Incubation experiment data from R/V Melville, R/V Roger Revelle cruises MV1101, RR1202 in the Southern Ocean (30-60S); 2011-2012 (Great Calcite Belt project)

Website: https://www.bco-dmo.org/dataset/560475
Version: 17 June 2015
Version Date: 2015-06-17

Project
» The Great Southern Coccolithophore Belt (Great Calcite Belt)

Contributors	Affiliation	Role
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Dataset Description

Data from incubation esperiments conducted aboard the vessels during the two Great Southern Coccolithophore Cruises - MV1101 and RR1202.

Related files and references:
Parsons, T.R., Miata, Y. and Lalli, C.M. (1984) A Manual of the Chemical and Biological Methods for Salt Water Analysis. Pergamon Press, New York.

Methods & Sampling

Eight deck-board metal-addition incubation experiments were conducted in total during two cruises across the ‘Great Calcite Belt’, which served as the focal point for this project. All incubations were conducted with water collected from 20 m with a 30-L GO-Flo bottle deployed on non-metal wire (1/4” Aracom Mini-Line). Bottles were immediately transported into a positive-pressure clean van, and water was dispensed gently into 10-L low-density polyethylene cubitainers. A 200µm mesh was placed in-line to remove mesozooplankton grazers. All bottles and plasticware was stringently acid-cleaned prior to use, and trace metal clean techniques were employed for all steps. Cubitainers and polycarbonate incubation bottles were soaked in 1% Micro detergent for several days, then rinsed copiously with ultrapure >18.2 M□ water and soaked in 1M reagent HCl for several more days before being rinsed again and dried before use.

Cubitainers were spiked with either Fe, Zn, Co, or left unamended. Trace metal solutions were produced from traceable AAS standards diluted into 0.01 M Optima HCl. On MV1101 cruise, the first two incubation experiments involved Fe, Zn and Co additions of 0.02, 0.02 and 0.004 nM, respectively. The third and fourth incubation experiments involved Fe, Zn and Co additions of 2, 2 and 0.4 nM, respectively. Incubations 3 and 4 also involved nitrate additions of approximately 4 µM for the Fe and Zn treatments. On RR1202 cruise, Fe, Zn and Co additions of 2.0, 2.0 and 0.5 nM were used for each experiment, each involving addition of negligible

nitrate.

Treatment cubitainers were gently homogenized and water decanted into triplicate 2.5-L polycarbonate bottles. Bottles were filled completely (minimizing headspace) and sealed with Parafilm and vinyl tape, then placed in incubators at 50% surface irradiance. On MV1101 cruise incubator temperature was maintained with surface water circulated through the ship's through-hull system. On RR1202 cruise a deckboard heater/chiller unit was used to control the temperature of recirculating seawater.

Incubation bottles were sampled several times over the course of each incubation for total chlorophyll and macronutrients (nitrate, phosphate, silicate). Additionally, bottles were sampled at the final timepoint for particulate inorganic carbon (PIC) and biogenic silica (bSi). Chlorophyll samples (100 mL) were filtered through 0.45µm 25-mm Millipore HA filters, frozen, extracted in 90% acetone and quantified fluorometrically. PIC samples (200 mL) were filtered through 0.4 µm 47-mm polycarbonate filters, rinsed with 0.02 M potassium tetraborate, and then dried at 60°C prior to storage. Samples were digested in 0.8 M (5%) nitric acid and analyzed by inductively-coupled plasma optical emission spectrometry. PIC concentrations in filter digests were corrected for contributions of seasalt using Na and a Ca/Na mass ratio of 0.0382. Biogenic silica samples (200 mL) were filtered through 0.4 µm 25-mm PCTE filters and then dried at 60°C prior to storage. Samples were digested in 0.2 M NaOH and quantified spectrophotometrically.

Dissolved nutrients were analyzed by ODF technician on ship using segmented flow injection analysis following the approach of Parsons et al (1984).

Data Processing Description

Data are reported as measured. Samples that were not measured are indicated as 'NM'. Values below detection limits are indicated 'ND'.

