS transect between Portland, ME, USA, and Yarmouth, Nova Scotia, Canada. Journal of Plankton Research, 30(2), 119–139. doi:10.1093/plankt/fbm097
Methods

Brzezinski, M. A., & Nelson, D. M. (1989). Seasonal changes in the silicon cycle within a Gulf Stream warm-core ring. Deep Sea Research Part A. Oceanographic Research Papers, 36(7), 1009–1030. doi:10.1016/0198-0149(89)90075-7
Methods

JGOFS. 1994. Joint Global Ocean Flux Study Core Measurement Protocols, JGOFS Report #6. SCOR, Halifax, N.S., Canada, pp. 107-110 (Chapter 12: The Determination of Reactive Silicate in Sea Water)
Methods

JGOFS. 1994. Joint Global Ocean Flux Study Core Measurement Protocols, JGOFS Report #6. SCOR, Halifax, N.S., Canada, pp. 123-125 (Chapter 15. Determination of Particulate Organic Carbon and Particulate Nitrogen)
Methods

Strickland, J.D.H. and T.R. Parsons. 1977. A practical handbook of seawater analysis. Fisheries Research Board of Canada Bulletin 167, pp. 65-70.
Methods

Trees et al., Fluorometric Chlorophyll a: Sampling, Laboratory Methods, and Data Analysis Protocols. Chapter 3. Ocean Optics Protocols for Satellite Ocean Color Sensor Validation, Revision 5, Volume 5.
Methods

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Related Datasets

IsSupplementTo

Balch, W. M., Archer, S. D., Drapeau, D. T., Godrijan, J. (2023) **Hydrography and environmental conditions measured with CTD at nine stations during R/V Endeavor cruise EN616 in July 2018.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2023-02-24 doi:10.26008/1912/bco-dmo.887800.1 [view at BCO-DMO]

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Parameters

Parameter	Description	Units
Cruise	Cruise identifier	unitless
Station	Station number	unitless
Longitude	Longitude	degrees East
Latitude	Latitude	degrees North
Depth	Depth	meters (m)
ISO_DateTime_UTC	Date and time (UTC); formatted to ISO8601 standard: YYYY-MM-DDThh:mm:ssZ	unitless
POC	POC	micromoles per liter (umol L^-1)
PON	PON	micromoles per liter (umol L^-1)
PIC_umol	PIC	micromoles per cubic meter (umol m^-3)
PIC_mol	PIC	moles per cubic meter (mol/m^3)
BSi	Bsi	micromoles per liter (umol L^-1)
Avg_Corr_Chl_a	Avg Corr Chl a	micrograms per liter (ug L^-1)
Avg_Corr_Phaeo	Avg Corr Phaeo	micrograms per liter (ug L^-1)
NO3	NO3	micromoles per liter (umol L^-1)
PO4	PO4	micromoles per liter (umol L^-1)
SIL	SIL	micromoles per liter (umol L^-1)
NO2	NO2	micromoles per liter (umol L^-1)
NH4	NH4	micromoles per liter (umol L^-1)

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Instruments

Dataset-specific Instrument Name	Perkin Elmer 2400 Series II CHNS/O
Generic Instrument Name	Elemental Analyzer
Generic Instrument Description	Instruments that quantify carbon, nitrogen and sometimes other elements by combusting the sample at very high temperature and assaying the resulting gaseous oxides. Usually used for samples including organic material.

Dataset-specific Instrument Name	Lachat QuickChem 8000
Generic Instrument Name	Flow Injection Analyzer
Generic Instrument Description	An instrument that performs flow injection analysis. Flow injection analysis (FIA) is an approach to chemical analysis that is accomplished by injecting a plug of sample into a flowing carrier stream. FIA is an automated method in which a sample is injected into a continuous flow of a carrier solution that mixes with other continuously flowing solutions before reaching a detector. Precision is dramatically increased when FIA is used instead of manual injections and as a result very specific FIA systems have been developed for a wide array of analytical techniques.

Dataset-specific Instrument Name	ICP-AES (Inductively Couple Plasma - Atomic Emission Spectrometry)
Generic Instrument Name	Inductively Coupled Plasma Optical Emission Spectrometer
Generic Instrument Description	Also referred to as an Inductively coupled plasma atomic emission spectroscope (ICP-AES). These instruments pass nebulised samples into an inductively-coupled gas plasma (8-10000 K) where they are atomised and excited. The de-excitation optical emissions at characteristic wavelengths are spectroscopically analysed. It is often used in the detection of trace metals.

Dataset-specific Instrument Name	Hitachi U-3010 spectrophotometer (SN 0947-010)
Generic Instrument Name	Spectrophotometer
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.