BCO-DMO Processing Notes
- Generated from original file "Twining et al GCB incubation expt data for BCO-DMO.xlsx" contributed by Ben Twining
- Parameter names edited to conform to BCO-DMO naming convention found at Choosing Parameter Name
- Date formatted to YYYYMMDD

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Data Files

File	
Incubation_Experiments.csv	(Comma Separated Values (.csv), 24.16 KB) MD5:cd5337fd51efe0fce572c439c5057067
Primary data file for dataset ID 560475	

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Parameters

Parameter	Description	Units
CruiseId	Official UNOLS cruise id	text
Station_Number	Cruise-specific station number where water for experiment was collected	dimensionless
Local_Date	Local date water for the experiment was collected	YYYYMMDD
Latitude	Station latitude (South is negative)	decimal degrees
Longitude	Station longitude (West is negative)	decimal degrees
Depth	Depth from which water was collected	meters
Temperature	Temperature of collected water	degs C
Experiment_No	Sequential experiment number	dimensionless
Timepoint	Timepoints sampled for each experiment	hours
Treatment	Experimental treatment designation (unamended control; +Fe; +Zn; or +Co; with A-C triplicates for each treatment)	text
Chl	Total chlorophyll concentration measured in the bottle	ug/L
NO3	Dissolved nitrate concentration measured in the bottle	uM
PO4	Dissolved phosphate concentration measured in the bottle	uM
SiOH4	Dissolved silicate Si(OH)4 concentration measured in the bottle	uM
PIC	Particulate inorganic carbon measured in the bottle	uM
bSi	Biogenic silica concentration measured in the bottle	uM

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Instruments

Dataset-specific Instrument Name	Flow Injection Analyzer
Generic Instrument Name	Flow Injection Analyzer
Dataset-specific Description	Dissolved nutrients were analyzed by ODF technician on ship using segmented flow injection analysis following the approach of Parsons et al (1984).
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	Fluorometer
Generic Instrument Name	Fluorometer
Dataset-specific Description	Chlorophyll samples (100 mL) were filtered through 0.45µm 25-mm Millipore HA filters, frozen, extracted in 90% acetone and quantified fluorometrically.
Generic Instrument Description	A fluorometer or fluorimeter is a device used to measure parameters of fluorescence: its intensity and wavelength distribution of emission spectrum after excitation by a certain spectrum of light. The instrument is designed to measure the amount of stimulated electromagnetic radiation produced by pulses of electromagnetic radiation emitted into a water sample or in situ.

Dataset-specific Instrument Name	GO-Flo bottle
Generic Instrument Name	GO-FLO Bottle
Dataset-specific Description	All incubations were conducted with water collected from 20 m with a 30-L GO-Flo bottle deployed on non-metal wire (1/4” Aracom Mini-Line).
Generic Instrument Description	GO-FLO bottle cast used to collect water samples for pigment, nutrient, plankton, etc. The GO-FLO sampling bottle is specially designed to avoid sample contamination at the surface, internal spring contamination, loss of sample on deck (internal seals), and exchange of water from different depths.

Dataset-specific Instrument Name	Spectrometer
Generic Instrument Name	Spectrometer
Dataset-specific Description	Samples were digested in 0.8 M (5%) nitric acid and analyzed by inductively-coupled plasma optical emission spectrometry.
Generic Instrument Description	A spectrometer is an optical instrument used to measure properties of light over a specific portion of the electromagnetic spectrum.

Dataset-specific Instrument Name	Spectorphotometer
Generic Instrument Name	Spectrophotometer
Dataset-specific Description	Biogenic silica samples (200 mL) were filtered through 0.4 µm 25-mm PCTE filters and then dried at 60°C prior to storage. Samples were digested in 0.2 M NaOH and quantified spectrophotometrically.
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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Deployments

MV1101

Website	https://www.bco-dmo.org/deployment/473222
Platform	R/V Melville
Start Date	2011-01-11
End Date	2011-02-16
Description	Original data are available from the NSF R2R data catalog

RR1202

Website	https://www.bco-dmo.org/deployment/473230
Platform	R/V Roger Revelle
Start Date	2012-02-18
End Date	2012-03-23
Description	Original data are available from the NSF R2R data catalog

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Project Information

The Great Southern Coccolithophore Belt (Great Calcite Belt)

Website: http://greatbeltresearchcruise.com/gbr11/

Coverage: Southern Ocean. 60W to 120E; 30S to 60S;

Collaborative Research: The Great Southern Coccolithophore Belt

Intellectual merit: Recent advances in satellite remote sensing enable estimation of suspended calcium carbonate (particulate inorganic carbon or 'PIC') from space. This radiative approach is operationally specific to marine coccolithophores (Haptophyceae) and sensitive enough to quantify PIC concentrations in oligotrophic

gyres. Global images of suspended PIC taken over the seven years of the MODIS Aqua mission show a 'Great Belt' of PIC near the sub-Antarctic front of the Southern Ocean that circles the globe. This feature occurs every year during austral summer and appears to be within the high-nutrient, low chlorophyll region of the Southern Ocean. The area of the Great Belt is ~88 million km2, 26% of the global ocean. Evidence from several cruises into the Great Belt region of the Atlantic, Indian and Pacific sectors has verified elevated concentrations of coccolithophores; previous work in the Atlantic sector verified high optical scattering from PIC. The few ship observations we have are entirely consistent with the satellite views. In this project, the investigators will systematically study the coccolithophores of the Great Belt guided by the following science goals: (a) identify the coccolithophore species within this belt; (b) measure the abundance of coccolithophores and associated PIC; (c) measure coccolithopore calcification rates; (d) elucidate factors that may limit coccolithophore latitudinal range (e.g. stratification, temperature, macronutrients, trace metals, grazing); (e) demonstrate whether the variability in PIC relates to shallow export flux; (f) define how variability in PIC production relates to the pCO2, total alkalinity and dissolved inorganic carbon budgets; and (g) examine the impact of short-term ocean acidification on coccolithophore growth and calcite dissolution.

The research will involve cruises along the 50 S parallel to sample the Great Belt, during the austral summer. The investigators will use a combination of underway surface sampling (primarily optical and hydrographic) and vertical station profiles (using CTD/rosette and large volume submersible pumps) to address hypotheses related to the above goals. The cruise track will elucidate both zonal and meridional variability in the Great Belt. Controlled carboy incubation experiments will examine the impact of ocean acidification at various future scenarios on coccolithophore growth and dissolution. Dilution experiments will address grazing-related mortality and dissolution questions. Controlled metal-addition incubations will focus on potential iron, zinc and cobalt limitation of the coccolithophores or competition from diatoms related to silica availability. The proposed field observations and metal-addition experiments will provide important information on the current status of the Great Belt in the context of global biogeochemistry. The ocean acidification experiments to be undertaken are more forward-looking in terms of the fate of the Southern Ocean coccolithophores in a future acidified ocean.

Broader impacts: The globally significant size of the Great Belt indicates that it likely plays a major role in global biogeochemistry and climate change feedbacks. Thus, the investigators expect this work to have broad, transformative impacts in biological and chemical oceanography. Ocean acidification from the burning of fossil fuels is predicted to lower the pH of the surface ocean by 0.3 units in the next century and up to 0.7 units - a 5-fold increase in the proton concentration by the year 2300. A major goal of this study is to examine the effects of ocean acidification on coccolithophores in a region of low calcite saturation (i.e., one of the first regions expected to become sub-saturating for calcite). The results of these experiments will therefore be highly relevant to our basic understanding of the marine carbon cycle. Related to career development and Criterion II activities, the project includes field experience on two cruises for NSF REU undergraduates from Maine universities or colleges, providing funds for them to attend a scientific meeting. Participation of undergraduate students from Maine colleges builds capacity in our rural coastal state and helps thwart the serious issue of 'brain drain', in which the best students are leaving Maine to seek opportunity in wealthier, more populated states. A teacher will also participate on the cruises (via the NSF-sponsored ARMADA program). This teacher will develop learning modules for students about such topics as coccolithophores, calcification, export production, metal-plankton interactions, ocean acidification and climate change.

PUBLICATIONS PRODUCED AS A RESULT OF THIS RESEARCH

Balch, WM; Drapeau, DT; Bowler, BC; Lyczskowski, E; Booth, ES; Alley, D. "The contribution of coccolithophores to the optical and inorganic carbon budgets during the Southern Ocean Gas Exchange Experiment: New evidence in support of the "Great Calcite Belt" hypothesis," *JOURNAL OF GEOPHYSICAL RESEARCH-OCEANS*, v.116, 2011. View record at Web of Science

Poulton, AJ; Young, JR; Bates, NR; Balch, WM. "Biometry of detached Emiliania huxleyi coccoliths along the Patagonian Shelf," *MARINE ECOLOGY-PROGRESS SERIES*, v.443, 2011, p. 1. View record at Web of Science

BOOKS/ONE TIME PROCEEDING

Brown, Michael S, W. Balch, S. Craig, B. Bowler, D. Drapeau, J. Grant. "Optical closure within a Patagonian Shelf coccolithhophore bloom", 06/01/2011-05/31/2012, 2012, "ACCESS'12. Atlantic Canada Coastal & Estuarine Science Society. Dalhousie University, Halifax, Nova Scotia. 10-13 May, 2012.".

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-0961660

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