Dataset-specific Instrument Name	Turner Designs 10AU
Generic Instrument Name	Turner Designs Fluorometer 10-AU
Generic Instrument Description	The Turner Designs 10-AU Field Fluorometer is used to measure Chlorophyll fluorescence. The 10AU Fluorometer can be set up for continuous-flow monitoring or discrete sample analyses. A variety of compounds can be measured using application-specific optical filters available from the manufacturer. (read more from Turner Designs, turnerdesigns.com, Sunnyvale, CA, USA)

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Deployments

EN616

Website	https://www.bco-dmo.org/deployment/837075
Platform	R/V Endeavor
Start Date	2018-07-03
End Date	2018-07-15
Description	See additional cruise information from the Rolling Deck to Repository (R2R): https://www.rvdata.us/search/cruise/EN616

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Project Information

Coccolithophore Mixotrophy (Cocco-Mix)

Coverage: Partially lab-based, with field sites in Gulf of Maine and NW Atlantic between the Gulf of Maine and Bermuda

NSF Award Abstract
Coccolithophores are single-cell algae that are covered with limestone (calcite) plates called coccoliths. They may make up most of the phytoplankton biomass in the oceans. Coccolithophores are generally considered to be autotrophs, meaning that they use photosynthesis to fix carbon into both soft plant tissue and hard minerogenic calcite, using sunlight as an energy source ("autotrophic"). However, there is an increasing body of evidence that coccolithophores are "mixotrophic", meaning that they can fix carbon from photosynthesis as well as grow in darkness by engulfing small organic particles plus taking up other simple carbon molecules from seawater. The extent to which Coccolithophores engage in mixotrophy can influence the transfer of carbon into the deep sea. This work is fundamentally directed at quantifying coccolithophore mixotrophy -- the ability to use dissolved and reduce carbon compounds for energy -- using lab and field experiments plus clarifying its relevance to ocean biology and chemistry. This work will generate broader impacts in three areas: 1) Undergraduate training: Two REU undergraduates will be trained during the project. The student in the second year will participate in the research cruise. 2) Café Scientifique program: This work will be presented in Bigelow Laboratory's Café Scientifique program. These are free public gatherings where the public is invited to join in a conversation about the latest ideas and issues in ocean science and technology. 3) Digital E-Book: We propose to make a digital E-book to specifically highlight and explain mixotrophy within coccolithophores. Images of mixotrophic coccolithophores would be the primary visual elements of the book. The E-book will be publicly available and distributed to our educational affiliate, Colby College. The goal of the book is to further communicate the intricacies of the microbial world, food web dynamics, plus their relationship to the global carbon cycle, to inspire interest, education, and curiosity about these amazing life forms.

Coccolithophores can significantly affect the draw-down of atmospheric CO2 and they can transfer CO2 from the surface ocean and sequester it in the deep sea via two carbon pump mechanisms: (1) The "alkalinity pump" (also known as the calcium carbonate pump), where coccolithophores in the surface ocean take up dissolved inorganic carbon (DIC; primarily a form called bicarbonate, a major constituent of ocean alkalinity). They convert half to CO2, which is either fixed as plant biomass or released as the gas, and half is synthesized into their mineral coccoliths. Thus, coccolithophore calcification can actually increase surface CO2 on short time scales (i.e. weeks). However, over months to years, coccoliths sink below thousands of meters, where they dissolve and release bicarbonate back into deep water. Thus, sinking coccoliths essentially "pump" bicarbonate alkalinity from surface to deep waters, where that carbon remains isolated in the abyssal depths for thousands of years. (2) The "biological pump", where the ballasting effect of the dense limestone coccoliths speeds the sinking of organic, soft-tissue debris (particulate organic carbon or POC), essentially "pumping" this soft carbon tissue to depth. The biological pump ultimately decreases surface CO_2. The soft-tissue and alkalinity pumps reinforce each other in maintaining a vertical gradient in DIC (more down deep than at the surface) but they oppose each other in terms of the air-sea exchange of CO_2. Thus, the net effect of coccolithophores on atmospheric CO2 depends on the balance of their CO_2-raising effect associated with the alkalinity pump and their CO2-lowering effect associated with the soft-tissue biological pump. It is virtually always assumed that coccolith particulate inorganic carbon (PIC) originates exclusively from dissolved inorganic carbon (DIC, as bicarbonate), not dissolved organic carbon (DOC). The goal of this proposal is to describe a) the potential uptake and assimilation of an array of DOC compounds by coccolithophores, b) the rates of uptake, and potential incorporation of DOC by coccolithophores into PIC coccoliths, which, if true, would represent a major shift in the alkalinity pump paradigm. This work is fundamentally directed at quantifying coccolithophore mixotrophy using lab and field experiments plus clarifying its relevance to ocean biology and chemistry. There have been a number of technological advances to address this issue, all of which will be applied in this work. The investigators will: (a) screen coccolithophore cultures for the uptake and assimilation of a large array of DOC molecules, (b) perform tracer experiments with specific DOC molecules in order to examine uptake at environmentally-realistic concentrations, (c) measure fixation of DOC into organic tissue, separately from that fixed into PIC coccoliths, (d) separate coccolithophores from other phytoplankton and bacteria using flow cytometry and e) distinguish the modes of nutrition in these sorted coccolithophore cells. This work will fundamentally advance the state of knowledge of coccolithophore mixotrophy in the sea and address the balance of carbon that coccolithophores derived from autotrophic versus heterotrophic sources.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1635748

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